A socio-technical systems approach to improving vascular access for haemodialysis

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Thesis submitted in fulfilment of the requirements for the degree of PhD

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October 2018

Abstract

Patients who develop kidney failure require renal replacement therapy (RRT) in order to survive. Renal transplantation is the best treatment but is often not forthcoming. Many patients therefore require haemodialysis treatment, for which a means of vascular access (VA) is necessary. There are substantial morbidity, mortality and cost benefits from using arteriovenous fistulae (AVF) rather than central venous catheters (CVC) for this purpose.

Despite audit standards recommending that most patients should dialyse using AVF there has been longstanding, marked variation between centres in Scotland and further afield as to the proportions of patients who dialyse using each VA modality. Many studies have documented this variation and its clinical consequences, but little progress has been achieved over more than a decade of registry-documented practice. The present study aims to understand this variation using systems approaches to delineate the structure of VA clinical pathways in Scotland and the manner in which they function; to quantify the clinical workload associated with VA services; to illuminate gaps between 'work-as-imagined' and 'work-as-done' from the perspectives of those working in the services; and to present the findings in a manner that facilitates quality improvement activities.

The study characterises VA as a complex socio-technical system, with reference to the patient safety, quality improvement and systems theory literatures. A novel approach to investigating complex clinical systems was developed, in keeping with the principles of Safety II and healthcare resilience engineering. A mixed-methods approach was used to investigate every Scottish VA service, including detailed semi-structured interviews, a clinical activity census, and linkage with pre-existing registry data.

An in-depth, thematic analysis of audio-transcripts was considered in light of clinical activity and registry data. The results were distilled into four major themes: VA creation, VA maintenance, service performance, and development needs. A substantial associated clinical workload was quantified for the first time, despite a shortage of clinical resources dedicated to the service. VA creation procedures were proportional to the size of the local RRT cohort, but maintenance activities did not reflect the local cohort size and varied widely between centres. Recommendations for practice were disseminated using a novel 'scorecard' tool, designed with the principles of resilience engineering in mind. Centres were encouraged to report their concordance with recommendations; the resulting data suggested a statistical relationship between published incident and prevalent AVF use, and the degree to which the recommendations were implemented by each centre.

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Acknowledgements

I gratefully acknowledge the support provided by the following people:

Professor Aidan Halligan, whose enthusiasm, patience and encouragement first stimulated my interest in health services research;

Professor Moira Fischbacher-Smith, who encouraged me to develop these interests as a junior medical student;

Mr Phillip Evans, whose teachings helped develop my interest in the power of qualitative research;

Dr Peter Thomson for his support and friendship over many years of clinical training; his interest, encouragement and practical help to develop this project from a basic concept into an internationally recognised service appraisal, and his unwavering enthusiasm and encouragement throughout the study;

Mr David Kingsmore, whose passion for improving vascular access care proved both inspirational and motivational throughout the study period and beyond;

Dr Ram Kasthuri, Dr Ann Humphrey and Mr Stuart Suttie, who provided invaluable assistance in the conduct of interviews;

Mrs Leigh Bainbridge for her support in collation and formatting of the clinical activity census data;

Mrs Jacqueline Campbell and her colleagues at NHS Information Services Division Scotland for their support in performing statistical data analyses;

The Scottish Renal Registry and NHS Information Services Division Scotland for financial, technical and graphic design support in publishing the Scottish Haemodialysis Vascular Access Appraisal report, and catering the presentation event in November 2015;

Jean Thomson, Antonella Grimon, Kellie Callender and Christina Hays for their invaluable audio-transcription work;

All those who agreed to be interviewed as part of the study, and everyone who provided data for the six-week clinical activity census;

Professor Alan Jardine and Professor Denis Fischbacher-Smith for agreeing to supervise this project, for tolerating the many twists and turns along the way, for giving me space to develop, and for their academic wisdom and guidance as and when it was needed along the way.

I would like to thank Darlinda's Charity for Renal Research, who generously funded the travel expenses and audio-transcription costs arising from the interviews; without their support the project would not have been possible.

I am also extremely grateful to NHS Lanarkshire's Medical Education department for the robust support provided throughout this project. This was the first time the department had funded a Clinical Teaching Fellow to pursue a PhD, and I greatly appreciated the opportunity to work with such an inspirational team. I learned a huge amount and gained many friends along the way.

Most importantly of all, I thank my wife, our families and our friends for their patience, support and good humour throughout this endeavour: I really couldn't have done it without you!

Author's declaration

This thesis describes and presents research work I have conducted while training in Renal Medicine in the West of Scotland, between February 2014 and February 2017. During this period, I was employed by NHS Lanarkshire's Medical Education department. I declare that the work presented in this thesis was undertaken by me, except as indicated below:

- I was assisted with semi-structured interview data collection by Dr Peter Thomson, Mr David Kingsmore, Dr Ram Kasthuri, Dr Ann Humphrey and Mr Stuart Suttie;

- I was assisted in the collation and formatting of clinical activity data by Mrs Leigh Bainbridge;

- I was assisted with statistical analyses of the data, and linkage with registry data, by Mrs Jacqueline Campbell from the Scottish Renal Registry / ISD Scotland.

I have written this thesis myself. It has not previously been submitted for a higher degree.

List of abbreviations

AVF	Arteriovenous fistula
AVG	Arteriovenous graft
CKD	Chronic kidney disease
CVC	Central venous catheter
ecAVG	Early cannulation arteriovenous graft
EDTA	European Dialysis and Transplant Association
eGFR	Estimated glomerular filtration rate
EHR	Electronic health record
ESRF	End-stage renal failure
FRAM	Functional Resonance Analysis Method
HD	Haemodialysis
HLA	Human leucocyte antigen
IR	Interventional radiology
IT	Information technology
MDT	Multi-disciplinary team
NHS	National Health Service
NICE	The National Institute for Health and Care Excellence
NTCVC	Non-tunnelled central venous catheter
PD	Peritoneal dialysis
PDSA	Plan, Do, Study, Act
PESTLE	Political, Economic, Social, Technical, Legal, Environmental
PS	Patient safety
QI	Quality improvement

RAG	Resilience analysis grid
RDU	Renal dialysis unit
RRT	Renal replacement therapy
STAMP	Systems Theoretic Accident Model and Processes
SWOT	Strengths, Weaknesses, Opportunities, Threats
TCVC	Tunnelled central venous catheter
TTG	Treatment time guarantee
UK	United Kingdom
USA	United States of America
USS	Ultrasound scan
VA	Vascular access
VAN	Vascular access nurse
WTE	Whole-time equivalent

Chapter 1: Introduction

Patients with end-stage renal failure (ESRF) are reliant upon renal replacement therapy (RRT) for survival. While renal transplantation remains the gold standard of care[1], for many patients this is not immediately forthcoming or a realistic possibility[2]. For this cohort alternative means of RRT, namely haemodialysis or peritoneal dialysis, are required to sustain life.

A means of Vascular Access (VA) is required to provide haemodialysis treatment, with the main options in modern times comprising an arteriovenous fistula (AVF), an arteriovenous graft (AVG), or a central venous catheter (CVC)[3,4]. CVCs may be non-tunnelled (NTCVC) or tunnelled (TCVC) with the former typically providing temporary VA on an emergency basis, while the latter can provide longer-term bloodstream access[5]. Each VA modality has its relative advantages and disadvantages. There is a clear survival benefit for patients who dialyse with an AVF or AVG in comparison with those who dialyse using a TCVC[6,7]. Despite this, widespread variation has been described over many years in relation to the provision of VA in renal units across Scotland[8], the United Kingdom[9], Europe[10] and further afield[11,12]. While audit standards in the United Kingdom recommend that 60% of incident patients, and 80% of prevalent patients, should dialyse using an AVF or AVG[3], most centres regularly fall short of this target and instead provide haemodialysis to a high proportion of their patients using TCVC[8,9].

This thesis seeks to explore this variation in detail by taking a systems approach to how VA care is delivered in Scotland, with the aim of delineating the structure, function and workload of VA care. The findings from this work will inform the development of recommendations for practice, which will be presented in a format that prompts and facilitates quality improvement (QI) in this area. In this introductory chapter, the context for the study will be delineated. There are two distinct parts to the introduction: the first, chapter 1A describes the clinical condition of ESRF. The various options for treatment are discussed, along with the variable timings in which they may become available or become necessary. The relative merits of RRT and VA modalities are explored with reference to the available literature concerning their longevity, clinical efficacy and associated complications. It will become apparent to the reader that many aspects of treating renal failure have significant associated uncertainty which vary depending upon the individual patient. These include the timing of

ESRF, the merits of active versus conservative treatment, the likelihood of receiving a renal transplant, and the burdens associated with haemodialysis or peritoneal treatment.

The second part of this introduction, chapter 1B, frames this clinical problem and its associated challenges, in the context of the sociotechnical systems literature. In this section the sociotechnical systems literature, as it relates to healthcare, is described and reviewed. The reader is introduced to ‘systems thinking’, the differentiation between complicated and complex systems, and emerging work concerned with ‘resilience engineering’ in healthcare. Published works relevant to patient safety and healthcare quality improvement, along with models of investigating and modifying complex systems are also discussed.

Together, these introductory sections set the scene for an exploration of VA care across Scotland. This thesis will describe VA care through the lens of systems theory, making use of the concepts introduced in chapter 1B. This approach is used for the first time to illuminate and understand the configuration and workings of VA services, and enables the design and implementation of strategies to improve patient care.

Chapter 2 is concerned with methodology, both theoretical and practical. The reader is introduced to a novel approach to exploring complex clinical systems. The rationale for developing a new approach and its underpinning literature base are described here. The chapter emphasises the simplicity of this approach and its ability to inexpensively capture the relevant detail in a manner that facilitates the design and implementation of improvements to the system and its function. The chapter then describes the use of this model in the current study, to explore and broaden understanding of VA services across Scotland. A detailed description is provided as to the conduct of the study. Chapter 2 concludes by considering how one may assess the quality of qualitative research and goes on to describe a sub-study to quality assure the current work. The results and analysis provide assurance to the reader as to the validity of the following results chapters.

Chapters 3 – 10 describe the study results. In chapter 3 the reader gains an understanding of the clinical pathways used to create VA, while chapter 4 concerns the influence of clinicians' opinions about the various VA modalities on VA creation practice. Chapter 5 considers the clinical pathways used to maintain VA and chapter 6 discusses variations in surveillance practice between centres. Chapter 7 contextualises the preceding chapters by demonstrating the volume of clinical work associated with the provision of VA services. This data sets the scene for chapters 8 and 9, which respectively consider the reported influences on VA services' operational performance and their development needs. Chapter 10 considers the recommendations for practice arising from the study, alongside the VA ‘scorecards’, a novel tool developed during the study to present the findings to the clinical community.

Chapter 11 discusses the findings from this work and likely implications for further study. It also relates the work to the sociotechnical systems literature described in the introduction. Chapter 12 draws conclusions on the study and considers the capacity to use this model to investigate other complex areas of clinical practice, and suggested further work.

Chapter 1A: Renal failure and renal replacement therapy

The major roles of the kidneys are to excrete waste products and to manage fluid balance, with additional important functions including the activation of vitamin D, the stimulation of haematopoiesis and blood pressure modulation. A wide range of medical problems can result in renal failure[13], and once ESRF is present the patient requires treatment with renal replacement therapy if they are to survive for the long term.

The four main treatment options consist of renal transplantation, dialysis treatment in the form of haemodialysis or peritoneal dialysis, or conservative management. While transplantation and dialysis therapies address the primary functions of the kidneys in terms of waste product excretion and fluid balance, conservative management has a less invasive approach and seeks to provide high quality palliative care[14].

ESRF can arise over a variable time course, with variable disease trajectory[15,16] and symptom burden[17] as renal excretory failure progresses. Some patients first present to a renal physician many years before their kidneys fail, while others present late in the course of their illness, in some cases at the point of ESRF[18,19]. All therapeutic choices are intended, ultimately, to optimise the patient's longevity and quality of life without causing undue suffering[14]. In most cases several treatment options are feasible for a particular patient but for medical, technical and logistical reasons some are more easily achieved than others. It is therefore common for patients to commence one form of RRT[13], with a longer term plan to transfer to a preferred form when possible.

Each treatment option brings with it a degree of complexity in terms of the demands it places upon the patient, the prerequisite procedures needed to facilitate treatment, and the resulting morbidity and mortality burden borne by the patient – which in turn may influence the potential viability or success of the preferred, alternative form of RRT. These are discussed below.

Renal transplantation

Renal transplantation is widely regarded as the gold standard RRT modality[1]. It conveys substantial benefit to patients in the form of increased life expectancy, improved quality of life and the ability to resume normal social and occupational function[1,13]. No other form of

RRT can provide equivalent morbidity or mortality benefit to transplantation[1,20]. Its utility is constrained by organ availability[21] and the need for patients to be technically and medically suitable to receive the transplant and survive the perioperative period[1].

Patients may receive renal transplants from living or cadaveric donors. Specific legislation governs the use of organs donated by living donors in the United Kingdom: The Human Tissue (Scotland) Act 2006[22] and The Human Tissue Act 2004[23] (England, Wales, Northern Ireland). Live donors are mostly genetic or social relatives of the patient with kidney failure, and a small number are donated altruistically by members of the public[21]. Living donor transplantation is usually directed towards a specific patient, whereas cadaveric organs are made available on a national basis and allocated to patients on a transplant waiting list that is coordinated centrally using a published algorithm[24].

Kidney transplantation can fail due to technical problems arising during the surgical operation, but these are uncommon and transplant failure is more commonly caused by immune-mediated rejection[25]. The risk of rejection is minimised in two ways: matching the donor and recipient blood group and human leucocyte antigen (HLA) types as closely as possible; and using immunosuppressant medications to reduce the immune response to the implanted organ. These measures have proven highly successful in extending the longevity of transplanted organs[25] but they also serve to limit the available pool of organs for individual patients, since only donors with the appropriate blood group and HLA type can ordinarily be matched. Techniques exist to limit this problem, including the paired pool matching scheme and blood group incompatible transplantation[26], but these bring social and medical complications that many patients find unattractive. Even those receiving “perfectly” matched organs require immunosuppressive therapy, usually for the duration of the transplanted kidney’s lifespan. These drugs are recognised to cause various adverse effects including life-threatening infections, malignancy, and sometimes reduced function of the transplanted organ[13].

Potential transplant recipients must undergo a series of assessments before being able to receive an organ. The perioperative morbidity burden around kidney transplantation is such that patients’ personal mortality risk becomes substantially higher in the first three months following transplantation than it would have been with alternative RRT[1]; only thereafter do the significant morbidity and mortality advantages emerge. Patients must therefore be able to withstand this perioperative risk if the procedure is to be beneficial.

Considerable time delays are common in transplant pathways. Potential living donors require extensive assessment before donation can proceed[26], in a process that may take over a year to conclude. The waiting time to receive a cadaveric kidney in the United Kingdom can exceed thirty months, or significantly longer for those with unusual HLA types[21].

It is clear that kidney transplantation is commonly not available in the short or medium term, and for others it is unfeasible. In this context, most patients will require at least a short period of dialysis treatment: as a bridge to transplantation, or for the longer term.

Haemodialysis

Haemodialysis is the most common form of RRT in the non-transplanted ESRF population in Scotland[8]. This technique involves the passage of blood through an extra-corporeal circuit that includes an artificial dialyser. Waste products are removed using the processes of convection and diffusion, while excess fluid is removed by the process of ultrafiltration.

Haemodialysis can be delivered in patients' homes ('home haemodialysis') or in hospital ('outpatient haemodialysis') in a renal dialysis unit (RDU); the latter is substantially more common[8,27]. While the required duration of haemodialysis treatment can be calculated for individual patients, for practical purposes most patients' haemodialysis prescription is for four hours of haemodialysis treatment, three times per week[27]. Patients treated with home haemodialysis often dialyse more frequently[28]; this conveys survival advantage[29].

VA is required for haemodialysis, and each means of VA for haemodialysis has an associated package of risks; these are discussed in the following sections.

Central venous catheters

NTCVC are typically utilised in the setting of emergent haemodialysis, whereas TCVC are preferred in the context of elective or semi-elective haemodialysis[3,5]. While NTCVC are typically inserted in a ward-based setting by middle grade nephrologists or equivalents[30], TCVC are more commonly inserted by interventional radiologists under radiological screening, although practice varies considerably across the United Kingdom and elsewhere[30,31]. Either form of CVC insertion can typically be achieved within 30 minutes, requires minimal preparation, and the CVC is available for use immediately after insertion[32].

Connection of a CVC to a haemodialysis machine requires minimal training. No needles, injections or other direct physical patient contact is required; similarly, when the haemodialysis treatment finishes patients can be ‘disconnected’ with minimal effort. Despite the relative logistical ease of CVC insertion and subsequent use, they come with a significantly increased burden of morbidity and mortality[33,34] in comparison with other VA modalities, including particular problems with bloodstream infection and central venous stenosis[35].

Bloodstream infection is strongly associated with CVCs, particularly infections caused by *Methicillin Sensitive Staphylococcus aureus* (MSSA) or *Methicillin Resistant Staphylococcus aureus* (MRSA)[34,36]. These are often collectively termed *Staphylococcus aureus* bacteraemia (SAB) episodes. These infections are most prevalent in the three months following CVC insertion but can arise at any time a CVC is in-situ[35]. Significant efforts to reduce CVC-associated infections have been reported[37]. MSSA and MRSA infections cause significant complications for patients, and financial costs for providers[38]. Patients typically develop a systemic inflammatory response requiring antibiotic treatment and, frequently, hospitalisation[36,38]. Metastatic infection deposits can cause endocarditis, discitis, or prosthetic device infection including orthopaedic implants or cardiac pacemakers[38]. The CVC usually requires removal (and replacement) to successfully treat the infection[32]; the associated mortality can be up to 28%[38]. All-cause hospitalisation approximately doubles for a given patient in the six months following an infective episode, in comparison with the prior six months[38].

The financial cost to provider organisations of CVC-associated SAB episodes can be over £8500 per patient[38]. SAB prevalence has reduced in recent years, in part because of government initiatives[39]. Various successful strategies have been reported including the use of citrate line locks; chlorhexidine impregnated dressings or adjuncts, and regular inspection and replacement of CVC dressings[32,40] (although some doubt remains as to the efficacy of frequent dressing changes[41]). It remains difficult to entirely eradicate CVC-associated infections; registry data suggest an incidence of approximately 0.5 bacteraemia episodes per 1000 haemodialysis-exposed days[13].

While infective episodes are often acute, dramatic events with a clear temporal association with an in-situ CVC, central venous stenosis presents with a more indolent course. It is seen to develop in approximately 1 in 5 patients[42], and reflects overall CVC use throughout a haemodialysis ‘career’ rather than arising from one particular CVC episode[43,44]. As a late complication, central venous stenosis within a patient cohort may reflect historical CVC use rather than current practice. It has also been reported in patients with no prior documented central venous catheter use[44]. As with infective episodes, central stenosis carries a high morbidity and mortality burden for patients, and substantial financial cost for provider organisations[42]. Subsequent CVC placement becomes increasingly difficult[45] and AVF or AVG become less likely to function because of limited blood flow[42]. This can potentially render VA impossible to achieve; if alternative RRT (peritoneal dialysis or transplantation) is unavailable death will likely result within two weeks[46]. Established central venous stenosis requires periodic angioplasty procedures, usually performed by an interventional radiologist. This can cost up to £23,000 per patient per annum (personal communication).

Notwithstanding these major complications, CVC may also fail for various practical reasons[32]. They may be inadvertently placed in inappropriate vessels; their position may migrate after insertion; or intra-luminal thrombus may form, limiting blood flow and effectively preventing CVC utilisation[45]. While these are anecdotally noted as ‘common’ complications of CVC use it is unusual for their occurrence to be formally, systematically recorded or otherwise measured[47].

Given the significant morbidity and mortality risks associated with TCVC use for haemodialysis, some authors consider their use to be ethically and potentially legally unacceptable for most patients[48].

Ateriovenous fistulae

AVF are created by a surgical procedure and require up to 6 weeks maturation before they can support haemodialysis[32]. The procedure requires an artery and vein of sufficient calibre, along with patent proximal vessels and adequate cardiac function to supply blood to the resulting AVF and prevent its collapse[49]. AVF creation can be technically challenging in the setting of vascular disease (including central venous stenosis), repeated venepuncture, or with previous failed AVF or AVG more proximally in the same limb; various other factors have also been reported[50,51]. Unintended complications of AVF creation include the development of distal limb ischaemia or neuropathy, high output cardiac failure, or aneurysmal AVF transformation[52].

The success of AVF creation surgery can be expressed according to ‘primary patency’ (the proportion of AVF that successfully mature) and ‘secondary patency’ (the longevity of matured AVF beyond the initial maturation period), although the definitions used in the literature vary considerably. Reports in the literature suggest primary patency sits between 56-84% dependent upon the AVF’s anatomical location[32,53], but in NHS practice neither primary nor secondary patency data is routinely reported by centres performing AVF creation surgery.

AVF cannulation for haemodialysis requires a degree of technical skill and experience and is usually performed by a nurse whose primary role is the delivery of haemodialysis treatment[54]. The main approaches to cannulation are ‘rope ladder’ and ‘buttonhole’; these involve using needles to access the bloodstream[3,55]. ‘Rope ladder’ involves AVF cannulation at different locations for each haemodialysis session, using a sharp needle[3]. Moderate technical skill is required, the major consideration being to avoid cannulating the same area used in the preceding session. ‘Buttonhole’ cannulation prolongs AVF longevity by generating a tract from the skin to bloodstream using sharp needles inserted at the same place, using the same angle, over several haemodialysis sessions[3]; the tract can subsequently be cannulated with blunt needles by removing the superficial scab. Tract creation requires dexterity and technical skill; secondary patency is improved although the bloodstream infection risk slightly increases compared with rope ladder, but remains substantially below the equivalent risk for CVCs[32,34]. The third AVF cannulation strategy, known as ‘area puncture’, is associated with higher rates of access failure than rope ladder and buttonhole, and may also carry a higher risk of infection[3,56].

AVF failure is often mediated by the development of a proximal stenosis that ultimately results in AVF thrombosis or collapse. Early signs of stenosis include difficulty with cannulating, reduced haemodialysis blood flow and reduced haemodialysis efficiency (measured using urea reduction ratios)[51]. Suspected stenosis can be confirmed on a fistulogram imaging study and corrected with a fistuloplasty procedure. The optimal timing of this procedure is controversial[57].

Arteriovenous grafts

AVG represent an alternative approach when patients' poor vasculature renders AVF creation impossible[32]. These prosthetic devices connect an artery and vein using a loop of prosthetic material that can be repeatedly cannulated for haemodialysis. The morbidity and mortality profile is similar to AVF, but AVG tend to require more intensive maintenance activity[58]. Significant technical expertise is needed for AVG insertion, which limits their availability. Several AVG products are licensed in the United Kingdom, including 'early cannulation' AVG (ecAVG) that can be utilised for haemodialysis immediately following insertion[32,59], avoiding the need for a period of maturation before use.

The logistical challenges of AVG insertion, maintenance and use are balanced by substantially improved morbidity and mortality compared to CVC[34,60]. The economic advantages of AVF or AVG are considerable. One study explored the financial cost of inserting and maintaining AVF, AVG and CVC in a large haemodialysis cohort[61]: the equivalent costs per patient with CVC were significantly more than the equivalent AVG or AVF costs, accounting for consumables, drugs, notional hospital admission charges and associated factors. Another study compared CVC versus ecAVG for emergency incident haemodialysis access, finding that ecAVG reduced SAB episodes and mortality while remaining cost neutral, in comparison with CVC[60].

Peritoneal dialysis

Peritoneal dialysis (PD) presents a further, alternative, means of RRT. It is widely used but tends to be relatively underutilised in comparison with haemodialysis within any given centre[8,9].

The basic premise of PD is to utilise the peritoneum as a dialysis membrane, using dialysate fluid that is infused into the abdominal cavity. This requires that a 'Tenckhoff' catheter is surgically inserted into the lower abdomen, to facilitate the passage of dialysate fluid into the abdominal cavity. This fluid is left in-situ for a pre-determined number of hours, during which time the peritoneum acts as a dialysis membrane. The fluid is exchanged for fresh fluid, and the process repeats. Once inserted, the Tenckhoff catheter can remain in-situ for several years.

PD is a home therapy. Most patients are trained, over a period of days to weeks, to perform PD manually, or using a semi-automated PD machine installed in their home[62]. Alternatively a process of 'assisted PD' can be provided, whereby a trained member of staff attends patients' home to conduct PD[63]. Typically, PD is performed every night using an automated machine while the patient sleeps; the patient may retain relatively normal occupational and social function despite their RRT treatment. Where assisted PD is provided, the treatment usually occurs during daytime hours for practical reasons.

PD is a viable option for the majority of patients, however several practical issues require consideration. They require adequate housing, in terms of storage space and accessibility for consumables to be delivered; this is a key limiting factor in providing PD (and home haemodialysis)[64]. The patient also requires adequate cognition, visual acuity and manual dexterity, and should not have had significant previous abdominal surgery or illness[65].

PD confers equal survival benefit compared with outpatient haemodialysis[66], but a slight survival disadvantage compared with home haemodialysis (albeit only when PD commences after at least six months haemodialysis)[28]. In other groups PD may confer a survival advantage, including those for whom haemodialysis would practically require TCVC use[7]. Avoiding bloodstream access avoids risks associated with haemodialysis such as VA-associated bacteraemia or central venous stenosis, but PD carries its own risks of potentially life-threatening PD-associated peritonitis and encapsulating peritoneal sclerosis[67].

Some renal units offer acute PD, but across the UK it is mostly considered a chronic therapy[68]. Patients referred to nephrology late in the course of their renal disease, or who commence RRT using PD, are much more likely to choose haemodialysis for ongoing RRT[69]. While PD does not require VA, a Tenckhoff catheter needs to be inserted to facilitate treatment; when treatment commences soon after insertion the technique may fail due to leaks around the surgical wound[70]. Despite this a broadening body of literature supports acute PD[71,72] and a forthcoming randomised study will explore its merits[73].

Conservative care

Conservative management aims to address the symptomatology that develops in the latter stages of renal failure but without providing RRT[14,74]. This includes anaemia management, optimisation of mineral bone disease and fluid balance, and minimising harm associated with reduced renal excretory function. It is designed to consider the wishes of patients and their relatives in the terminal phases of their illness[75].

Conservative management has traditionally been used to palliate symptoms rather than prolong life expectancy. It is recognised however that for some patients, including the elderly and those with significant comorbidity, active RRT may not ultimately bring significantly improved survival or quality of life[76]. Indeed, some patients in this cohort may gain survival benefit with conservative approaches to ESRF[76,77].

Complexity in renal replacement therapy

RRT options are complex, have substantial morbidity and mortality burdens, and require planning before initiation. Options vary in their attractiveness and practicality between patients, and several options may require exploration in parallel for pragmatic reasons (table 1).

Modality	Potential challenges	Potential benefits
AVF	Requires technically adequate artery and vein, surgical procedure (although not always with general anaesthetic), may then fail to mature sufficiently for use; Needs 6 weeks maturation after surgery before first use; Requires technical skill to cannulate; Periodic maintenance procedures may be required to detect or repair evolving AVF stenosis; Potential risks of bleeding, rupture, ‘steal syndrome’ or ‘high-output cardiac failure’; Requires needle insertion for each haemodialysis session	Better quality haemodialysis compared to other modalities; Lowest infection risk; Lowest mortality risk; No associated risk of central venous stenosis; Lowest overall financial cost of VA modalities.
AVG	High initial financial cost; Technically difficult procedure to insert into patients’ arm or leg, usually requiring general anaesthetic Requirement for more frequent maintenance procedures than AVF; Higher infection risk than AVF; Cannulation requires technical skill; Requires needle insertion for each haemodialysis sessin	Potential to use them where patients’ artery or vein inadequate for AVF creation; Many are usable within hours of surgical insertion; Otherwise similar benefit profile to AVF.

CVC	Higher financial cost than AVF; High associated mortality risk (vs other VA modalities); High associated infection and central venous stenosis risk; Requires patent vessels for insertion – this becomes increasingly difficult as central venous stenosis becomes apparent	Does not require needles to be used for haemodialysis; Quick insertion with minimal advance planning; Can be used immediately after insertion for haemodialysis
PD	Requires adequate housing and easily accessed storage space at home for consumables; Patients requires adequate cognition, visual acuity and manual dexterity; Unable to use if previous abdominal surgery or illness; Requires insertion of Tenckhoff catheter, and brief delay before first use to deliver PD treatment; Risks of Tenckhoff exit-site infection, PD-peritonitis or encapsulating peritoneal sclerosis.	Home therapy allowing patients to avoid unnecessary hospitalisation and to continue working / other social functions; Equivalent survival benefit to hospital haemodialysis; Avoids risks of central venous stenosis and bacteraemia.

Table 1 Challenges and benefits of each Vascular Access modality

While the gold standard RRT is transplantation[1], an organ must be available and the patient must be fit enough to undergo the operation. The pre-transplant assessment process for live donors may take longer than a year, and waiting times for cadaveric organs can exceed three years[21,26]. It is thus challenging to achieve the ‘ideal’ solution: a pre-emptive transplant just at the point where RRT first becomes necessary, avoiding the need for haemodialysis or peritoneal dialysis.

While a patient awaits transplantation, or where transplantation is impossible, that alternative RRT must be delivered in a way that minimises morbidity. Factors associated with morbidity and mortality in PD and haemodialysis have been described[8]. Many such factors are not practically modifiable, but some can potentially be influenced, for example those associated with PD peritonitis[78]. The major modifiable risk factor in haemodialysis is the means of VA used to deliver treatment, with a clear hierarchy of risk across the available VA modalities[33,34].

As described above, many patients who requiring urgent initiation of RRT receive haemodialysis, although acute PD is increasingly an option. PD catheter insertion can be arranged at relatively short notice but still requires a degree of logistical coordination, along with patient education and consideration of the practicalities involved in using PD, and usually a period of postoperative recovery before beginning treatment. AVF or AVG require more detailed advanced planning, including consideration of the surgical approach most likely to succeed, patient education and their decision to proceed with AVF creation, scheduling of surgery, then a six -week period of maturation before the AVF can be used.

In contrast, for patients who require RRT before a Tenckhoff catheter is in-situ for PD or an AVF has matured for haemodialysis, the default is usually to insert a CVC for haemodialysis[32]. TCVC are preferred from the perspective of reducing the associated infection risk, but in many centres only NTCVC are available out-of-hours or at short notice in normal working hours. Many patients therefore have an NTCVC inserted first, that is later replaced with a TCVC.

Timing the initiation of renal replacement therapy

A key challenge in RRT planning is determining the time at which ESRF will develop and RRT will become necessary. Formal assessment of renal excretory function requires the use of specialist substances such as inulin, or radio-isotope imaging techniques that enable measurement of glomerular filtration rate[79]. Such measurements are impractical to regularly conduct, but the estimated glomerular filtration rate (eGFR) forms a useful surrogate measure[79,80]. This is derived from mathematical equations accounting for patients' serum creatinine and other variables including gender, age and weight. eGFR enables patients' kidney failure to be visualised on a spectrum ranging from 'normal' to 'end-stage', and the assessment of disease trajectory. Five stages of chronic kidney disease (CKD) are described, with stage 5 CKD, also called ESRF, representing eGFR <= 15ml/min[81].

Clinicians disagree about when RRT should be initiated based upon eGFR. This creates difficulties estimating the remaining time before RRT will be required. Symptomatology, fluid balance and biochemical markers all contribute to the final decision. One study evaluated the utility of protocol-driven haemodialysis initiation that compared 'early' (eGFR 10-14ml/min) or 'late' (eGFR 5-7ml/min) strategies[82]. There was no survival benefit to earlier RRT initiation and no significant difference in adverse events between the groups, but most of those in the 'late start' required to start RRT earlier than protocolised because of intolerable symptoms. Other studies confirm this finding, although it is noted that the typical eGFR at RRT has risen in recent years, meaning RRT tends to be initiated earlier[83]. Patients' symptom burden can become highly significant as CKD progresses, particularly in the later stages[17,74]. The relatively rapid appearance of symptoms may preclude the use of RRT modalities that require significant planning time in advance of commencing treatment, for example to create AVF for haemodialysis. The progression of symptoms and development of morbidity despite RRT is a recognised phenomenon and may be grounds for considering adopting a more conservative treatment strategy[84,85].

Further difficulty exists in the absence of a validated tool to predicting the timing of ESRF for a given patient. It is possible to consider the various clinical, physiological and other risk factors which have been described as contributory to the risk of developing ESRF. However, patients with advanced renal failure often have other serious comorbidities, which themselves are subject to flares and decompensation. The trajectory of declining renal function has been shown to be widely heterogeneous[15,17,74] and for many patients a seemingly trivial intercurrent illness can be sufficient to prompt the initiation of RRT.

Guidelines for Vascular Access care

A number of professional groups have issued guidelines about aspects of VA practice.

The Renal Association recommends that 60% of incident patients, and 80% of prevalent patients, should receive haemodialysis via AVF[3]. It suggests that AVF are preferable to AVG, which are preferable to TCVC, and that NTCVC should only be used when absolutely unavoidable. The guideline makes further recommendations as to the most appropriate location for AVF creation (distally, on the non-dominant upper limb); about vein preservation to facilitate AVF creation; preferred needling technique for AVF and AVG; and the need to perform regular VA surveillance and maintenance procedures.

NICE mandates that NHS providers should specifically measure the proportions of incident and prevalent patients receiving haemodialysis with each VA modality, rates of VA associated-SAB and other infections, VA rupture, and VA interventions[86]. It also states that VA should be "monitored and maintained" but does not specify how this should be achieved. This 'quality standard' is based upon the Renal Association guidelines[3].

The European Dialysis and Transplant Association (EDTA) guidelines similarly recommend using AVF first, then AVG, before TCVC[87]. They also recommend implementing vein preservation strategies to facilitate AVF creation. They provide additional detail in relation to the manner in which VA surveillance should be performed (including regular physical examination and access blood flow measurement), along with the investigation and management of VA thrombosis, stenosis, infection, and VA-associated ischaemia.

The National Kidney Foundation in the United States have produced a highly detailed guideline document that broadly agrees with the above recommendations[88]. The most recent guidelines, issued by the European Society of Vascular Surgeons, similarly agree with the earlier guidance[89]. They make detailed technical recommendations about the choice of AVF site, and several additional recommendations including the need for 'early referral' for AVF creation (specified as between 3-6 months prior to haemodialysis initiation); the potential benefits of Vascular Access Nurse (VAN) roles; and a need for educational programmes to provide exposure to at least 25 AVF creation operations for trainee vascular surgeons.

The guidelines make clear what VA should be offered to patients, and the preferred approaches to creating, maintaining and using it. They acknowledge the lack of high-quality clinical evidence for many recommendations and, with the exception of the most recent guidelines, ignore how services might be configured in order to meet with these standards.

Reality in Scotland and beyond: variation in Vascular Access practice

Despite the uncertainty and complexity of planning for the initiation of RRT, there is broad agreement among experts that most patients should be evaluated for transplantation if this is deemed feasible[90], and that where haemodialysis is contemplated the patient should ideally commence treatment, and be maintained on treatment, using an AVF for VA[3].

Renal registries around the world measure concordance with these guidelines and typically demonstrate wide variation in practice between centres[8,12,68,91]. In Scotland a substantial inter-centre variation has existed for many years in the proportions of patients who commence and are maintained on haemodialysis using an AVF[8] (figures 1 and 2).

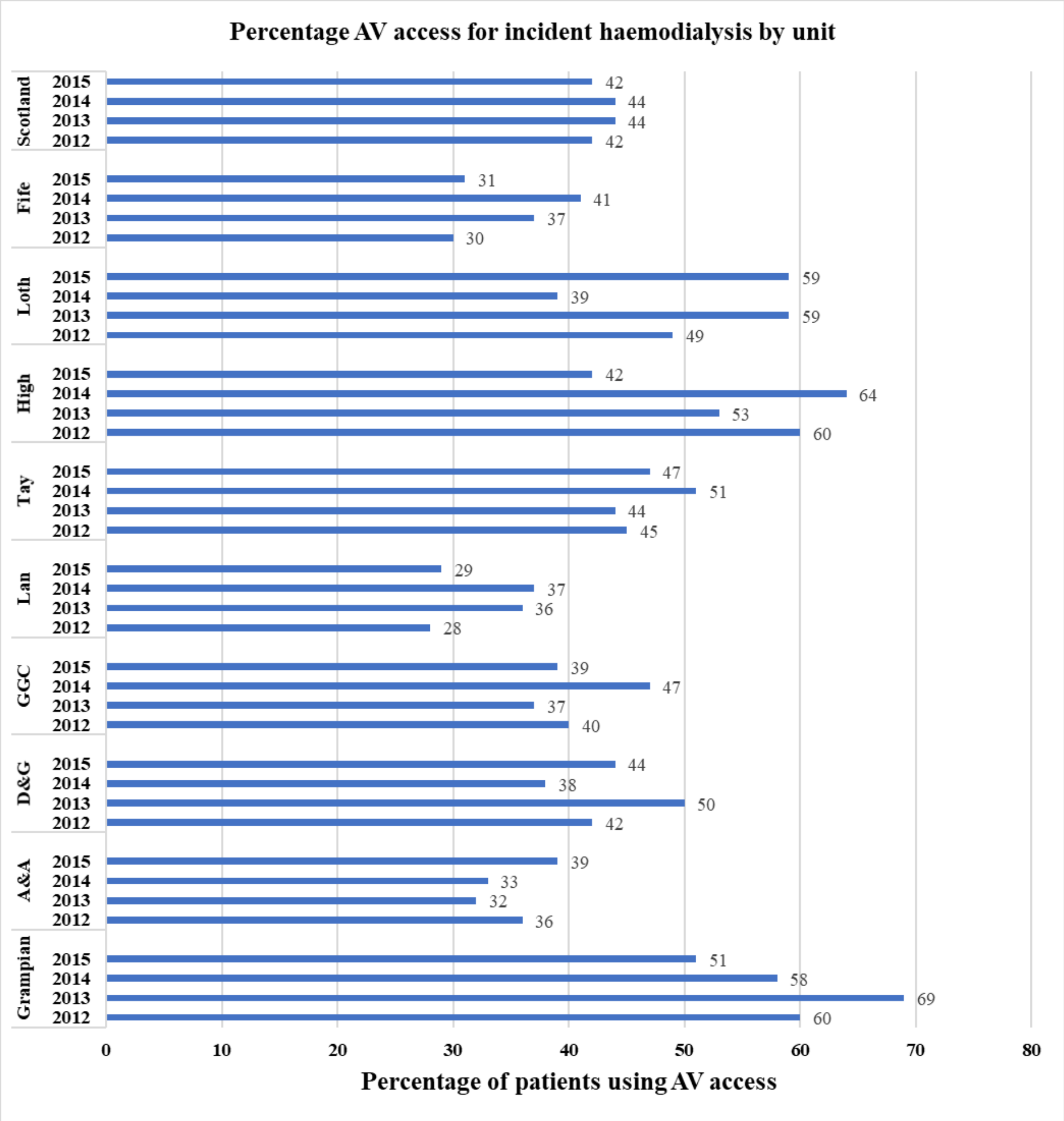

Figure 1 Percentage arteriovenous fistula access for incident haemodialysis, by unit

This data has been reproduced from the Scottish Renal Registry Report 2015[13]. Each bar represents the percentage of patients who commenced haemodialysis in the unit during the years 2012-2015 and who used an AVF for their first haemodialysis session. The data demonstrates substantial variation between units in respect of the proportion of patients using AVF for their first haemodialysis session each year. The Scottish average remained constant at 42-44% during this period. (Grampian = NHS Grampian, A&A = NHS Ayrshire & Arran, D&G = NHS Dumfries & Galloway, GGC = NHS Greater Glasgow & Clyde, Lan = NHS Lanarkshire, Tay = NHS Tayside, High = NHS Highland, Loth = NHS Lothian & Borders, Fife = NHS Fife.)

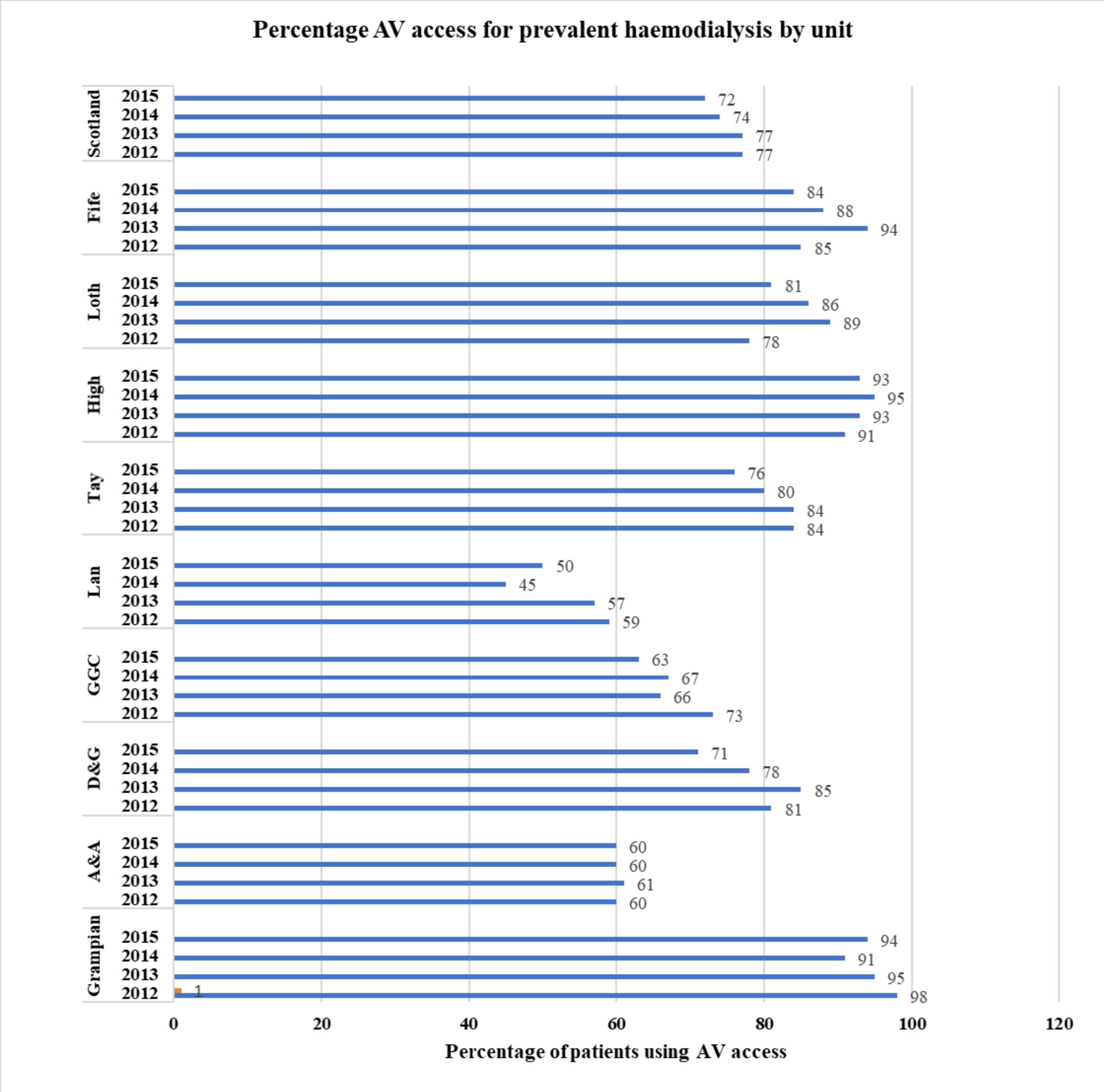

Figure 2 Percentage arteriovenous fistula access for prevalent haemodialysis, by unit

This data has been reproduced from the Scottish Renal Registry Report 2015[13]. Each bar represents the percentage of patients whose haemodialysis was delivered using an AVF during each year (as measured on the annual census date). The data demonstrates substantial variation between units in respect of the proportion of patients using AVF for haemodialysis treatment each year. The Scottish average increased slightly from 72-77% during this period. (Grampian = NHS Grampian, A&A = NHS Ayrshire & Arran, D&G = NHS Dumfries & Galloway, GGC = NHS Greater Glasgow & Clyde, Lan = NHS Lanarkshire, Tay = NHS Tayside, High = NHS Highland, Loth = NHS Lothian & Borders, Fife = NHS Fife.)

The Scottish Renal Registry has measured concordance with these audit standards since 2007, and has demonstrated persisting variation between centres in the proportions of patients who commence haemodialysis with an AVF, and who are maintained on haemodialysis treatment with an AVF[8,13,92]. In some parts of the country it is apparent that most patients have an AVF at the initiation of haemodialysis, while almost all prevalent patients dialyse using an AVF[8]. Elsewhere the opposite is true: in some centres less than one in five patients commence haemodialysis with an AVF, and less than half are maintained on haemodialysis with an AVF.

It is recognised however that performance in respect of these standards should be considered in the context of variation between centres in the utilisation of different RRT strategies, including conservative care. The ‘take-on’ rate for RRT – meaning the number of patients who are offered active RRT rather than conservative management of ESRF - and the utilisation of renal transplantation, are also seen to vary by centre[8,9,21]. It has been suggested that pre-transplant counselling may vary between transplanting and non-transplanting renal units[8]. These findings are relevant when considering variation in AVF use for incident and prevalent haemodialysis patients because centres who are more likely to offer RRT rather than conservative care to frailer patients, or those who refer for transplantation less frequently, could potentially have larger pools of patients for whom haemodialysis with a TCVC is the only realistic RRT option. The literature also suggests differences in patterns of referral for AVF creation according to patients’ gender, race and other factors[93,94]. Similarly, it is appreciated that later referral to a nephrologist reduces the likelihood of commencing haemodialysis with an AVF[69].

A similar pattern of inter-centre variation is seen in the broader UK renal registry[68]. Some centres in England report using PD in a much greater proportion of patients than is seen in Scotland; two units have almost 40% of patients commencing dialysis with PD rather than HD[68], while much lower rates are more typical in Scotland[8].

Variation is also seen across Australia and New Zealand[91]. Incident AVF access ranges from 8-64% in Australia and 17-45% in New Zealand, while prevalent AVF access ranges from 69-100% in Australia and 71-93% in New Zealand. While this still represents significant variation between centres, there is perhaps less variation overall than is seen with the equivalent measures in the Scottish haemodialysis cohort. Variation in AVF use is seen worldwide, with some studies attributing this to clinical, technical and geographical factors[95,96]. "Geographical" factors related to undefined differences between centres rather than differences caused by physical geography.

Interestingly, UK registry data suggests that timeliness of vascular surgeon review is the most significant predictor of commencing haemodialysis with an AVF; those seen by surgeons before commencing haemodialysis were seven times more likely to have a functioning AVF in place for their first haemodialysis treatment[68].

Concerns have been raised about the hidden pitfalls of strategies aimed at maximising AVF usage. In a hypothetical situation where every patient commences haemodialysis with an AVF, it would logically follow that some patients might have AVF fashioned but ultimately die without requiring its use, by dying from non-renal causes or opting for conservative ESRF management. Opinion also varies as to whether AVF genuinely represent 'optimal' VA for every patient[97,98]; for patients who opt for haemodialysis but who have a very limited life expectancy due to comorbid illness, some clinicians believe the overall burden of hospitalisation, procedures and associated morbidity does not justify the benefits of AVF over CVC use. Others argue that the substantial, adverse, difference in morbidity and mortality profiles between AVF and CVC justifies the use of AVF in every case[99].

It can be appreciated that VA for haemodialysis treatment is an extremely complex problem. While in one sense there is an aspiration to provide AVF for most patients, this is extremely difficult to achieve in practice. For many patients the reality of RRT is a lengthy wait for transplantation, during which time haemodialysis treatment is provided with suboptimal VA. Despite significant evidence favouring AVF use, it seems extremely difficult to provide this for most patients who require haemodialysis[8,9,11,12]. The complexity of the subject area, the failure to significantly improve AVF use over a long period of time, and patients' interest in the subject[100], demands the use of alternative approaches.

This study frames these longstanding problems in the context of the sociotechnical systems literature. The literature provides ample descriptions of the complexities associated with providing RRT and widespread variation in practice between centres; the reasons underpinning this variation have been the subject of the discussion text in many of the studies cited earlier, but few studies have been specifically designed to explore this in detail.

The following chapter 1B introduces concepts relevant to complexity in healthcare. The literature pertaining to sociotechnical systems theory is reviewed: this is a well-developed area of social science whose application remains unusual in healthcare settings. The reader is invited to consider how challenges providing VA care could be seen through a systems theory lens. Existing approaches to approaching variation and complexity in healthcare are considered, setting the scene for chapter 2 which describes the development and use of an investigative model which is then used to explore the structure and function of VA services across Scotland. The results of the study, and the subsequent recommendations for practice, are described in the chapters that follow.

Chapter 1B: Healthcare and complexity

Healthcare represents an extremely complex and high risk industry[101]. It has become enormously sophisticated, with the ability to identify, manage and cure many illnesses hitherto regarded as deadly or life limiting. With advances in technology and public expectations the processes involved in care delivery have increased in complexity, been subjected to greater scrutiny, and carry significant potential to cause physical harm to patients and financial harm to providers[102]. From a policy perspective it has become increasingly unacceptable for healthcare to be associated with harm, and clear mandates exist from government for healthcare providers to improve the safety and quality of delivered care[103].

The following sections discuss the ‘patient safety’ and ‘quality improvement’ literatures, and how variation in healthcare has been approached in other areas of practice. The chapter then discusses systems theory, the concept of complex sociotechnical systems, and provides context as to how this literature might be used to characterise and explore VA care.

Patient safety and quality improvement

'Patient safety' (PS) and 'quality improvement' (QI) movements have become prominent in western healthcare. They have complementary and overlapping, but not identical, aims: PS aims to eradicate avoidable harm, while QI seeks to improve the quality of care provided.

The definition of 'safety' is complex. It is not simply the absence of harm, and it is neither static nor linear[104–106]. It encompasses a status relating to inadvertent, preventable or avoidable harm that arises within a constantly shifting context. In a healthcare setting it may be influenced by patients' physiology and pathology, staff skill mix, resource availability, competition from others who require access to common or limited resources, acts of omission or commission, and many other factors. It may relate to conditions where unwanted, negative outcomes are minimised, or those where intended, positive outcomes are maximised[107,108]. Similarly, 'quality' may refer to the achievement of desired outcomes, the avoidance of undesired outcomes, optimised resource usage, reduced hospitalisation, the ability to perform at a predicted and reproducible standard or to sustain operations in the face of disruption, or many other factors[104,109–112]. Table 2 lists definitions from the literature that relate to this discussion.

Safety	"The absence of accidents"[104] "The absence of unwanted events"[105] Safety is a system property rather than a component property[106]
Safety I	"A condition where the number of adverse outcomes… is as low as possible"[107,108]
Safety II	"The ability to succeed under expected and unexpected conditions alike, so that the number of intended and acceptable outcomes… is as high as possible"[107,108]
Adverse event	"An injury resulting from a medical intervention"[101]
Quality	"The ultimate test of the quality of a health care system is whether it helps the people it intends to help."[111] "Quality of care is the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge"[112]
Failure	"When a component does not satisfy its specified requirements"[104]
Reliability	"The probability that a component satisfies its specified behavioural requirements over time, and under given conditions, i.e. it does not fail"[104]; Reliability is a component property (not system property)[106]
Resilience	"The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions."[109] A system property that enables organisations to understand how to avoid failure and achieve success[113]

Table 2 Definitions from the literature

Interest in healthcare-associated harm has been reported in the published literature for many years[114], but momentum in PS research has only gathered in recent years. Its development has been described in three phases[114]: ‘sporadic’, with periodic, isolated reports in the literature that did not lead to specific action; ‘cult’, where small groups of enthusiasts began tackling the problems and illuminating their nature to wider audiences; and ‘breakout’, where concern about PS became a mainstream concern for health professionals, politicians and the public at large. While not the first study of healthcare-associated harm, the Harvard Medical Practice Study was perhaps the first to attract significant public interest with its quantification and analysis of potentially preventable harm suffered by large numbers of patients across New York State[115,116]. The later Institute of Medicine publication “To err is human”[101] equated the number of avoidable deaths in American hospitals to large numbers of aircraft crashing each day, and despite their figures relying to some extent upon extrapolation and inference they generated substantial public and political interest in this area of study. Subsequent publications confirmed the extent of the assertions and began to delineate the broad range of harms and potential harms occurring in hospitals. Around the same period, the UK Department of Health report “An organisation with a memory”[117,118] discussed the extreme financial cost of healthcare-associated harm in the NHS, and called for systematic approaches to identifying, cataloguing and learning from adverse events in British hospitals. This led to 'clinical incident’ recognition, recording and investigation becoming a matter of routine for NHS clinicians, albeit underreporting and inadequate investigation remains problematic[119].

Various analytical models for investigating such incidents have been described, including ‘root cause analysis’ and ‘fault tree analysis’[120–122]. Root-cause analysis is a process of adverse incident evaluation that seeks to identify the factors responsible for creating the conditions that resulted in the adverse event[120]. Fault tree analysis provides a similar approach, evaluating the various domains associated with an incident and exploring the specific situation that led to it occurring[122]. These techniques often involve retrospective analysis of potentially contributory factors to the incident in question. While many publications and reports praise their apparent successes, these methods are vulnerable to criticism for their historical focus, narrow fields of investigation, and the tendency to produce recommendations that are impractical, or not ultimately implemented[123–125].

Attempts to enhance PS often centre upon the recognition and measurement of adverse events, with steps taken to reduce potential recurrence or to limit the resulting harm. Most NHS PS surveillance programmes rely upon incident logging into central databases, for example Datix[126], whose utility for improving safety outcomes remains uncertain[127]. Resources tend to be focused on the incidents arbitrarily graded in the most severe categories, and/or those felt likely to recur. It should be noted however that frequent adverse events may have a relatively limited impact[128], while infrequent events can prove catastrophic; this approach may therefore not be the best use of available resources.

QI methodologies tend to be more firmly grounded in industrial approaches than the equivalent PS techniques. Early QI work is often credited to Dening, Toyoda or Ford[129]. During the Industrial Revolution it was felt that "scientific management" (or Taylorism)[129] was the most efficient way to operate; managers would specify while workers mindlessly performed tasks. Toyoda recognised the importance of developing this to improve the internal working practices within his factories in Japan, and his work developed into what is now known as Lean Methodology[130].

More recently the United States Institute of Healthcare Improvement has moved to implement QI methodologies in healthcare. A broad range of techniques have been described, but notably the UK NHS Improvement Model, which focuses around 'Plan, Do, Study, Act' (PDSA)[131], has gained significant support (figure 3).

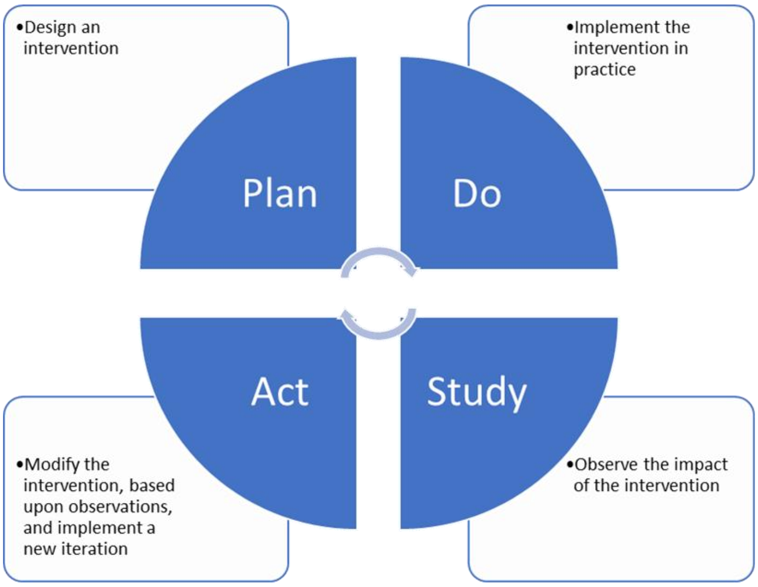

Figure 3 The NHS Improvement Model: Plan, Do, Study, Act

The model involves a four-stage approach. First the problem space should be researched, with the intention of understanding the issues and recognising targets for intervention ('plan'). Next an intervention should be implemented in the clinical environment ('do'). The impact of the intervention should then be measured and evaluated ('study'). Modifications to the original intervention should be designed, based upon the findings of the measurement and evaluation stage; these should then be implemented ('act'). The four stages should repeat until the problem is considered to be addressed. Each revolution is termed a 'PDSA cycle'.

A significant literature base champions the use of PDSA, which is now the dominant model for UK healthcare QI projects[131]. Its simplicity makes it attractive and facilitates its use with minimal methodological training; however, this can encourage disordered approaches with insufficient strategic oversight and governance, and can cause unforeseen or unintended consequences[132]. It is also common for the “plan” and “do” elements to be done, with less attention given to “study” and “act”[133]. This may partly reflect current requirements for junior doctors to conduct QI projects over short timescales[134,135]. Time pressures could incentivise clinicians to overlook more complex problems in favour of those with higher potential to be completed more rapidly.

A further criticism of PDSA and other QI methodologies is their basis in mechanical, industrial processes, that are grounded in linear chain causality. Healthcare is an example of significant complexity and such linearity is infrequently encountered. The use of ‘simple’ methods to tackle ‘complex’ problems may be disadvantageous; this may explain the surprising paucity of publications describing successful VA PS or QI projects. Reported projects tend to have a narrow focus, for example improving pre-haemodialysis care[136]; haemodialysis nurse education[137]; or reducing haemodialysis-associated infection[138]. No studies were identified that considered VA services as a whole or accounted for the significant clinical complexity described in chapter 1A.

Investigating variation in healthcare

Variation in the delivery of healthcare interventions has been recognised for many years in a broad range of clinical specialties. The earliest reports date to the 1930’s when Glover demonstrated wide geographical variation in tonsillectomy rates for British schoolchildren[139]. More recently the NHS Atlas of Variation and Dartmouth Atlas Project have shown variation across numerous areas of practice in the UK and USA[140,141]. It is recognised however that variation may be desirable in some cases, for example where the degree of illness or patient preferences justifiably modifies practice between centres. Several frameworks seek to categorise the nature of less desirable ‘unwarranted variation’ with that proposed by Wennberg perhaps the most widely recognised[140,142,143]. He defines ‘unwarranted variation’ as that which has no basis in variable illness or patient need between studied populations. He categorises it according to:

- ‘Effective care’ – where the evidence points to one intervention holding clear benefits over others;
- ‘Preference sensitive’ – where multiple options are reasonably possible but variation can arise through patient and professional opinions, with concern about undue influence of clinicians’ opinions;
- ‘Supply sensitive’ – where variation reflects differences in supply and demand for a given treatment.

Reducing or removing unwarranted variation requires an understanding of how and why it arises in practice. Greenhalgh and colleagues make a significant contribution to this literature through their model for the diffusion of interventions into clinical practice[144]. This is based upon extensive review of a broad literature and considers the influence of the intervention in question, the relevant clinical system, and their surrounding contexts. It provides a strategic conceptual framework that may explain why some interventions are more readily adopted than others in different healthcare settings.

Panella considered the implementation of new ‘streamlined’ clinical pathways to reduce variation across several specialties, and found their successful implementation was associated with improved clinical outcomes and metrics such as length-of-stay and the financial costs of treatment[145]. However significant difficulty was noted in actually implementing the pathways in practice, and they used a relatively brief observation period of 6 months before and after implementation to calculate any effect; this limits any ability to comment on the sustainability of their results.

Interventions have also been designed to tackle variation in specific areas of practice. One study describes the successful piloting of an integrated primary and secondary care approach to implementing evidence-based treatment for patients with respiratory disease[146]. Others have considered the use of clinical decision aids and guidelines to reduce variation in surgical practice, reporting mixed results[147]. In cancer care, calls have been made to reduce variation in screening for common cancers by standardising approaches across cancer types[148]. In NHS primary care a financially incentivised Quality and Outcomes Framework was used to improve standards of care across several domains[149]. It was shown to reduce some variation between areas of socioeconomic prosperity and deprivation, but clinical outcomes have been modest at best and the proscriptive nature of the programme led to concern around clinician autonomy and reduced patient satisfaction[150].

Financial incentives have also been explored in VA[151], as perceived by clinicians working in a small sample of renal units in England. Fistula use was reported to be more likely in light of financial tariffs incentivising this practice, but this was not borne out in subsequent registry data[68]. Financial motives for facilitating RRT are also referenced in literature pertaining to conservative management of ESRF[152], with an inference that financial incentives may prompt active RRT being offered when conservative strategies could be considered more clinically appropriate. Concern has also been raised that financial incentives could paradoxically disincentivise other areas of good practice[153].

In the UK registries collate metric data in an effort to reduce variation through the public benchmarking of renal units. In recent years the scope of registry data has increased in an effort to measure additional variables that may then be subject to improvement efforts[154].

Across the literature variation in care is increasingly recognised; no intervention provides a panacea, but the available work provides frameworks with which to begin understanding variation, and suggested approaches to improvement. These findings may be of value in this study. Using Wennberg's framework[143] VA variation could be categorised under 'effective care' given the evidence supporting AVF use; also 'preference sensitive' given the complexities and differences associated with using AVF rather than AVG or TCVC and the potential for variable clinical opinion to influence this; 'supply sensitive' seems unlikely given the geographic confines of NHS Scotland, but also requires consideration.

Complexity

Systems approaches to exploring clinical practice can generate insights that assist clinicians within the system, and which enable service redesign in a manner that benefits patients and provider organisations[155,156]. At this stage it is helpful to consider the meaning of 'complexity' in the context of systems theory and healthcare, and how applicable it may be to VA.

Complexity has been an evolving challenge in industry since the industrial revolution, as technological advances change the nature of the workplace and expand the possibilities of what can be achieved. Complexity can be understood in engineering terms, where an environment may be described as 'simple', 'complicated' or 'complex', or in biological terms as 'ordered', 'complex' or 'chaotic'[157–160].

In ‘simple’, ‘ordered’ linear sequences, actions are understood as direct consequences of preceding activities; these predictably generate subsequent actions in programmed chains of events[161]. If components fail the consequences are the predictable sequelae of that component not functioning. ‘Complicated’ systems, e.g. car engines, represent advancement beyond linear sequences but the sum of system outputs remains predictable, contained within a defined envelope. Modifications to complicated systems can have unexpected effects but can ultimately be traced back to their dependent relationships, understood and controlled by individuals with sufficient technical expertise. Linear process mapping can enable understanding of simple and complicated engineering problems, identifying problems and modelling the impact of a component modification. The underpinning assumptions of such models – that processes are linear, and operate in predictable, programmed fashions – are flawed in the setting of complex systems such as healthcare[104,161,162].

‘Complex’ systems comprise multiple interacting and interdependent components; together these elements and their interactions form a whole[163]. Complex systems are modelled hierarchically; each level becomes increasingly complex as a function of ‘emergence’: the properties resulting from the predictable and unpredictable interactions of system components[104]. These emergent properties are irreducible and cannot be understood as the sum of the component parts[104]. Emergence may influence system operating properties (e.g. modifications to processes based upon previous ‘near misses’); may itself be an endpoint of system function (e.g. reaching a clinical diagnosis based upon a clinical history, examination, laboratory and radiological tests and a multi-disciplinary team discussion); or may have any number of conspicuous or inconspicuous impacts. Chaotic systems are characterised by instability and aperiodicity: they never reach a true state of equilibrium and are highly sensitive to small disturbances in their environments[158,160]. Complexity and chaos are not mutually exclusive but do not always co-exist; some texts describe complexity as being “at the edge of chaos”[159]. Table 3 compares simple, complicated and complex systems.

Simple	**Complicated**	**Complex**
Few elements contained within a closed envelope Usually linear relationships between elements Simple change will have predictable impact Reproductible output Failures can be traced backwards to their origins Little expertise required Output equates to sum of components Can be analysed according to component parts (E.g. small electrical circuit)	Many elements contained within a closed envelope Simple change creates a describable impact on system output Failures can be traced backwards to their origins, but this requires technical understanding of the system Some expertise required to construct or modify the system Output equates to sum of components Removal of components may cause the system to fail Can be analysed according to component parts (E.g. motor engine)	Many interacting elements which are not contained within a closed envelope Unpredictable relationships between elements Simple changes may have unpredictable and/or inconspicuous impact Failures cannot reliably be traced backwards to their origins System output characterised as ‘emergence’ arising from element interaction Adaptable over time, and can survive despite removing or modifying system components Cannot be analysed according to component parts; the level of analysis should be the whole system (E.g. an international airport)

Table 3 Characteristics of simple, complicated and complex systems[158,164–167]

Healthcare contexts, including VA, may be regarded as complex systems characterised by their emergent properties rather than simply by their component parts. Sophisticated analytical tools are required to understand complex systems, which must be understood as a 'whole system'. Reductionist approaches that fragment the system into individual elements will potentially miss the central importance of system component interactions which generate the systems emergent properties. Complex system analysis should understand how system components interact, rather than how individual elements function in isolation.

The absence of published work analysing VA services as a whole may explain why so little improvement has been demonstrated over prolonged periods of registry scrutiny[8,9]. VA problems are also challenging to analyse using existing PS or QI tools. Clinicians may not recognise routine, apparently successful, TCVC use as an 'adverse event'; and the fragmented nature of VA care involving clinicians from several specialties, spread across multiple hospital campuses, serving a heterogenous and medically complex patient population, does not lend itself well to relatively fast moving and simplistic QI techniques like PDSA.

More sophisticated analyses based upon 'complex socio-technical systems' theory may be better suited to improving VA. The following sections discuss the theoretical basis of such approaches.

Sociotechnical systems

Complex systems where humans interact with technologies are termed 'socio-technical systems'. Human involvement in the system brings added complexity with their inherent strengths (e.g. ability to adapt, learn and improvise), weaknesses (e.g. fatigability, limited concentration) and external influences (e.g. personal ambition, political interests, regulatory concerns). Socio-technical systems were first described in the coal mining industry, where the addition of new technological tools into working environments traditionally characterised by manual labour led to a broad range of unanticipated challenges[168]. The interaction of humans with technologies generate a socio-technical system within the workplace, in which system components interact in a manner that is not necessarily predictable, linear or apparent to the observer, generating the system's emergent properties and consequential complexity[169].

Since its earliest descriptions the sociotechnical systems literature has evolved to incorporate healthcare settings[102,170,171]. Clinical environments provide an especially complex substrate for study in view of their scale, wide range of variables and potential for very severe harm in the event of a negative outcome[101]. Such highly complex systems are sometimes referred to as a 'system of systems', whereby the units within the system are operationally and managerially independent but the systems collaboratively function as a whole[172,173]. For example, within a health provider organisation there may be primary and secondary care services each providing private and public services; despite their arrangement as discrete, standalone units they depend upon and influence one another significantly, and interact at multiple operational and strategic levels.

Sociotechnical systems theory, and the concept of 'emergence', provide a window for understanding complex interactions in healthcare settings, and a perspective from which to investigate and improve clinical systems. Traditional PS and QI approaches consider adverse events as discrete episodes that may be understood using retrospective analysis tools; when such incidents are instead framed as 'emergence' in the context of 'complexity', a mandate is provided to explore broader system functioning.

Are adverse events 'normal'?

Healthcare adverse events are often considered preventable, and investigations seek to create barriers that will prevent recurrence. An alternative perspective considers safety (and its absence) as an emergent system property[104]. Adverse events are thus framed as emergent conditions arising from complexity within the system, whereby the adverse outcome represents 'undesirable emergence' rather than the 'designed emergence' the system intends to generate.

This thinking resonates with Perrow's 'normal accident theory', which contends that adverse events are an inevitable feature of any complex system[174]. His studies of complexity in various high-risk industries concluded that all complex systems generate emergence of one form or another, and the label of 'positive outcome' versus 'adverse event' was largely a matter of perspective. Some criticise what they considered an unnecessarily nihilistic tone throughout Perrow's theories[175,176]; but acknowledging the nature of complex systems[104] it is surely inevitable that adverse as well as desired outcomes will occasionally arise from a given system. This does not render safety efforts futile; instead the system's malignant potential should be recognised, understood, and efforts made to limit the associated risks[177]. This becomes especially important since public opinion is increasingly intolerant of adverse events, even those which are difficult to mitigate[178].

The challenges in providing VA care could be considered examples of 'normal accidents': despite longstanding variation in AVF use, and large-scale efforts to improve (general) clinical quality and safety, there have been few if any objective measures of sustained improvement in clinical outcomes[179], and no reported studies specific to VA. The apparent lack of progress could reflect inadequate tools for change that do not account for healthcare complexity. An alternative argument would characterise these issues in the frame of 'wicked problems': first described by Rittel and Webber in 1973[180], these are problems which can be resolved, but not "solved" in mathematical sense, for example those relating to anti-terrorism[181] or climate change[182] policy.

This study could suggest that VA is a wicked problem. This would be consistent with the apparent lack of recent progress towards increased AVF use for haemodialysis. Declaring a problem to be 'wicked' does not however mean efforts to resolve it should cease; rather, the recognition of its 'wicked' status should shape the resulting efforts to achieve improvement, perhaps with acknowledgement of the limits to what can reasonably be achieved. Alternatively, determining that VA does not have the characteristics of a wicked problem would be a helpful step towards engaging clinicians and designing service improvements. Chapter 11 revisits this issue.

Table 4 describes the key characteristics of wicked problems.

1. It has no definitive formulation	It is not possible to comprehensively document all necessary information in order to define the problem, its parameters, and the means of solving it. Instead, one's perspective on a potential solution to the problem determines what is needed to understand it.
2. It has no stopping rule	The problem cannot be said to be definitively 'solved'; attempts at resolution end when the individual can no longer focus their effort on enacting their solution.
3. Solutions are 'good' or 'bad', not true or false	Many parties are able to critique solutions to wicked problems, but no one has an objective measure of success for a given proposed solution. The attractiveness of a proposal relates more to its social, political and ideological acceptability than to what it might achieve in practice.
4. It has no immediate or definitive test of a solution	The result of an intervention cannot be judged in the short term, as it will have many apparent and unseen sequelae that in turn generate their own consequences. Only with hindsight and in the longer term can a judgement be made about the merit of an implemented solution.
5. Every attempted solution has consequences	Solutions cannot be tested without real world consequences, which in turn may become integrated into the wicked nature problem itself.
6. They do not have a finite set of potential solutions	Whereas logical problems may have a pre-determined number of potential solutions, wicked problems can have infinite potential solutions that cannot be comprehensively described.
7. They are unique	Each wicked problem is essentially the first of its kind; it does not belong to a recognised category or taxonomy of problems, and therefore has no precedent to guide further action.
8. They can be considered a symptom of another problem	The wicked problem is interconnected with many other issues; it cannot be seen as a standalone issue that can be tackled as a closed system.
9. Perspectives on the problem govern the attempted solutions	An individual's assumptions, values and beliefs, and the solutions they therefore consider to the problem, will determine the lens through which the problem is seen. Alternate perspectives may be equally valid but not considered by a given investigator.
10. Those proposing solutions are compelled to be correct	The impact longevity of any implemented solutions means that those designing corrective measures will be held accountable for their success or failure.

Table 4 Characteristics of a wicked problem[180,183]

Latent and active factors in socio-technical systems

Perrow states that adverse events are an inevitable feature of any complex system[174]. He suggests that more tightly coupled systems – those with multiple processes happening in rapid sequence, with little opportunity for human intervention – have the greatest risk of unwanted emergence[174,176]. This raises questions about the underlying architecture of a socio-technical system, and whether certain features of its design are conducive to such incidents taking place.

Reason conceptualises such features as 'latent conditions', which include general working conditions, policies and other contextual elements. These are then modified by events, actions and inactions to ultimately generate emergence[184]. He further characterises system components as 'types' and 'tokens'[185,186] that act to generate emergence. 'Types' are further subdivided into 'source types' and 'function types': the former describes the tone of strategic management decision making, and the latter refer to operational line management decision making which leads to the implementation of organisational policy.

In his 'Swiss Cheese' model[187], Reason describes how (unforeseen) combinations of latent and active conditions can result in the generation of adverse events. This provides a useful framework for exploring the circumstances of an adverse event and broadening the scope of investigations beyond the incident itself. Various criticisms of the model have been published[188], including its encouragement of rather linear approaches to examining highly dynamic systems[189]. There is also a tendency to adopt reductionist strategies seeking to identify a single 'root cause' of a problem[124] and investigators may fail to appreciate the wider influences of the overall system on the specific incident in question. This has also been described as 'single loop learning' (where one examines the direct cause of an event) rather than 'double loop learning', which seeks to explore the underpinning rationale for the cause[190]. Despite these criticisms, Reasons' model is easily understood and has been used to encourage those investigating adverse events in healthcare to consider broader 'system issues'.

Consideration of these conditions, as they relate to VA, may explain why services function as they do, and could illuminate opportunities for improvement. This literature underlines the importance of understanding how VA services function at both strategic and operational levels, appreciating the roles of senior policymakers and those who implement their decisions.

System migration

Incident investigations in healthcare and other industries commonly report that checks and balances built into a system were bypassed, knowingly or otherwise, by those working within it; sometimes this is associated with the adverse event under investigation. Often it becomes apparent that such 'workarounds' have been in place for some time, perhaps reflecting evolution of the system from an original planned state into its current position. This phenomenon has been described in terms of 'system migration' by Rasmussen[191]. His work explores the interplay between Reason's latent and active conditions, and builds upon Perrow's work to describe system migration over time[191]. He considers shortcuts and workarounds employed by staff, intentionally or otherwise, in their efforts to resolve perceived misalignments or inefficiencies within the 'system as designed'.

Such workarounds may be influenced by external regulations, staff turnover or skill development, new technology, or refocusing of system purpose[191,192]. More subtle adaptations arise from individuals within the system seeking to work efficiently, to achieve parallel objectives, or perhaps to fit with unrecognised practical or regulatory considerations[192]. Altered working arrangements may involve simply functioning in a manner that was unanticipated or can involve active choices to deviate from a specific approach.

Changes to system elements, intentional or otherwise, can facilitate migration of system properties. The system may enter a hazardous state with an increased propensity to generate unfavourable outcomes. The system may operate in this hazardous state for a long time before adverse events emerge[191]. Indeed, migration may be inconspicuous, or may be actively facilitated in pursuit of perceived benefits. Amalberti conceptualises three stages of system evolution where changes occur, stabilise, then the system 'recovers' or progresses towards adverse events[192].

The concept of system migration is likely to be highly relevant to any comprehensive analysis of VA services. AVF and TCVC have been used for many years to provide haemodialysis treatment, but VA is not recognised as a specialty in its own right; it is better understood as a virtual service comprised of clinicians who usually work across different clinical specialties, and in many cases do VA work as part of a broader clinical role. The fragmented nature of VA services may result in a vulnerability to system migration, due to dependence upon individuals with competing clinical interests. This concept will be explored in detail in the present study.

Understanding normal system functioning

The concepts of latent and active factors, types and tokens, and dynamic system migration, are useful constructs for this study. They emphasise the need to appreciate 'normal system functioning' to achieve and sustain improvements in quality and safety. This is slightly at odds with the retrospective analytical techniques traditionally used in healthcare quality improvement, described earlier in this chapter.

Work-as-done versus work-as-imagined

In complex healthcare systems it may be insufficient to simply retrospectively explore the circumstances surrounding adverse events. Hollnagel emphasises the requirement to understand normal function in order to enhance safety[193]. He terms the focus on why things usually go well 'Safety II'; in contrast 'Safety I' approaches focus on why something went wrong[193,194]. Emphasis on maximising positive outcome is a pragmatic means of exploring a system's operational characteristics and may reveal opportunities to improve efficiency or remove unwanted characteristics[156,194–196]. The value of Safety II approaches is increasingly recognised, especially those including comparisons of 'work-as-done' versus 'work-as-imagined'[155]. This is a key facet of healthcare resilience engineering, an emerging movement that seeks to understand how healthcare systems work and use this knowledge to create safer processes[156,195,196].

Hollnagel describes 'work-as-done' as 'how tasks are actually performed', noting that the individual executing the task has awareness of granular details about how the task is done that exceeds any written specification for the task; in contrast, 'work-as-imagined' presents a less granular version of how that task is performed, 'imagined' by individuals removed from the front-line, who view the process through the lens of filters and metrics[197]. As an example, a phlebotomist will have a detailed understanding of precisely how venepuncture is performed at the patient's bedside ('work-as-done'); a hospital manager will see this process through the prism of policies and data such as phlebotomists' job descriptions, reports of clinical errors, and metrics concerning the number of patients requiring venepuncture in a given ward (work-as-imagined). The phlebotomist relies upon the manager to provide the necessary working environment and resources to fulfil the task, while the manager relies upon the phlebotomist to implement policy in relation to venepuncture. Achieving an understanding of misalignments in their respective perspectives on venepuncture is thus important to ensure that the process proceeds optimally.

Positive deviance

'Positive deviance' is an interesting practical approach based upon Safety II principles[198]. 'Positive deviants' –system elements demonstrating unexpectedly good performance – are studied with the aim of identifying the reasons behind their apparent successes. Quantitative metrics associated with the behaviour are developed and used to generate statistical analyses to test the apparent success of the deviant behaviour, which can then be propagated throughout the system. This technique has proven highly successful in various areas of healthcare and associated fields, with a key strength lying in the fact that the 'interventions' have, by definition, already proven workable within the contextual factors of the system in question[198–200]. It has been used in the setting of VA: one paper reported its successful use to reduce bloodstream infections in American haemodialysis units[201]. This shows the promise of the technique in the VA context, albeit all reported studies had a narrow focus on bacteraemia reduction that perhaps fails to recognise additional important aspects of VA care as described in chapter 1A. No published works were identified that used positive deviance to address these other elements of VA care.

Criticisms of positive deviance include difficulties identifying positively deviant behaviours, the potential for bias when these are self-reported, and the challenges in generating statistical metrics to test the effect of the behaviour in laboratory conditions. A key strength however is the assumption that good practice already exists within a system and does not therefore require to be 'created' externally: this provides a useful starting point for exploring VA services. There are some barriers to the widespread use of resilient healthcare engineering principles. A key challenge is clinicians' unfamiliarity with non-positivist techniques. Positivism is the dominant paradigm in traditional medical research, and clinicians are often suspicious of work that cannot provide statistical certainty. Non-quantitative works are perceived as being overly susceptible to bias, and factors that cannot be measured are disregarded as unimportant or irrelevant; this is termed 'McNamara's fallacy'[202]. Moreover, many funded QI and PS programmes require that objectively measurable 'results' are demonstrated; their absence may cast doubt on the project's value. Safety II projects, focused upon maximising positive outcomes rather than minimising negative outcomes, do not always lend themselves well to these requirements.

Understanding complex system functioning requires significant time and effort. Many medical trainees in UK are mandated to perform quality improvement projects as a professional development activity[135], and formal programmes have emerged to provide training in PS and QI methodologies[203]. As such projects become a requirement for career progression, individuals are effectively compelled to tackle “quick” problems rather than devoting time to more thorough evaluations that might prove more fruitful in the longer term[204].

Various analytical tools have been developed to assist investigators wishing to understand and improve complex systems. Many are sympathetic to the principles of resilience engineering, for example ‘system-theoretic accident model and processes’ (STAMP)[161] and ‘functional resonance analysis method’ (FRAM)[156]. These sophisticated tools tend to involve an in-depth analysis of every conceivable domain that could have influenced a given incident. They are seen to generate comprehensive reviews of adverse events, and multiple recommendations to prevent future occurrences are typically generated[175,205]. However these thorough analyses come at the expense of considerable time investments; their routine use may be unfeasible without dedicated investigative teams[194]. Additionally, some recommendations arising from the analysis may not be within the direct influence of the investigator, for example where legislative processes, economic conditions or political policy require to be amended.

FRAM analyses focus upon the manner in which work (or normal system performance) is carried out on a routine basis: this is termed ‘work-as-done’[155]. This is compared with an operational view of routine work, or ‘work-as-imagined’. Misalignments in these two perspectives facilitate system redesign to realign strategy and operational practice, preventing processes, policies and protocols becoming unfit for purpose. FRAM analyses can become highly complex and time consuming to conduct but are likely to provide requisite detail and recommendations that can be practically applied to the system in question.

The FRAM tool has been utilised to investigate other areas of clinical practice[155,206] and may lend itself well to exploring VA services. It is noted however that such an analysis may become extremely complicated (and/or complex) in view of the potential for differences between individual services. This study intends to explore the configuration of VA services across Scotland, and to make recommendations for practice that are applicable (and implementable) by a broad range of clinicians and managers who are not directly connected with the project. The FRAM model may be a useful tool for exploring a single VA service and comparing it with a gold standard setup; a simpler approach is likely to be better suited to this project, both to optimise the illumination of notable practice and to enable the creation of study outputs that have meaning and credibility for the clinicians and managers who will be expected to implement the resulting recommendations.

Sociotechnical system design

The preceding sections have discussed the nature of complexity and sociotechnical systems; tools that enable researchers to understand such systems' normal functioning; and the dynamic migratory changes that can occur over time. The current study will seek to unravel these issues as they relate to VA services, with the aim of improving the quality and safety of VA care. Since a potential output from this project is VA service redesign, it would be helpful to consider whether it is possible to 'design' complex sociotechnical systems such as VA services.

Most systems are not genuinely 'designed' from the ground up; they evolve over time as people and technologies seek to address specified problems. As the organisation changes to take on new, emergent states, the original system configuration may no longer be fit for purpose. Acknowledging this, design principles may provide a helpful means to understand and contrast different systems and could alert investigators to potential pitfalls as system changes are contemplated. In this study these principles serve as a useful framework for evaluating VA services, and guide the design of the subsequent recommendations.

Perhaps the most comprehensive approach to the design of sociotechnical systems can be found in the work of Cherns, who developed a series of components requiring consideration in any (idealised) sociotechnical system[207,208]. His principles are described in table 5, which represents a modified version of Cherns' original and updated principles of sociotechnical systems design.

1. Compatibility	System design must be mindful of overarching system objectives. Social (human) and technical (machinery) roles within the system should be designed together and with one another in mind, not simply modifying one to better suit the other.
2. Minimal critical specification	Only those rules that are essential to system functioning should be defined; rules and restrictions should be limited to those that are genuinely necessary to enable system flexibility to adapt.
3. Variance control	Variances (changes which critically impact upon outcome) should be controlled as early in their existence as possible. System elements should be given the means to become aware of, and eliminate, variance.
4. Boundary location	Physical, managerial, financial and other boundaries within the system should not impede the flow of knowledge, information or learning between system elements.
5. Information flow	Information should be provided to the appropriate person at the most appropriate time. Data requiring action should go directly to the person who requires to act; reference material should be available only if, and when, needed.
6. Power and authority	Individuals should have the appropriate access and authority to use all resources necessary to fulfil their role; in turn, individuals should be accountable for their optimal use.
7. Multifunction	The system must have a range of responses that enables it to adapt to changing requirements, for example the ability to generate different outputs as the environment changes.
8. Support congruence	System elements should complement one another, sharing philosophies and oriented towards achieving the same goal. For example, back office functions should be oriented towards supporting front-line staff.
9. Transitional organisation	As systems transit from ‘old’ to ‘new’ states, the transitional version of the system should be acknowledged as especially complex: redundant processes should be retired, staff retrained or redeployed. The manner in which this is done will directly impact upon the new system’s success.
10. Incompletion	The system is unlikely to ever reach a truly ‘steady state’ since contextual factors are always changing. With this in mind, the system and its components must have capacity to think strategically, and to intelligently anticipate forthcoming changes.

Table 5 Principles of sociotechnical systems design (adapted from Cherns’ original and revisited works[207,208]*)*

Some of these principles complement other literature; for example, Ashby's law of requisite variety[209] describes the need for systems to match potential inputs with sufficient options for output, or exit strategies for dealing with potential scenarios that could be encountered through system functioning; this resonates strongly with Cherns' multifunction principle[207,208].

Cherns' original work has been adapted and updated by more recent authors. Clegg proposes a series of meta principles, content principles and process principles[210]. His meta principles advance Cherns' work by suggesting that system construction is a predominantly social (rather than technical) function; his content principles sharpen focus upon problem visibility and the need to complement human and technological interactions; while his process principles explicitly acknowledge the influence of politics in system design and the requirement for specified resources and an evaluation strategy in order to create and operate a given system. The last requirement is especially intriguing in the setting of complexity and is perhaps an explicit acknowledgement that systems exist within a constantly evolving context that includes political, economic, social, technical, legal and economic influences. Indeed, the context within which a system exists can be considered infinitely more complex that the system itself[102].

Clegg's principles[210] are essentially a modernisation of Cherns' original papers[207,208], reflecting updated popular approaches to organisational design and management from Taylorist 'scientific management' perspectives[129] to those valuing contributions from individuals within the system, and acknowledging their power to shape, modify, improve (and/or derail) system performance. This resonates with Rasmussen's model of system migration towards and beyond control parameters, and into potentially hazardous states[191].

In his work exploring sociotechnical systems in the setting of security, Fischbacher-Smith applies thinking by Cherns and Reason to real world contexts[178]. His crucial additions to Cherns model include a central focus upon 'consensus', and grouping of his principles into those which heighten system potential and those which defend against erosion of performance capacity[178]. 'Consensus' describes the set of attitudes, values and assumptions held by those who design, manage and operate a system[178]. This develops Reason's types and tokens concept[185,186] to also account for Rasmussen's factors influencing system migration. These 'consensus factors' may be considered the key to generating Reason's 'latent conditions'[169,187]: they collectively form the context within which a system operates and generates desirable and undesirable emergence.

Empirical evidence of this core principle can be seen (at a focused level) in the importance of "shared mental models" in healthcare critical events. High profile adverse event analyses have shown the consequences of misaligned "shared mental models"[211]. Other data demonstrates the clinical value of working in consensus[212]. At a strategic level it can be seen that the engagement between boards and front-line staff enhances measures of safety and patient experience, while reducing staff absenteeism and improving overall organisational performance[213,214].

Building upon Clegg's requirement for a clear evaluative strategy[210], and Fischbacher-Smith's illustrations of flawed system configuration[178], it can be appreciated there is a need to explore, refine and adapt complex systems. The process of system adaptation will otherwise occur passively – potentially resulting in disastrous outcomes[191] – so it appears preferable for strategic thinkers to take active control of this process, bearing in mind the potential to inadvertently generate adverse events in the process of attempting to avoid them[215].

Systems approaches to Vascular Access care

This introduction has demonstrated the complexity associated with caring for patients with advanced kidney failure, and who require haemodialysis treatment. Ambiguity often exists as to the practically available treatment strategies for a given patient, and which is most appropriate for the clinical context. For most patients who require haemodialysis, the means of VA used to deliver the treatment is a key modifier of morbidity and mortality, with AVF providing substantial survival, cost and morbidity advantage in comparison with TCVC. For this reason guidelines recommend that AVF should be used in preference to other VA modalities, but registry data suggests wide variation in VA practice between centres in Scotland and further afield. This warrants further exploration, particularly to determine if the nature of renal units' VA service structure or function is responsible for this observed variation.

The socio-technical systems literature has also been reviewed and used to frame current approaches to safety and quality improvement in healthcare. Many popular approaches to safety improvement are limited by their focus upon historical events rather than an appreciation of how things normally work. Commonly used QI methodologies tend to encourage narrow, focused views on systems that are contextualised by recognised clinical problems or adverse events. More recent techniques take a broader, systems view of such incidents and attempt to reconcile them with the normal functioning of the clinical system in question.

Chapter 2 describes the development of a new model to investigate clinical systems, based upon the principles of Safety II and sociotechnical systems theory, and sensitive to the needs of clinicians wishing to pursue QI work. The chapter goes on to describe its use to explore VA services in Scotland and address the research aims noted below. The subsequent chapters describe and analyse the data generated from an appraisal of VA services in Scotland.

Research Aims

This study has been prompted by the observation of unwarranted variation in AVF use for haemodialysis treatment between renal units in Scotland. It is hypothesised that variation between centres may reflect differences in the structure and function of local VA services. This work investigates this issue with the overall intention of improving patient care by maximising AVF use.

The specific aims of this study are as follows:

1. To delineate the structure of VA clinical pathways in Scottish renal units;
2. To explore the manner in which clinical work occurs within and around these pathways;
3. To quantify the clinical workload associated with VA services;
4. To illuminate gaps between 'work-as-imagined' and 'work-as-done' in relation to Scottish VA services;
5. To present the findings in a manner that facilitates quality improvement activities.

Chapter 2: A mixed-methods model for exploring clinical systems

Current approaches to patient safety and quality improvement are limited in their ability to achieve meaningful change in complex healthcare systems. It is therefore necessary to consider alternative approaches, drawing upon the literature described in Chapter 1, and accounting for the pragmatic realities of complex clinical systems.

This chapter describes a novel mixed-methods model for exploring clinical systems. The first section describes the theoretical basis for the model, while the second part details its use in this study, which sought to understand variation in VA care by delineating the structure, function and workload of VA services in Scotland.

The model was developed based upon the principles below:

1) Healthcare delivery is highly complex, and provides an excellent context for the application of the socio-technical systems literature;
2) There is significant risk involved in attempts to improve clinical systems, since poorly designed changes that do not account for real-world system conditions may inadvertently increase the risk of harm;
3) Clinical service redesign works best when frontline clinicians are engaged with the process, take ownership of the improvement process, and show commitment to achieving its goals;
4) Improvement efforts should focus around the needs of patients who use the service, rather than the wishes of clinicians or managers within the provider organisation;
5) Clinicians respond favourably to evidence-based approaches; they may be unfamiliar with, or distrustful of, non-positivist methods;
6) Qualitative methods have the potential to yield powerful insights into the way a system functions, the potential hazards it faces, and the practical implications of suggested improvements.

The model frames the delivery of safe, high quality healthcare in the socio-technical systems literature. It focuses upon patients’ experience as its central measure of success, and defines high quality, patient-centred care as that which is effective, carries minimal risks of complications, and which provides an optimal experience of receiving care. The model uses quantitative and qualitative data to delineate the normal functioning of the system, to challenge aspects of its function, and to facilitate system redesign. It provides a platform for system analysis and improvement, with rapid implementation of changes that are sympathetic to the complex environment in which care is provided, and which achieves engagement and support from clinicians working in the system. Finally, it facilitates rapid evaluation of system changes as they are implemented and encourages ongoing evaluation in the longer term.

Elements of the mixed-methods model

There are three main elements within the mixed-methods model. These seek to understand the current configuration of the system; to appreciate the current definitions and measurements of system "success"; and to appraise the impact of the current system arrangement on patients, clinicians and the provider organisation. This three-step process of system evaluation provides a means to engage with the clinicians and managers who hold operational, strategic and other stakeholder roles within the system.

The process of determining the realities of system function, and discussing measures of successful system operation, facilitates conversations around possible improvements to the system, and encourages the development of new metrics which illuminate hidden areas of system performance. These new metrics provide further insight into the impact of current system configuration and performance, prompting the implementation of changes suggested during discussion with system stakeholders. The new metrics then provide a way of monitoring the impact of these changes as they become embedded within the system.

The model is displayed pictorially in figure 4. Each stage is then discussed in further detail below. This theoretical discussion is then followed by a description of the practical steps employed in this study.

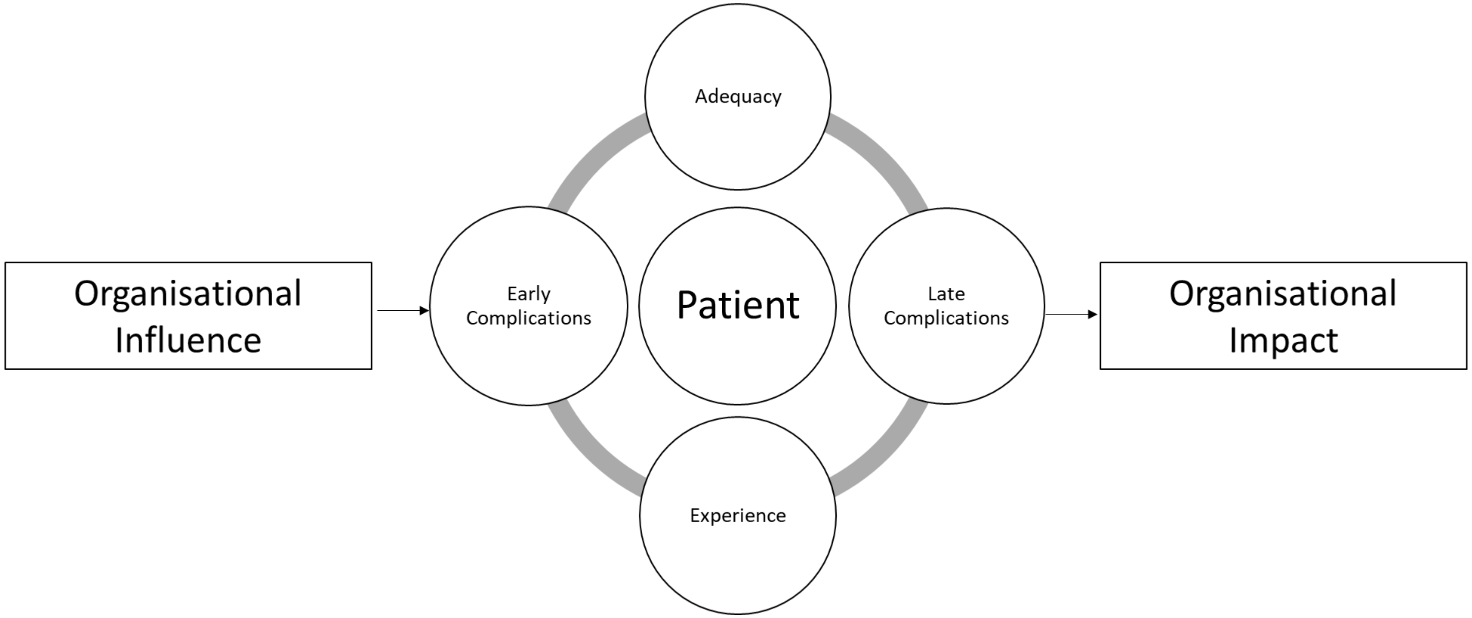

Figure 4 Mixed-methods model for investigating clinical systems

This model takes a three-stage approach to investigating complex clinical systems. The first step is to understand contextual influences on system function. These include other systems with which the system interacts or has interdependence; operational parameters; staffing; and relevant political, economic, social, technical, legal and environmental factors. Collectively these are the 'organisational influence' on system function. Next, the performance metrics are considered, including measures of adequacy, early and late complications, and patients' experience. These data collectively describe the system's 'organisational impact' upon the provider organisation, in terms of clinical risk, financial cost and clinical outcomes. Together the 'organisational influences', 'performance metrics' and 'organisational impact' frame conversations with key stakeholders in an effort to understand normal system function. A Safety II perspective contrasts 'work-as-imagined' with 'work-as-done'. This enables the creation of new metrics to fully illuminate system performance and facilitate change. Key stakeholder engagement with the model, and hence in the creation and use of new metrics, then facilitates ongoing quality improvement.

Understanding organisational influences

The first stage of investigation concerns the context within which the system operates. Drawing on the 'system of systems' concept described in chapter 1B, the surrounding systems that have interdependence with the system in question, must be understood. It is also necessary to understand the system parameters, its configuration, the staff who work within it, potential external influences on system function and performance, and the routine working practices. Together this information creates an impression of the "organisational influences" on system performance and frames the subsequent exploration of how the system functions on a practical basis.

System parameters

Baseline investigative work is required to understand the context within which the system operates, and the boundaries of its activity. In mechanical or technical systems, the parameters, feedback loops and control mechanisms that exist to regulate system activity can be straightforward to identify. In socio-technical systems the boundaries are often more blurred[161], particularly in healthcare where an individual patient, member of staff or clinical area may be included in multiple systems.

Control mechanisms in mechanical systems can be regarded as sensors, whose inputs result in a decision based upon pre-determined logic. In a complex socio-technical system the control mechanisms may include organisational policies, protocols and guidance notes – some of which may be known or unknown to individual members of staff, and relevant or irrelevant to a specific patient or clinical scenario.

The boundaries of a clinical system could also be more challenging to define. While a patient may attend a clinical service for a specified problem, the nature of healthcare is such that there may be an overlap with other related (or unrelated) clinical problems, and there is likely to also be an interface with other health and social care services (for example the ambulance service, outpatient and inpatient staff, or homecare providers).

External influences

Given the nature of healthcare and the need to cater to the whole population, there are a broad range of factors external to the healthcare system that may be influential in its routine working. These may be highly relevant to the understanding of how the system operates, and the ways in which the system may practically be modified. Horizon scanning tools such as a 'political, economic, social, technical, legal, environmental' (PESTLE) analysis[216,217] reveals several such factors (figure 5). Each of these contextual factors requires consideration in the exploration of a complex clinical system, both to understand the influence on system function and to consider if, and how, they may be modified with improvements to the system.

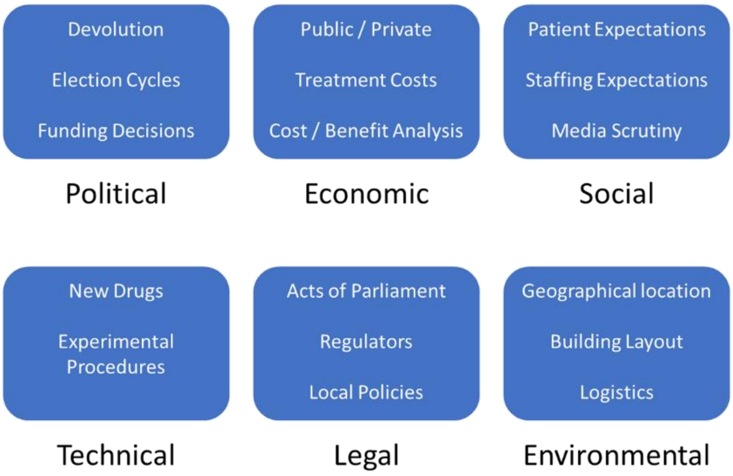

Figure 5 PESTLE influences on healthcare[216,217]

PESTLE (Political, Economic, Social, Technical, Legal and Environmental) is a horizon scanning tool which facilitates the exploration of these domains which may act as external influences on the system in question. Thorough analysis enables recognition of factors that may be relevant to system functioning, which may require to be accounted for in forthcoming planned system modifications, or which may prompt the need for system reconfiguration. The figure provides examples of the sorts of issues that may be highlighted by using this tool.

Political

Healthcare in the United Kingdom is mostly state-funded, and heavily influenced by national party politics. The UK Cabinet's Secretary of State for Health is ultimately responsible for the direction of the NHS in England, while the devolved assemblies in Scotland, Wales and Northern Ireland each have a Health Minister (or equivalent) who is responsible for the operation of their respective NHS service. The cycle of elections to the UK Parliament and the devolved assemblies, cabinet reshuffles, and other political influences, can impact upon health system function. While politicians are unlikely to exert a direct effect on a specific clinical system at an operational level, political climate influences aspects of system functioning including service funding, entitlement to care, demand and capacity.

Economic

Health and social care funding is highly politicised in the United Kingdom. Only a minority of procedures are funded directly by patients or private health insurance. NHS budgets are continually discussed in the media. As the population continues to age, patients live longer, and more expensive drugs and procedures become possible and desirable, financial pressure continues to grow. It remains unusual for funding to impact upon basic decision making around clinical investigations and treatments in the NHS, but it does influence organisations' abilities to provide services; occasionally some types of care must be prioritised over others to maintain financially solvency.

In other parts of the world, patients' ability to pay for treatment, or the extent of their insurance coverage, plays a significant role in the overall healthcare journey. Patients may be unwilling to engage with expensive preventative strategies without perceiving any personal benefits and may only have funds to afford part of an overall treatment package recommended by their physician. Payment for healthcare remains a leading cause of bankruptcy in the United States of America.

Social

Patients increasingly expect to have rapid access to clinical tests and treatments and are often less able to appreciate the limitations or risks associated with healthcare. As patient expectations expand, clinical practices may become more defensive, and some processes may experience changes in clinical demand or in their capacity to perform the same procedure safely. Social changes also impact upon the healthcare workforce.

Technical

As scientific and clinical advances enable more advanced diagnostic tests and treatments, further complexity is introduced to the clinical systems into which these new therapies are introduced. New processes bring new risks that can be predictable or unpredictable, related to the process going wrong or as an unforeseen consequence of the process going well. For example, with the advent of highly detailed clinical imaging it has become common to identify incidental findings on a scan, which then require further investigations that can lead to psychological distress and/or physical harm. Some technical advances have had a significant impact upon service configuration, infrastructure and workforce planning, for example the introduction of primary percutaneous coronary intervention to treat some forms of myocardial infarction.

Legal

A myriad of legal frameworks governs medical practice in the United Kingdom, including formal Acts of Parliament and guidance issued by the General Medical Council and other regulatory bodies. Other published guidance is also important, including recommendations made by learned societies, and government agencies. The legal context may also influence clinical behaviours, for example where clinicians adopt more defensive clinical strategies in response to higher risks of litigation[218].

Environmental

The physical healthcare environment can significantly impact upon the practicalities of a clinical system, and has also been shown to influence patients' perceptions of the care they receive[219]. Potential influences include the impact of service co-location on one campus, patient transportation and communication between clinicians in person, by telephone, post or electronic means.

Staffing

The complex staffing matrix of a health service also requires attention. Medical staffing comprises those with substantive hospital contracts, and those who are placed in hospitals for specified periods of time as part of a specialty training programme. Patient care is directed by clinicians who are licensed to practise independently, but patients are highly likely to also interface with several other clinicians working under varying degrees of supervision. Contractual arrangements vary, including those employed by the hospital in question, those employed by third party agencies, and those given employment by the hospital under the direction of an authorised training organisation.

The large number of professional and non-professional staff from a wide range of clinical and non-clinical backgrounds; with different experience and variable familiarity with the broader organisational context, generates significant potential for human error to be introduced into the clinical system. These may arise in the form of "slips, lapses and mistakes", or occasionally as violations or deliberate acts[220], as discussed in chapter 1B.

Spatial and temporal factors

Healthcare in the United Kingdom is broadly separated into community-based 'primary care' and centralised 'secondary care' facilities. Secondary care is delivered across district general hospitals and centralised teaching hospitals. The former provides a general level of care for a range of clinical problems at a local level, whereas more specialised services tend to be provided by the latter, which are usually located in major population centres. While the distribution of care between primary and secondary care services introduces an obvious potential for communication issues, there are other subtler factors requiring to be accounted for too. These include the need for sufficient capacity in both primary and secondary care to cope with the demand for service; a requirement for robust follow-up arrangements in the event that an investigation or treatment is ordered in one setting but has to be delivered or otherwise acted upon in another; consideration of transport arrangements for patients; and in some cases the need to provide overnight accommodation for patients in view of the distances between sites. This particularly affects remote and rural areas.

Additionally, patients may need to attend more than one hospital to receive care for the same problem, depending upon the clinical expertise, technical equipment and service configuration. When patients transit between hospital sites additional considerations are required, including the provision of transport and the need for communication between staff on multiple sites. Governance arrangements are required to clarify lines of clinical and administrative responsibility for the patient at each stage of the journey.

System configuration (‘work-as-imagined’)

It is necessary to establish the formal processes that exist to fulfil the objectives of the system. For example, in an outpatient clinic setting there may be processes for appointing patients; another used when patients are in the outpatient department; and another for managing the clinical administration associated with their appointment: test results, correspondence with other health professionals and so on. There may be associated policies, protocols, standard operating procedures and other documentation that has been formally approved by those responsible for governance in the system. These arrangements represent the formal system configuration, and how managers understand its function: ‘work-as-imagined’. This might form the basis of existing system function or ‘success’ measures; understanding this will frame the realities of system working revealed in the subsequent investigation. The contrast of ‘work-as-done’ and ‘work-as-imagined’ can provide key insights that lead to improved system function[196].

Existing performance metrics

Having established the system configuration and how it is thought to function (‘work-as-imagined’), the next steps are to understand the definition of “success” currently applied to the system, and the metrics used to gauge this. Public audit standards, published clinical guidance, internal productivity measures, or other measures may be relevant here. Understanding the definition of success is important because this is likely to significantly influence system functioning and may explain differences between ‘work-as-done’ and work-as-imagined.

Using data to engage clinicians

Having established the system’s parameters, and how managers imagine its function, the next step is to explore routine working: ‘work-as-done’. Understanding routine system function, adherence to policies and protocols, and workarounds for practical problems, illuminates potential levers for system migration[191,192].

Metrics used to describe system functioning can be used to engage clinicians in an investigative process that determine the reality of ‘work-as-done’ within the system. Credible, quantitative data is used for this purpose, comprising a series of metrics that describes the output of the system in question. This may take the form of published registry reports, clinical audit data, or the findings of an external review process. The rationale for using quantitative data at this stage is twofold: clinicians are typically familiar with quantitative methods since positivist research forms the basis for most contemporary published clinical studies[221]; they often have little understanding of the nature, value or reliability of qualitative research methods[222]. Quantitative data is therefore likely to be more familiar to the clinicians whose engagement is required for the investigation to succeed and for its findings to be implemented. Additionally, the use of system metrics will highlight the perceived system inadequacies that may have prompted the investigation to begin with, for example: longstanding variation in AVF use for haemodialysis[8]. It is well recognized that the creation of such cognitive dissonance can be a strong motivator for change[223].

Determining system impact

Having understood system configuration and performance metrics, the overall impact of the current system arrangement in terms of clinical outcomes, patients’ experience and financial cost should be demonstrated. This can partly be achieved by the investigator, but system stakeholders should also be consulted. To move beyond the investigator’s first impression of ‘system impact’ will require insights from those working within the system including clinicians, managers, and others. The requirements of patients who interact with the system are then considered, to provide as rounded a view as possible. New measures of success, productivity and so on are then created in conjunction with system stakeholders: for example, a clinical system that manages a particular symptom (e.g. “headache”) might consider the risk/benefit ratio from using or avoiding particular clinical tests; the clinical outcomes from using or avoiding a particular treatment; and the effect of actively or inadvertently not offering that same treatment to a given patient. The intention is to provide a rounded view of patient care within the system, using a suite of measures representing the financial, clinical and opportunity costs of system function in one form or another.

This stage is likely to be the most resource intensive. It is necessary to conduct interviews with stakeholders; to develop additional metrics to inform these conversations; and to consider aspects of the system not previously identified. Measures to limit the potential for bias and ensure maximum variation[224] are required to maximise the reliability, validity and credibility of the process. Confirmation of the investigative process face-validity is also required. Using the information gained from existing metrics, new metrics, stakeholder interviews and other data sources, a complete picture of system operation can be obtained. This can be related to published socio-technical frameworks[178,187,191,192,207,208,210] and used to identify potential strengths and vulnerabilities of the current system configuration. The information provided by the investigation is ultimately used to inform and promote improvements to the system. Engagement of clinicians during the investigative process is intended partly to inform the investigation, but more importantly to garner support for the subsequent design, implementation and evaluation of system improvements.

Quality assurance in qualitative research

The final part of the investigative process seeks to quality assure the preceding steps. Measuring ‘quality’ in qualitative research poses significant challenges, in contrast to those measures that can be applied to quantitative methodological designs[225–228]. Measures of reliability and validity can be considered markers of quality[225–227,229]. The following sections discuss these issues and describe the steps taken to quality assure this work.

Reliability

‘Reliability’ in qualitative research setting refers to the extent to which a given data collection tool would gather the same information, were it repeated by a different researcher on a different day, but with the same subject[227,230]. It can be argued that the interaction between interviewer and interviewee is a unique encounter, but for the purposes of ensuring the adequacy of the data collection exercise it is useful to determine whether substantial additional information could otherwise have been obtained during the interview process – in essence, whether the interview format was fit for purpose and would provide a consistent output were it conducted by another researcher.

Validity

The 'validity' of a qualitative research project can relate to the adequacy with which the methodology investigated the problem space and the congruence of the results with reality ('internal validity'), and the extent to which the findings are generalizable beyond the study cohort ('external validity')[231,232]. In quantitative work these can be demonstrated by repeating experiments (internal validity); and by careful consideration of sampling and statistical techniques (external validity). For qualitative works these approaches are often inappropriate[225]; the nature of qualitative research is such that participants' opinions, perspectives and values heavily influence the data and this cannot be 'controlled' in the manner of a randomised-controlled trial following a positivist paradigm. The equivalent measures of validity for qualitative research include the overall utility of the finished work to others (external validity), although this clearly can only become fully apparent once the data has been collected and analysed, and the results disseminated to a wide audience, at which point little can be done to change the conduct or analysis of the work.

Triangulation

Triangulation[225,227] is often used to determine validity and reliability in research projects. This refers to the use of multiple techniques, data sources or analytical lenses to confirm or refute findings within a dataset. Various categories of triangulation are described[233]:

- Method triangulation, where multiple methods are used to explore a given issue;
- Investigator triangulation, where multiple researchers are involved in a study to provide alternative perspectives;
- Theory triangulation, where different analytical lenses are used to analyse the same data;

- Data source triangulation, where data is obtained from different ‘categories’ of people within a population of interest.

The concept of triangulation is easily understood, but in qualitative research there can be pitfalls with its use. Apparent inconsistencies between data sources do not necessarily represent ‘invalid’ or ‘unreliable’ data; such conflicts may illuminate interesting data points, suggesting a strength rather than weakness of the methodology[234]. Similarly, the apparent corroboration of data collected from multiple sources does not necessarily confirm the accuracy of the data[235]. A key facet of this study’s methodology lies in comparing perspectives of ‘work-as-imagined’ and ‘work-as-done’ in complex healthcare systems; it is argued that conflict of opinion and perspective is inevitable and indeed valuable to the investigative process, and so the process of data triangulation should not seek to eliminate such disagreements within the dataset.

Other authors have demonstrated the value of triangulation within health research[236]; to this end, the present study employed several triangulation strategies:

- Method triangulation – a mixed-methods approach was taken comprising semi-structured interviews and a six-week census of quantitative data (as described later in this chapter);
- Investigator triangulation – an ‘interview panel’ format that included experts in nephrology, vascular surgery and interventional radiology respectively, was utilised for semi-structured interview data collection and to assist with triangulation during the data analysis stages (this is described in more detail in the "interviewers” section later in this chapter);
- Data source triangulation – interviews were conducted with clinicians representing all identified stakeholder groups within the VA system, from all ten adult and paediatric renal units in Scotland. Quantitative data was also collected from all nine adult renal units in Scotland. Pre-existing registry data was also considered in relation to each centre, including the incident and prevalent AVF use within each centre (figures 1, 2).

Face validity

A more useful measure of qualitative internal validity lies in its face validity: the degree to which participants considered that the methodology achieved its stated aim[237] (in this case, to understand the complex clinical systems concerned with the creation, maintenance and everyday use of VA for haemodialysis). This is distinct from ‘participant validation’, which involves inviting study participants to review the investigator’s analysis of the dataset, before the findings are formally reported and disseminated to the outside world. This can be hazardous since disagreement between the respondents’ perspectives and the conclusions drawn by the researcher do not necessarily imply that the project was invalid[238].

In the context of this study the methodological face-validity was considered most important, since the participants form a large part of the clinical audience to whom the eventual findings would be most relevant. Moreover, the mixed-methods model relies upon actions being taken by those who were engaged by the research process, and this engagement fundamentally depends upon participants’ perception that the project’s findings are credible.

Justification of model approach

The epistemology of the mixed-methods model is based upon social constructivism[227,239]. The function of any clinical system represents an amalgamation of professional opinions, provider infrastructure and governance, and individual patient factors. It is considered essential to ascertain the reality of system functioning – ‘work-as-done’ – rather than simply relying upon ‘work-as-imagined’ which may not reflect reality. The inclusion of multiple stakeholders in the investigative process can add time and expense, but a maximum variation approach is most likely to provide a realistic idea of ‘work-as-done’, while providing a rich bank of examples that can be related to theoretical socio-technical systems frameworks. This contrasts a little with ‘positive deviance’ approaches (described in chapter 1) which seek to identify ‘unexpectedly good performance’; test its utility in other contexts; and subsequently implement the identified ‘deviant’ practice elsewhere. The model is sympathetic to the principles of this approach in that areas of existing good practice within the system will be identified – but the purpose of this model is not just to identify and upscale examples of good practice within complex systems. Rather, it seeks to identify gaps between ‘work-as-imagined’ and ‘work-as-done’, from the perspectives of the system stakeholders, such that improvements can be designed to the system. In the frame of the current study too, it should be acknowledged that the complexity of VA care does not lend itself well in practice to statistical comparisons of different processes, which would form part of a positive deviance approach.

Preference is given to understanding routine system functioning rather than focusing upon occasions where system function did not proceed as intended, perhaps resulting in an adverse event. While it is sensible to remain mindful of hazardous episodes, these are regarded as one possible outcome of the current system configuration; it is argued that the finite time and resources available for improvement activity are better spent enhancing the resilience of everyday function, rather than attempting to prevent recurrence of specific, uncommon, scenarios. In this context, the term ‘resilience’ refers to the ability of the system to cope with unexpected events or to remain functioning despite deficiencies: for example, the ability of clinical areas to function despite computer failures, or when staff are unexpectedly absent.

The model relies upon metric data and stakeholder interviews to determine system configuration and function, but principally orients around patients’ experience of care. If this is optimised it is likely that the system is functioning appropriately[214,240]. The term ‘experience’ should be distinguished from ‘satisfaction’ and should not be regarded simply as a measure of convenience or some other aesthetic consideration. Multiple quantitative and qualitative data sources should be used to describe the system from multiple perspectives. These may provide contradictory information and might not be strictly “clean data” according to the positivist paradigm. This intends to highlight strengths, ambiguities, vulnerabilities and areas for improvement. A highly effective strategy for choosing quantitative metrics is to consider what might reflect optimised patient-centred care; this might include measures of efficacy, adequacy and appropriateness, along with measures of complications (including those associated with avoiding particular treatment options). This approach aligns with the Scottish Government’s Healthcare Quality Strategy[103] which aspires to orient every clinical interaction around values relating to patient-centeredness.

A qualitative approach to describing system function is necessary; the investigation seeks to understand normal working practices, but not to test whether one approach is necessarily ‘better’ than another. Qualitative enquiry remains relatively unfamiliar to medical communities but can reveal a substantial depth and breadth of detailed information that is difficult or impossible to obtain using quantitative methods.

Methods of Vascular Access Appraisal

The previous section described a mixed-methods model to investigate clinical care. This section details how this approach was used to explore Scottish VA services, and the subsequent quality assurance of the study.

The mixed-methods model aims to thoroughly explore the workings of a clinical system through understanding its strategic alignment, operational realities, and metrics that demonstrate the impact of the system's currently configuration. This is achieved by using existing quality measures to frame a series of semi-structured interviews with key stakeholders. The interview data is used to generate additional measures of quality and productivity. Together these qualitative and quantitative data describe the organisation and function of the clinical system; using the lens of socio-technical systems theory it becomes possible to analyse the system and design interventions to improve efficiency, quality and safety.

Vascular Access system definition

For practical purposes, most clinical systems are designed to serve specific clinical needs and are therefore organised according to the requirements of a specific illness, means of treatment or patient cohort. This study examines the clinical system concerned with haemodialysis VA, as discussed in chapter 1A. It seeks to understand VA as a "whole system" rather than by its constituent parts. It was intended that interactions between system elements, and their influences upon one another, would be appreciated and understood. The resulting insights will facilitate improvements to local services and benefit the broader clinical community delivering these services in Scotland and further afield.

Using the approach described above, a mixed qualitative and quantitative investigative strategy was developed to explore the services concerned with the delivery of VA services. This was defined as all clinical interactions concerned with the assessment of patients who may require VA; the processes involved in VA creation and maintenance; the routine use of VA for haemodialysis; and all associated clinical activities.

System Parameters

It was necessary to identify the parameters of VA systems, to consider potential external influences, and identify key stakeholders whose perspectives could provide insights about normal VA system function. It was also necessary to determine what metric data already exists to describe the VA service function.

The basic principles of VA have been described in the introduction. From a systems perspective, VA care is concerned with the needs of patients who (may) require VA to facilitate haemodialysis treatment. This includes the cohort of patients who may reasonably require referral for VA creation; the VA creation pathway; the ongoing maintenance of VA (to optimise its patency); and the routine use of VA for haemodialysis. For the purposes of this study the processes of care concerned with alternative RRT modalities (including renal transplantation and PD), as well as those concerning conservative care strategies, are not considered to lie within the VA system boundary. This is in keeping with the author’s professional experience of working in renal medicine. It is accepted that system boundaries are often dynamic and poorly defined in real-world practice[191,192]. PESTLE analysis[216,217] (see figure 5) would suggest that these other approaches to RRT provision could have potentially important interactions with VA systems, in keeping with the hierarchical nature of systems and the ‘system of systems’ concept discussed earlier[172,173]. Efforts will therefore be made to identify how these systems interact with, and potentially modify, VA services in each unit. It is judged however that a full examination of the separate systems concerned with creating, maintaining and using each alternative RRT strategy in each unit, in addition to those related to VA, would lie outside the scope of this project.

Figure 6 describes key VA system stakeholders. They include a range of doctors, nurses, sonographers and managers, whose activity is focused upon patients who require VA for haemodialysis treatment. Doctors include nephrologists with responsibility for managing patients’ renal disease and haemodialysis treatment; vascular surgeons who create AVF or AVG; and interventional radiologists who maintain AVF or AVG and may be involved in TCVC insertion. Nurses include haemodialysis staff and Vascular Access Nurses specialising in VA assessment and coordination of VA creation and maintenance. Specialist sonographers conduct imaging assessments before and after AVF or AVG creation. Clinical and non-clinical managers of the various clinical services interacting with the patient have budgetary, staffing and resource responsibilities.

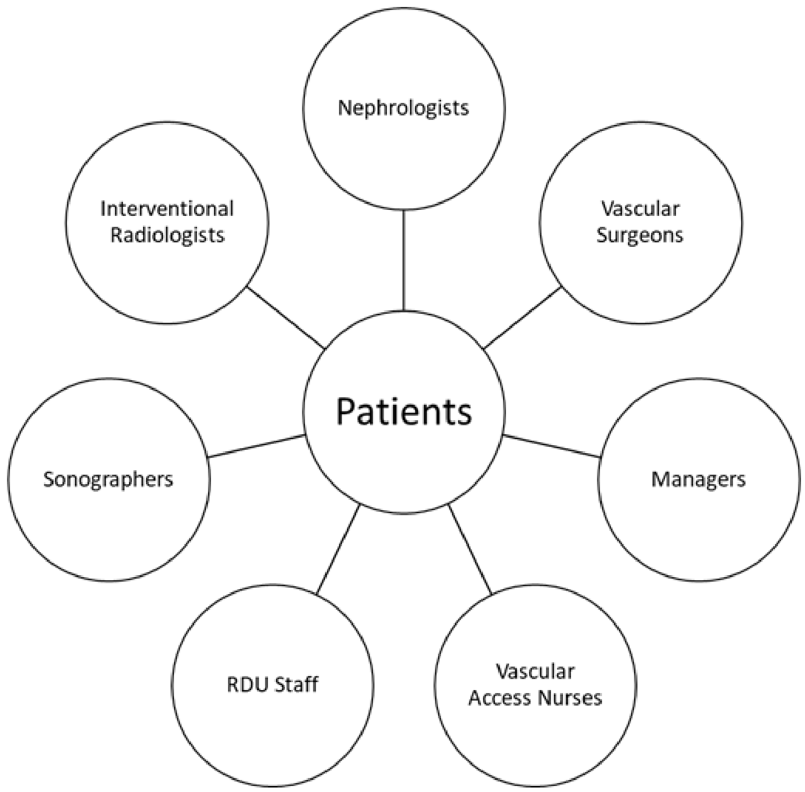

Figure 6 Key stakeholders in Vascular Access Services

The key stakeholders in VA services include a range of doctors, nurses, sonographers and managers. It should be noted that this diagram denotes the key stakeholders in the VA service but does not include the many other clinicians and administrators who are also involvement in patients' journeys.

Metrics

The most widely available data about VA services arise from published registry data. The annual Scottish Renal Registry report includes a dedicated VA chapter[8]; similarly, the annual UK Renal Registry report includes VA data[9].

The predominant measures of success in VA services relate to the proportion of patients whose first ever chronic haemodialysis session is delivered using AVF/G ("incident access"); and the proportion of patients within the haemodialysis cohort whose chronic haemodialysis sessions are routinely delivered using AVF/G ("prevalent access")[3]. These data are published in registry reports[8,9,11]; see also figures 1 and 2. A related measure relates to SAB prevalence. Although not exclusive to haemodialysis patients, this cohort accounts for a large proportion of the overall SAB burden[241]. Bloodstream infection rates are published in registry reports and are also scrutinised by government agencies. The Scottish Government has instructed health boards to reduce SAB episodes[39], hence this area receives significant attention at local and national level.

No other measures of VA system function are routinely available in the public domain, although it is possible that individual renal units hold unpublished audit data. This may include numbers of hospital admissions, numbers of requested and completed procedures, and procedure outcomes.

Qualitative data collection strategy

Using the definitions, parameters and metrics described above, a qualitative data collection strategy was devised that would gather information on the routine working of VA clinical services from the perspectives of all key stakeholders. This was intended to realise aims 1, 2 and 4 of the study: to delineate the structure of VA clinical pathways in Scottish renal units; to explore how clinical work occurs within and around these pathways; and to illuminate gaps between 'work-as-imagined' and 'work-as-done' in relation to Scottish VA services.

Several means of data collection were considered, including questionnaire-based approaches, focus groups, and interviews. Table 6 describes their relative advantages and disadvantages.

Means of Data Collection	**Advantages**	**Disadvantages**
Questionnaire	Inexpensive Rapid data collection	Limited level of detail Low response rate
Focus groups	Time efficient Group discussion of concept	Individual views may be over or underrepresented Controversial views may not be expressed Technically difficult to transcribe
Structured interview	Level of detail limited by question design	Rigid structure creates difficulty in exploring new ideas
Semi-structured interview	Rich level of detail Balance of standard questions with scope to explore new ideas	Time intensive Interviewee may feel threatened by process
Unstructured interview	Rich level of detail	Difficult to standardise between interviewees Relies upon forthcoming interviewee

Table 6 Means of qualitative data collection with their relative advantages and disadvantages[242–247]

Questionnaires

While questionnaires would provide a rapid and inexpensive mechanism for data collection, there was concern about the likely response rate and the potential for a lack of detail in respondents' answers.

Focus groups

Focus groups[242,245,247] were likely to provide a rich dataset in a relatively short time; there was a risk however that individuals could dominate the conversation while subtle political, financial and other influences could be difficult to ascertain. Besides the potential logistical and scheduling challenges organising focus groups of this nature, it was also unclear whether it would be most productive to hold focus groups involving clinicians representing individual renal units, to mix clinicians representing the same specialty in different units, or another iteration. Other authors have reported difficulty capturing data during focus group interviews[242,244,247], and it was preferable to avoid situations where focus groups took place but the resulting audio recording was not practically usable.

Interviews

Interviews[243–245,247] seemed the most appealing approach. Structured, unstructured and semi-structured variants were considered.

Structured interviews were deemed likely to have similar drawbacks to questionnaire-based approaches, with inflexibility for interviewers to discuss emergent issues without risking inconsistent data collection between interviews.

Unstructured interviews were rejected in view of difficulties ensuring consistency between interviews, and the potential for interviews to focus on 'bugbear issues' rather than exploring the breadth of each interviewee's VA service experience. This was judged particularly important since it was planned to interview clinicians from multiple professional backgrounds, who would likely hold differing perspectives on VA.

Semi-structured interviews

Semi-structured interviews were considered to provide an optimal format. They would allow for individual perspectives to be sampled, using a consistent format between interviews but with flexibility to explore issues arising in the discussion using an 'emergent probing[243,248]' technique. There was also scope to modify the interview format as the project progressed by utilising 'constant comparison[249]' between interviews.

Interview format

Telephone interviews were considered impractical. The literature suggests telephone interviews tend to be shorter, afford interviewees less time to speak, and ultimately have reduced data yield, in comparison with equivalent face-to-face interviews[250]. Audio-recording telephone interviews would be difficult without specialist equipment; it would be difficult to involve multiple interviewers in the process; and participants' body language and other nuances of conversation would be better appreciated in person. It would also be difficult to obtain written interviewee consent for telephone interviews.

It was considered that face-to-face, semi-structured interviews with key VA stakeholders from each renal unit was most likely to yield useful data. From a logistical perspective it was considered more practical to visit each renal unit site to conduct interviews, rather than inviting participants to a central interview location.

Sampling strategy

Various sampling considerations were necessary, accounting for the need to balance detailed investigation with pragmatic concerns around investigator time and financial expense.

'Deviant case analysis'[251] was considered as an alternative to involving all ten renal units in the study. This would involve comparing units considered 'good' and 'bad' by some measure, rather than including every unit in data collection. This could significantly reduce the time and cost associated with the study but was judged unlikely to provide a credible description of VA delivery across Scotland. Basing the sampling strategy upon a small number of existing metrics would involve unsafe assumptions, principally that these metrics were true representations of each centre's organisation and function. Moreover, this would mean basing the study on an arbitrary definition of 'success', which would significantly bias the methodology. It was therefore determined that a comprehensive interview strategy, involving all ten (adult and paediatric) renal units, was necessary.

A purposive sampling strategy appeared advantageous for this study[252,253]. This is a non-random sampling technique whereby specific individuals within the study population – in this case, within the VA system – are deliberately targeted to bring their perspective into the dataset. In keeping with other literature[253], multiple purposive sampling techniques were used to maximise data capture:

- A maximum variation approach[224,253] was considered necessary, meaning that every perspective from each renal unit would be represented in the study;
- Snowball sampling[253,254] was utilised alongside recruitment via the investigators' professional networks, as described below.

The result of this process was that semi-structured interviews were arranged with all key stakeholders from the VA services in each Scottish renal unit.

Interviewee recruitment

The roles of key VA stakeholders are described in table 7.

Team Member	**Typical Role**
Nephrologist	Responsible for overall medical care of the patient with kidney failure
Vascular Surgeon	Creates AVF, inserts AVG, and manages associated complications
Interventional Radiologist	Performs x-ray guided procedures including fistulography and fistulaplasty
Sonographer	Specialist imaging using ultrasound techniques
Vascular Access Nurse / Coordinator	Coordination of patients moving through Vascular Access clinical pathways; provides expertise in cannulation and troubleshooting access problems in RDU
RDU Nurse	Utilises Vascular Access to administer haemodialysis treatment to patient

Table 7 Roles of Vascular Access team members

The first potential interviewees were identified using the investigators' professional networks; they were approached via an email invitations. Snowballing[254] was then used to identify and recruit additional interviewees, with the aim of achieving 'maximum variation'[224]. Snowballing was utilised at the point of recruiting the original interviewees, and at the conclusion of each interview. The interviews continued on each site until all available interviewees had been interviewed, or until data saturation[224,248,255] was reached.

A nominated individual on each site agreed to host interview days. Their roles included arranging a private interview room, coordinating interview times, and liaising with an administrator to confirm interview dates and logistical arrangements.

For logistical and financial reasons, visits to renal unit sites were planned on dates where most interviewees were available. Snowballing[254] was used in advance of site visits to optimise the interviewee list, and during each interview to confirm that all stakeholders had been included in the process. Further site visits were scheduled to meet additional stakeholders when necessary.

Interview guides

Detailed interview guides[243] (appendix 1) were created to facilitate each interview. These served as a reference point enabling the interview to flexibly cover all relevant topics during the interview, without requiring rigid adherence to a particular sequence of questioning[256]. They were also used by the lead interviewer and other members of the interview panel to make field notes.

The guide was developed in a manner sympathetic to the published methodological literature[257,258]. The investigators' prior knowledge of VA and the published VA literature (see chapter 1A) was used to create seven general questions that would explore the structure, function, productivity, strengths and vulnerabilities of each service. The questions were developed with reference to the VA system parameters and metrics described earlier, and with mindfulness of socio-technical systems properties, also described earlier.

In addition to each question, interview guides listed what were considered key issues to be discussed within each category. These were intended to prompt the interviewer and to ensure consistent discussion of topics with each interviewee while allowing for free-flowing conversation. Mock clinical vignettes were appended to the interview guide to stimulate discussion if necessary. These were designed to mimic ‘typical’ patients likely to be encountered by VA services, with the intention that interviewees could potentially use these mock cases to describe how such a patient could progress through the local VA service.

It is good practice to pilot interview guides[257,258]. The nature of VA services, the small clinical VA community, and the sampling strategy for this study (see above) meant it was not practical to conduct pilot interviews with individuals who were not participating in the study. Instead, the first interview date was scheduled around six weeks before the subsequent interviews, allowing for the interview guide to be piloted and amended if necessary before the main data collection period began. In the event, no major changes were required based upon the pilot interview.

Interviewers

The author was present at, and led, every interview. He had previously worked in three of the ten renal units (NHS Tayside, NHS Greater Glasgow and Clyde, NHS Lanarkshire) but at the time of the study did not have a full-time clinical role. Between one and three additional interviewers were also present at each interview. The panel was constructed based upon interviewer availability, and in a manner that avoided colleagues who normally worked together interviewing one another. A total of six individuals participated in the interview panels; one interviewer was also an interviewee, who was recruited to join the interviewer panel after being interviewed herself at the beginning of the investigation.

Traditionally, research interviews are conducted by solo interviewers, but for this study a panel interview format was used, using a panel comprising clinician experts in nephrology, vascular surgery and interventional radiology. This was considered essential in view of the clinical complexities surrounding VA, and to prevent interviews becoming sidetracked by uncertainties around technical aspects of VA care.

Little has been written about panel (rather than solo) interviews in qualitative health research, although the technique has been recognised in other areas for decades. The dynamic of the interview is clearly different from a one-on-one encounter, but various advantages have been cited in the literature: the ability to create less formal discussions; better awareness of time and progress through the interview guide; more capacity to ‘observe’ interviewees’ body language; and greater overall capacity to gather information from the interview process[259,260].

In this project, the presence of an expert panel also enabled triangulation of data during the interviews, for example to identify and develop points where a key clinical detail was noted to vary between interviewees within or between centres.

Interview format

Interviews were conducted in a private room within the interviewees' host institutions, during normal working hours. Only the interview panel and interviewee were present in the room. Efforts were made to interview individuals without colleagues being present, but on one occasion for logistical reasons it was necessary to interview two vascular surgeons together.

Interviewees had received written information about the interview in advance of the interview date; before each interview the same information was conveyed orally, and the participant had the opportunity to ask questions. Written, informed consent was obtained before the interview began.

The lead interviewer opened and led the discussion on each occasion. The interview guides were used to guide the discussion, which flowed in a dynamic fashion. Reference was made to the mock clinical cases where necessary, for example to illustrate how a patient could progress through a clinical pathway. Expert contextualisation was sought from interview panel members where necessary, for example to clarify technical aspects of interventional radiology procedures.

Emergent probing[261] was used in two ways during the interview. The lead interviewer probed issues arising in the discussion that were not featured, or out of sequence in the interview guide. When the lead interviewer had concluded the discussion as directed by the interview guides, the remaining interviewers were then given the opportunity to ask further questions that clarified or expanded upon the issues discussed. In this way the full content of the interview guide and any emerging issues were covered.

All interviews were audio recorded using a laptop computer running Windows Sound Recorder (Microsoft Corporation, Seattle, USA). A pocket Dictaphone provided backup audio recording. Audio files were stored on a secure drive, for subsequent audio-transcription by secretarial staff. Contemporaneous field notes were made by the interview panel, using the printed interview guide templates.

Constant comparison[249] was utilised between interviews, and between site-visits. This optimised data capture and enabled the exploration of emerging issues within centres and as the project progressed.

Interviews

Between September 2014 and February 2015 all ten adult and paediatric renal units in Scotland were visited and interviews conducted with staff. Tables 8 and 9 provide further interview details.

Renal Unit	Number of Interviews	Total Interview Duration
Unit 1	4	2 hours18 minutes
Unit 2	4	2 hours 57 minutes
Unit 3	5	3 hours 3 minutes
Unit 4	1	43 minutes
Unit 5	5	2 hours 8 minutes
Unit 6	4	2 hours 21 minutes
Unit 7	4	2 hours 52 minutes
Unit 8	9	6 hours 48 minutes
Unit 9	4	3 hours 32 minutes
Unit 10 (Paediatrics)	2	1 hour 3 minutes

Table 8 Number and duration of interviews by centre

A total of 42 interviews were conducted with a broad spectrum of clinicians in each unit. Interviews lasted approximately 45 minutes on average.

Specialty	Number of Interviews	Total Interview Duration
Nephrology	13	8 hours 35 minutes
Nurses	4	2 hours 42 minutes
Vascular Access Nurse	7	5 hours 25 minutes
Vascular Surgeon	9	6 hours 14 minutes
Interventional Radiologist	8	4 hours 32 minutes
Sonographer	1	20 minutes

Table 9 Number and duration of interviews by specialty

A total of 42 interviews were conducted with clinicians across all ten adult and paediatric renal units in Scotland. All but one interview was conducted with a solo interviewee in a private room; for logistical reasons, one of the surgical interviews had two surgeons present during one interview. "Nurses" refers to nurse practitioners and RDU nurses but does not include Vascular Access Nurses, who are counted separately.

Interview transcripts

Audio transcripts were typed by a team of secretarial staff, using the interview audio recordings, to facilitate thematic analysis of the data. It was considered impractical for thematic analysis to be carried out using the raw audio recordings. Similarly, it was not feasible for the lead interviewer to transcribe every recording.

Each typed transcript was quality assured by the lead interviewer. This involved comparison of each line of prepared transcripts with every word of spoken audio from each interview. Transcripts were amended as required until they fully reflected the recorded interview. Many audio files required digital enhancement to remove background noise to facilitate quality assurance; this was achieved using freely available software (Audacity version 2.0.6, audacityteam.org). The final, combined, quality-assured transcript word count was approximately 260,000 words. The quality assurance process took several months to complete.

Transcript analysis

The completed, quality-assured transcripts were subjected to thematic analysis[262]. This technique enables the recognition of 'themes' emerging from the data in a manner that facilitates their presentation and further analysis, and ultimately reach conclusions and generate recommendations for practice. The purpose of this study was to delineate the structure and function of VA pathways (being mindful of socio-technical systems theory), and to illuminate gaps between 'work-as-done' and 'work-as-imagined' from the perspectives of VA system stakeholders (being mindful of healthcare resilience engineering principles). To this end it was considered that thematic analysis would provide a revealing analysis of the interview data and enable the formulation of conclusions and recommendations for practice.

Other techniques were considered. Content analysis has many similarities to thematic analysis but has a tendency to seek quantitative weighting within the data, potentially at the expense of discrediting the analytical process[263]. Narrative analysis is a process of finding meaning by presenting data in a (narrative) story format[264]. This often requires a degree of 'narrative smoothing', which may be considered as selective reporting of dataset elements to enable the final story to coherently fit together. This seemed at odds with the study ambition to illuminate ambiguities in VA care. Discourse analysis provides understanding of meaning through analysis of language[265]; while this may provide interesting insights into elements of VA care, the technique seemed unlikely to fully meet the aims of the study. An ethnographic approach would combine interview data with close observation of VA services[266]. This was considered impractical in view of the large number of hospital sites involved, and the disparate nature of VA services within a given renal unit (based upon the investigators' professional experiences). Moreover, it is acknowledged that ethnographic approaches tend to amalgamate researcher and subject perspectives and do not provide generalisable data; each of these factors were considered disadvantageous to this work.

Thematic analysis

Thematic analysis was conducted according to published methodological standards[267,268]. The author became fully immersed[251] in the data through leading the interviews and performing detailed quality assurance of the audio-transcripts. Initial codes were generated through review of the full dataset. Coding was done manually, using qualitative analysis software (nVivo 10, QSR International Pty, Melbourne, Australia) to visualise the data, record codes as the analysis progressed, and to provide an audit trail of the overall coding process.

Themes were identified in the data through line-by-line analysis of each transcript, using constant comparison[249] throughout the process. A 'theme' was taken to mean a piece of data that seemed important in relation to the research questions. An inductive coding process was used, with the intention to provide a rich description of the whole dataset. Themes were identified at a latent level, that is, the coding sought not only to locate data of interest within the transcripts, but also to consider the assumptions and beliefs underpinning the data.

All initial themes were considered by the author in conjunction with the other investigators, who had formed the interview panels (described earlier). Through a series of meetings, further transcript review, and ongoing constant comparison, the perspectives of those working in the same unit, those holding similar professional roles in different units, those with similar and contrasting views on a topic, and every iteration thereof, were considered in detail. This process led to the generation of several themes that were then combined to form four axial themes, around which a series of recommendations could be made (table 10). The full results of the thematic analysis are described in detail in the results chapters of this thesis.

Theme	**Inclusions**
Creation of Vascular Access	Processes involved in VA creation, including formal, informal and workaround processes. Clinicians' opinions of VA modalities are also considered.
Maintenance of Vascular Access	Processes involved in VA maintenance, including formal, informal and workaround processes. VA surveillance is also considered here, including clinicians' opinions and the processes involved for centres who routinely perform surveillance.
Service Performance	Issues that were said to impact upon routine function are considered here. These include historical and geographical context; clinical time and resources; tracking patients' journeys; unscheduled care; timelines; the recording and reporting of clinical outcomes.
Development Needs	Areas for service development are considered here. These include the self-reported strengths and weaknesses from each service; multi-disciplinary working; strategies for vein preservation; the use of electronic health records; barriers to efficiency; and issues around team working.

Table 10 Axial themes arising from the thematic analysis

Inevitably with a very rich dataset, the centres where more interview time was possible – thought to be a function of unit size and staffing complement – tended to generate more coded data (see tables 8 and 9 above). The nature of thematic analysis is such that themes cannot be assessed according to a weighting or other form of prioritisation, simply based upon their frequency within the dataset. Indeed, analyses where data is weighted according to its frequency in the dataset re generally discredited in the literature, although similar techniques to identify themes based upon recurring phrases have been described[263,267].

Data coding was exclusively performed by the author. A weakness of this approach is the potential introduction of bias into the data coding strategy, however various authors have described additional complexities, costs and other challenges associated with multiple researchers coding the same dataset[269,270]. It is suggested the benefits of dual coding lie more in the discussion of disagreements in coding rather than simply ensuring both researchers are following the same pattern of coding[271]. With this in mind, and for practical purposes, we held a series of informal team meetings throughout the coding process where the coding strategy, transcript content, and emerging themes were reviewed and debated. This served as a proxy for dual coding, accepting that the absence of formal dual coding was a limitation of the methodology used.

Quantitative data collection

This phase of the study was designed to answer research aim 3: to quantify the clinical workload associated with VA services. This would supplement existing registry data concerned with incident and prevalent Vascular Access[8], and inform the development of new metrics to better describe VA system function.

The paediatric centre was excluded from this component of the project, due to the significant differences in its patient population and VA-related clinical workload (as described during the interviews).

Quantitative data collection began after the semi-structured interviews had concluded. A coordinating clinician on each site was recruited by email or telephone discussion. Data was collected using a pre-formatted spreadsheet (appendix 2) provided electronically to each unit. This was designed to enable data collection in an efficient manner that struck a balance between collecting a sufficiently detailed dataset for analysis, with mindfulness that the coordinators on each site were collecting and providing this data in addition to their usual duties at work.

Each unit was asked to record all VA-related hospital admissions, along with surgical and interventional radiology procedures requested or performed during the six-week period 26/1/15 – 6/3/15 inclusive. The definition of "VA-related" was left at the discretion of the coordinating clinicians, within the parameters described on the data collection spreadsheet (appendix 2). Coordinators were also asked to indicate whether 'unusual events' occurred during data collection period, for example staff absence, theatre downtime, extraordinary disruptions to clinical services and so on, which could have influenced the quantity of work performed during the census period.

The dates and duration of this clinical activity census were chosen for convenience, avoiding major holiday periods, and striking a balance between maximising data returns without the process becoming overly onerous for coordinators in each centre. It was judged unlikely that many procedures would be requested and performed within the six-week window, hence details of both 'requested' and 'performed' procedures were sought, and efforts made to eliminate duplicate entries. This was intended to gauge the volume of procedural activity, and, where the date of referral and procedure were available, the indicative waiting times in each centre.

The data-collection spreadsheets were returned electronically to the lead investigator at the conclusion of the six-week period. The data were collated to provide a national picture of access-related clinical activity across all nine adult renal units. Where data was missing, ambiguous or incomplete, efforts were made to resolve this through dialogue with the local coordinator at the appropriate renal unit.

The dataset was analysed using Microsoft Excel 365 (Microsoft Corporation, Seattle, USA). Procedure names were coded to ensure consistency between centres. The complete dataset was then subjected to analysis and used to contextualise the interview data.

Avoidance of bias

The qualitative nature of this study, and the lack of consensus on many aspects of the clinical system in question, emphasised the importance of taking steps to limit the potential for bias during the investigative process. Several techniques were used to protect the process from becoming overly influenced by isolated opinions. These are discussed below.

1. *Sampling strategy*

A purposive sampling strategy[252], augmented by snowballing[254], enabled the identification of all stakeholders in each renal unit, to provide a comprehensive view of the VA service as judged by the others working in that centre. It was highly unusual throughout the interview process to encounter the name of a key individual who did not already have an interview scheduled, or who had already been interviewed. This sampling strategy prevented bias arising from over-representation of a particular group of clinicians, individuals known to the interviewers, or those with a particular viewpoint.

Significant efforts were made to accommodate interviewees. Site-visits were made to twelve hospital campuses, with return visits where needed, to meet all the participants. Everyone who originally agreed to participate in the study was interviewed.

The sampling strategy involved every key clinician from VA services in each renal unit. While it was not feasible to interview every clinician interfacing with every service, the sampling approach provided as near to a full-population sample as was practically possible.

The large sample size, and the depth of each interview, enabled the reliability of the data to be confirmed. By triangulating comments by different interviewees about the same service, it was possible to corroborate assertions made. It must be acknowledged however that ‘perceptions’ of a system, as opposed to ‘facts’, are equally valuable to the analysis[225], hence assertions that were not triangulated were not discounted from the analysis.

2. *Interview format*

The semi-structured interview format was advantageous for the reasons described earlier. Emergent probing[243,248] and constant comparison[249] ensured the key points were covered in each interview, while the interview panel format prevented important issues being omitted. Solo interviewees meant there was less risk of social bias or power gradients influencing the interview, at least from within the centre. It is acknowledged that the interview panel was composed of senior clinicians; while this may have influenced participants’ willingness to speak freely, investigator familiarity with the context being studied is considered a criterion for quality qualitative research[235]. Participants' willingness to speak honestly was explored in more detail in a face-validity sub-study, described at the end of this chapter.

3. Data saturation

Interviews continued at each renal unit site until data saturation[224,248,255] was reached within that unit. The interview panel agreed by consensus when saturation had been reached in each centre. This was further confirmed during interview transcript quality assurance. Additional site visits were arranged if the scheduled interviews did not result in data saturation being reached.

4. Transcript coding

Each transcript was quality assured before the thematic analysis began, as described above. Frequent discussion among the investigator group, and with clinicians from each renal unit, enabled sense-checking of ambiguities emerging from the dataset.

A single investigator performed all data coding during the thematic analysis. This avoided potential problems with ambiguous or divergent coding strategies employed by multiple coders. The potential for bias with this approach is acknowledged; this was limited by the frequent comparison of transcripts from interviews of individual clinicians, those representing the same professions on different sites, and those representing the same renal units.

Initial coding was conducted according to the chronological order of the interviews (and hence the chronological order with which transcripts became available); however, during the several months of data coding each transcript was examined in detail, on several occasions, and in random order.

A summarised version of the coded data within specific themes was created and shared within the group of investigators. This document represented the major perspectives from each professional group and geographical centre on each coded theme. This ensured that a consensus could be reached as to the important points arising within each theme, without neglecting unusual or polarised points within the data.

Dissemination of findings

The final aim of this study was to present the findings to the clinical community in a manner that facilitated ongoing QI. Three strategies were employed to achieve this.

The findings and associated recommendations for practice were formulated into a written report, which was distributed to all project participants and made freely available online.

A full-day feedback event was convened at the Queen Elizabeth University Hospital in Glasgow on 26 November 2015, where members of the VA community from Scotland and further afield were introduced to the result, the report, and the recommendations. This event was supported and introduced by the Chief Medical Officer for Scotland.

The third strategy involved the creation of a ‘scorecard tool’, detailed below.

Scorecards

The recommendations arising from the study were intended to facilitate QI across the VA community. Being mindful of the large number of recommendations and the limited clinical time available within VA services, a novel ‘scorecard’ approach was designed. This aimed to present the recommendations in an operationalised format that prompted QI activity while enabling units to benchmark their service characteristics against other centres.

To construct the paper scorecard tool, which was launched at the feedback event and published online alongside the report, each recommendation was broken down into simple questions that could be answered with a binary ‘yes’ or ‘no’. A total of 68 questions were written (appendix 3) using language judged accessible to clinicians and managers alike. The original version was subsequently amended for online data collection using the Google Forms platform (Google; Mountain View, California) where a third ‘don’t know’ option was added to the possible responses. This was added to avoid the scenario whereby respondents were unsure about a question but felt compelled to answer ‘yes’ or ‘no’ and therefore potentially bias the results. Demographic information was also collected, about the unit being represented, respondents’ professional background, and their main role within the local VA team.

Clinicians and managers representing all specialties in every adult renal unit in Scotland were invited to complete the scorecard questionnaire with respect to their own unit. For practical purposes the Google Forms platform was used to collect this data, and paper responses were not solicited. The invitation to complete a scorecard was first extended to those who had agreed to be interviewed for the study; in keeping with the principles of snowballing[254] they were also asked to forward the invitation to others within their organisation who may also be willing to respond. Responses were partly anonymous: demographic information was collected to ascertain the location and specialty of the respondent, but not their name or other identifying information. Demographic information was 'required' but all other questions were optional.

It was intended that the scorecards would provide a 'map' of Scottish VA services with respect to the implementation of the study recommendations. The first data collection exercise would provide a baseline for future comparison. This map would enable benchmarking of units and allow colleagues from across the community to consider VA service elements missing from their local service, but which were present in adjacent units. It was hoped that the process of completing the online scorecard tool would itself bring local services together and stimulate local QI activity by effectively providing a menu of 'things to do'.

The submitted data was collated and analysed at the level of individual units, by professional group, and as a whole. These results are discussed in Chapter 10.

Face validity of the Vascular Access Appraisal

A sub-study was designed to evaluate the face validity of the semi-structured interviews. Its aims were firstly to determine the extent to which interviewees felt able to express their views, whether there were additional areas of interest that had not been discussed during the interview, and if there were any problems or concerns relating to the interview format. A secondary aim was to assess participants' perceptions of the importance of the VA project, as a surrogate of their willingness to engage with any recommendations arising from the project findings.

Methods

Being mindful that potential participants in this sub-study had already spent considerable time being interviewed, efforts were made to minimise further inconvenience while maximising the response rate. Anonymity was considered important to increase the chance of receiving negative opinions about the methodology. A web-based questionnaire format was therefore determined to provide the best format for this sub-study, achieving a balance between participant convenience and anonymity, but with the ability to collect meaningful data.

The online survey engine ‘Surveymonkey’ (SurveyMonkey, San Mateo, California) was used to host the survey, using a free account. Questions were designed to capture relevant information, without the survey taking an onerous amount of time to complete. The questions are in table 11.

The purpose of the interview was to hear your experience, and your views, of "how Vascular Access works" in your unit. To what extent did the interview achieve this?
Were you asked leading questions, or did you feel able to answer freely?
Were there issues you felt unable to discuss during the interview?
Did the interview cover all of the relevant points? What else should we have asked about?
Were the interviewers interested in what you had to say?
Did you feel uncomfortable or intimidated by the interview process?
Was the interview **[**about the right length, too short, or too long**]**?
Do you think this project is worthwhile overall?
What did you think of the interview format? Is there anything you would change?
Did the interviewers make the best use of your time?

Table 11 Face-validity questionnaire

During the interview phase of the study, all participants were invited to provide a contact email address after their interview and after audio recording had ended. Their email address was noted on the interview guide used to record field notes during that particular interview.

Participants who provided an email address were sent a single, email invitation to complete the online questionnaire. Invitations were sent by the end of the next working day after the interviewers had concluded interviews on that site, and only after the interview panel had physically departed from the site. The questionnaire was continuously accessible online for a period of at least four weeks after the invitation was issued, meaning the final interviewee had at least four weeks to respond while earlier interviewees had several weeks longer.

An individualised email invitation was sent to each participant, but the same response weblink was provided to everyone. This meant it was not possible to track who had responded to the questionnaire, although the total number of respondents was visible. No reminder invitations were sent to avoid ‘pressuring’ non-participants to participate, to avoid inconveniencing those who had already responded, and to minimise the risk of receiving duplicate responses.

Results

A total of forty-three staff were interviewed across the nine adult and one paediatric renal units in Scotland. Every member of staff provided an e-mail address and was invited to respond to the online questionnaire.

A total of forty (77%) respondents completed the online questionnaire. Responses were anonymous thus it was not possible to determine respondent demographics. The high response rate to the online questionnaire provided assurance that most participant subgroups were included in the results.

All respondents considered the interview had achieved its intended aim (26 “completely achieved”, 14 “mostly achieved”): to hear interviewees’ experiences and views about the configuration and function of VA in their renal unit. All 40 respondents felt able to speak freely, and none felt they had been asked leading questions. Most respondents (37) felt the interview covered all relevant points. Suggested additional points included questions around the demand for inpatient beds. Most (37) respondents reported there were no issues they had felt unable to discuss during the interview. Two felt that some topics had been missed, and one stated there was one topic they had felt uncomfortable discussing.

All 40 respondents felt the interviewers were "completely" interested in what they had to say Most interviewees felt comfortable during the interview process. 33 were "not at all uncomfortable"; 5 were "not very uncomfortable"; 1 was "a little uncomfortable" and 1 was "completely uncomfortable". Free text comments included one respondent who felt uncomfortable with being audio recorded, and another who felt uncomfortable being asked questions that related to their colleagues' clinical performance. Most (38) thought the interview was the right length of time; 1 felt it was too long; 1 felt it was too short. Respondents were mostly satisfied with the interview format, although several commented that they would have preferred more information about the process in advance.

Most (38) felt the project was worthwhile. One respondent did not feel it was worthwhile, and 1 was unsure. Free-text comments included "this will lead to better collaboration across Scotland" and concern about "what clout this [study has]". All respondents (37 of 40 who answered question) felt their time had been used optimally, with many commenting that they had enjoyed participating. Many participants additionally used free-text comments to express their thanks for being included; their enthusiasm for effecting positive change following their interview; and to volunteer their ongoing support.

Discussion

These data suggest that the semi-structured interviews had face validity across a broad range of interview participants. While not all interviewees participated, the response rate was very high and comparable with similar questionnaire-based approaches to research.

The typical interview time of around 45 minutes was comparable with reports from the literature, albeit some interviews were considerably longer[247]. It is encouraging that interviewees generally felt the interview length had been appropriate to the topic and considered their time had been used well.

It was not intended that participants should feel uncomfortable during the process, and indeed this would be disadvantageous to the subsequent workings of this model for investigation (where interview participants are actively engaged in implementing changes). The results suggest that the interviewers' probing for details was probably to an appropriate level, and it seems likely that the true 'work-as-done' function of VA services was captured from a variety of stakeholder perspectives.

Some of the reported discomfort may have arisen from participants feeling they were being "assessed" rather than interviewed, and indeed it was clear many clinicians felt personally responsible for their service and its results, regardless of their practical ability to directly or immediately influence it.

Participants were not pre-briefed about interview content, other than that it concerned their role in the local VA service. This was intentional and to avoid participants attending interviews with prepared answers; it was judged important that they gave spontaneous responses to questions.

In conclusion the semi-structured interviews appeared, from the perspective of the participants, a to have good face-validity as a means of determining the configuration and functioning of VA services.

Results

Earlier chapters have highlighted the unwarranted variation between Scottish renal units in their use of AVF for haemodialysis treatment. VA services have been framed using the socio-technical systems literature, and a mixed-methods model for investigating clinical systems has been described, developed with sociotechnical systems theory and Safety II in mind. This model has been used to explore Scottish VA services with the aim of delineating their structure, function and workload. The face-validity of the investigative process has been assessed, and the resulting data subjected to detailed thematic analysis. The following chapters 3-9 describe the study findings. These findings then lead to the development of recommendations for practice, which are presented to the clinical community using a scorecard tool, described in chapter 10.

The study yielded a rich tapestry of data. Where possible, findings are illustrated with verbatim quotations arising from the transcripts. In some cases the data was best suited to presentation by unit and/or in tabulated form; in others the findings were best described in summary form across all units. It should be recognised that the findings arising from the thematic analysis reflect the coding process and the themes that emerged from the dataset. The chapter headings are therefore derived from the findings of the study, rather than strictly following the order of questioning in the interview guide, albeit there are obviously broad similarities.

For the purposes of clear presentation, the findings are related across several chapters. It is acknowledged however that their separation under discrete chapter headings is somewhat arbitrary given the interdependent nature of socio-technical systems, and in keeping with systems principles, the results chapters and discussion should be considered as a whole.

They are presented as follows:

1. Creation of Vascular Access (chapter 3), including clinicians' opinions relating to different Vascular Access modalities (chapter 4);
2. Maintenance of Vascular Access (chapter 5), including the surveillance of Vascular Access (chapter 6);
3. The results of the six-week clinical activity census (chapter 7);
4. Issues affecting Vascular Access service performance (chapter 8);
5. Development needs for Vascular Access services (chapter 9).

The subsequent chapters discuss the findings and associated recommendations for practice, and their presentation using the scorecard tool.

Chapter 3: Creation of Vascular Access

This study aimed to delineate the structure, function and workload associated with VA services in Scotland. The data were acquired using the mixed-methods model described in chapter 2, and subjected to thematic analysis. This chapter addresses the first research aim of the study, relating the first set of results grouped under the theme ‘creation of Vascular Access’.

Perhaps the most obvious finding from the thematic analysis was that no renal unit routinely made a distinction between ‘VA creation’ or ‘VA maintenance’ as two distinct processes involving separate clinical pathways, different clinicians, and different clinical need. Rather the VA service was considered as one entity, with some patients requiring procedures by surgeons, and others needing interventional radiology work.

It was unusual for the VA creation clinical pathway to exist in written form, although interviewees could describe how the relevant processes were arranged and how they typically functioned. It is helpful to first consider the formal ‘work-as-imagined’ processes before describing the reality of how these processes function. These are considered in the following two sections.

Processes

The major elements of the VA creation pathway are shown in figure 7, which represents an amalgamation of the clinical pathways used by each centre. Table 12 describes the characteristics of VA creation pathways in use by each centre. These should be considered alongside the unit-specific VA creation pathway diagrams (appendix 4).

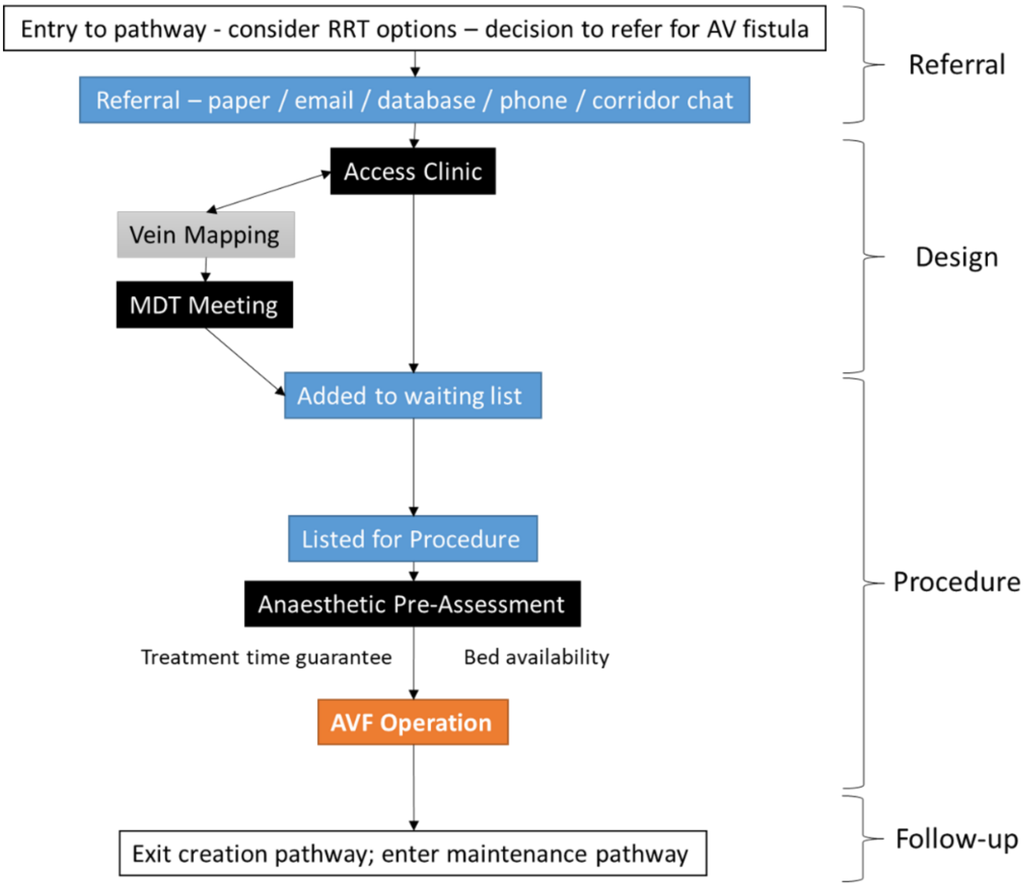

Figure 7 Generic Vascular Access creation pathway

This pathway diagram reflects an amalgamation of the clinical pathways in use by each renal unit. The pathways used by each individual unit are described in appendix 4. Several steps were identified in the process of VA creation: 1) referral of the patient into the pathway, 2) design of a VA approach, 3) a VA procedure, and 4) subsequent follow-up. Patients were referred for AVF creation once a decision had been made that they were going to receive haemodialysis treatment. The formality and mechanism of referral varied by unit. Patients were typically seen in a VA clinic and may require vein mapping and/or further discussion at an MDT meeting prior to joining the waiting list for a specified procedure. They were then listed for a procedure that would variably proceed dependent upon anaesthetic pre-assessment, bed availability and treatment time guarantees. They would then enter the VA maintenance pathway. Note that post-operative follow-up is considered later in this chapter.

Unit	1	2	3	4	5	6	7	8	9
VA Creation Policy	No	No	No	Yes	Yes	No	No	No	No
Referral trigger	eGFR <15 or clinician judgement	Clinician judgement	eGFR <20 or clinician judgement	Within 12 months of RRT	eGFR <15 or rapidly deteriorating	eGFR <15	Within 3-4 months of RRT	Within 12 months of RRT or clinician judgement	eGFR 15-20 or clinician judgement
Referral mechanism	VAN written proforma	VAN email and surgeon letter	VA coordinator informal discussion during low clearance clinic	Written proforma with email or letter to surgeon or secretary	VAN written proforma	Surgeon and VAN letter	VAN letter or written proforma	VAN email referral or letter	VAN email referral
Referral tracking	Paper	Electronic	Paper	Memory	Electronic	Electronic	Whiteboards	Electronic	Memory
Access clinic	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Clinic frequency	Monthly	N/A	Weekly	Fortnightly	Fortnightly	Informal	Twice weekly	Twice weekly	Fortnightly
Clinic attendees	Surgeon	N/A	Surgeon, VA Coordinator	Surgeon, sonographer	Surgeon, sonographer	Surgeon	VAN	VAN	Surgeon, VAN
Procedure planning	Surgeon	MDT	Surgeon	Surgeon	Surgeon	Surgeon	VAN	MDT	Surgeon
Procedure listing	Surgical secretary	Surgical secretary	VA Coordinator	Surgical secretary	Waiting list secretary	Waiting list secretary	VAN	Surgical secretary	VAN

Table 12 Vascular access creation pathway characteristics, by centre

Referral

Prior to the patient being referred for VA creation, it was necessary for a nephrologist to decide that the referral was warranted, and to determine the most appropriate timing of referral. The referral was typically intended to facilitate the creation of AVF, rather than to seek opinion as to the optimal VA modality for that patient.

Patients were usually attending a renal clinic which was either labelled as ‘general nephrology’ or ‘low clearance’ (or equivalent), although some patients would also enter the pathway rather more urgently, usually because of late presentation with advanced or ESRF.

A means of referring the patient into the pathway was required. This could be in the form of an electronic referral, a typed letter, or a verbal discussion between colleagues. The referral then required to be managed in order that the patient could be seen by those responsible for creating VA.

Design of Vascular Access approach

Next, the specific means of VA to be used required consideration. In general terms the VA creation pathway was intended for the creation of AVF or AVG, but it was also very commonly used to arrange TCVC placement.

Most centres used an outpatient clinic to review patients referred for VA. A typical setup involved a clinic run jointly by a surgeon and Vascular Access nurse (VAN); in some centres this also included a sonographer, while elsewhere the clinic was run solely by VAN.

In some centres the clinic visit would involve a clinical assessment, a duplex ultrasound scan, and would conclude with a decision as to the best surgical approach for that patient. In other centres the patient would have a clinical assessment, but if imaging was considered necessary they would then be referred to radiology (as a separate outpatient visit) for the duplex ultrasound scan to be performed. The results of the scan would then either be discussed at a multidisciplinary team (MDT) meeting, or at a further outpatient VA clinic visit, where a decision about the best approach would be made. In one centre with a VAN-led clinic the surgical approach was determined based upon clinical examination and duplex ultrasound scanning; where the best option was not immediately obvious the patient would be listed for an 'explore-and-proceed' procedure.

Procedure

There was wide variation in the clinical context used to perform VA creation surgery. Most centres had some form of designated theatre list for AVF surgery, but the degree of formality varied. Larger centres tended to have a specific list (or lists) for such patients, while smaller centres tended to book these cases among other vascular surgery cases.

Most centres used predominantly local anaesthetic to facilitate AVF surgery, but one unit reported using general anaesthetics much more commonly. No audit data was forthcoming to confirm or refute this assertion. Not all units reported using AVG, but those who did reported using general anaesthetics for these cases, and occasionally for some AVF procedures.

There was variation within and between centres regarding the use of day surgery beds or overnight beds for patients having AVF created. In some centres most cases were performed as day surgery, while in other centres this was much more variable.

TCVC insertion was usually performed by an interventional radiologist, although in some units a nephrologist would do this on a scheduled or ad hoc basis. No centres had any designated interventional radiology slots for any VA procedures, so TCVC insertion would be requested in the same manner, and was afforded the same priority, as other routine interventional radiology procedures.

Post-operative follow-up

It was normal in all centres for patients to be followed-up after their AVF or AVG surgery, although the manner of follow-up varied considerably.

Most patients were invited to attend the VA clinic between 4 and 6 weeks following surgery; in some centres there would be a clinical review by VAN, but elsewhere a surgeon would assess the patient, and sometimes a duplex ultrasound scan would also be performed. In one centre the patient was reviewed thrice weekly in the fortnight following surgery by VAN.

Where there was concern about the maturation of a fistula, in some centres patients would be discussed at an MDT meeting. Elsewhere, radiology investigations or interventions would be arranged via the VA clinic, or the patient would be listed for a further surgical procedure.

In one centre where the surgeon did not routinely review patients postoperatively, their operation note would include recommended steps to take if the fistula failed to mature; this directed actions arising from the post-operative assessment.

Function

The above section describes the formal configuration of VA creation pathways. Numerous factors were reported to regularly influence the routine functioning of these pathways, and these are detailed below. These can be considered in the frame of 'work-as-done versus work-as-imagined'[196]. The following sections consider the realities of VA creation pathway function.

Timing of referral for Vascular Access creation

Considerable uncertainty was seen to exist around the best timing for VA referral. Practice seemed to vary considerably between and within units. Many centres reported referring patients for VA creation, but who ultimately required haemodialysis treatment before an AVF was ready to use. These patients required CVC placement to facilitate haemodialysis until the AVF had matured. Similarly, there were many reports of patients having AVF created but not requiring haemodialysis treatment for several years, if at all. Almost every interviewee reported experience of these cases, albeit reports appeared anecdotal rather than based upon audit data. One unit had conducted a limited spot-audit of unused AVF, but nowhere systemically audited (or discussed) their rates of (late) AVF referral or complications arising from unused AVF.

There was widespread acknowledgement that many patients known to the low clearance service require RRT sooner than anticipated, but nephrologists considered this "unavoidable" and "unpredictable in the majority of cases". Nephrologists were generally opposed to creating VA that would not ultimately be required; they considered this a worse outcome than a patient requiring haemodialysis before an AVF was available for use. This was particularly the case when a patient was perceived to require complex AVF surgery, or where an AVG would be required. Nephrologists' opinions about different RRT modalities are discussed in more detail in chapter 4.

Referral timing was generally judged based upon patients' eGFR and relative rate of decline. This was typically assessed at the point of reviewing the patient in a clinic setting, using an electronic patient record with the facility to visually plot eGFR against time. No centre had created an automated algorithm or equivalent means of predicting the timing of requiring haemodialysis. Most nephrologists used an arbitrary eGFR threshold to prompt referral, ranging between 12-20ml/min. It was noted that 'referral for VA' in many cases really meant 'referral for RRT education'; this was considered a prerequisite step to VA creation, and effectively delayed patients' entry to the VA creation pathway until their eGFR had declined further.

This referral threshold varied within and between centres, dependent upon clinicians' discretion and patient factors. Many VANs described this variation as a major source of frustration, both for the receipt of very late referrals (patients considered likely to commence haemodialysis before an AVF would realistically be ready to use) and very premature referrals (patients who were unlikely to require haemodialysis for several years, based upon their eGFR trajectory). It was suggested by clinicians in some larger centres that nephrologists who appeared 'out of touch' tended to refer patients prematurely, whereas their colleagues would refer 'as late as possible' to avoid being characterised in this way.

Variations in referrals for VA creation appeared to be attenuated to some degree when individual nephrologists had responsibility for a specific patient cohort, or where a VAN was able to maintain an overview of the clinic patient population. Where groups of clinicians were jointly responsible for the patient cohort this appeared to reduce strategic thinking about patients' illness trajectories, and they seemed more likely to be referred late for access.

There was little awareness within each centre of the time required for VA creation in a typical patient, or the likelihood that a given patient would need multiple procedures to create an AVF that would support haemodialysis. No centres were seen to use information of this nature to modify referral patterns for VA creation, but individual nephrologists who complained of excessively long waiting times also tended to report earlier referral of patients into the access creation process.

Prerequisites for Vascular Access creation referral

Patients were generally referred for VA creation only once their need for RRT had been recognised, they had received RRT education, and had reached a decision as to which RRT modality they would be treated with. There was a general reluctance to engage with patients about the detail of RRT treatments until they had reached an advanced stage of CKD.

In most centres, RRT education was delivered by a specialist nurse in the low clearance clinic. It was common for this specialist nurse to have no other role in RRT delivery, and therefore little involvement in other aspects of the patients' care before or after RRT education. Interestingly, no one from this specialist nurse cohort was identified as a member of the VA team by other interviewees. The apparent lack of urgency completing the education process was considered a difficult challenge, frequently causing delayed referrals for access creation.

In centres without VAN overview of the low clearance patient cohort it was reported to be common for patients to be referred for VA creation at a very late stage, in part because of the delay introduced between recognition of the impending need for RRT, and the delivery of RRT education.

Referral mechanism

The referral mechanism varied greatly within and between centres. In some cases, patients were proactively identified and 'taken' from the low clearance cohort by a VA coordinator. Elsewhere the referral was more formal and required a dictated letter; some centres operated a similarly formal referral pathway but used an electronic patient record to generate a referral letter including fields automatically populated with the patient's demographic and clinical information.

In all centres it was common for nephrologists to circumvent the usual referral pathway on occasion, whether in an attempt to expedite a particular patient's referral or for apparent convenience. In these instances, the referral ranged from a verbal corridor discussion, to the patient's details being conveyed via a handwritten sticky note or similar.

Referral handling and subsequent flow tracking

When patients are referred for access creation, their flow through the pathway is dependent upon the sequential referrals for clinic reviews, scans and theatre listing all proceeding as planned. Given the clinical complexity of the patients and the relatively large number of clinicians involved in the access creation pathways, patients' progress can be delayed for various reasons.

Tracking patients' progress through the access creation pathway was assumed by nephrologists, surgeons and radiologists, to be a function of the local VAN or equivalent. There was little awareness of how this was practically achieved, and most VANs reported having limited or no time to fulfil this 'tracker' role.

Regardless of the referral mechanism, most VANs relied upon their memory to move patients through the clinical pathway. Some VANs kept track of patients using an electronic database, though this was usually in the form of a Microsoft Excel spreadsheet (or equivalent) to which only they had access, and its contemporaneity varied dependent upon their competing commitments.

One VA coordinator reported a previous crisis incident whereby they were called upon during an unexpected absence to attend their office and retrieve patient details from the database on their office computer. In contrast, another centre maintained a 'VA control room' with several whiteboards upon which active patients' details were recorded and tracked.

The oversight of patients transiting through the VA creation pathway was largely internal to the VA team, with little involvement from the NHS Boards or centralised waiting list offices.

Imaging

There was general agreement that many patients required imaging before surgery, in most cases a duplex ultrasound scan. In some centres this would be performed at the VA clinic; elsewhere patients would be referred for imaging via the general radiology service. The lack of designated slots for such scans was considered to cause significant delays, with some patients anecdotally reported to wait over six months for an appointment.

In one unit, VAN performed scans in clinic and had clinical authority to recommend a surgical approach based upon the scan, including exploratory procedures where there was no obvious 'best' approach to pursue clinically. VAN and the vascular surgeon independently reported that this had significantly reduced the overall VA creation waiting time.

Many VANs and surgeons considered that referring nephrologists should be more involved in patients' clinical assessment for VA, and that this could enable better prioritisation of those requiring imaging before listing for AVF creation. It was reportedly common for patients to be referred for VA creation without any details of their blood vessel suitability, or details of relevant past medical history that might impacted upon their vasculature.

Multi-disciplinary discussion

'MDT discussion' features in the VA creation pathway in most centres, but it was unusual in most units for patients to be discussed at the MDT before listing for their first VA creation procedure.

Most centres reported that the surgeon or VAN would determine the most appropriate procedure at the VA clinic. This was particularly the case when a 'one-stop' clinic operated, with at least a surgeon and VAN in attendance. Where additional imaging studies were required before a patient could be listed, the imaging results were usually passed to a surgeon for a decision about the most appropriate approach. Most centres had one surgeon who acted as the 'lead AVF surgeon', but this was usually a de facto rather than formally allocated title. They usually determined the surgical approach for each patient in their cohort.

It was unusual for a radiologist to be consulted in advance about the intended VA strategy for a given patient. They would more typically only become involved once a patient was referred for TCVC insertion, and effectively functioned as technicians in such cases. In almost every centre, the decision to refer a patient for TCVC was usually made by a nephrologist, with the VAN performing an administrative and coordinating role. The surgeon would usually have no role in this discussion and would usually be unaware of the TCVC referral.

One centre reported using the MDT to discuss the majority of patients requiring VA creation. VAN would meet the patient in a clinic, and the surgeon would first meet the patient on the day of surgery. The MDT discussion would focus around potential problems with the proposed surgical approach and consider if additional investigations were needed before the day of surgery. The MDT was also used as a mechanism for identifying patients with TCVCs, for whom AVF or AVG surgery could be attempted.

In other centres the role of the MDT was largely focused around the maintenance of VA, (discussed in chapter 5).

Procedure scheduling and waiting list management

Scheduling VA procedures was reported as a significant source of frustration to VANs and others in the clinical team in almost every centre. Slot availability on surgical or IR lists was unpredictable, relying upon external factors including competing clinical demands, and the availability of surgeons and support staff including anaesthetists and theatre nurses.

Slots were usually made available via administrators external to the VA team; this was reported to be a relatively passive process that did not often account for patients' clinical needs. It was difficult for VANs or others to influence slot provision as there was no clear managerial oversight: the patients were considered to be under nephrology care, but the procedure was proposed by a surgeon or radiologist working in another directorate with its own management structure and priorities.

The ideal scenario envisaged by most centres was the ability to allocate patients to specific theatre slots at the point of deciding which procedure to attempt. This was possible in some units, usually where there were allocated VA theatre slots. This enabled patients to be listed via MDT meetings or at the VA clinic. However, in most cases this was not possible, and instead VANs required to liaise with waiting list administrators to optimally use the available capacity.

Where slots became available at short notice it was often impossible to use them for VA procedures in view of patients' medical complexity, a lack of inpatients beds on an appropriate ward, the challenge of fitting ongoing haemodialysis treatment around the proposed procedure, and logistical challenges where procedures were performed on another hospital campus.

The apparent lack of transparency with regard to waiting lists greatly frustrated nephrologists. They often described referring patients for AVF creation, but several months later needing to separately arrange TCVC insertion because AVF surgery had not been forthcoming within the necessary timescale. This was often perceived as a failure of the VA team to create access, without acknowledgement of the parameters within which they had to work.

Bed booking

Some centres considered issues relating to bed booking as absolute barriers to creating VA, while for others it was more of an inconvenience. While this may partly reflect the degree of team cohesion within the centre, it could also be a measure of the potential options available to VANs requiring beds for VA procedures (table 13).

Unit	Transcript data
1	*"Beds are booked, but they are just being absolutely farmed [out] everywhere and I just think it is unsatisfactory."* (Consultant Surgeon)
2	*"I just tell [surgical secretary] who needs booking in and they do the booking"* (Vascular Access Nurse)
3	*"No, it is very difficult, that is one of the worst things recently is trying to get beds." "Sometimes they can [be] admitted and decanted around the hospital"* (Vascular Access Coordinator)
7	*"They normally do find something and it's very unusual to cancel surgery due to the lack of beds."* (Vascular Access Nurse)
8	*"What often happens is they don't end up being admitted; they end up coming up to the day ward and recover in there for 4 or 6 hours, then the surgeon will come and see them and see if they're happy for them to go home."* (Nurse Practitioner)
9	*"I think there is an element of a bed situation, so it's again not an ideal situation. You can be in a situation where there is no beds, because they tend to keep the patient overnight and there is just no beds to keep them."* (Associate Specialist Surgeon)

Table 13 Bed booking for procedures

(No data was coded under this theme for units 4, 5 or 6)

Various bed ‘categories’ were utilised for VA creation procedures. Some units used day surgery beds; others admitted every patient to hospital, variably into beds formally allocated to vascular surgery, general surgery or renal medicine. Where ‘day surgery’ beds were used, these were sometimes within the main hospital day surgery unit but could also be situated within a ‘short stay medicine’ unit or a renal ‘day area’.

Where day surgery beds were available, these tended to be used for the least medically complex patients and procedures. More complex patients, or higher risk procedures, would usually require that the patient was admitted to hospital. Reserving beds for VA procedures was problematic in most centres, particularly where patients were being admitted to areas that did not otherwise take elective admissions, and which therefore had no formal bed booking facility. While electively-admitted patients account for a large proportion of surgical wards’ workload, this is unusual in medical wards and centres using renal medicine beds tended to report the greatest difficulty.

Even when beds could be found within acute renal medical wards, patients undergoing VA surgery tended to be vulnerable to being ‘boarded’ to another ward in the event of bed pressures. In addition to the inconvenience to patients and staff, boarding was said to contribute towards suboptimal postoperative management and unnecessary delays in subsequent discharge home.

Surgeons and radiologists who performed VA procedures tended to prefer when their patients were admitted to renal medical beds rather than to other parts of the hospital. They reported feeling more confident that patients’ specific perioperative needs would be attended to: for example, close observation of blood pressure with appropriate, timely intervention. The ability to efficiently book a bed in what was perceived as an appropriate area of the hospital was seen to facilitate efficient scheduling of VA procedures. It probably also encouraged surgeons and radiologists to tackle more challenging cases.

Treatment time guarantee

The Patient Rights (Scotland) Act[272] affords patients a legal guarantee as to the maximum time they will wait for a particular diagnostic test or therapeutic procedure. This is commonly known as the ‘treatment time guarantee’ (TTG). It serves as an umbrella target for all procedures and is specified by statute rather than taking account of clinical timelines.

Patients awaiting AVF creation are subject to TTG from the point at which their name is added to the waiting list for a specified surgical procedure, rather than the point of nephrology referral for access creation. All centres reported that the TTG was not practically relevant for patients requiring AVF creation since the pre-dialysis clinical timeline was almost always significantly shorter than the TTG time. In practice, the TTG was more likely to delay AVF surgery as it was a commonly cited cause for VA cases being postponed for non-clinical reasons.

The centres whose published registry data suggested highest rates of incident and prevalent AVF usage[8] tended to report formal or informal prioritisation of VA surgery over other cases. (The registry data are not reproduced here to protect anonymity.) In Unit 3 all such cases were afforded "urgent" priority, while in Unit 2 it was reported there was sufficient capacity to perform AVF surgery within one week, albeit this prioritisation was informal. In larger centres the lack of formal protection, coupled with "routine" priority, was reported to regularly cause VA cases to be delayed in favour of other cases that were less clinically urgent, but which were approaching a TTG deadline.

Anaesthetics involvement

Most VA surgery was reported to be performed under local anaesthetic. Centres varied in the proportions of patients reported to undergo general anaesthetic procedures. In Unit 6 this was highly unusual, whereas in Unit 9 it was said to be very common. Cases involving general anaesthesia were said to be more complex or involving AVG insertion. No audit data was available to support these assertions.

Some centres routinely sent patients for anaesthetic pre-assessment prior to listing for surgery, even where their procedure might not require general anaesthesia. In many cases patients could wait several weeks for pre-assessment, which would often then be 'failed' owing to their clinical complexity. They then had to wait for a further appointment with an anaesthetic doctor.

Surgeons who did not work with a regular anaesthetist on their VA cases reported that it was common for surgery to be cancelled on the day if the individual anaesthetist felt uncomfortable performing the general anaesthetic for a patient with renal failure or associated comorbidity. The best strategy for minimising cancellations appeared to be where a small group of vascular anaesthetists (or equivalent) dealt with these theatre lists, with a pre-assessment process that accounted for the clinical complexity of this patient cohort.

Documentation of surgical procedures

All patients undergoing a surgical procedure have an operation note documented as a routine practice. For VA cases, it was common practice for the operation note, or an abridged version, to be duplicated in the (renal) electronic patient record. In most centres this administrative task was usually performed by VAN or equivalent.

In Unit 1, at the point of initial surgery, the surgeon routinely recommended the actions to take if the AVF failed to adequately mature. This served as direction to VAN during the post-operative period and was said to expedite referrals for interventional procedures that became necessary. No other centre routinely documented this information, although some units reported having easy access to a surgeon who could discuss the case if problems were identified.

Post-operative follow-up

While there was general agreement that all patients should be reviewed postoperatively, there was variation as to how this occurred. The process is described in figure 8. This represents an amalgamation of the pathways in use in each centre; appendix 5 contains diagrams with the specific pathways in use by centre for comparison.

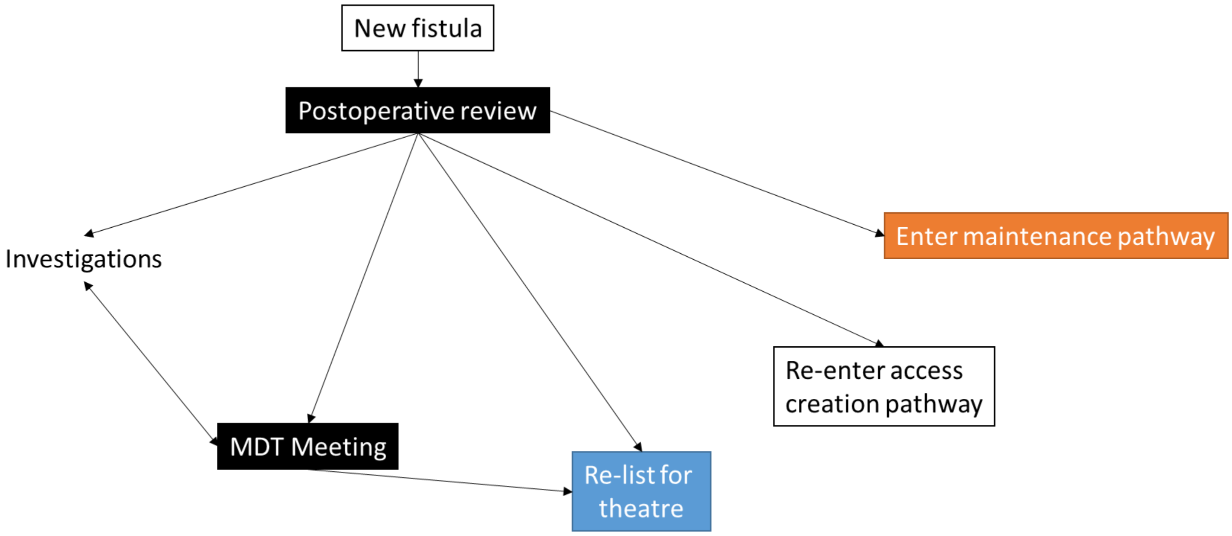

Figure 8 Generic post-operative Vascular Access follow-up pathway

This pathway diagram reflects an amalgamation of the clinical pathways in use by each renal unit. The pathways used by each individual unit are described in appendix 5. When a new AVF or AVG was created every centre had an arrangement to review the patient postoperatively. This assessment was usually conducted by VAN or surgeon. If the review was satisfactory the patient would then enter the VA maintenance pathway. Otherwise the patient could re-enter the VA creation pathway, or be re-listed for an alternative operation, or sent for investigations, or discussed at an MDT meeting. Practice varied significantly by centre.

In some units the purpose of this review lacked clarity; elsewhere it was clearly designed to assess AVF maturation and arrange corrective action where necessary.

Most centres appointed patients to attend the VA clinic 4-6 weeks after their operation. In Unit 9 the patient was reviewed on a total of six occasions during the first fortnight following surgery, and not thereafter. This appeared to stem from the timing of scheduled haemodialysis sessions for those already attending for haemodialysis, but also applied to patients not yet undergoing haemodialysis treatment.

The commonest outcomes from postoperative reviews were either that no action was clinically indicated, or that an IR procedure was required to assist maturation. Occasionally patients needed further surgical procedures, or a further attempt to create a new AVF. No centres provided designated interventional radiology slots for this purpose. In some units the radiology service seemed able and willing to prioritise these cases, but elsewhere patients were said to face lengthy waits. It was reported that the waiting time for interventional procedures could at times mean the AVF was unsalvageable by the time the procedure date arrived.

As with other elements of VA creation there was no audit or statistical data relating to postoperative reviews.

Discussion

This section has illustrated idealised VA creation and postoperative review pathways, along with their practical realities and limitations in each unit. The success of VA creation pathways is likely to be reflected primarily in the published proportion of ‘incident’ patients using AVF or AVG for haemodialysis in a centre. The following sections consider challenges in the VA creation pathways identified by the thematic analysis.

Referral timing

Variation in practice and difficulties predicting the timing of needing an AVF resonates with the literature. There are many VA articles published describing this issue, and attempting to solve it with a variety of calculators and algorithms[273–275]. This study adds a systems perspective and demonstrates additional service characteristics not necessarily recognised by existing audit standards and guidelines.

There was marked variation in waiting times between centres for AVF creation surgery (see chapter 7). This was seen to be a function of local process, resource availability and competing demands from elsewhere in the organisation. It was notable that waiting times were not published internally despite their central importance to nephrologists' judgement as to when patients should be referred for surgery.

It was also appreciated that AVF surgery had a relatively high rate of technical failure, but no data was available at local, regional or national level to enable proper scrutiny. It is unknown if success rates or failure rates varied significantly between centres. The literature and clinical community has acknowledged this in general terms, but this study is perhaps the first to illuminate the inadequacy of current recording and scrutiny of procedural outcomes. It is at odds with Department of Health guidance[117,118] and the need for change is emphasised by the unexpectedly high volume of VA procedures (see chapter 7). It is recommended that renal units routinely publish their waiting times, success rates and repeat procedure rates for AVF creation surgery. The product of these values should be used to guide the timing of future AVF referrals.

AVF planning

It was clear that clinical evidence was lacking in many aspects of VA creation. There was uncertainty surrounding the 'best' VA modality (i.e. TCVC or AVF or AVG) for a given patient, partly due to a lack of robust published outcome data to guide treatment decisions. It was unclear which surgical approach was technically best for AVF creation, and little consensus as to what constituted suitability for AVG insertion rather than attempted AVF creation. Further studies should evaluate these questions.

Resource utilisation varied substantially between centres. In one centre patients were listed for surgery following clinical assessment by VAN; elsewhere the same patient required appointments with VAN, a subsequent appointment for a vein-mapping scan, followed by MDT meeting discussion, before eventually being listed for surgery. It is not asserted that one strategy is better than another, particularly in the absence of published outcome data, but these divergent approaches to AVF planning require further investigation to delineate the clinical, financial and opportunity costs of both approaches.

Variation in the use of general anaesthetics for AVF creation is striking between centres. Notably, Unit 6 almost never used general anaesthesia, whereas Unit 9 routinely sent patients for anaesthetic pre-assessment whenever AVF creation was contemplated and were unable to quantify how frequently operations proceeded with just local anaesthesia. Similarly, the differences in financial cost, patient-experience and resource use between centres who typically perform VA procedures as day cases, versus those who normally admit patients overnight for similar types of operation, deserves closer study.

Vascular access clinic

The VA clinic varied in almost every regard between units. Its function included evaluation of new patients before VA creation, postoperative assessment of those who had recently had VA creation surgery, assessment of problematic VA, or a combination thereof. The staffing and location also varied greatly; in some centres this was a VAN-led clinic held in a general outpatient area, but elsewhere it was staffed by VAN, surgeon and sonographer and was hosted in a vascular lab or ultrasound department.

The possible actions following VA clinic review were limited in many centres. It is suggested that designated IR and imaging slots are required if this clinic is to successfully evaluate postoperative patients or those with problematic VA. Otherwise there appeared to be little realistic prospect of a clinic visit resulting in a meaningful attempt to salvage failing VA.

The role of the clinic surgeon also requires definition. In some centres every patient is seen by a surgeon preoperatively, while in others it seemed possible for the patient to only meet a surgeon for the first time immediately before their AVF operation. It may be that surgical time is more optimally used with the latter approach, but further study is required before formal recommendations can be made.

Treatment time guarantee

The impact of TTG provides a useful example of healthcare complexity in action. The intention of the TTG[272] was to guarantee that patients would not face excessive waits for treatment. In the context of VA however, clinicians reported in this study that TTG had the effect of reducing the likelihood that a patient would have their VA surgery within a clinically appropriate time.

A lack of ringfenced resources was said to render VA operations vulnerable to the competing demands of higher volume, but perhaps clinically less important, procedures. Varicose vein surgery was often cited by interviewees as regularly displacing VA work, despite the former being essentially 'routine' or even 'cosmetic' in nature, while the latter has potential to impact upon patients' survival.

In seeking to enhance the general NHS patient experience, TTG may have had the unforeseen consequence of creating an additional barriers to high quality VA care.

Chapter 4: Clinicians’ opinions of Vascular Access modalities

This study aims to delineate the structure, function and workload associated with VA services in Scotland. It is hoped that this will illuminate opportunities for improvement, in the context of observed unwarranted variation in AVF use for haemodialysis between Scottish renal units. A novel systems approach (described in chapter 2) has been used to conduct the study, sympathetic to the socio-technical systems theory and Safety II approaches to quality improvement described in chapter 1B.

Chapter 3 considered the structure and routine functioning of VA creation pathways. Among many barriers to VA creation, it was clear that in many units referral for VA creation was often delayed until the referring clinician felt haemodialysis was imminent. This chapter explores this ‘clinician discretion’ in greater detail and considers clinicians’ opinions about the various VA modalities. These opinions are important, in view of the literature presented in chapter 1 around ‘consensus’ and ‘latent factors’[178,186,187,276].

It was clear that clinicians’ opinions varied considerably regarding the potential role of the available VA modalities, within centres and within each professional group (table 14).

Unit	Transcript Data
1	*"There is a cohort of patients that we have looked at… and said look we have got 50 central catheters and I am saying 20 I don't want to know anything about… There are 20 or 30 that are either refuseniks because they are perfectly happy, or they could have something done but they just haven't properly gone through the system. Now hopefully there is none of the people that aren't being properly assessed it is just people refusing and that need a bit more work done on them."* (Consultant Surgeon) *"I do keep stats and I know the patients that haven't been referred so then I hound the consultant"* (Vascular Access Nurse) *"The fact is they have to start. If, occasionally you'll get one and you think: 'well they're really urgent' so you will obviously try, if you can, you will try and put them first, to get them the fistula… once they have been reviewed and once they have had their duplex. … if you are asked you can try and rush them through. You will not always have that option so at the end of the day they will start with a catheter."* (Vascular Access Nurse) *"I would get a letter from one of the nephrologists. 'This patient has to start, and I have referred them and asked for a catheter', so then that is where I take over: after they have been referred."* (Vascular Access Nurse) *"How soon are the nephrologists referring the patients to the Vascular Access and how soon are they landing up in the low clearance? That again is our responsibility, so if we aren't doing it on time then obviously the surgeon can't do anything more than that. Of course, the surgeon can only start working from the day you ask the surgeon to do something so that is all our responsibility."* (Associate Specialist Nephrologist) *"Well, we actually have a number of line patients that present problems when they come back for repeated lines, with poorly functioning lines, migrating lines, patients with central venous stenosis, they are actually quite difficult to manage, as I'm sure you are well aware. Clearly patients with recurrent stenosis despite repeated venoplasties, so, just the problems every unit will face."* (Consultant Interventional Radiologist)
2	*"I don't think there's anybody… yes there's maybe one person at the moment who might… we might have given up on, in terms of native access"* (Consultant Nephrologist) *"It's always difficult when you have a death in somebody who is relatively frail and you think, 'ah should we have done a done a fistula' or, 'they could have got line sepsis'"* (Consultant Nephrologist)

3	*" I think the fewer lines they have, the fewer problems they have with central stenosis and problems later on. So we try and prevent them having lines really because we think that is the best, fewer sepsis and fewer central stenosis later on."* (Vascular Access Coordinator) *"[TCVC are] used as a bridging access if their fistula failed and we haven't been able to save it. We never look at them as a permanent access. We have just got one patient that I can think of that is a permanent access."* (RDU Nurse) *"It is there as a temporary procedure, all lines are temporary, tunnelled or not! [laughter] They are not allowed to call them anything other than temporary, until we get [a] fistula."* (Vascular Access Coordinator) "*Nope, so I think in [Unit 3] we don't, as a rule I would think, any Nephrologist talks about lines with their patients, on the basis that we, I think, pretty much universally don't believe there is anyone who can't be dialysed in another fashion."* (Consultant Nephrologist) *"I have never had a conversation with somebody that needed to start on a line because no other access in my whole time here, you know as a first access."* (Consultant Nephrologist) *"If someone is dying of cancer we will put them in a graft, you know if we think they are going to die within 6 months, to get a line out quick and give them a better quality of life we will put in a graft. There is one or two I can think of two patients we did that to rather than have a line in."* (Vascular Access Coordinator) *"I think there is a very good buy in both from renal and vascular, I think we all see that in actual fact just sticking lines in and saying 'we'll think about a new fistula next week' just makes more work in the long run."* (Consultant Nephrologist)
4	*"I am not sure that we would actually be able to improve much on our incident fistula rate, but we are reasonably happy using permcaths [TCVC] for a short period bridging to a fistula."* (Consultant Nephrologist)
5	*"I think the more central lines we're accessing per week, the greater risk of SABs we have and then, you know, the mortality, the morbidity and mortality associated with SABs is worrying."* (Vascular Access Nurse)
6	*"Most of the time the folk will end up having dialysis with a line coming from the pre-dialysis setup are the ones who had fistulas done, they are not matured, they have clotted, they needed multiple surgeries, those are the ones…"* (Consultant Nephrologist)

	"If I were counselling, I would give them the options of both and I will obviously tell them that fistula is better for various reasons and obviously it's their choice. Thankfully, we have not come across many patients who insist that, 'oh I don't want a fistula'". (Consultant Nephrologist)
7	*"Now if there is a thrombosed fistula in an outpatient, yeah they might well get involved in organising the permcath [TCVC] to prevent the admission to take keep things moving."* (Consultant Nephrologist) *"…very elderly, frail people who can't survive their line sepsis, so we don't see that as a reason not to try and get a fistula. You sometimes have a, patient… who prefers not to have a fistula, but not for comorbidity reasons."* (Consultant Nephrologist)
8	*"In particularly elderly patients as well because maybe, I think sometimes we have that emotional thing of 'poor old soul, poor wee soul' or 'they don't need a fistula', I think we've all been guilty of that. But I think the longer I have been doing this job and the more education that I've learned about it and the value of good access comparison to lines because I have seen patients with so many awful problems."* (RDU Nurse) *"Older in age seem to like the lines and don't want [AVF], I think because they know their veins are frail… they just say they'll stick with the line long-term now… there's quite a number of patients who would say 'not for any further access at this time – patient's choice'."* (Nurse Practitioner) *"I have got a lot of patients who have had lots and lots of access issues, who have had fistulas, they have failed, they have ruptured, some of them have nearly died because their fistulas have ruptured so there is just no way that they are ever going to be persuaded…some patient's lines, they are always absolutely fine, we don't really have any problems with them and they've had them for a long time, other patients, their lines are, they just, they are problematic, difficult flows, sometimes they reverse the lines, get urokinase locks, get intra-dialytic urokinase, tends to be the same."* (RDU Nurse) *"The problem is, most of these crash landers, they need dialysis there and then and so we don't have access to someone in the PD unit, we don't have an emergency Tenckhoff insertion, whereas we can put a line in right away and dialyse them that night and know that it will be fine…… well, it will be controlled."* (Consultant Nephrologist) *"It's a dreadful shame to have a pre-emptive live donor [transplant] 3 months after having a fistula made. That's a bit of a waste and if we can be more confident that it's likely to happen… but again that needs to be pushed as well and that often doesn't happen, and they end up having dialysis."* (Consultant Nephrologist) *"They will put a temporary line in. They'll do nothing else. It's just left on my desk for when I come back."* (Vascular Access Nurse)

	"I think more and more, based on what I've been hearing from research done by the Vascular Access Team here, that if this is a patient just presenting and they've got a reasonably good chance of getting a transplant in the future, there's a strong case for pushing PD more and preserving their central veins." (Consultant Nephrologist) *"Our default tends to be, in most places it tends to be haemodialysis. It shouldn't necessarily be so. … PD probably has more of a role in difficult Vascular Access then we use it for… PD … patients can do pretty well."* (Consultant Nephrologist) *"We've had one or two situations of people having catheters in for 8 months because people thought they were ready to start, but in actual fact, things were okay, left the catheter in and in one of those cases they had severe peritonitis that may have contributed to their death."* (Consultant Nephrologist) *"I would be reasonably keen that we do more PD, particularly in difficult access patients. A PD catheter is probably better than a TCVC."* (Consultant Nephrologist)
9	*"I think they would get a line. Most of them would get a line straight away and we have a problem with that… They get a line and after they get the line then they think about creating a fistula."* (Associate Specialist Surgeon) *"We know no-one should ever get a line in unless it's an absolute extreme. No-one should get a line in, end of story. All my problem cases are line related. You know, I spent the best part of three hours yesterday ploughing my way through someone's superior vena cava simply because she had a whole pile of line-related problems. All avoidable if possible."* (Consultant Radiologist) *"We have only started doing grafts so that isn't an option at the moment. So therefore it would have to be a tunnelled line until I could get, and, although at that point in time I would be asked to get more permanent access, it would have to be a line that they would be put on to the list for AVF."* (Vascular Access Nurse)
10 (Paediatrics)	*"Recurrent issues of line and infection risk, we don't generally, that is medically, don't get involved as much as say [nurse] would."* (Consultant Nephrologist) *"We have had a period up to maybe about a year ago that we hadn't had an infection for a long time, and [specialist nurse] will be able to give you the figures. But latterly we have had quite a few, with similar patients, and there's more a hygiene thing."* (Consultant Nephrologist)

Table 14 Clinician opinions about Vascular Access modalities

Views appeared to be influenced by several factors including:

- Anecdotally reported personal experience with each modality;
- Perception of the morbidity and mortality burden associated with each modality;
- Practical availability of each modality within the centre;
- Perceptions around surgeon and radiologist enthusiasm and technical skill;
- Appreciation of what was technically possible and achievable for a given modality in a particular patient group;
- Perceived transplant availability and likelihood of success for a specific patient.

The following sections detail clinicians' opinions about the use of TCVC, AVF, AVG and PD for RRT. It was clear that opinion was almost exclusively based upon the above factors, and there was a conspicuous absence of data-driven opinion. Anecdotes and local experience appeared to significantly influence clinicians' views and would be cited as rationale for taking one clinical approach over another. It was also striking that clinicians appeared to consider "haemodialysis with a line", "haemodialysis with a fistula" and "haemodialysis with a graft" as a single modality with some technical differences, instead of separate treatments with divergent associated burdens of morbidity and mortality.

The most contentious opinions related to the use of TCVC. Clinicians working in centres with higher TCVC use tended to give more detailed opinions about them. It was apparent that centres where TCVC were used frequently, and where TCVC insertion required challenging logistical arrangements, this would occupy a substantial portion of the available VAN time. In centres where TCVC were mostly inserted by IR, this task occupied significant volumes of clinical IR time, and was often viewed negatively by individual radiologists.

It was apparent that TCVCs were more difficult to access in some centres than in others. In some units, a designated nephrologist would insert TCVC, usually during a scheduled weekly list. It was more common however for TCVC to be inserted by radiologists. Interestingly, the apparently easier availability of TCVC in nephrology-led centres did not seem to significantly increase their usage, so long as other nephrologists in the centre were bought-into the value of AVF or AVG as the preferred alternatives. This may have reflected the reduced TCVC-related workload for radiologists, who could then devote their time to the maintenance of AVF and AVG.

There was a clear difference in attitudes towards lines between centres, and less so, between individuals and professional groups within a given centre. TCVC were variably considered as temporary, bridging measures, to being long-term “necessary evils” required in order to deliver haemodialysis treatment. The difference in views was most apparent when considering the language used by clinicians to describe NTCVC and TCVC: the centres with lowest TCVC use referred to “non-tunnelled” and “tunnelled” lines, while centres with higher use tended to use the terms “temporary” and “permanent” to describe the same VA devices. Many staff would also refer to TCVC by the brand name “Permcath”; some appeared to think this was a clinical term meaning that the patient had a “permanent catheter” and were unaware “Permcath” was in fact a brand name for a particular type of TCVC.

PD is generally seen as a favourable option. Some clinicians felt it was not offered it as readily as it could or should be. The driver for that seems to be mostly historical rather than being based upon data.

AVGs are afforded ‘special’ status which perhaps limits their use. They were sometimes considered as an alternative to a TCVC, although interestingly this was not the case in the unit with the lowest TCVC and highest AVF usage. There was significant uncertainty about the frequency of AVG surveillance, the required actions when imaging anomalies were identified without corresponding clinical signs, and the infrastructure required to rapidly manage emerging clinical problems. There was also significant budgetary concern about AVGs, as in many cases these required to be funded on a named patient basis. Financial issues were not a specific consideration for other VA modalities. Clinicians almost universally expressed a wish for additional clinical evidence and 'normalisation' before AVG were used on a wider scale. It was also apparent that RDU nurses felt inexperienced and unsupported using AVGs, and there was a clear need for further training.

Unit 1

There was a realisation that significant historical reliance upon TCVC would leave a legacy of significant clinical problems for some time to come. It was recognised that for some patients it would now be very challenging to find alternatives to TCVC for clinical reasons; in some cases, it was also thought that patients would simply refuse to consider alternatives to TCVC in view of their previous experiences.

The heavy TCVC reliance is reflected in the VAN role, which almost completely revolves around coordinating TCVC insertion or replacement. VAN had clear ownership of this process, contrasting with the AVF / AVG pathway. It was clear that TCVC coordination consumed the vast majority of her working time, partly because of the required complex logistical arrangements as TCVCs were inserted on a separate hospital campus. This raised various problems, including ambiguity as to who was clinically responsible for patients who were in transit or on the other campus.

There was a sense that patients requiring VA have a very limited timescale before haemodialysis treatment would commence. This may have reflected a tendency for patients to be referred for VA creation late in the progression of their kidney disease, without mindfulness of the likely timeline involved in the process. It was clear that while VAN had an overview of the patients who would soon require VA, the patient required to be formally referred by their nephrologist before any action could be taken.

It was described as almost impossible for a patient to navigate the AVF pathway before starting haemodialysis, and it was ‘normal’ to start haemodialysis with a line and attempt to transit to AVF later. There was little discussion of the potential to utilise AVG in patients who were referred late, although the vascular surgeons considered them logistically difficult to organise in view of the need for a general anaesthetic (whereas most other procedures simply required a local anaesthetic).

There was some awareness from nephrology that late referrals impeded VAN’s ability to push a patient through the AVF pathway. It was inferred that this insight did not extend throughout the clinical team. There was awareness of TCVC-related complications such as sepsis and central venous stenosis, but they were regarded as being inevitable within haemodialysis patient cohorts. This was in stark contrast with other centres. There was also insight into the need to increase AVF use. Some patient education initiatives had been undertaken to this end, but little had been done to engage other clinicians in the unit with the problem.

Unit 2

It was considered that AVF or AVG should be achievable for all patients, although as in other centres there was uncertainty about how appropriate this would be in frailer patients. TCVC were considered a bridge to AVF, and there was widespread recognition of the associated infection risks. There was less awareness of central venous stenosis as a longer-term risk, but in keeping with the very low TCVC use this was very uncommon. Where TCVC were needed they are usually inserted on the same day by IR, and this required minimal involvement of VAN. TCVC were historically inserted by vascular surgeons, but their available time was now considered better spent creating AVF. There was no nephrology-led TCVC list.

All patients with a TCVC in-situ were discussed every week at the VA MDT meeting, until alternative access was in use. This was reported as a highly successful strategy to maintain awareness of such patients, and as a mechanism to migrate them onto AVF or AVG.

AVG were used infrequently. They were spoken of as an option if there was no feasible AVF option, but for patients referred late for VA it would be more likely they would start haemodialysis via a TCVC and subsequently have an AVF fashioned, than to have an AVG used to avoid the use of the TCVC.

Unit 3

In Unit 3 it was clearly felt that lines equated to short-term sepsis and long-term central stenosis, both of which were seen to outweigh any potential convenience benefits. AVF and AVG were considered 'a better option' than a line, rather than a line being 'easier' to obtain and use. Action to expedite or salvage an AVF or AVG was considered action that would "save a line from being used". This strategy of line avoidance was used to justify actions that would perhaps appear unwarranted or over-the-top in other centres, for example coordinating out-of-hours surgeons, radiologists and theatre staff to attempt to de-clot an AVF. This strategic approach was consistently observed between professional groups in the centre.

NTCVC or TCVC are inserted in emergency situations but both are considered 'temporary lines'. This language prevents staff or patients thinking these are 'permanent' access strategies. Lines are not offered as an elective access option when patients are receiving pre-dialysis education.

It is believed that AVF or AVG (or peritoneal dialysis) are viable options for all patients; this contrasts with opinion encountered elsewhere. When patients decline AVF they clearly communicate their belief that this is a bad decision. If an AVF option was not apparent they'd then discuss AVG or PD rather than going to a line. An example was cited of a patient with needle phobia who had counselling and psychotherapy rather than settling for a line.

There is enthusiasm to use AVG when AVF are not feasible in a given patient. Vascular surgeons were mindful of the need for closer surveillance than AVF, and the significant uncertainty around the most appropriate action following the detection of a stenosis without a clinical event. There was also concern about the need to rapidly manage any clinical events to prevent graft loss, with some doubt expressed about the ability of the local infrastructure to reliably cope with this. RDU staff felt there was a need for greater expertise to be developed for optimal cannulation and assessment of patients with AVG.

Nephrologists considered that the overall morbidity burden and quality of life with AVG favoured their use above TCVC, particularly for patients with a short life expectancy. This contrasted sharply with the opinions voiced in other centres.

Patients do still occasionally start haemodialysis via a TCVC. This can prove logistically difficult since their infrequent use means there is no established process for expedited referral to a radiologist who can insert one. It is generally thought that having as few patients as possible dialysing with a TCVC probably means less overall work for interventional radiology.

Unit 4

It was stated that many patients commenced RRT with unpredictable timing. This was said to explain why so many patients commenced haemodialysis using TCVC. There was reluctance from nephrology to refer patients for AVF or AVG until it was beyond any doubt that haemodialysis treatment was required. It was considered better for a patient to commence haemodialysis without an AVF or AVG than to ultimately not require haemodialysis but have had an AVF or AVG fashioned. In addition, nephrologists were reluctant to refer patients for AVG insertion as this was thought to remove options for future AVF creation.

They share VA surgery and IR services with Unit 5 and enjoy short waiting times for creation and maintenance procedures. It was considered that TCVC were an acceptable 'first modality' when it was possible to convert patients to using AVF or AVG within a few months of commencing haemodialysis.

Unit 5

In Unit 5, TCVC use was ultimately considered to represent a SAB risk. Minimising TCVC usage was the main factor used to prioritise patient referrals to their VA service.

New patients were offered an AVF as a default first access option, with AVG as the fall-back if AVF were not technically feasible. Patients 'crash-landing' on RRT tended to start haemodialysis with TCVC, but it was reported that the assessment process for AVF creation would begin during the index admission unless this was not possible due to the nature of the patients' acute illness precipitating the need for dialysis treatment. There was usually a presumption that all patients should be assessed for AVF, and TCVC used only as a bridging solution or if no feasible alternative was identified. AVG were available but their use was limited to specific named patients, and clear criteria for their use had not yet been identified. PD was offered to new patients as an alternative means of RRT, but not normally as a line avoidance strategy. Staff reported PD was increasingly offered to 'crash landing' patients although haemodialysis using a TCVC was still the most common outcome.

TCVC insertion was generally nephrologist-led, with a scheduled list in the IR department performed by a nephrologist, with 3 patient slots per week. While this meant TCVC insertion was readily available, in practice the effect was to reduce overall TCVC usage as more IR time was available for AVF maintenance. It was notable that VAN spent almost no time coordinating TCVC insertion, in contrast to other centres where this occupied significant proportions of VAN time.

There was a general sense that 'home therapies', whether home haemodialysis or PD, should be offered to any appropriate patient, and it was reported that the uptake of PD was increasing.

Unit 6

They tended to discuss AVF and AVG with patients as their preferential VA modality, but would also offer TCVC as part of the discussion. It was felt that AVG were the best option for patients with poor blood vessels (who would otherwise have needed TCVC), although TCVC were preferred for urgent access or for those presenting late with ESRF.

AVG were considered technically challenging by the surgeons so they would only be considered for selected patients, and on an elective rather than emergency basis. There was a sense that nephrologists viewed AVG as 'special procedures' not in routine use. It was also recognised that RDU staff had limited experience with AVG cannulation, while VAN had limited experience of AVG surveillance and subsequent management of problems. There was also uncertainty about whether the patients required anticoagulation.

It was reported to be straightforward to have a TCVC inserted since two nephrologists would routinely do this. This did not tend to result in large numbers of TCVCs being used, as the local vascular surgeon was enthusiastic about creating AVF and had the capacity and willingness to fit such patients into operating lists at short notice. The lack of interventional radiology on-site limits the ability to manage acute AVF problems, and TCVC were largely considered a by-product of this deficiency, rather than an equivalent to AVF.

It was clear that the VAN role primarily oriented around AVF creation and maintenance, in contrast to other units where it was more oriented around TCVCs. The relatively low TCVC use meant there was less clinical experience of TCVC-related problems; while the nephrologists who regularly inserted TCVC were mindful of the associated morbidity, this may have been less apparent to others.

There was no clear timescale for AVF creation in the unit, although it was not felt to be a protracted process. The uncertainty about timescales may however have resulted in inappropriately early or late referrals for access creation.

Unit 7

The overall focus of the VA team is on achieving a functioning AVF for the patient. It was reported to be difficult to obtain a TCVC in practice, as there was no dedicated IR resource for this and no nephrologists routinely inserted them. There had also historically been little attention paid to creating a robust TCVC pathway as the VA strategy in the unit was concerned with minimising TCVC use and maximising AVF use. The difficulty obtaining TCVCs was said to result in delayed patient discharges. There was a reluctance to improve the TCVC process as it was perceived that this would increase the overall TCVC use at the expense of AVF. When TCVC are required it was reported to be normal practice for VAN and nephrologists to liaise with IR, to optimise the TCVC location in order to prevent the compromise of future potential AVF sites. If an AVF presents a problem they make several attempts to preserve it rather than just abandoning and settling for a line.

Staff reported being aware of the likely timelines involved in TCVC insertion or AVF creation. While striving to maintain AVF, they would also attempt to expedite TCVC if the alternative would be admission to hospital because of a thrombosed AVF.

AVF were considered preferable to TCVC in frailer patients. Their approach to AVG appeared less aggressive than in other centres. Whereas other centres reported using AVG specifically to prevent TCVC use, in Unit 7 it appeared that AVG were reserved for a more selective patient group. It was suggested that AVG use would likely increase once a better evidence base existed for them. NTCVC practice appeared very clinician-dependent, with little standardisation across the unit.

VAN reported concern that it was possible for patients to effectively 'disappear' within the outpatient RDU setting. For example, if a patient had started haemodialysis using a TCVC and had not already been referred by their nephrologist for AVF creation, it was unusual for RDU nursing staff to prompt this referral. It was also said to be common for patients to have an AVF ready for use, but for RDU nursing staff to continue providing haemodialysis via their TCVC (and therefore prolong the duration of TCVC use).

PD is used relatively infrequently, and appears to run as a standalone service, with a different surgical team and different nursing staff.

Unit 8

In Unit 8 many nephrologists and RDU nurses considered TCVC to be preferable for frail and elderly patients. There was a perception that AVF or AVG use would involve procedures that were unnecessarily invasive in this patient cohort. Indeed, there was a focus upon the need for a surgical procedure to provide haemodialysis via an AVF or AVG, whereas TCVC were considered less invasive.

It was notable that clinicians tended to refer to "permanent lines" rather than "tunnelled lines" or similar, whereas in other centres the language associated with CVCs reflected their technical status (tunnelled or non-tunnelled) rather than their perceived longevity (temporary or permanent).

There was a perception among RDU staff that AVF exposed patients to significant burdens of morbidity, including seemingly minor skin irritation through to catastrophic bleeding and the likes. In contrast, TCVC-associated problems were viewed as coincidental, chance occurrences rather than predictable events. It was notable that when AVF or AVG problems arose, the overall access strategy for the patient was considered to have failed; whereas TCVC-related problems tended to be labelled as challenges with a particular TCVC rather than the strategy of 'haemodialysis via TCVC'.

A recent clinical trial had provided substantial experience of AVG use. They were viewed by nephrologists and vascular surgeons as excellent alternatives to for patients who would otherwise have required TCVC for haemodialysis treatment.

Clinicians across the VA team reported a significant lack of resources for VA maintenance, and some acknowledged that this was likely to contribute significant to the perception that AVF and AVG were troublesome. IR were particularly mindful of this, and the need for significant investment to adequately maintain AVF and AVG.

Nephrologists and VAN noted that TCVC use had become habitual within some satellite RDUs. It was reported that when higher proportions of patients were dialysing using TCVC within a given satellite RDU, it became progressively more difficult to convince patients or staff that AVF or AVG was a better alternative. Nephrologists were mindful of the longer-term risks associated with TCVC, particularly central venous stenosis. They considered that PD could provide a better alternative to haemodialysis with a TCVC, but thought it reasonable for patients to take time deciding upon their preferred RRT modality while using a TCVC. PD was reportedly less easy to access in the acute setting, whereas it was perceived that NTCVC or TCVC were easily obtained.

As with other units there was a sense that the patient group with high historical TCVC use would have accumulated irreversible morbidity, and for VA purposes they should be considered a separate cohort to other patients attending the centre.

Unit 8 is a transplant centre, with a large cohort of patients who have successfully been transplanted. It was perceived that the availability of transplantation had effectively selected out a frailer, more comorbid group of patients who would then require haemodialysis or PD.

Much of the morbidity and mortality in this patient group was said to relate to this high degree of comorbidity, with less emphasis placed upon their respective VA strategies.

It was said that RDU nurses had limited support in cannulating AVF or AVG, some of which would prove technically challenging. It was perceived that technical difficulties with AVF or AVG reflected 'failure' on the part of the RDU nurse, rather than a physical problem with the AVF or AVG that required interventional maintenance activity. RDU staff were said to prefer using TCVC as they were technically much easier, and whenever problems arose they could be managed using a simple protocol or would require onwards referral to the nephrology service.

Staff reported that it was common for existing VA to fail without a fall-back plan existing. Usually the patient required NTCVC or TCVC insertion, and it was rare for the patient to transit directly onto another AVF, AVG or PD. When NTCVC were required, this usually precipitated an acute hospital admission to await replacement with a TCVC.

There was considerable uncertainty in the unit about the absolute and relative waiting times for different procedures. Nephrologists were reluctant to consider AVF or AVG in patients for whom transplantation was perceived to be imminent, while accepting that sometimes the transplant was then not forthcoming.

It was apparent that nephrologists had a perspective of the relative merits and risks of each VA modality, but this was not shared with the wider VA team or among the broad range of individuals who could influence patient choices, such as RDU nurses, ward nurses, and interventional radiologists. Anecdotes and opinion appeared to guide access planning for individual patients, rather than data-driven evidence.

As was the case in other centres, there was no formal policy about preferred NTCVC site or duration for a given clinical scenario, nor was there a formal VA policy for patients requiring chronic RRT. It was perceived by some that VA was not always a high priority for clinicians who weren't directly involved in the VA team.

PD was considered under-utilised, and there was an appetite among nephrologists to explore the possibility of increasing PD use. Logistical difficulties are still a challenge with PD catheters. On one hand it was said to be relatively common for them to be inserted long before they were needed, but it was sometimes difficult to have one placed at very short notice.

It was reported to be much easier to have a PD catheter inserted than to have an AVF created for a given patient. This was thought to reflect the relatively low usage of PD in comparison with haemodialysis.

Unit 9

TCVC were considered inevitable for patients 'crash-landing' on haemodialysis, or those with no feasible AVF options. NTCVC or TCVC were considered appropriate access modalities for the short term and AVF could be created at a later date – however in many cases this never ultimately happened. The perceived inevitability of CVC use was borne out by recent quality improvement efforts in the unit, which had focused upon reducing TCVC-associated infections rather than upon increasing AVF use.

As seen elsewhere, CVCs were referred to as "temporary" (NTCVC) or "permanent" (TCVC), reflecting that for many patients a TCVC would be the only VA modality on offer. There was a nephrology-led TCVC list held fortnightly in the renal unit, offering 2 slots per fortnight. It was viewed as a means of converting NTCVC to TCVC more rapidly (and so facilitating patients' discharge from hospital), rather than a mechanism to maximise IR time for AVF maintenance.

There were significant logistical difficulties reported in accessing vascular surgery or IR, since both services were based on another campus. This seemed to result in TCVC being a default access modality, at least for those starting haemodialysis treatment. Significant VAN clinical time was occupied by coordinating TCVC insertion.

AVG usage was reportedly very low. They were not routinely inserted by the vascular surgeons, RDU staff were unfamiliar with them, and there was no clear process for their surveillance and maintenance. Their use also caused significant uncertainty around internal funding for the AVG device and associated maintenance costs, since nephrology, vascular surgery and IR sat within three separate directorates with different managers, different budgets, and many other competing priorities. The logistical, practical and financial issues meant AVG were not considered achievable options for most patients.

PD was considered underutilised by nephrologists, who showed interest in increasing its use. It was offered to patients as an alternative modality to haemodialysis but was not considered a means of avoiding 'haemodialysis with a TCVC' if no AVF option existed. It was considered easier to achieve PD catheter insertion than to have an AVF created in most cases.

Unit 10 (Paediatrics)

In the children's renal unit there was a notable focus upon TCVC as the default means of VA for haemodialysis. Staff reported it had been several years since a patient last dialysed in their unit using an AVF.

For some very young patients, for whom TCVC insertion was not physically possible, PD would be offered. PD was also offered to patients who lived far away from the centre, but it was not offered routinely to patients whose vessels were suitable for a TCVC but not for AVF creation. PD was not considered a strategy for preserving central vessels.

The complications of TCVC use were not readily acknowledged by clinicians. TCVC-associated infections were often attributed to a lack of patient hygiene rather than as a recognised complication of treatment. There was a lack of awareness of central venous stenosis as a late complication of TCVC use. It was said to be highly unusual for their patients to develop this under paediatric care, when patients typically dialysed (and thus required VA) for only short periods before receiving a transplant; central venous stenosis was more typically seen in these patients many years later when they attended adult services.

Discussion

This chapter has considered clinicians' opinions relating to the different VA modalities. Overall the data suggested that viewpoints on VA modalities varied by unit rather than by professional background. The historical context of each unit is likely also relevant.

It would be overly simplistic to suggest that clinicians' values were the only contributor to the relative utilisation of each VA modality in each centre: clearly there are many other issues including resource availability, local technical expertise and other factors discussed elsewhere in this thesis. However, clinicians' opinions define many of the assumptions and values that underpin the function of the VA service, and given the relative power gradient that exists with patients it may be argued they must also influence clinical decision making and the consent process. These opinions may be considered 'source types' or 'function types', dependent upon perspective[185,186]. Cherns' sociotechnical system design rules[207,208], modified by Clegg[210], and updated by Fischbacher-Smith[178],would position them as central 'assumptions' that are key to system functioning. Amending these assumptions through education or by other means, may hold the key to changing VA clinical practice.

Current audit standards measure the proportion of patients receiving haemodialysis using AVF within a given centre[3]. It is apparent that this figure could be 'unfairly' influenced by the availability of alternatives such as AVG and PD, and access to transplantation. In turn, this may be modified by clinicians' opinions about these modalities and their suitability for specific patients. Centres who make proportionally higher use of PD, AVG or transplantation may be unfairly disadvantaged by current audit standards. A suggested alternative audit standard is 'the proportion of patients in a given centre whose RRT modality is haemodialysis delivered using a TCVC'. As well as generating a more comparable dataset between centres, this also characterises 'haemodialysis with TCVC', 'haemodialysis with AVF' and 'haemodialysis with AVG' as discrete RRT modalities, characterised by their unique and divergent burdens of morbidity, mortality and financial cost.

Chapter 5: Maintenance of Vascular Access

This chapter describes and analyses the processes used to maintain VA in Scottish renal units. Since all VA modalities may fail over time these processes are considered essential to any VA service. It is likely that VA creation pathways (chapter 3) and clinicians' opinions of VA modalities (chapter 4) influence the proportion of patients who receive their first haemodialysis with an AVF; however, the proportion of patients who receive ongoing haemodialysis with AVF is likely to reflect how well existing VA is maintained. This study aims to understand variation between centres in this regard, and to design improvements; understanding each unit's maintenance processes is therefore vital to achieving the study's aims.

As with VA creation pathways, it is helpful to explore the formal processes involved in the VA maintenance pathways ('work-as-imagined') before considering their routine functioning ('work-as-done').

It has been acknowledged in earlier chapters that centres varied considerably in the extent to which VA pathways were formally recognised as distinct entities. This was notable for VA creation, and strikingly apparent for VA maintenance. The pathway elements, the language used to describe these elements, and the nature of clinical interactions across the pathway, all vary considerably between centres and, in some cases, between satellite haemodialysis centres associated with the same renal unit.

Processes

The major elements of the VA maintenance pathway are described in figure 9. This represents an amalgamation of the pathways used by each centre; Table 15 describes components of the pathways in each centre; these should be read alongside appendix 6 which contains diagrams with the specific pathways in use by each centre for comparison. The stages are detailed below.

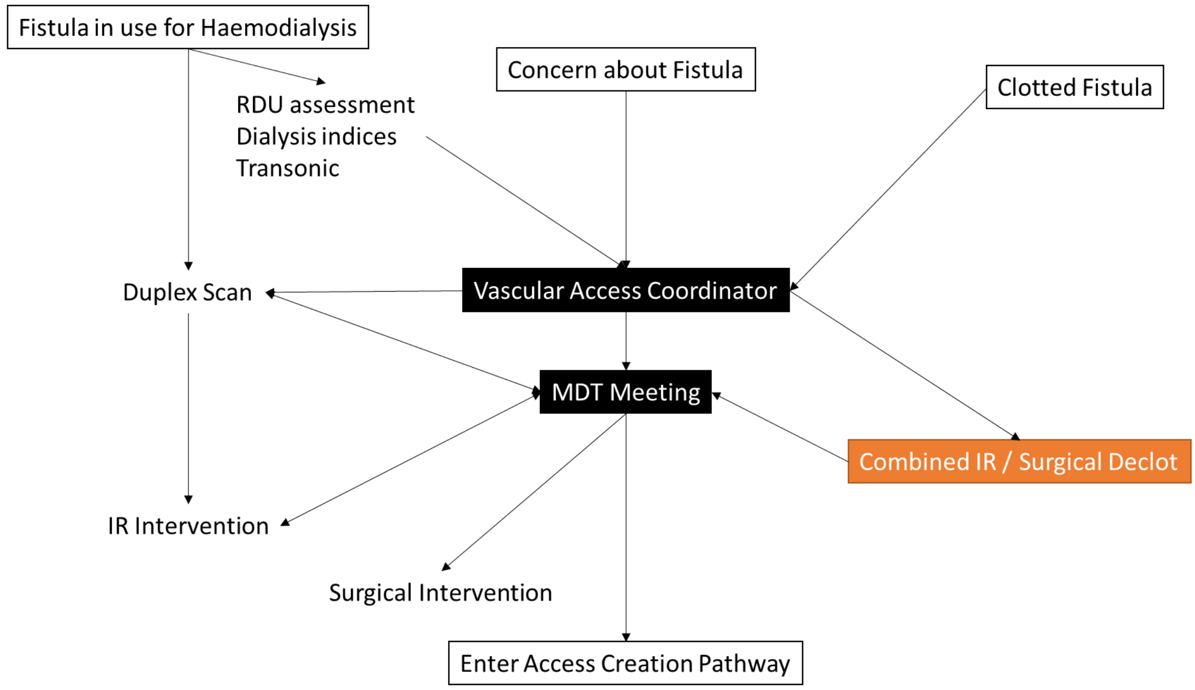

Figure 9 Generic Vascular Access maintenance pathway

This pathway diagram reflects an amalgamation of the clinical pathways in use by each renal unit. The pathways used by each individual unit are described in appendix 6; they vary considerably between units. In most centres the patients' VA was assessed at the time of haemodialysis sessions, using dialysis indices, and/or by transonic measurement. VAN would be informed if there was concern based on these findings or for any other reason. Investigations and/or intervention would then follow, sometimes arranged via an MDT meeting. In cases of clotted AVF most centres relied upon a combined IR and surgical de-clotting procedure, although in many cases this proved impossible to facilitate with a clinically appropriate timeframe. If VA failed the patient would then enter the VA creation pathway (see chapter 3).

Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Protected IR slots?	No	No	No	No	Informal	No	No	No	No
AVF history used in planning AVF interventions?	Yes	Yes	No	Yes	Yes	No	No	Yes	No
Declotting – usual practice	Surgical	IR	Surgical	Combined surgical / IR	Combined surgical / IR	Combined surgical / IR	Combined surgical / IR	Variable	IR
Declotting – unit's preferred practice	Surgical	Combined surgical / IR	Combined surgical / IR	Combined surgical / IR	Combined surgical / IR	Combined surgical / IR	Combined surgical / IR	Unknown	IR

Table 15 Vascular access maintenance pathway characteristics, by centre

Surveillance

Surveillance of VA, and what this means in different centres, forms a major component of VA maintenance. For clarity of presentation, chapter 6 is dedicated to this issue.

Clinical assessment

VAN and RDU nurses in all units considered the VA clinical assessment to be a routine part of the clinical activity associated with all outpatient haemodialysis sessions. No units routinely recorded this assessment, and no unit had a written protocol (or equivalent) describing this assessment in any detail. Clinicians who were not directly involved in the delivery of haemodialysis sessions had limited awareness of this assessment.

Clinical assessment also involved nephrologist review of haemodialysis indices on a monthly or three-monthly basis, although this was not usually performed directly alongside the nursing staff responsible for delivering haemodialysis treatment.

Referral of clinical concern

In most centres, VANs acted as the first contact point for any VA-related concerns. VANs expressed frustration at the variable timing of such referrals: on one hand, it was common for AVF problems to be referred at the point of AVF failure, despite a lengthy prodrome being retrospectively apparent in the haemodialysis indices; whereas other patients were often referred to VAN with apparently trivial problems, for which no remedial measures had been tried by RDU staff before referral.

There appeared to be no clear distinction between the role of VAN and RDU staff with respect to identifying and managing clinical problems, or coordinating more complex management such as referrals to surgeons or IR.

Referrals to VAN were largely informal, with little formal documentation required by the referring clinician. No unit had a written policy describing the conditions in which a patient should be referred, or the actions that would be taken following referral.

Interventional radiology

Most patients with identified AVF problems were said to require fistulography imaging and/or fistuloplasty. No units had IR slots formally designated for VA work, although some units informally protected some slots for this purpose. In Unit 5 slots informally designated for VA were allocated to named patients during the VA MDT meeting (discussed below). In Unit 2 there was sufficient capacity and engagement from IR such that cases were usually appointed within one week. Elsewhere, patients were placed on the general waiting list for any patient awaiting an IR procedure; it was said that many patients' AVF would then fail irreparably before their IR procedure was appointed, although no audit data was forthcoming to support this assertion.

In most centres it was normal for fistuloplasty to immediately follow fistulography, during the same procedure, where it was indicated; however, in Unit 9 patients were appointed first for diagnostic fistulography, and where fistuloplasty was required they would receive a further appointment to attend for this on a later date.

Vascular surgery

A small patient cohort required surgical maintenance procedures. This was in addition to those who were thought to require a new AVF creation, in which case the VA creation pathways would be followed (see chapter 3). VANs reported it was more straightforward to schedule surgical maintenance cases (rather than IR cases) since they occupied the same theatre lists used for VA creation.

De-clotting

The approach to patients presenting with clotted AVF varied considerably between centres, at different times of day, and occasionally between clinicians in the same team. Most units aspired to providing combined surgical / IR de-clotting procedures, but this was not routinely possible in many units. Various barriers to providing this service were described, including:

- Lack of available theatre space;
- Lack of available (non-medical) theatre staff out-of-hours;
- Non-co-location of the renal unit (and hence the patient) with interventional facilities;
- Variable clinical engagement by individual surgeons and radiologists providing out-of-hours cover.

In some centres it was common for a radiologist or a surgeon to attempt a de-clotting procedure, but not working together. Surgeons and radiologists both expressed frustration with such procedures, which were considered technically challenging and likely to prove futile.

The benefits of combined approaches seemed most apparent to surgeons and radiologists working in centres where this was normal, routine practice. These were also the centres that tended to describe aggressive, early intervention strategies for problematic AVF.

Staff in Unit 2 maintained a specific ‘AVF history’ that detailed interventional procedures and other relevant clinical details; this was used to inform decision-making in the event that an AVF developed problems or failed altogether. If an AVF was considered to be failing, new VA would be created before original AVF failed. Similarly, in Unit 5 it was reported that patients whose AVF began to show signs of failing would be listed for a new AVF procedure. In both centres it was highly unusual for patients to present with a thrombosed AVF without an alternative access strategy in place.

The centres with closer teamworking between vascular surgery and radiology, where combined procedures were more common, also tended to report performing the fewest de-clotting procedures – although as with many other aspects of VA practice, no audit data was available to corroborate this. The benefits of combined procedures were least likely to be discussed by nephrologists in centres with more passive surveillance programmes and where combined de-clotting procedures were not routinely available.

Function

Multi-disciplinary team meetings

The term ‘MDT’ was familiar to all clinicians interviewed in this study. The term was understood in most centres to refer to the “multi-disciplinary team [meeting]”, but also

referred to the concept of a multi-disciplinary approach or to the broader concept of teamworking.
The generic VA team composition includes representation from nephrology, vascular surgery, IR, VAN, sonographers, and administrative support. Substantial variation was seen between centres in the extent to which each clinical group engaged with MDT meetings, and with the broader VA service. In some centres a surgeon and VAN informally discussed VA patients without any regular input from nephrology, IR or others. Elsewhere there were weekly meetings attended by multiple representatives of each clinical group. The purpose, composition, frequency and impact of these MDT meetings also varied between centres. In some units meetings were infrequent and poorly attended; elsewhere they formed the cornerstone of the VA service. Meetings were conspicuously absent in Unit 6, yet the MDT functions described elsewhere were clearly evident and were said to be facilitated by effective interdisciplinary co-operation and regular, albeit ad hoc, communication about shared patients with VA problems.

No unit clearly articulated the specific role of the MDT meeting. There was an implicit assumption in all centres that the MDT meeting would be the forum for discussion of any VA issues, whether clinical, operational or strategic. In practice, most MDT meetings focused efforts upon improving secondary patency, that is they managed problematic VA within the prevalent HD cohort. The role of the MDT in the creation of new VA (for new patients not previously known to the team) was less clear. Similarly, it was apparent that MDT meetings were not typically concerned with more strategic approaches to improving the proportion of patients dialysing with AVF or AVG. There did not appear to be a natural forum for discussion of these issues.

Surgeons and radiologists placed more value on the MDT meeting process than nephrologists, but nephrology involvement was regarded by surgeons and IR as being key to the meeting’s success. Surgeons and radiologists appeared more familiar than nephrologists with MDT processes, from the other aspects of their clinical roles. Nephrologists had with limited insight into the value with which surgeons and radiologists held their opinions. Some regarded themselves as passive participants in the MDT, whose role was to refer patients into the clinical pathway rather than being involved directly in the ensuing discussion. Overall it was clear that face-to-face contact between members of the team was a key attribute of a successful service, and regular MDT meetings usefully facilitated this.

Co-location of nephrology, vascular surgery and radiology units, along with the provision of protected job-planned time to attend meetings and manage the associated clinical issues, seemed to strongly influence individual clinicians' ability to engage with MDT working.

The importance of MDT meetings appeared as much about building interpersonal relationships between clinicians as with the specific clinical discussions that took place. Some units credited the mutual trust established by MDT working with the development of efficient clinical processes, for example VAN listing patients for theatre, without direct surgeon involvement, at the VA clinic. Some centres clearly regarded the MDT as the cornerstone of their VA strategy, crediting it with better clinical outcomes for patients and substantial reductions in unscheduled VA care. In centres without a functioning MDT it was common for clinicians to be unfamiliar with the names of colleagues working in other parts of the service; in some units they reported never having met one another in person.

Important prerequisites for a successful MDT meeting appeared to be as follows:

- Availability of a comprehensive patient list for discussion;
- Reliable presence of all stakeholder groups;
- Administrative support to record and disseminate decisions and to book procedures;
- Available slots to be allocated to named patients who require radiological or surgical procedures.

Table 16 describes MDT meeting characteristics in each centre. Table 17 demonstrates quotations from interview transcripts describing the MDT meetings. The function and capability of the MDT meeting is then discussed in detail.

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Unit	1	2	3	4	5	6	7	8	9
MDT meetings	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Meeting on renal unit site?	Varies	Yes	N/A	Yes	Yes	N/A	Yes	Yes	No
Regular or on request	Regular	Regular	N/A	Regular	Regular	On request	Regular	Regular	On request
Meetings per year	12	39	0	12	17	0	26	52	12
MDT frequency	Monthly	3 weeks in 4	N/A	Monthly	3 weekly	On request	Fortnightly	Weekly	Monthly
Who attends	Surgeon, VAN, sometimes nephrology	IR, surgeon, nephrologists, VA nurse, sonographers	n/a	Nephrology, IR, possibly others?	IR, surgeon, nephrologist, vascular lab, VA nurse	Informal	Nephrologist, IR, surgeon, VAN, RDU staff	Nephrologist, Surgeon, VAN, IR	Surgeon, IR, occasionally VAN and nephrologist
Job planned	Yes	Yes	n/a	Unclear	Yes	No	Yes	Some	No
Time protected	Yes	Yes	n/a	Unclear	Yes	No	Yes	Yes	No

Table 16 Multi-disciplinary team meeting characteristics by unit

Unit	Transcript Data
1	*"We do have a forum for Vascular Access discussion which is barely used. But again, you know, I don't like to say 'you must come to this meeting to discuss patients' when, you know, I take as much responsibility as them for not turning up to the MDT sometimes"* (Consultant Surgeon) *"No, it is just a general Vascular MDT so there is no specific renal MDT… it is just a case of discussed ad hoc at that meeting, again there is no ring-fenced time, it is just part of the general meeting."* (Consultant Radiologist)
2	*"We are a relatively small place. On occasion, people can't come… and you notice that you do suffer when … you want the advice of a renal physician… but by and large it runs well."* (Consultant Surgeon) *"We still have difficult patients and there are still failures. We've had a few patients who needed a few attempts to get an access going but just sharing that around helps a lot."* (Consultant Surgeon)
3	*"it's most useful because it allows the interventional radiologists to be engaged with a case and take on something that they might not have been very keen to do, or they may have just not done what was wanted"* (Consultant Surgeon) *"I think the structure was better, the overall management picture was better when we had the MDT because everyone was involved and even a simple fistulogram that was done was discussed and there was an MDT approach … there was a structure previously and that was good and I think it would be useful if we could go back to that."* (Consultant Radiologist)
4	*"We have got a monthly Vascular Access meeting in the team meeting so that's looking at planning but also surveillance results and intervention planning mostly from that meeting."* (Consultant Nephrologist)
5	*"When I used to go to other centres in Scotland, they didn't have specific Vascular Access MDTs. They didn't have surveillance. I strongly believe that, having seen it here, that it works very well having a specific MDT to only discuss Vascular Access cases, having surveillance programme with interested sonographers running it and having some protected slots to some extent."* (Consultant Radiologist)
6	*"We tried to set up a MDT meeting, but our patients, which are so few, that is wasn't worth it and to be fair, phone calls or corridor meetings are just as productive really."* (Vascular Access Nurse) *"We see each other pretty well every day, so it's not difficult."* (Consultant Surgeon)
7	*"MDTs have been very good in terms of, you know, not even just about the discussion. The discussion can be quite really boring, because we've actually sorted things out but it actually brings everyone together and we discuss other aspects of problems."* (Consultant Surgeon)

8	*"The MDT meetings which we don't go to, it's difficult to go to them. But there is some nephrologists who do go, I have been to them before, but particularly in [this unit] they're so big, that the majority of the patients will not be relevant to me, and my influence in them may not be particularly useful for most of the patients."* (Consultant Nephrologist) *"I think that's not well attended by all the groups, to my understanding, and possibly not even well attended within the groups if you follow, so even the groups who come along, there are individual who are clearly driven to get involved and there are others who are not. But there is a formal MDT yeah."* (Consultant Radiologist) *"It doesn't really work, currently. It runs on alternate weeks on different days. So it's not weekly, and which day of the week varies. It's done in lunch time slots in a day when we [are often on offsite clinics]. The radiologists sometimes are unable to make it because they are [offsite]. So it doesn't really work as well as we would like it to. It would be much better if there was a more consistent way of protected time."* (Consultant Surgeon)
9	*"There is a vascular MDT meeting that I infrequently manage to get to"* (Consultant Nephrologist) *"[Nephrologists] used to come [to the MDT meeting] and they do come every now and then to the meeting. Not very regularly, but equally enough not all the 3 vascular people are in, but there will be a representative."* (Associate Specialist Surgeon) *"[Nephrologists] do [attend the MDT meeting] when they can. But again, because of your two sites, it's actually easier, we tend to have it just before the vascular MDT meeting so timing wise we're all on site at [campus]. It would be much easier to have the nephrologists present"* (Consultant Radiologist)

Table 17 Multi-disciplinary team meetings

Unit 1

Unit 1 has a monthly MDT meeting that is almost never attended by consultant nephrologists or interventional radiologists. Meetings were said to be short, infrequent and poorly attended. One staff grade nephrologist tries to attend but other timetabled clinical commitments can hamper attendance. Functionally the MDT is mostly an informal discussion between the surgeon and VAN in the RDU, where the surgeon attends on at least a weekly basis. All interface between surgery and IR occurred through the general vascular surgery MDT meeting, without direct nephrology or VAN involvement.

Unit 2

There was a weekly MDT coordinated by VAN and well attended by all specialties. The agenda was formed using an ‘active patient’ list including all those using TCVC or with other VA creation or maintenance issues. The meetings were the mechanism for clinical referrals to surgeons and radiologists. Clinical decisions were assisted by VA intervention records maintained by sonography staff, who also attended each meeting. This enabled timely planning of maintenance for problematic AVF, or new VA creation if this seemed more appropriate.

Patients were listed by VAN for the relevant surgical or IR procedure directly from the MDT meeting. VAN also prioritised theatre lists and scheduled further discussion of patients at the next meeting following their procedure. Ad hoc emergency referrals were normally accommodated between meetings, but the bulk of clinical activity arose from the meetings; this was said to benefit all parties. Strategic service issues were discussed separately in an annual review meeting.

The meeting’s value was widely appreciated. Radiology considered that the meetings had all but eliminated clinically inappropriate procedure requests, while surgeons credited them with successfully reducing unscheduled VA care.

Unit 3

The MDT was previously viewed as a useful forum for discussing problem cases, but meetings had become infrequent and it was now common for VA issues to be discussed at the general vascular surgery MDT meeting. The surgeons felt meetings enabled closer MDT working than was otherwise possible, while radiologists suggested this helped them feel more involved in the overall care of the patient, rather than simply acting as technicians.

Unit 4

The monthly MDT meeting was a forum for discussion of elective VA creation, intervention planning and problems identified during surveillance imaging; most of the agenda arose from their surveillance programme.

Unit 5

Unit 5 held a well-attended MDT meeting every three weeks, and it was unusual for the meeting to be cancelled or rescheduled. There was broad buy-in from clinicians representing all specialties. Cases could be listed for discussion by VAN or by the vascular lab; RDU staff could send patients to the vascular lab via liaison with VAN, or for scheduled routine surveillance imaging. The meeting was used to plan forthcoming surgical or IR intervention on the existing AVF cohort. Where IR intervention was planned it would be scheduled directly at the meeting and was usually completed in time for further discussion at the next meeting, three weeks later.

Radiologists particularly valued having a VA-specific MDT that was not subsumed by the general vascular surgery MDT. They considered that the VA service generally functioned well because of the face-to-face discussions, scheduling and overview of the active patients that was facilitated by the MDT.

Unit 6

It was reported that attempts to establish a regular MDT meeting had been unsuccessful as there was insufficient workload to justify the time commitment. Clinical issues were managed on a case-by-case basis; clinicians reported that this was straightforward in view of their proximity to one another within the small hospital, and their mutual enthusiasm for VA work. It was acknowledged that this did mean there was limited strategic overview of the VA service.

Unit 7

The MDT meeting was considered a good use of time. It was seen to streamline the patient experience, provide a forum for discussing clinical challenges, and enable new access creation when maintenance of an existing strategy was proving difficult. The MDT meeting was thought to reduces the overall VA workload, albeit there was no audit data to confirm or refute this.

Meetings were generally well attended, but geography and pressures of service delivery were cited as reasons for some clinicians having difficulty attending. Regardless of attendance, all MDT meeting decisions were circulated to the nephrologist responsible for the patient after the meeting.

Surgeons viewed the MDT as a helpful forum in which to review recent interventions and newly fashioned AVF, but considered the most important element to be the bringing together of each profession and the face-to-face contact.

Unit 8

There was an established MDT meeting, but attendance was variable. RDU nurses were effectively unable to attend for logistical reasons, and it was said that they were expected to attend in their own time (i.e. on a day off) if they had issues to discuss.

Some nephrologists referred to “meetings to review the radiology” rather than discussions around individualised VA planning. They did however recognise the MDT meeting’s potential to tackle complex VA problems. They did not consider meeting attendance a good use of their time as most patients being discussed were not under their care.

The referral pathway for patients to be discussed at the meeting was not clearly defined. Meeting outcomes were recorded on patients’ electronic health records but were not directly distributed to the referring clinician. Some nephrologists felt these outcomes lacked credibility, stating it was common for agreed actions to not be successfully carried out.

Meeting agendas were populated using an Excel spreadsheet with details of patients who had recently undergone VA interventions. Ad hoc VAN referrals could also be discussed. It was reported that many ‘routine’ cases were listed for discussion: typically patients who had attended for vein mapping in advance of AVF creation. Some clinicians felt the meeting time could be better utilised by removing these cases. In common with many other centres, there was no time at the meeting for strategic service discussions.

Unit 9

The VA MDT meeting was held on a different hospital campus to the renal unit, immediately before the general vascular surgery MDT meeting. It was logistically challenging for VAN to attend, and impossible for the nephrologist to attend in view of competing clinical demands before and after the meeting, on the renal unit site. It was noted that VA cases were usually not discussed if VAN or a nephrologist did not attend.

MDT meetings did not have a formal agenda, and the discussion would usually focus upon ad hoc cases raised by VAN. It was not normal practice to review all patients who had recently undergone VA intervention or who had other active VA problems pending resolution.

Discussion

VA maintenance is essential if patients are to successfully use AVF for haemodialysis treatment. The success of maintenance pathways may thus be reflected in the proportions of ‘prevalent’ patients using AVF for ongoing haemodialysis treatment. This section has considered the configuration of maintenance pathway and their practical limitations in units across Scotland. An idealised pathway has been described, and comparison with current models of practice have generated many recommendations for practice. These have considerable overlap with other areas of VA care; for ease of presentation the recommendations are described in chapter 11.

Clinical resources

The interview transcripts suggested there was a significant, unmet demand for VA investigations and procedures, ultimately with the potential to modify patients’ life expectancy. This assertion is supported by the findings of the clinical activity census, which demonstrated a very high workload across VA service over a short time period (this is reported fully in chapter 7). This contrasts starkly with the lack of any designated resources to meet these needs, as described in this chapter.

Specific adverse events arising from this unmet clinical need were not directly identified by this study, but it was also notable that no audit data existed as to the exact demand for, and capacity to perform, VA procedures, or any consequential morbidity and mortality. Further work should examine this issue. It is interesting also to note that the Safety II approach taken by this study has served to highlight the scale of the potential clinical need; it is possible that Safety I oriented investigations, focusing upon discrete adverse events, may not have detected this lack of resource with such detail. Understanding the normal functioning of VA maintenance pathways, including the clinical workload has also enabled estimations to be made of the resource gap in each unit (see chapter 7).

Team working

Multi-disciplinary teamworking seems vital to effective functioning of VA maintenance pathways, perhaps even more so than with VA creation pathways. Cherns' principles[207,208] (and updates[178,210]) concur with the central relevance of the team and its core values, assumptions and beliefs. The VA clinical context presents a wide range of clinical, technical and logistical challenges, and team members must be adequately equipped to deal with these. The importance of the multi-function principles is evident when contemplating these myriad presentations. Similarly, the need for proper information flow (e.g. the prompt availability of a fistula intervention record); support congruence (e.g. test requesting systems that are synchronised across all hospital campuses); power and authority (e.g. VAN-led test requesting or discussion with IR) are all highlighted in these pathways.

The sense of 'team' within each service also seemed to influence clinicians' perceptions of their own role. Where the team functioned well it was clear that individuals felt empowered to make decisions with confidence that colleagues would support them. A notable example related to VAN-led discharges from hospital following AVF surgery. In Unit 2 this was perceived as patient-centred care being delivered by the most appropriate member. In contrast, the VAN in Unit 9, whose postoperative discharge role was very similar, felt vulnerable and 'left to get on with it' with little support from other team members.

Clinicians working in units where teamworking appeared strongest also seemed to take more 'ownership' of VA clinical pathways and accepted more personal responsibility for patients within the service. The existence of a regular MDT meeting, and the degree of clinical engagement with this, tended to signify how involved individuals were with the VA service. It should be noted though that staff in Unit 6 appeared to work as a strong team without having a formal MDT meeting.

Perhaps the simplest marker of teamwork was the extent to which interviewees named others in the team as they discussed the processes. In the centres where 'ownership' did not appear to be a problem it was common for individuals to name one another through the course of their respective interviews; whereas in other units it was more common to refer to colleagues by job titles or by other impersonal descriptors. In other cases, individual clinicians expressed frustration with others' apparent lack of interest in the service or spoke of difficulties identifying who was responsible for a given patient as they transited through a VA pathway.

Table 18 demonstrates transcript data, which is then discussed by unit in the following sections.

Unit	Transcript Data
1	*"So I don't take any ownership of who requires priority from that point of view. I will let the nurse in conjunction with the nephrologist"* (Consultant Surgeon) *"What the nephrologist needs to do if they want any Vascular Access at all, there is a paper referral form and that, I don't do anything until I have got that… As soon as we do the referral form that's the ownership over to their work"* (Vascular Access Nurse) *"I am not personally aware, to be honest they are managed pre and post by surgical staff, we don't routinely see them"* (Consultant Radiologist) *"I don't know who this patient belongs to… we are probably leaving the whole monitoring and everything down only to the Vascular Access nurses"* (Associate Specialist Nephrologist) *"Our Vascular Access nurses, who presumably link between nephrology and surgery and they link between nephrology and surgery and interventional radiology as well."* (Consultant Surgeon) *"I would imagine the process, generally, is it is discussed with [the surgeon] who would then make the decision whether the referral was made for fistuloplasty, so that is probably the pathway that is taken."* (Consultant Interventional Radiologist) *"The rest of the team is very intermittent so usually it will be left to us even though the patients like you know belong to [another dialysis shift]… but then you have to deal with the access issues"* (Associate Specialist Nephrologist)
2	*"Not sure we've ever thought that anyone in particular has ownership, bit of shared responsibility, I mean, if a patient needs an access or a revision I think the surgeon takes charge of that process… I think the renal physicians feel over all they are in charge of the care of the patient. I think we essentially agree with that."* (Consultant Surgeon) *"We are all part of one big team and we have all got a role to play… a small part, a large part of this and we work together."* (Vascular Access Nurse) *"You have to remember this is very much a team-based process… everybody has an input, and everybody has a voice… I think that attitude, I think that is the crux of why it works so well is that we have such a good set-up with the MDT and with the teamwork."* (Consultant Radiologist) *"I have two colleagues… the one that does fistuloplasties won't put lines in whereas the one who won't do fistuloplasties does put lines in. And then I do everything."* (Consultant Radiologist) *"I think [named surgeon] is probably an important factor"* (Consultant Nephrologist)

	"There is a bit of an issue with radiology as well because it's really essentially [named radiologist] who's taking the interest and he's the only one who comes to the MDT… so that service is single handed which is not ideal." (Consultant Surgeon)
3	*"I think… you have got to make it easy for the surgeons. We admit all the patients, we prepare them for theatre, the surgeon sees them… we get them all ready and organise their diabetic treatment, warfarin and they come and see them in our ward and take them to theatre… I am aware that I just, you know if something needs done I will just do it rather than, you know, it is quicker than trying to hassle some others to do it."* (Vascular Access Coordinator) *"They are our responsibility and you need clear areas of who is looking after this patient… I do it because it's the right thing to do."* (Vascular Access Coordinator) *"Usually within 3 or 4 hours we will get a vascular person over to have a look and they could be in theatre that night if it's starting to fail."* (RDU Nurse) *"One of us can't really take the lead: half the time I'm here, and half the time I might not be here"* (Consultant Radiologist)
4	*"If we get a problem on dialysis then they are usually accessible instantly to have a look at the scan either to see if there is an active problem, or simply to indicate a point the nurses can needle. So that's a very good service and so from identifying a problem with a fistula to getting a scan is usually same session and often is, if it requires interventional radiology, that that happens the same day."* (Consultant Nephrologist)
5	*"It's the ethos rather than one person, it's the ethos of the whole, the way it runs and this is important… I think that's probably what's running the place."* (Consultant Radiologist) *"We're very comfortable with our vascular lab … I mean all of the way in which I do a fistulas presuppose the Duplex is going to be correct, and it almost always is"* (Consultant Radiologist) *"So I suspect some of…how units work has much more of an impact than what they actually do when they find something."* (Consultant Radiologist)
6	*"I have full faith in that bunch around the corner, they're fine people and we get on really well, and if they say it needs doing, then we will do it."* (Consultant Surgeon) *"We're a happy family, we talk to each other… we don't need quite so many rules because, you know, we've got more flexibility."* (Consultant Surgeon)
7	*"It's a really good team: our Vascular Access team are brilliant! We nominated them for the [health board awards] team of the year."* (Consultant Nephrologist)

	"I think that the complications of Vascular Access are our problem and I think that we have, we are kind of the patient's guardian in a way aren't we?" (Consultant Nephrologist)
8	*"I feel just now there's no one person responsible and that causes issues… that causes delays that probably don't need to be there."* (Nurse Practitioner) *"I'd say that that's not them all but there are certainly some who just don't think it's appropriate [for a nurse to make a referral] and I don't know whether it is or not."* (Nurse Practitioner) *"There is a whole bunch of people, if you like, doing the selection process, it seems to me, I think they outnumber the people doing the delivery process! Clearly the renal physicians are involved, we have got renal nurse practitioners who are often the interface between us and the competing priorities during the day."* (Consultant Radiologist) *"I will phone down because we have good rapport, I would contact nursing staff where I guess the surgeons would go directly to the radiologists… sometimes it feels like they're doing you a favour."* (Nurse Practitioner) *"I don't think there is a clear trail of who is responsible but I'm not sure whether that has much of an impact clinically."* (Consultant Surgeon) *"Yeah that's the problem, because see if I get somebody that comes in with 'Oh their fistula's clotted', oh that's a medical problem. And we're like that, 'well no it's a surgical problem'. And you're like that, 'it's the patient's problem – they've now got no access, could somebody do their access please!'"* (Vascular Access Nurse) *"It is difficult to know who the responsible nephrologist is…you can look at letters from [clinics] and see six different consultant nephrologists have been seeing the patient and none more than anywhere else. So you never quite know who to write to."* (Consultant Surgeon) *"It all floods into an MDT and goes out to other people you don't really know"* (Consultant Nephrologist) *"I bet [RDU nurses] feel very unsupported… we have to do some serious diplomacy work when people have written in [the electronic health record] 'nurses unable to do such and such'"* (Consultant Nephrologist) *"It's a group of people ultimately headed by [surgeon]"* (Consultant Nephrologist) *"I can do as much as I need to and then it's handing over, it's other people from them on"* (Consultant Nephrologist) *"Once they go on the list for surgery that's my bit done"* (Vascular Access Nurse)

	"It just gets blocked and you have to kind of push it… it just does keep bouncing back and if it is not happening, you have to keep pushing it. You have that feeling all the time." (Consultant Nephrologist) *"If it's something that they think: 'well this patient could get a temporary line, they don't need to be dealt with today', then it will just be 'on you go with them'"* (Nurse Practitioner)
9	*"There has to be someone feeling the ownership of the patient and this patient needs to have so and so. This patient needs priority of so and so, but it's like I am not the direct clinician looking after this patient, it's the renal physician, if they want something, they come to us. Unfortunately we do not have a lead renal access surgeon and I think that's the problem…. My view, this has to be a surgical lead, a radiology lead and a nephrology lead, with [VAN], these people to be the arc of the renal access"* (Associate Specialist Surgeon) *"I just give you an example, in a different scenario. Diabetic patient, coming in with diabetic septic foot, ulcers. They have the podiatry clinic, there is a diabetic consultant and there is a vascular surgeon. I say why you don't apply the same to the renal!"* (Associate Specialist Surgeon) *"I hope that is the case, [VAN] feels there is no barrier, that she can phone me, and she knows that if she needs me to see the patient today, I see the patient at the end of the day. She might not feel, and I will be very honest here, she might not feel the same thing of communication may be with radiologists, but I think she is trying to work around that."* (Associate Specialist Surgeon) *"We have an informal duty of care to renal patients… I think each element external to nephrology has a technician role to some extent"* (Consultant Radiologist)
10 (Paediatrics)	*"We don't specifically put in the access as it's the surgical role, so we make the decision of when the child needs haemodialysis"* (Consultant Nephrologist) *"Recurrent issues of line and infection risk, we don't generally … get involved as much as say [nurse practitioner] would."* (Consultant Nephrologist) *"It tends to be the nursing staff that kind of, I would say leads, apart from the actual connection between the surgeon and the consultant for permission formally, the nurses, we do most of the rest of it."* (Nurse Practitioner)

Table 18 Teamworking

Unit 1

There was a striking lack of ownership of VA processes, and little evidence of collaborative working in the centre. The surgeon and nephrologist had struggled greatly to engage others within the centre and were aware of difficulties streamlining patient care arising from this. Without significant ongoing contact with other members of the team, the radiologist adopted a passive 'technician' role and did not feel responsible for VA care.

Teamworking was considered necessary to cope with the complexity of patients requiring VA work, but nobody appeared to lead the VA team, and clinical activity essentially depended upon individuals doing what they felt able to do, with variable support from others. There was uncertainty as to the specifics of clinical processes in the centre, and poorly defined lines of clinical responsibility for patients attending the offsite IR department for TCVC procedures.

There was an apparent lack of interest from the wider nephrology team. The service did not seem to focus upon patients' needs, but instead viewed the clinical pathways as technical processes.

Unit 2

There was a strong sense of team and striking lack of hierarchy. Team members referred to one another by name and as colleagues, rather than as "the surgeon" or "the nephrologist" as heard elsewhere. It was perceived that nephrology had overall charge of the service, but in the context of a flat hierarchy.

There was clear ownership of the VA patient's clinical problems, and a desire to provide patients with the best possible service. Flexible working arrangements were seen to work in patients' and the service's favour. Each clinician reported feeling able to fulfil their role without requiring to be responsibility for other areas which were outside their area of clinical expertise. As was seen in other centres, this mutual support was felt to enable team members to tackle clinical problems they would otherwise be reluctant to take on. Interestingly, one clinician referred to another (non-VA) clinical role, where he felt less engaged with that team because he was treated as a technician rather than a clinician in his own right.

It was acknowledged that the collaborative approach did rely to some extent on individuals' personalities and enthusiasm, and that this made the service vulnerable in the event of unplanned absence.

Unit 3

The VA coordinator was clearly identified by all interviewees, including herself, as the key person with ownership of the VA service. The configuration of their team enabled an individual to maintain an overview, while other clinicians retained awareness (and overall responsibility) for their individual patients. This was said to allow everyone to function optimally. Her view is that patients requiring VA ultimately have a nephrology problem and should therefore be primarily cared for by a nephrologist. She sought to optimise patients' journeys by enabling others to participate in the service, or where this is not possible by solving the problem herself. Others in the team valued having one individual motivated to lead and coordinate the team. Her success in this role was attributed to maintaining a good relationship with the key players across the multidisciplinary team.

One surgeon was particularly visible within the VA team, and due to their interest in the service there is a responsive surgical involvement that responds to patient needs. Surgeons valued having someone else to coordinate the overall process, dealing with medical issues and liaising with others. Radiology seemed dislocated from the main service, but they too valued teamworking and appreciated the clinical imperative for patients.

On a broader scale the "Scottish Renal Nurses Strategy Group" was cited as a useful forum for general renal nursing collaboration. This was not restricted to VA issues, but staff valued having a safe place to canvass opinion and share ideas with colleagues.

Unit 4

It appeared that all members of the VA team were committed to the service, and problems were thus usually addressed effectively. Patients were said to receive an excellent service in view of the collaboration between vascular lab and radiology. Identified problems were managed by the most appropriate person without any requirement for 'permission' to be granted by another member of the team.

Unit 5

There was a clear sense of team and each clinician appeared to enjoy VA work. The sense of sharing this clinical interest with colleagues was thought to generate a shared feeling of ownership over the service. There was a very strong, supportive engagement between radiology and the vascular lab. Team function was also recognised as a key element of successful VA clinical outcomes.

Unit 6

All team members expressed a sense of responsibility towards patients, but nephrology appeared to have overall ownership of the VA pathways and maintained an overview of the clinical situation. This allowed others to contribute their expertise without feeling overly burdened with the nephrology aspects of patient care. It was perceived by others that the renal team valued and benefited from this approach.

Close working proximity seemed important, and there was a sense of team with a common goal, characterised by accessible team members who could be relied upon contribute whatever was necessary to meet patients' needs.

In contrast with other units where collaboration appeared to be lacking, interviewees tended to use open language and the focus of discussion was about what could be achieved for patients instead of what felt impossible. There was also a degree of humility and enthusiasm for learning from others; this was not always apparent in centres where clinicians did not seem to have such a strong sense of team.

Unit 7

There was a sense of collegiality between team members. Nephrologists considered that they had primary responsibility for VA problems, but the VAN team was supported and resourced to manage and coordinate clinical problems on a day-to-day basis. Team members were familiar with one another and referred by name to colleagues in their own professional groups and in other parts of the service. It seemed important that each component of the service (surgery, IR, VAN, nephrology) had a number of individuals contributing to the team; this meant nobody was over burdened with clinical workload, and there was not a dependence upon a single individual for the service to remain functional.

Unit 8

There was a sense that nobody owned the overall VA process. Individual clinicians felt they lacked permission to take control of the service, and there was no one clinician or manager who had an overview of the service. Unlike other units, it was highly unusual for specific individuals to be named as key team players. There were many references to unidentified third parties who were considered responsible for managing a clinical problem. This contrasted with other centres, where interviewees usually expressed an ability to manage such problems themselves. There was also a feeling of hierarchy, which inhibited team working. This was perhaps most apparent in IR, where it was said that some radiologists refused to discuss clinical cases with VAN or other senior nurses.

The lack of clinical leadership was particularly evident in the IR team, where referral handling appeared chaotic and variable. Staff felt they had to coerce the IR team to perform VA procedures, rather than these being core clinical activities. Radiologists also viewed their involvement with the service as being quite separate from that of the surgeon and considered that VA accounted for a considerable volume of work that was unrecognised in their job plans.

The lack of clear VA team working was also apparent in surgery and nephrology. Scheduling of cases was haphazard and it was said to be difficult to solve problems unless specific individuals were available. There was no definition as to which clinician would deal with problems, and it was apparent that team approaches to VA problems were unusual.

The lack of proper teamworking reduced the VA team’s credibility in the eyes of the wider clinical team in the unit. This also left RDU nurses feeling isolated and often led to conflict within the team, that would further add to the workload associated with the VA service.

A lack of collaborative working between clinicians meant there was no collective sense of shared responsibility for providing optimised patient care. Problems tended to be managed reactively, with little evidence of forward planning. There was mixed understanding of how clinical problems were ‘normally’ managed. One individual was named as being the key driver of clinical activity across the VA service, but it was felt that their contribution could only go so far.

Unit 9

Nephrologist and VAN transcripts from this centre had a conspicuous lack of any references to teamworking or collaboration. One nephrologist described themselves as de facto VA lead, but without the necessary time or resource to optimally fulfil this role. As a result, most clinical leadership was effectively delegated to VAN, who also lacked adequate time, resource and authority to fulfil this role; this was especially problematic during periods of leave, as colleagues would not backfill in her absence.

The surgeon was aware of the leadership vacuum and recognised the need for a more patient-centred approach. His attempts to provide leadership to the team were limited by his being based on another campus. He felt excluded from VA clinical decisions, treated more as a technician than as a properly qualified clinician in his own right. He contrasted this with positive teamworking he enjoyed in other, non-VA, parts of his job. He was aware that the service provided by IR was often haphazard, and that VAN was often left in a difficult situation because of this.

IR described informal involvement with the VA service, without any formally responsibility for the patients. Overall, the radiology team felt disconnected from the wider VA team. This may have been influenced by their lack of designated clinical resources for VA and being based on another campus. They did recognise that clinical leadership was needed across the VA team, and that VA work had to become a routine part of their jobs instead of the current ad hoc ‘voluntary’ service. They echoed the surgical view of feeling reduced to technician status, rather than full members of the team. It was unclear if this was considered a cause or effect of the current way of working.

There was some awareness that the current service was not delivering care within a clinically appropriate timescale. An idealised VAN role was described, but there seemed little awareness of how this might be achieved.

Unit 10 (Paediatrics)

It was seen that collaborative working was required to deliver optimised patient care, but in the paediatric centre the ad hoc, low volume, nature of VA work meant it was difficult to build close working relationships to achieve this. The nephrologist viewed herself more as a coordinator rather than the person in overall charge of VA clinical processes. Nurses view themselves as patients' advocates, and felt they had greater ownership over VA as a key factor in caring for a patient requiring haemodialysis.

Chapter 6: Surveillance of Vascular Access

This study seeks to delineate the structure, function and workload associated with VA services in Scotland. Using a systems and healthcare resilience engineering approach, the aim is to highlight gaps in ‘work-as-imagined’ versus ‘work-as-done’ (see chapter 1B), with the intention of generating recommendations for practice that will stimulate ongoing QI efforts in this area. Thus far chapter 1 has introduced the study context: of marked, unwarranted variation between Scottish renal units in relation to their use of AVF for haemodialysis. This is despite clear evidence of a morbidity and mortality benefit from using AVF, and various guidelines mandating their use. Chapter 2 described the development of a mixed-methods model to investigate complex clinical systems, and its use in this study. Chapters 3 and 4 have described the manner in which VA creation pathways are structured, how they function, and explored how clinicians’ opinions on the various VA modalities influence this process. Chapter 5 has described the structure and function of VA maintenance pathways. Several challenges were encountered including poorly defined clinical pathways, a lack of designated resources for maintenance activity, variable MDT working that was at times dysfunctional, and reliance upon key individuals with unrealistic workloads to coordinate clinical activity. This chapter considers VA ‘surveillance’ practice, as a discrete set of findings arising from the thematic analysis.

VA surveillance is closely allied to VA maintenance, but it was apparent that clinicians in different centres were referring to different things when using the term. Similarly, it was clear that some units considered surveillance an essential component of the overall VA service, while others regarded it as essentially a waste of resources. This chapter discusses these issues, which should be considered in the context of guidelines that recommend routine surveillance of VA[3,89].

The term ‘surveillance’ was generally considered to be the ongoing process of monitoring existing VA, but it was also used to describe:

- postoperative reviews in the days or few weeks following AVF creation surgery;
- routine VA assessment performed by RDU nurses immediately before, during and after outpatient haemodialysis sessions;
- routine nephrologist review of haemodialysis indices, not necessarily involving clinical examination;

- Transonic or duplex ultrasound imaging with or without any of the other measures.

It was widely recognised that patients with existing VA were a different cohort, in terms of their requirement for clinical assessment, to those in the immediate postoperative period following AVF creation surgery. In Unit 9 this distinction was not clearly made, and the term "surveillance" was generally applied to postoperative reviews.

The formality and timing of surveillance varied considerably within and between centres (table 19). This partly reflected the available resources, geographical considerations and the prevailing opinion within the centre about the financial and clinical efficacy of such activity (table 20).

Unit	1	2	3	4	5	6	7	8	9
Routine	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes
Location	RDU	RDU	Vascular lab	Vascular lab	RDU and vascular lab	RDU	N/A	N/A	RDU
Transonic	Yes	Yes	No	No	Yes	Yes	No	No	Yes
Sonosite	No	Yes	No	No	No	No	Yes	No	Yes
Clinician	VAN	RDU nurses	Sonographer or surgeon	Sonographer	Vascular lab	RDU nurse	N/A	N/A	VAN
Frequency	Monthly	Monthly (quarterly in satellites)	3 monthly	4 monthly	6 monthly	Monthly	N/A	N/A	4 monthly

Table 19 Surveillance practices by unit

The location, frequency and nature of surveillance varied considerably between centres. Some centres did not have a routine surveillance programme, while another had a programme that varied between the main RDU and satellite RDUs.

Unit	Transcript Data
1	*"It can vary between 2 weeks and 6 weeks. It just depends how busy they are. Because obviously they don't have a designated time slot for renal"* (Vascular Access Nurse) *"That is when I would refer them on to [surgeon]... Only two people actually do the referrals, because there were some mix-ups… we will go and highlight there's an issue and discuss what it is and they will see yeah ok that warrants a duplex or a fistulogram."* (Vascular Access Nurse) *"[Surgeon] would generally see the referrals and then refer on to IR as appropriate, and that is just done through the [electronic requesting system], there is no pre-discussion this is just requested as a radiological procedure if you like, a fistuloplasty or whatever."* (Consultant Radiologist) *"Again, that is something we are not involved in in radiology. I am sure there is a surveillance programme but the details I don't know"* (Consultant Radiologist)
2	*"We have reduced [unscheduled care] dramatically, we think by having our MDT and in particular having our sort of surveillance scan programme and scanning all problematic AVFs so the majority of our workload now is elective which is great"* (Consultant Surgeon)
3	*"There is a number obviously who [surgeon] is seeing for regular surveillance, there is a number who come through for regular, who just go straight to radiology regularly for fistulograms and plasties, you know recurrent stenosis and stuff."* (Consultant Nephrologist) *"We have a very small number of patients on high risk grafts who are going to the vascular lab for some surveillance. The main method of surveillance, there is also another small group of patients who we deem to be very high risk who will come back to that clinic… if we had a little more formal support from them, for example I would probably want all the grafts in a surveillance programme. Although it is still a dilemma what to do with them when you find a stenosis. No one knows what the best thing to do is."* (Consultant Surgeon)
4	*"It's usually 4 monthly vascular scans and there is a dedicated person that does that and again it is the routine scans, but if we get a problem on dialysis then they are usually accessible instantly to have a look at the scan either to see if there is an active problem, or simply to indicate a point the nurses can needle. So that's a very good service and so from identifying a problem with a fistula to getting a scan is usually same session and often is, if it requires interventional radiology, that that happens the same day."* (Consultant Nephrologist)
5	*"I get the feeling that our surveillance programme has identified… failing AVFs… early before they've failed, and we intervene and maintain AVFs. We seem to have been maintaining a large number of AVFs by repeat angioplasties or stents, and creating less."* (Consultant Surgeon) *"I think it's probably the identification of what you're supposed to do is the important thing and places that have, you know do maybe lots of thrombectomies are probably not identifying those AVFs that are just about to go down in a satisfactory manner, in my view."* (Consultant Radiologist)

6	*"As far as AVGs are concerned, we are sort of still feeling our way because I haven't done very many of them, so we probably would do scans now and again just so that we've got an idea of what's happening."* (Consultant Surgeon)
7	*"Well, actually we don't do a great deal of surveillance work ourselves. You know, surveillance is taken care of by the vascular lab. So we hear from them once they're running into difficulties and then [VAN] or somebody will come round with a Duplex scan"* (Consultant Radiologist) *"Then in the back of my mind I'm thinking I'll go and speak to [radiologist]. Hopefully we can get a fistulaplasty done in three or four weeks. So I'm sort of thinking about then."* (Vascular Access Nurse) *"New fistulae get planned surveillance. Established fistulae get reactive surveillance at the first hint of any trouble at all. We don't have a kind of planned, just routine scanning"* (Consultant Nephrologist)
8	*"Why on earth would you start doing surveillance when you can't even do the very basics when somebody clearly doesn't have an AVF there! It is definitely not working because it's not there!"* (Consultant Nephrologist)
9	*"There is no point in us creating more AVFs if we are not going to look after them properly and deal with a problem, which we can't."* (Consultant Nephrologist)

Table 20 Surveillance of Vascular Access

Some centres credited high prevalent AVF use and low rates of unscheduled VA care with robust surveillance programmes. This was most apparent in centres maintaining records of individual patients' VA, where there was rapid access to fistula intervention, and very low rates of unanticipated fistula thrombosis requiring de-clotting procedures. Others thought surveillance activities offered poor value for money; these views were typically held in centres that also reported having little available resource to manage the clinical problems identified through surveillance activities. Surgeons tended to hold favourable views of surveillance, but nephrologists were less certain of its utility.

There was agreement that AVGs probably required surveillance beyond that considered adequate for AVF. It was unclear what represented ‘optimal’ AVG surveillance and there was considerable uncertainty about the threshold for interventions, especially if imaging suggested an AVG problem without this being clinically apparent.

Unit 1

Unit 1 reported performing regular ultrasound surveillance imaging for all patients with an AVF, including those on ‘night shift’ haemodialysis and who attended outlying satellite units. Surveillance was coordinated (and largely performed) by VAN and was said to generate a considerable workload.

There was no formal vascular lab facility available to perform formal duplex ultrasound imaging; patients who required this were referred to the echocardiography department, and appointments for formal scans were said to have considerable waiting times. There was no forum for routine discussion of such patients with an interventional radiologist, since there was no regular MDT meeting.

When fistulography or fistuloplasty was considered necessary based upon surveillance imaging, VAN was unable to directly request this or to allocate specific radiology slots to patients; these requests had to come from a nephrologist or a surgeon.

Unit 2

The surveillance programme in Unit 2 varied considerably between patients attending the main unit or an outlying satellite centre for their haemodialysis treatment. Patients had monthly (three-monthly in satellite units) transonic readings, supported by informal RDU nurse-led assessment at each haemodialysis session and a patient education programme. Patients who lived in the very remote parts of the catchment area had no routine VA imaging as no transonic machine was available.

Potential AVF problems were usually referred by VAN directly to the sonographer. Similarly, the sonographer could directly refer patients to IR when duplex imaging demonstrated a problem. It was said to be common for patients to attend for routine surveillance and end up undergoing fistuloplasty on the same day. Patients from very rural areas with identified problems would slot into the same clinical pathway, with air ambulance transport being provided to and from the main unit.

The sonographers maintained an ‘AVF intervention history’ for each patient. This was said to inform MDT discussions, and would often prompt the creation of alternative access in patients with increasingly problematic AVF. It was felt that the combination of intensive surveillance and subsequent MDT working had brought large reductions in unscheduled access work.

Unit 3

Unit 3 reported informal AVF surveillance performed by RDU staff as part of routine haemodialysis patient care. This was supported by a formal renal competency training programme for haemodialysis nursing staff. Plans were in place for a scheduled AVF imaging programme in the form of duplex ultrasound scans performed by RDU nurses; this had not been formalised and no start date had been agreed.

The small cohort of patients with recurrent VA difficulties were known to the VA coordinator. They tended to have more regular, scheduled fistulography and fistuloplasty rather than attending for screening duplex ultrasound imaging. It was said to be normal for these patients to have new VA created pre-emptively before the existing AVF failed.

Patients with AVGs had more formal surveillance on a scheduled basis. There was considerable uncertainty around the management of AVG problems identified on surveillance in the absence of a clinical issue.

Unit 4

There was no formal strategy for routine clinical AVF assessment in the RDU, but there was some interest in establishing parameters to guide this. Patients were invited to attend scheduled vascular lab AVF imaging every four months. If this identified a problem, the sonographer liaised directly with IR to arrange fistulography and fistuloplasty. USS-guided AVF cannulation was also possible via the vascular lab if an AVF was proving difficult to cannulate in the haemodialysis unit.

Unit 5

A comprehensive surveillance programme was described by Unit 5. All patients with AVF underwent regular transonic scans during haemodialysis sessions, supplemented by routine, scheduled duplex ultrasound imaging in the vascular lab. Additional scans were arranged following any AVF interventions.

Vascular lab imaging was performed by a highly skilled operator who had a higher degree qualification along with substantial clinical and technical experience imaging AVF. Radiologists said this had largely replaced the need for diagnostic fistulography.

It was felt that the early identification and management of AVF problems had significantly reduced the number of patients in the prevalent haemodialysis cohort who required repeated surgical AVF fashioning procedures, or unscheduled hospital attendances for emergency de-clotting procedures.

Unit 6

RDU nurses performed clinical AVF assessment and regular transonic scans as part of routine haemodialysis patient care. Formal duplex ultrasound imaging could be requested by VAN, and appointments were said to usually be available within the week. Patients who had had an AVF fashioned, but had not yet commenced haemodialysis treatment, did not have regular AVF surveillance beyond the initial post-operative checks.

Unit 7

The main feature of surveillance was reported to be the monitoring of haemodialysis indices. Formal imaging was not normally requested without a clinical problem being apparent; but when such problems arose there were regular opportunities to discuss patients at the VA clinic or MDT meeting, and requests for imaging or IR tended to be readily accommodated.

Unit 8

Surveillance mostly took the form of informal observation by RDU staff during routine haemodialysis care. The nurses were not formally trained to assess AVF or AVG, there was no formal scheduling of surveillance activity, and no formal parameters for identifying or managing potential clinical problems.

Patients with suspected AVF problems could be referred to the VA clinic. Imaging was performed here by VAN, before discussion at the MDT meeting or direct referral for fistulography, fistuloplasty or a surgical procedure. It was reported that IR imaging and procedures often had waiting times exceeding several months, during which time it was common for patients to represent with AVF thrombosis. There was a strong sense throughout the team that most VA problems were predictable and preventable, but when patients presented with AVF thrombosis there was no capacity to deal with this as a medical emergency.

Clinicians were interested in the possibility of formalising surveillance and introducing a regular VA imaging programme. Some however worried this would compromise VA creation activity, by displacing patients from the same limited imaging resources.

Unit 9

RDU nurses assessed AVF at each haemodialysis session, and VAN performed four-monthly transonic measurements. It was said there was no capacity for formal duplex ultrasound imaging to investigate potential problems, and very limited access to IR or vascular surgery for intervention. This was considered a significant barrier to increasing AVF usage.

It was said that almost every clinical concern or question relating to patients' existing VA was directed to VAN; this generated an unmanageable clinical workload and distracted from other important aspects of the VAN role.

Normal post-operative AVF monitoring involved significantly more clinical contact than in other centres; VAN would assess new AVF three times per week in the fortnight following surgery, whether or not a patient was already attending the hospital for outpatient haemodialysis. As was described with the general surveillance programme in Unit 9 there were very limited resources available to intervene when problems were encountered during these postoperative checks.

Discussion

Several aspects of the described surveillance practices are helpfully contextualised by the socio-technical systems literature.

Clinicians' subjective opinions about the utility of surveillance may significantly influence local practice, including at the most basic level whether formal surveillance happens at all within the unit. Reason would characterise this decision making in the manner of 'source types', and arguably the variations in practice within and between centres as 'function types'. These together create some of the latent factors that could enable the generation of subsequent adverse events. Some would argue that consequential adverse events would include opportunity costs of surveillance, if the resources used for surveillance led to capacity problems elsewhere in the VA service. It is suggested that further clinical studies are required to ascertain the utility and value of VA surveillance, and to determine the intensity of such activity that provides the best balance of clinical outcomes relative to resource use.

Several of Cherns' (modified) sociotechnical system principles[178,207,208] are also illustrated in this data (table 21). These issues are considered in more detail in chapters 8-11. Chapter 7 describes the clinical activity associated with current VA services; this emphasises the 'system impact' of current VA creation, surveillance and maintenance practices as per the model described earlier in figure 4.

Information flow	Without regular MDT meetings it is more difficult to efficiently share information about potential VA problems between VAN, sonographers, nephrologists, surgeons and radiologists (see also chapter 5); Reference to an AVF intervention history when planning future interventions was associated with pro-active creation of new VA before existing strategies failed, and fewer unscheduled care episodes generated by failed access.
Power and authority	Functional MDT working enabled rapid intervention when clinical problems were detected (e.g. Unit 2 sonographer could liaise directly with a radiologist, rather than waiting for the next MDT meeting).
Support congruence	In units with the most ‘active’ surveillance programmes VAN and sonographers performed imaging studies; IR support corrected identified AVF problems; surgeons created new VA before existing strategies failed; and nephrologists maintained an overview of dialysis indices in the context of the patients’ overall care. The absence of any of these elements appeared to limit the potential of surveillance activities to contribute positively to AVF use.
Multifunction principle	Surveillance programmes increasingly require to accommodate patients with AVG, which had different (and uncertain) needs in terms of imaging frequency and actions resulting from abnormal results.

Table 21 Cherns’ principles applied to Vascular Access surveillance

Chapter 7: Clinical Activity Census

This study aims to delineate the structure, function and workload associated with VA services in Scotland. It seeks to illuminate gaps between ‘work-as-imagined’ and ‘work-as-done’, and to present recommendations for practice in a manner that facilitates ongoing QI work. The preceding chapters 3-6 have described the operational structure and function of VA creation and VA maintenance pathways. This chapter contextualises these findings by quantifying VA clinical workload, in the first reported clinical activity census of its kind. The methodology is described in chapter 2.

It is considered important to quantify clinical workload for several reasons. The data illustrates patient throughput using the pathways described in earlier chapters and facilitates benchmarking between centres. Does clinical activity correlate with incident and prevalent AVF use? This chapter also provides a baseline for further comparative work, and for others to consider the financial and other resource implications of running their VA service.

The collective chapters 3-7 set the scene for subsequent chapters that discuss the strategic issues influencing VA service performance, and their development needs.

Results

All nine adult renal units in Scotland provided data concerning every investigation and procedure related to VA creation or maintenance during the census period, which was Monday 26/01/2015 – Friday 06/03/2015 inclusive. Investigations and procedures that were requested or performed during the census period were recorded.

All units confirmed they had provided a complete dataset, except for Unit 5. Unfortunately, it was not possible to obtain this missing data. Most units struggled to record data relating to emergency hospital attendances and admissions related to VA, and this was felt to have been significantly under-reported.

In this six-week period 429 patients were noted to have undergone a total of 550 procedures, of which 118 procedures required an overnight stay of at least one day, and 331 procedures were undertaken as day cases.

A total of 150 surgical procedures and 400 radiology procedures were reported during the six-week clinical activity census period. The volume and activity varied by centre. There were considerably more TCVC-related than AVF-related procedures. Tables 22 and 23 present the surgical and IR procedures respectively.

Procedure/ Unit	1	2	3	4	5	6	7	8	9	Total
AVF Creation	6	3	5	5	7	2	17	23	4	**72**
AVF Ligation	0	0	0	1	0	0	1	4	0	**6**
AVF De-clotting	1	0	4	0	1	1	1	3	0	**11**
AVF Revision	4	3	1	0	0	2	9	7	0	**26**
AVF Maintenance	0	0	4	0	0	1	1	0	0	**6**
AVG Creation	1	1	3	0	2	1	1	4	0	**13**
AVG Ligation	0	0	1	0	0	0	0	0	0	**1**
AVG De-clotting	0	0	0	0	0	0	0	5	0	**5**
AVG Revision	0	1	0	0	0	0	0	0	0	**1**
AVG Maintenance	0	0	0	0	0	0	0	1	0	**1**
PD Catheter Insertion	0	0	1	3	3	0	0	0	0	**7**
PD Catheter Exchange	0	0	1	0	0	0	0	0	0	**1**
Total	**12**	**8**	**20**	**9**	**13**	**7**	**30**	**47**	**4**	**150**

Table 22 Surgical procedures by unit

150 surgical procedures were reported during the six-week clinical activity census period. There were considerably fewer surgical than radiology procedures (see table 23). (Note that unit 5 submitted an incomplete dataset.)

Procedure / Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
TCVC Insertion	5	7	5	5	10	0	14	34	4	**84**
TCVC Exchange	0	0	0	0	5	0	3	10	0	**18**
TCVC Removal	4	1	0	0	0	0	0	5	0	**10**
TCVC Declot/ Strip	0	1	0	0	0	0	1	0	0	**2**
NTCVC Insertion	0	0	8	1	1	0	5	8	4	**27**
AVF Fistulogram	0	6	6	0	4	1	0	4	4	**25**
AVF Fistuloplasty	3	7	0	0	0	0	7	3	8	**28**
AVF Fistulogram and Plasty	0	0	7	5	0	5	0	16	0	**33**
AVF Fistulogram, Plasty and Stent	0	0	0	0	1	0	0	2	0	**3**
Venogram	0	1	1	0	3	0	0	2	0	**7**
Lineogram	0	0	0	0	0	0	0	0	3	**3**
AVF Stent	0	2	0	0	0	0	0	0	0	**2**
Clinical Science USS	0	0	0	0	0	0	63	0	0	**63**
Departmental Duplex USS	0	24	1	0	0	26	0	25	0	**76**
Vein Mapping	0	6	0	0	0	3	0	10	0	**19**
Total	**12**	**55**	**28**	**11**	**24**	**35**	**93**	**119**	**23**	**400**

Table 23 Interventional radiology procedures by unit

400 interventional radiology procedures were reported during the six-week clinical activity census period. There were more TCVC-related than AVF-related procedures, and many more radiology than surgical procedures (see table 22). (Note that unit 5 submitted an incomplete dataset.)

The Scottish Renal Registry publishes the size of the haemodialysis and total RRT cohorts, respectively, from each renal unit[13]. These data are not reproduced here to avoid directly identifying units, given the sensitive nature of the semi-structured interviews. Nonetheless it has been possible to use these published cohort sizes to perform some analyses of the data to estimate annualised activity within each centre. Tables 24 and 25 respectively show these analyses for surgical procedures and IR investigations. The data are presented as the number of events recorded during the 6-week period 26/1/15 – 6/3/15 alongside the respective HD and RRT populations in that unit (from registry figures[13]). To facilitate comparisons between centres the ‘total procedures’ are then standardised as a value per 100 patients, and this is extrapolated from 6 weeks to 52 weeks, to provide an estimate of annual activity per 100 patients in each centre.

Unit	Total procedures	HD population	RRT population	Surgical Procedures / 100 HD patients / year	Surgical Procedures / 100 RRT patients / Year
1	21	137	310	132.85	58.71
2	17	92	252	160.14	58.47
3	33	217	535	131.80	53.46
4	15	148	292	87.84	44.52
5	29	186	422	135.13	59.56
6	7	54	130	112.35	46.67
7	30	283	780	91.87	33.33
8	104	602	1718	149.72	52.46
9	12	192	423	54.17	24.59

Table 24 Surgical procedures in proportion to the haemodialysis and renal replacement therapy cohort sizes, by unit

'HD population' and 'RRT population' are taken from published registry figures[13]*. 'HD population' includes all patients from a given centre who undergo hospital haemodialysis or home haemodialysis, while 'RRT population' includes all patients from a given centre who undergo hospital haemodialysis, home haemodialysis, peritoneal dialysis, or who have a functioning renal transplant. 'Surgical procedures / 100 HD patients / year' = ((Total Procedures / (HD population / 100)) / 6) x 52; 'Surgical procedures / 100 RRT patients / year' = ((Total Procedures / (RRT population / 100)) / 6) x 52*

Unit	Total Investigations	HD population	RRT population	Interventional Radiology Investigations / 100 HD patients / year	Interventional Radiology Investigations / 100 RRT patients / Year
1	3	137	310	18.98	8.39
2	46	92	252	433.33	158.20
3	15	217	535	59.91	24.30
4	5	148	292	29.28	14.84
5	8	186	422	37.28	16.43
6	35	54	130	561.73	233.33
7	70	283	780	214.37	77.78
8	62	602	1718	89.26	31.28
9	15	192	423	67.71	30.73

Table 25 Interventional radiology procedures in proportion to the haemodialysis and renal replacement therapy cohort sizes, by unit

'HD population' and 'RRT population' are taken from published registry figures[13]*. 'HD population' includes all patients from a given centre who undergo hospital haemodialysis or home haemodialysis, while 'RRT population' includes all patients from a given centre who undergo hospital haemodialysis, home haemodialysis, peritoneal dialysis, or who have a functioning renal transplant. 'Interventional Radiology Investigations / 100 HD patients / year' = ((Total Investigations / (HD population / 100)) / 6) x 52; 'Interventional Radiology Investigations / 100 RRT patients / year' = ((Total Investigations / (RRT population / 100)) / 6) x 52*

The data suggested some variation between centres as to the number of VA surgical procedures performed, but this was largely proportional to cohort size with correlation co-efficients 0.96 (annual procedures vs HD population) and 0.96 (annual procedures vs RRT population) (figure 10).

There was significant variation in IR investigations by centre that wasn't proportional to the cohort size. Correlation co-efficients were 0.52 (annual procedures vs HD population) and 0.59 (annual procedures vs RRT population). This may have been skewed by the incomplete dataset provided by unit 5, or by variable TCVC use between centres (figure 11).

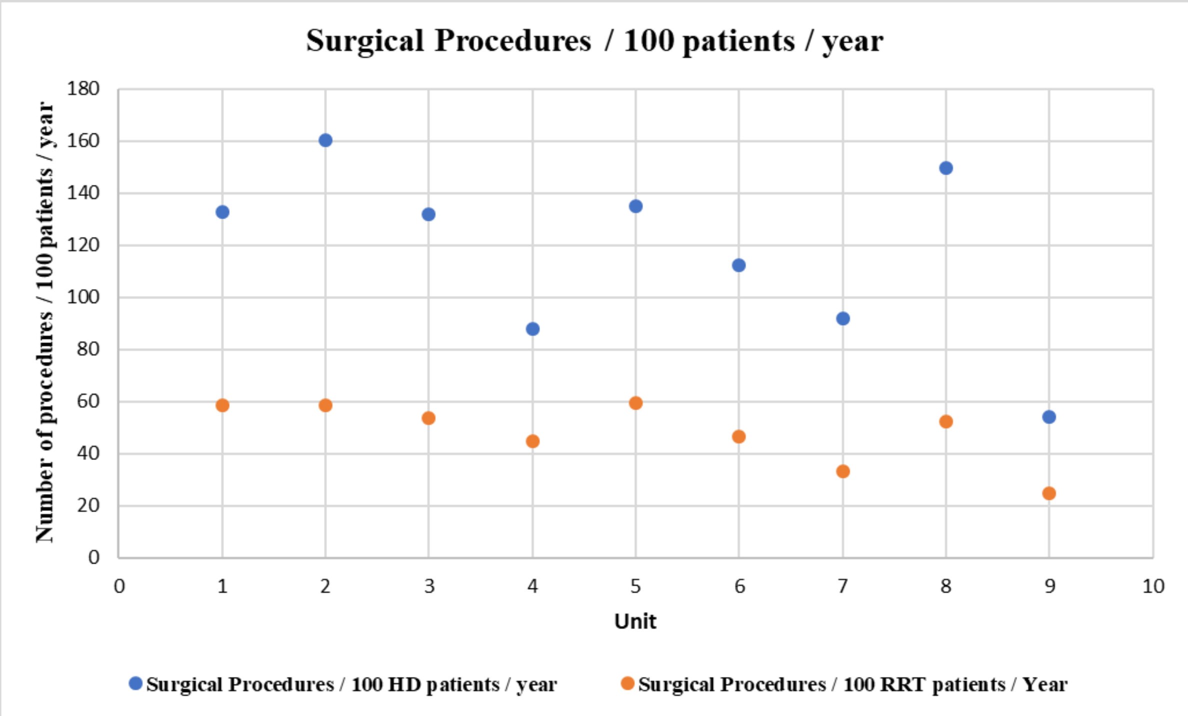

Figure 10 Scattergram: surgical procedures / 100 patients / year, by unit

Correlation coefficient for surgical procedures / 100 HD patients / year = 0.96; correlation coefficient for surgical procedures / 100 RRT patients / year = 0.96

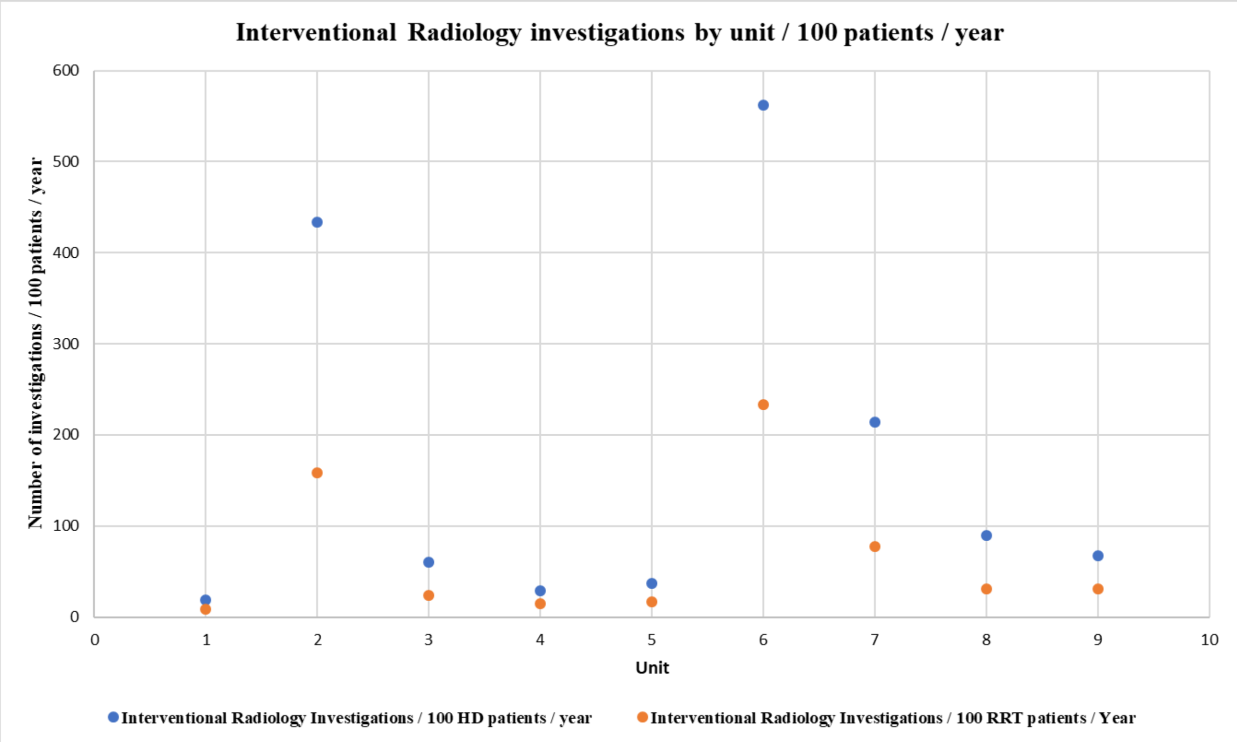

Figure 11 Scattergram: interventional radiology investigations / 100 patients / year, by unit

Correlation coefficient for interventional radiology investigations / 100 HD patients / year = 0.52; correlation coefficient for interventional radiology investigations / 100 RRT patients / year = 0.59

Eighteen unscheduled hospital admissions and 26 unscheduled day case hospital attendances were reported during the six weeks, with significant variation between centres. In some cases, the need for admission and prompt for the VA procedure may have been the same, for example in the case of a bleeding AVF. In others it may have been easier to facilitate an IR or surgical procedure as an inpatient rather than as an outpatient. Table 26 describes these data.

Eight ‘unexpected events’ were also logged during the six-week period. These are described in table 27. These data were originally collected in an effort to understand whether the reported activity was ‘atypical’ due to disruption to services. It was apparent that major service disruption was relatively common.

Unit	Day Cases	Admission
1	Pus from needle site Blocked TCVC	SAB associated with AVF (x3) Blocked TCVC (x4)
2		Steal syndrome
3		Stenosed fistula Blocked TCVC
6	New AVF with no thrill or bruit	Ruptured AVF
7		Thrombosed AVF
8	Blown fistula HD post fistuloplasty Blocked TCVC (x2) Blister at TCVC site Unsecured TCVC AVF swelling (x2) AVG Haematoma AVG swelling Wound at TCVC exit site TCVC replacement (x2) AVG infection (x3) AVF review (x3) Steal syndrome Aneurysmal AVF (x2) Possible AVG infection	Thrombosed AVF (x2) Aneurysmal AVF Blocked TCVC Steal syndrome Failed fistuloplasty

Table 26 Reasons for day area attendance and admission, by unit

Forty-four VA emergencies were recorded during the six-week activity census period. Twenty-six of these patients were assessed and managed via a day area, while 18 required hospital admission. It was not possible to distinguish between patients who were admitted because of their VA problem, or who were already inpatients for other reasons. The data is understood to significantly underreport the number of emergency presentations, and no data was supplied by units 4, 5 or 9; the actual number of attendances and admissions may be significantly higher.

Unit	**Unexpected Events**
Unit 1	Theatre list cancelled as surgeon on call
Unit 2	VAN on long term sick leave
Unit 3	Vascular scanner broken All Vascular Access clinics cancelled for month of March
Unit 8	No sonographer available for booked Vascular Access ultrasound list (2 occasions) Patient's AVG surveillance appointment changed, but patient not informed; patient attended on original date
Unit 9	AVF Creation cancelled as no surgeon available Patient cancelled planned AVF creation

Table 27 Unexpected events logged by unit

Eight 'unexpected events' were logged during the six-week period. Some were issues that limited the ability of the service to function, while others reflected morbidity or critical incidents associated with a specific patient's Vascular Access or procedure. (No data was supplied by units 4, 5, 6, 7.)

It was possible to estimate the waiting time for investigations and procedures in each unit. Variable information was provided about each request; where a full dataset was available the information included the date of request, date of being added to the waiting list, and date of investigation or procedure as appropriate. Investigations or procedures with no waiting time data, or that were requested but not performed during the census period, were not included. Tables 28 and 29 show these data for surgical and IR procedures respectively.

Unit	Number of procedures	Median waiting time: referral to surgery (days)	Median waiting time: listing to surgery (days)	Range: referral to surgery (days)	Range: listing to surgery (days)
1	12	39	26	0-204	1-75
2	8	21.5	21.5	1-145	1-145
3	20	10	1.5	0-272	0-29
4	9	41	32	13-129	12-96
5	13	102	66	1-788	0-649
6	7	3	3	0-115	0-35
7	30	41	22	1-384	0-168
8	47	91	49.5	9-290	5-86
9	4	36.5	6.5	13-54	3-39

Table 28 Waiting times for surgery, by centre

It was apparent that waiting times for surgical procedures were highly variable within and between centres. The waiting time was often excessive and potentially clinically inappropriate in the context of VA creation and maintenance. Values are expressed as number of days waiting. Only procedures that were performed during the 6 week period 26/1/15 – 6/3/15 (inclusive) are included in this analysis; procedures requested during this period, but not carried out, are excluded.

Unit	Number of procedures	Median waiting time: referral to procedure (days)	Median waiting time: listing to procedure (days)	Range: referral to procedure (days)	Range: listing to procedure (days)
1	12	13	5.5	1-25	1-101
2	55	2	16	1-3	0-390
3	28	3.5	1	0-10	0-35
4	11	(no data)	22	(no data)	7-83
5	24	5	3	0-35	0-34
6	35	(no data)	13	(no data)	0-68
7	70	(no data)	19	(no data)	0-63
8	119	3	20	0-19	0-170
9	23	2	14	0-12	0-35

Table 29 Waiting times for interventional radiology procedures, by centre

It was apparent that waiting times for IR procedures were highly variable within and between centres. The waiting time was often excessive and potentially clinically inappropriate in the context of VA creation and maintenance. Values are expressed as number of days waiting. Only procedures that were performed during the 6 week period 26/1/15 – 6/3/15 (inclusive) are included in this analysis; procedures requested during this period, but not carried out, are excluded. Incomplete data was available for units 4, 6 and 7.

Discussion

These data represent the first reported clinical activity census for haemodialysis VA in Scotland. A substantial workload is demonstrated with significant variation between sites in both the volume and nature of the work.

The data suggests surgical workloads are broadly proportional to the haemodialysis and RRT cohort size, whereas only around half the variation in IR workload is explained by the haemodialysis cohort size. Most variation in IR workload relates to the overall RRT cohort size, likely a function of the procedures required to maintain large numbers of patients on TCVC (e.g. TCVC insertion, imaging and intervention related to central venous stenosis).

These data may reflect the existence of protected slots for surgical procedures in most centres, and the lack of protected IR slots for VA work. In the absence of designated slots clinical activity may vary depending upon competing demands elsewhere in the hospital, referral patterns, and operator willingness to take on what is effectively 'unpaid' VA work.

It is clear that significant numbers of procedures are being performed to create, maintain and revise VA. The data demonstrate substantial waiting times from initial referral to having procedures performed, with significant delays between referral, listing and the eventual procedure. Some of these delays may be clinically deliberate, for example postponing planned AVF creation in view of apparent stabilisation of renal function. Intercurrent illness may also have caused delays, for example deferral of AVG insertion in the context of a sepsis episode. It seems implausible however that these explanations account for the majority of delays documented above.

The data collection strategy employed here has several advantages. Data collected by local VANs was likely to be accurate given that their jobs are concerned with the coordination of such clinical activity. It is apparent they are the clinicians in the VA team most likely to have knowledge of such referrals and procedures, including any managed outside the usual referral pathway within the centre. A six-week period of data collection outside of major holiday periods, and at a time of year without significant risk of adverse weather, is likely to provide at least an indicative snapshot of the 'business as usual' clinical workload. Collecting data concurrently in each centre enabled fair comparison to be made.

There are also limitations to collecting data in this way. One centre's dataset was acknowledged to be incomplete; it is possible that other parts of the dataset are incomplete, which may underestimate the workload and/or proportions of investigations and procedures by each centre. This data was not routinely collected outside of this exercise, and procedures may have been incorrectly recorded by local data collectors or coded wrongly during amalgamation with other centres' data. The investigation or procedure performed may have differed from what was initially requested, and this may not have been reflected in the submitted dataset. A significant volume of data relating to referral and procedure dates was missing, which could have influenced the accuracy of apparent waiting times.

Despite these potential disadvantages, these data suggest significant variation in waiting times for VA procedures across Scotland. Surgical workload seems proportional to RRT cohort size, yet registry figures[8] suggest this volume of work is insufficient, given the consistently low proportions of patients who begin and remain on haemodialysis treatment with AVF or AVG. Wide variation is also seen with IR procedures, possibly reflecting local clinicians' interest and capacity to perform procedures. It is hypothesised that the provision of designated IR resources for VA could enable more robust AVF and AVG maintenance, positively impacting on incident and prevalent AVF and AVG use.

This clinical census exercise has illuminated the 'system impact' of maintaining VA services in the configurations described in chapters 3 and 5. There would be merit in periodically repeating this clinical activity census, or tracking such clinical activity in real time, for several reasons. First, the dataset provides an estimate of clinical activity across Scotland. This is helpful for individual centres and could facilitate regional or national collaboration to share the workload, managing peaks and troughs in demand. Next, it enables units to anticipate the likely interventional capacity required to accommodate different proportions of patients using AVF and AVG within their centre. Finally, it allows boards to document the workload associated with this relatively niche area of clinical practise, which should facilitate better provision of designated clinical time with which to perform VA procedures. Recognition of the clinical workload should also prompt discussions about the measurement of procedural outcomes, alongside the morbidity and mortality associated with individual procedures and the VA service in general.

Chapter 8: System Performance

This study seeks to understand variation in AVF use across Scottish renal units. The aims are to delineate the structure, function and workload in each VA service, to highlight inconsistencies between ‘work-as-imagined’ and ‘work-as-done’, and to present recommendations for practice to the clinical community in a manner that facilitates ongoing QI in this area.

Chapters 1 and 2 respectively introduced the study context and methodology. Chapters 3 and 5 respectively related the structure and function of VA creation and maintenance pathways from an ‘operational’ perspective, based upon thematic analysis of interview transcripts (see chapter 2). Chapter 4 considered whether clinicians’ opinions influenced their use of different VA modalities, relating this to published models of variation and the impact of ‘consensus’ on sociotechnical system function[143,178,186]. Chapter 6 explored variations in VA surveillance practice, which the thematic analysis had suggested as a potential influence on VA maintenance activity. Chapter 7 concluded the operational analysis of VA services by quantifying clinical activity through the pathways over a six-week census period.

This chapter takes a strategic view of VA service performance. Earlier chapters have described *how* VA services are structured and their function; this chapter addresses findings from the thematic analysis that could explain *why* services are configured, and operate, as described. It draws upon Cherns’ work describing sociotechnical system function[178,207,208,210], and Reason’s work around types and tokens. It considers strategic elements of VA services in relation to system performance: service context; the allocation of clinical time; scheduling and tracking of clinical activity; and measures of process and outcome. This chapter considers these strategic challenges around system performance arising from the thematic analysis; the subsequent chapter 9 discusses VA services’ development needs identified through thematic analysis. Together these chapters lead into the development of recommendations for practice.

Service Context

Each renal unit can be considered a product of history, local health service configuration, and the various improvement activities that have taken place at local, regional and national levels.

This section discusses the context of each VA service, focusing upon events attributed by clinicians to generating the unit's current position (table 30).

Unit	Contextual factors	Changes instituted	Transcript data
1	VA pathway bottlenecks Patients dialysing with TCVC without attempts to create AVF Haphazard referrals to VA service	Education programme VAN trained in ultrasound imaging techniques Standardised referral form	*“Patients sitting with catheters for a long, long time and not being addressed. There was an acute education programme set up for that reason.”* (Vascular Access Nurse) *“I have taken responsibility for some of the things like education of the staff and you know teaching cannulation skills, teaching them like, the Vascular Access Nurse the scanning skills so that we don’t have to wait for duplex scans, things like that.”* (Associate Specialist Nephrologist) *“There is a referral form which is [completed] ... I put it on [EHR] ... it was so haphazard that I was trying to streamline that a little bit”* (Associate Specialist Nephrologist
2	Recognition of MDT meeting value Strong team function	Annual service review meeting Regular MDT meetings with wide stakeholder involvement	*“Well the [MDT] meetings started off with just a vascular surgeon, a nephrologists and myself. Expanding to include the sonographers, the interventional radiologists was a huge, huge change … we have a yearly Vascular Access service meeting, so if there is anything we feel we want to take forward, which is like joining [national EHR].”* (Vascular Access Nurse) *“When I came it was just something I sort of took on. I didn’t realise actually, when I got here, that it hadn’t happened before. I just sort of – they just told me there’s a Renal/Vascular MDT so I used to turn up and do it. And it’s just grown into the role”* (Consultant Radiologist)
3	Sense of competition with other centres	Utilisation of vacant theatre slots for VA work	*“We never thought we could get over 90% and it is only when the Japanese did it that it upset [surgeon]: he said well we should have a shot at that and so we started going for*

	Recognised importance of maintaining secondary patency Historical strong working relationship between nephrology and surgery	Aggressive efforts to salvage thrombosed AVF	*it and he took over extra lists and you know it was hard getting it up there!"* (Vascular Access Coordinator) *"We were doing transplants and things initially so we were two wards down from the vascular surgeons so we were up and down there all the time and the relationship is crucial."* (Vascular Access Coordinator)
4	High bacteraemia rates	Working alongside microbiology colleagues to reduce infection rates	*"We have got very interested microbiologists … with their help and us putting in place bundles … we have managed to get, I think this might actually be our fifth month with no bacteraemias."* (Consultant Nephrologist)
5	Staffing crisis in neighbouring health board High proportion of patients dying with unused AVF	Joint working between health boards to improve capacity Development of conservative care programme	*"In the past when [neighbouring unit] lost their radiologist… [these] patients were coming here… and in fact they are now on a vascular network between here and [neighbouring unit] and they do some cross cover for emergencies and elective stuff."* (Consultant Nephrologist) *"We now have about 25% of our low clearance clinic population choosing supportive care … we're not placing fistulas in the … elderly or population that thought they might want it and then when dialysis comes they actually don't [want it]"* (Vascular Access Nurse)
6	Reliance upon visiting radiologist from another board	Surgeons trained as interventional radiologists	*"We used to have somebody come from [neighbouring unit] but he decided to go to [elsewhere]… we found somebody in Ireland that would train us [in interventional radiology]; so we persuaded the Health Board to hire a locum for a year [to enable us to do so]"* (Consultant Surgeon)

7	Relatively slow approach to managing failed AVF Recognition of redundant steps in VA creation pathway Lack of funding for capital investment	More aggressive joint surgical / radiological interventions for thrombosed AVF VAN was empowered to list patients directly for AVF surgery based upon her sole assessment Introduction of VAN secondment programme Use of endowment funds for capital investments	*"I think there's been a stepwise improvement in… the way that we deal with [failed AVF] …. down to communication and particularly with the surgeons … expedient treatment, both you know surgical and to [radiologically] delineate the cause of the underlying thrombosis; … I think that has certainly been… a sea change I've experienced"* (Consultant Radiologist) *"The idea is to get … a junior nurse who will come around for a period of about 6 – 12 months, who can learn obviously from me and my colleagues and then would back and share her knowledge with the dialysis staff"* (Vascular Access Nurse)
8	Straightforward access to transplantation may reduce the pool of patients requiring haemodialysis to those with less adequate veins Historical amalgamation of two units into a single unit, without maintaining proportional staffing and procedure slot numbers	Consideration of using same mindset for AVF as for transplant Business case developed for specific sonographer training in AVF imaging Attempts to 'optimise' working with a single VAN as a consistent point of contact	*"One thing that has improved things is our pre-emptive transplant … [but] that can remove the … and the easier proportion [for creating AVF]."* (Consultant Nephrologist) *"We've … never cancelled a live donor transplant. We've cancelled many, many fistulas and people need to be thinking that, under many circumstances, a fistula is as lifesaving, or a graft, is as lifesaving as live donor transplant."* (Consultant Nephrologist) *"I've recently been very fortunate, I can probably give more information as to the [VA] process now because I have just done a secondment with [VAN]"* (RDU Nurse)

		Use of VAN secondment programme to effectively increase VAN capacity	
9	High bacteraemia rates Skin irritation from soaps within the RDU, which may have contributed to infection rates Previous co-location of nephrology, surgery and radiology had enabled team working	New processes for AVF preparation for haemodialysis sessions, including patients in the process. Investigation of products used in the RDU to eliminate potential sources of infection risk.	*"We did a lot of work…we started to look at our processes and how we cleaned lines"; "We changed the whole process. We're [doing] the same steps but we do them in a different way. We do them thoroughly."; "We gave every patient a letter, we told the patient what we had to do [to clean AVF before haemodialysis]."* (Vascular Access Nurse) *"We found that some of our soaps are perfumed, which they shouldn't be and patients were starting to get reactions and itching and things."* (Vascular Access Nurse) *"I was on site 5 days a week. Then … [surgery and radiology] moved back to [another campus] … They had day to day contact and I learned a lot around renal access and nephrology that I hadn't appreciated before."* (Consultant Radiologist)

Table 30 Contextual factors by unit

Unit 1

The Unit 1 team reported making changes in response to awareness of clinical pathway bottlenecks. VAN undertook training in duplex ultrasound scanning to reduce lengthy waiting times. A one-stop clinic staffed by a VAN and surgeon was being set up to reduce the need for multiple clinic appointments about VA creation. In recognition of the high proportion of patients who presented late (and therefore missed the usual pre-dialysis education programme delivered via the outpatient clinic setting) an acute education programme was developed specifically for this patient group.

While there was no formal 'lead VA nephrologist', one found himself the de facto lead because his office was located close to the haemodialysis unit, and he was therefore regularly asked about VA issues. He introduced a standardised access referral form in an effort to streamline what he considered a haphazard referral process. He had overcome initial resistance from colleagues using this form by instituting a policy of only accepting VA referrals conveyed using this form.

Unit 2

Unit 2 was unique in holding an annual, formal review of the VA service. This was said to provide a useful forum for strategic discussion and was credited with facilitating moves towards more effective use of an electronic health record system.

The establishment of a weekly MDT meeting was lauded as the key element in the unit's consistently good performance regarding incident and prevalent AVF rates. This had evolved from a series of ad hoc meetings between the nephrologist and surgeon into a formal meeting with broad specialty representation (including sonographers), a formal agenda, and detailed record keeping in relation to AVF interventions. Each of these elements was said to contribute to the unit's success.

Strong team working was also credited with success. It was recognised that each team participated in a manner that minimised 'waste' elsewhere in the service: for example, IR recognised their willingness to place occasional TCVCs meant surgical slots were not ‘wasted’ on this purpose. The surgeons were mindful that regular MDT discussions and a policy of early, aggressive intervention for clinical problems had substantially reduced unscheduled VA care. The efficient MDT had also enabled surgeons to remove the pre-operative clinic visit, which reduced their overall time commitment to the VA service.

Unit 3

In Unit 3 it was reported that the primary driver to improve the service was a sense of competition with other centres. Local surgeons aspired to equal or exceed reportedly high proportions of incident and prevalent AVF use in Japan (historically). Various strategies were described for achieving this, including the utilisation of vacant theatre slots, and an enthusiasm for salvage procedures when a patient presented with a clotted AVF.

They actively sought out vacant operating theatre slots, for example when a surgeon was on leave and the theatre nursing team and anaesthetics staff were otherwise available. These slots would then be used to perform additional VA procedures, often at relatively short notice. They also recognised the importance of secondary AVF patency to maintain high prevalent AVF use, so took an aggressive approach to de-clotting thrombosed AVF.

Various aspects of teamworking were also credited with their VA successes. A good working relationship existed between local nephrologists and vascular surgeons, attributed to their historical transplant centre status. The VA coordinator's unique perspective was also considered highly influential in their success: her background differed from every other VA coordinator as she was a doctor rather than a nurse; her clinical training also contrasted with that of most other nephrologists, since she originally trained in psychiatry and general practice before working in renal medicine. All interviewees from the unit considered her highly skilled at coordinating clinical services and fostering a team approach. She reported success using clinical audit and data presentation to engage colleagues with the VA service.

Unit 4

Discussions about historical service context here focused around efforts to improve VA-associated bacteraemia. Successes in this regard were attributed to ongoing clinical audit, data-driven improvements in clinical processes, and engagement with key external stakeholder groups including microbiology and infection control teams.

Unit 5

Various improvement drivers were reported by clinicians, including clinical audit, networking with neighbouring health boards in the context of staffing crises, and innovative approaches to releasing effective clinical time for IR and vascular surgery.

It was said to be common historically for patients to be referred for AVF creation, but not to go on and receive haemodialysis treatment. Clinical audit had demonstrated this problem and had led ultimately to the development of a conservative care programme.

A robust approach to AVF creation and maintenance was partly attributed to joint working with clinicians from a neighbouring health board, which had been prompted by a staffing crisis in the other board. Surgeons considered that this process had brought together a group of radiologists with a collective interest in renal VA. They had also found success in negotiating with management to reserve 'urgent' theatre slots for AVF cases; previously when lists had been designated 'routine' they were unable to find slots within a clinically appropriate timeframe for AVF cases.

Unit 6

The major historical difficulty was the lack of on-site IR support. They had previously relied upon a infrequently visiting radiologist from another health board. Two vascular surgeons underwent formal endovascular IR training to mitigate this problem. This had required a considerable financial investment by the Board and substantial effort on the part of the two individual surgeons. When they launched the surgical IR service they found colleagues were reluctant to complete the appropriate referral paperwork (to comply with radiation legislation), but similarly to Unit 1, they had successfully instigated a policy of only accepting referrals that used the approved paperwork and process.

Unit 7

Clinicians reported that their recruitment of radiologists with an interest in VA had facilitated increased AVF maintenance activity. Surgeons felt better supported by a more proactive IR team, and reported that this made them more willing to consider complex or higher risk cases.

Nephrologists credit engaged clinical and non-clinical managers, and their investment in a comprehensive VAN team, with much success. Having several VANs had enabled them to function optimally without having an overwhelming workload. In common with other centres, the lead VAN had been recruited from another clinical discipline (vascular surgery); this was felt to provide useful alternative perspectives on VA processes, in comparison with more traditional 'renal' views. She had introduced a 'VAN secondment' programme to foster RDU awareness of VA problems; this was widely regarded as a successful project.

Surgeons had removed their usual clinic review before AVF surgery, having observed the VAN team’s abilities and in discussion with colleagues in other centres. This released additional clinical time and substantially reduced theatre waiting times for patients.

There was little formal audit of the VA service, but there was enthusiasm to change systems to improve clinical outcomes. For example, a postoperative review clinic had been established in an effort to enhance AVF maturation. Similarly, there had previously been a coordinated 'sweep' of all outpatient haemodialysis units seeking to identify patients dialysing with TCVC, for whom AVF could be a viable option.

It was reported that endowment funds were regularly used whenever capital investment was required in the service, for example to purchase an ultrasound machine for the VA clinic.

Unit 8

Nephrologists in Unit 8 felt their VA figures were inadvertently disadvantaged by having easy access to transplantation. They considered that most relatively fit patients received renal transplants within short waiting times, hence only the frailer and more technically challenging patients required ongoing haemodialysis VA. They thought other centres might have higher proportions of 'healthier' patients receiving haemodialysis treatment, who would potentially have already been transplanted in Unit 8.

Nephrologists, VAN and surgeons all felt that VA surgery was becoming more technically complex, perhaps as a function of the haemodialysis cohort having fewer ‘straightforward’ patients, as above. There was admiration for the technical skill and tenacity of surgeons in pursuing an AVF or AVG despite technical difficulties in some challenging patients.

A recently established VA fellowship post was considered hugely beneficial, particularly by nurses. This provided a single point of contact for VA surgical review, ensuring patients with VA problems had access to an interested clinician who could rapidly make decisions. There was concern about succession planning for this post beyond the incumbent post holder.

The radiology department reported a heavy pressure on their service to perform VA imaging studies. They recognised that significant volumes of clinical IR time was used for duplex scanning (in the absence of an adequately trained sonographer), reducing the available time for 'radiologist only' procedures like fistulograms and fistuloplasty. This was particularly problematic due to the recent increase in AVG use following an in-house clinical trial; these patients had more intensive imaging requirements than the equivalent patients using AVF. A business case was being drafted to create new sonographer posts to manage this problem. It was noted in Unit 8 and elsewhere that there was no recognised means of training sonographers in the subspecialty of VA imaging, and this obstructed service development.

The service in Unit 8 had historically existed as two separate 'north' and 'south' clinical units. It was reported that, before the units amalgamated, some surgical theatre slots were informally reserved for VA work; some of these had been lost when the units merged on to one hospital site. Staffing ratios and clinical slots for VA had not been specifically addressed when the units merged, meaning there was now one VAN left to manage the combined patient cohort. This seemed to be a disproportionately high workload in comparison with the equivalent arrangements in other centres. It was felt that having a single VAN did carry some benefit as she was the single and consistent contact point for all VA related enquiries.

Unit 9

The Unit 9 service had utilised government targets around SAB episode reduction to frame the overall need to improve their VA offering. A pragmatic approach was described, largely attributed to the non-renal (emergency department) background of the VAN. Simple interventions had brought great success: these included purchasing large clocks for RDU to facilitate adequate AVF washing time before use, and an investigation of soaps used for washing AVF that identified an undeclared perfume ingredient causing skin irritation.

They credited their efforts to empower patients and to engage with clinical and senior managers, with previous successes. They considered that a VAN secondment programme for

RDU nurses had been highly successful in improving awareness and skill level in relation to VA problems among the RDU staff.

The power of team working was also recognised, particularly by the radiologists. They noted that a previous service configuration had allowed radiology and nephrology teams to work in close proximity, before a reorganisation (separate from VA) moved the IR service to another hospital campus. It was felt that more frequent personal contact between clinicians had been useful to facilitate clinical decision making in challenging VA cases.

Geographical influence

Having considered the historical context of VA provision, this section discusses the geographical context of services, including those serving remote and rural communities, those with larger and smaller catchments, and the national paediatric renal unit serving the whole of Scotland from a single unit.

In general, the data suggest that geography is mostly a problem for VA services when elements of the VA service for one unit are physically separated from one another. This caused difficulties bringing the clinical teams together, and it was notable that no centres regularly used telemedicine (or equivalent) to facilitate clinical, MDT or service strategy meetings. Centres serving large catchment populations, or covering broad geographical areas, or remote and rural areas, did not consider that their territorial geography posed a significant problem. Rural areas did consider their patients were hospitalised for logistical reasons more often than in other centres, but this was not considered a barrier to providing adequate care. (Table 31.)

Unit	Transcript data
1	*"So, the interventional radiologists providing a service are [name] and [name]. But sadly, that is an outside service down at [another campus] which is one of the issues."* (Consultant Surgeon)
2	*"It's one of the difficulties working in such a rural community. You know, even the guys from [rural area], they can take 4 hours to get here. [Other rural area] the same, and that's in the summer. Or maybe a day to get here, a lot of them. So, one of the problems we have with fistuloplasties is that - in the afternoons - is transport. It's getting the folk back to wherever they've come from after a fistuloplasty. So sometimes they have to get admitted if there's a problem [with transport]."* (Consultant Radiologist)
3	*"Obviously having everything on one site makes things geographically much easier, it'd be more challenging without that."* (Consultant Nephrologist)
4	*"Usually [VA work is] all [done] here. So out of hours or if there's holiday cover things then sometimes patients will go up to [neighbouring unit]. Mostly it gets done here."* (Consultant Nephrologist)
5	*"We have low clearance in [peripheral and central sites] and our consultants and registrars and nurses go out to the clinics from here and see the more rural patients and we also offer education at home so a nurse goes out to the patient's home and will see family members."* (Vascular Access Nurse)
6	*"It's really good having everything in proximity. I mean we've got the renal unit there, you've got us, [surgeon]'s office is right beside this and the vascular lab is 20 metres that way so it's all very close together."* (Consultant Surgeon)
7	*"The trouble is that nobody wants to go [to peripheral hospital] and that's the issue we have. But it's funny, the patients that are in [remote areas] will travel … they haven't got an issue at all."* (Vascular Access Nurse)
8	*"Obviously there's one dialysis unit on site; the rest are [very far away]. I never get around them"* (Vascular Access Nurse) *"One of the problems we have [here] compared with a lot of big centres is we don't have a central dialysis hub. It's not a hub and spoke model it's a model of scattered small units. That sort of surprised me when I came up here for pre-interview visit."* (Consultant Surgeon)

	"The renal service is regional in [this unit], but the interventional radiology service is not, so that's part of the issue where the capacity is at, and I am very aware that there are [radiology] units around the [catchment] who don't provide fairly basic imaging support for fistula." (Consultant Radiologist)
9	*"We are a two-centred area: [radiologist] tends to do fistulograms here but then they've got to go [to another campus] for a fistuloplasty. I can't get it……there's no intervention done [here]. I can get a line, I can get a line stripping done here and… I can get a dialysis line put in but I can get no intervention done here because we don't have any Vascular Access surgeons here. … Within probably the last 2 years I've had patients that have waited up to 6 months by the time they'd got a fistula done and then a fistuloplasty."* (Vascular Access Nurse) *"It's very difficult when you've got to travel. It can take you, at 9 o'clock in the morning, the best part of an hour and ten minutes to travel here. And should that influence your decision making? No. But does it? Of course it does. I am sitting here today thinking if I don't get away from here today round about 4.30 it will take me an extra three quarters of an hour to get home and that's just a fact of life. So hopefully that answers that question."* (Consultant Interventional Radiologist)
10 (Paediatrics)	*"Particularly for patients who require only haemodialysis, then they have to not only, travel some families have to relocate. We've had families who've needed to relocate from… anywhere around Scotland. That's a major undertaking for a family." (Consultant Nephrologist)*

Table 31 Geographical influences on service provision

Unit 1

The Unit 1 team cite the non-colocation of nephrology, vascular surgery and interventional radiology as a key problem. It was apparent that VAN spent a considerable proportion of her clinical time coordinating logistical matters arising from the need to transfer patients between sites. The lack of physical proximity was also seen as a barrier to swift decision making and problem resolution.

Unit 2

The satellite RDUs serving Unit 2 were very remote from the main unit, limiting VAN's ability to visit more than twice per year. Clinicians in the unit felt that rural patients perhaps encountered more AVF problems than those attending the main unit, but this had not been formally audited.

In an effort to minimise patients' time in hospital, efforts would be made to create or maintain AVF for rural patients when they were in hospital for other reasons, and this meant they would sometimes not benefit from formal discussion at the MDT meeting, that other patients would have.

The hospital had a formal policy for accommodating patients who attended from rural areas for IR procedures but whose transport home was then unavailable. This was said to prevent cancelled procedures simply on the basis of where the patient lived.

Patients who lived in the very remote areas of the catchment did not have haemodialysis as a treatment option in view of the logistics that would be involved. PD was offered to these patients instead.

Unit 3

In Unit 3 patients are brought to the main centre in the event of a VA clinical problem. While this creates some inconvenience for the patient, the distances are not seen as a barrier to providing care. For more routine queries they correspond by email or telemedicine with peripheral RDUs. Attempts are made to feedback to peripheral staff about outcome of clinical problems as a means of educationally engaging with them across a remote area.

Unit 3 also provides renal services for two rural health boards. Patients who live in one rural health board area are seen by a visiting nephrologist who flies there on a regular basis, while those living in the other rural health board area are flown to the main hospital for routine consultations. This is largely dependent upon the service-level agreement. Patients from very remote areas were said to have disproportionately long hospital admissions, for example requiring overnight accommodation after late procedures where they could otherwise have travelled home.

Co-location of nephrology, vascular surgery and interventional radiology was cited as a key reason for their service appearing to function so well.

Unit 5

The Unit 5 team held outreach clinics in peripheral clinics in an effort to reduce inconvenience to their patients in remote areas. Efforts were made to provide care on an equitable basis, for example those in rural areas would still have home visits for pre-dialysis patient education.

Unit 6

Most of the catchment area served by Unit 6 is remote and rural. When patients from outlying areas required to be admitted this did cause inconvenience in relation to transport arrangements, but geography was not described as a barrier to providing care.

Unit 7

Patients were said to often be reluctant to travel to peripheral centres for elective AVF procedures. This was sometimes challenging as more procedure slots were available in the peripheral centre. Emergency cases were also less likely to displace scheduled procedures in the peripheral centre, whereas this was a common problem in the central hospital. Patients who lived in rural areas tended to be more amenable to travelling further distances for clinical interventions.

Correspondence with peripheral units was usually done by email. It was noted that geographical distance was a barrier to MDT meeting attendance for some team members. They had not considered using telemedicine to manage this problem.

Unit 8

The large number of peripheral RDUs in Unit 8 created difficulties for the solo VAN to adequately cover staff and patients attending each centre, in addition to managing new patients and inpatient problems. The historical service configuration was also a challenge: nephrology had become a regional service covering the whole health board area (which itself represented an amalgamation of several older health boards); however, the IR service on the hospital campus where the renal unit was situated was resourced only for the equivalent nominal catchment area of that hospital. IR perceived that this meant they received requests for interventional procedures that were grossly disproportional to local capacity.

Unit 9

The lack of nephrology, vascular surgery and IR co-location was cited as the biggest problem affecting the service. This caused difficulties discussing patients and scheduling procedures, and patients were often reluctant to travel between sites for procedures. The lack of on-site surgery made it difficult to have VA problems in the RDU assessed and managed timeously.

Confusion was reported in relation to the types of surgical and radiology procedures that could be performed on one site but not another. Surgeons typically performed AVF procedures in the middle of a general surgical operating list, but the use of a day surgery theatre list could lead to a procedure being cancelled if the patient was deemed unsuitable for day surgery. It was difficult to utilise vacant theatre spaces when the surgeon, patient and nephrologist were often not in the same location.

There were significant problems reported in transporting patients between sites. Ambulance transport was said to be unreliable, and when a patient moved from the renal unit for an IR procedure on another site there was no obvious clinician responsible for the patient while they were there. There was also nowhere for such patients to go within the offsite hospital if they became unfit to travel back to the renal unit, or (more commonly) if transport was unavailable before the IR department closed.

The need for clinicians to travel between sites influenced clinical decision making:

Unit 10 (Paediatrics)

The paediatric unit provides care to the whole of Scotland. Patients requiring RRT were offered PD but if HD was chosen (or was the only practical option) families had to move home to facilitate regular outpatient hospital attendance. This was said to be a relatively common occurrence, and it seemed preferable for families to relocate for HD than to pursue PD because of geographical concerns.

Job-planned time

This section considers the availability of formally allocated clinical time for VA services, and clinicians' opinions as to the amount of time typically spent delivering the service.

Across Scotland, and across most of the relevant clinical professions, it was unusual for VA service delivery to be formally job planned. It was also unusual for clinicians to have a genuine sense of the time commitment currently used to deliver the service, or what would be required to do this.

The commonest event in the VA calendar to be job planned was the MDT meeting, but usually only one or two clinicians present would have this in their job plan; others would effectively be attending in their own time, or when timetabled to be doing something else. One centre reported an MDT meeting that commenced before the start of normal working hours for most of those who attended. Most centres had either a dedicated vascular surgery operating list, or dedicated slots on specific list, for VA work. It was said to be common for these cases to be usurped by competing non-clinical and clinical demands. No centre had VA-specific IR lists, and no radiologists had specific time allocated for VA work.

It was clearly perceived by almost every clinician in the study that most other clinicians also performed VA work in their free time, sandwiched between other clinical commitments.

Clinicians reported participating in VA activity out of a sense of professional duty; from a belief they could improve clinical outcomes; or in an effort to improve the efficiency of their overall service. Nobody had a clear idea of others' job plans or how they related to VA. There was considerable uncertainty as to what work colleagues performed as part of their core role or as peripheral activities, and it was clear that most VA work was considered to be done ‘as a favour’ rather than as part of contracted clinical work. (Table 32)

(It should be noted that consultant job planning in the NHS is a confidential process; as such it was deemed inappropriate to directly ask interview subjects to provide details of their individual job plans.)

Unit	Transcript data
1	*"I wouldn't like to tell you when I was last properly job planned, but it is part of my job plan that I handed into them for discussion: that I need the time to do that"* (Consultant Surgeon)
2	*"MDT is actually in people's job plans but its slightly fudged, partly to… its one of the things that makes the books balance a little bit."* (Consultant Nephrologist) *"If I have got the time. Because obviously being 0.5 of a post… if you are working away in the background, some people often forget that you are already [doing] 0.5 of the post so you can't [fit additional commitments in]."* (Vascular Access Nurse)
3	*"I try and plan it ahead. I have the list, a huge list saying this is what I think might be coming up and I email it round to [surgeon] and some of the other surgeons saying look I need this, this and this within the next 2 – 3 weeks, this one within the next 4 – 5 weeks when you are planning and I try and get one of the physicians to take some responsibility for it so that there is somebody for contacting as well. It can be a problem for them."* (Vascular Access Coordinator)
4	*"Interviewer: Do you know what their [VA clinicians'] approximate time allocation is for renal/Vascular Access? Response: I don't know. I don't know. Interviewer: And how much time, in the real world, how much time roughly speaking do they spend on it? Response: I honestly don't know. It seems like we take up a lot of their time but I'm not sure we do."* (Consultant Nephrologist)
5	*"I have one session for doing the tunnelled lines and I think I put in times for…. we have 3 weeks, an MDT, with most of the people I mentioned, and then there's other sort of bits, of course!"* (Consultant Nephrologist) *"That's the only allocated time for Vascular Access in the job plan. It's the clinics, Vascular Access MDM and theatre time is just general theatre time."* (Consultant Surgeon)
6	*"No dedicated time as such. So they have not got sessions or anything, it is all just kind of ad hoc, as and when."* (Vascular Access Nurse)
7	*"We have tried to be very honest in our job planning and we try and work out how many of the meetings in a year you would actually make it to, and annualise that. But… there is a bit of you know, there's a kind of a collegiate feel to it as well." (Consultant Nephrologist)*
8	*"The difficulty is that that's not what they're paid to do. So they go and ask and again it's a please, please, please. It can't run like that!" Consultant Nephrologist*

	"I don't think that if you gave me more time, specifically for the Vascular Access issues of the patients that I look after, it would make any difference. I think, in the time I've got, that I've described there, I can do as much as I need to do and then it's handing over… it's other people from then on. My impression is that there isn't enough resource within the service, but I don't know whether that's the lack of human time from a sort of medical point of view. I think that there's a lack of time in terms of nursing. I think we don't have enough nursing time allocated to it specifically." (Consultant Nephrologist)
9	*"In terms of intervention – we have actually no fixed sessions allocated to renal"* (Consultant Radiologist) *[Asked about the required time commitment for VA service:] "when you speak to [VAN], it's just 5 minutes. I mean, I wouldn't have thought it would be a session." "[VA clinical problems] do need to be pushed forward. I guess they're our patients aren't they, so probably one of us [should do it]. You could argue it's me. I don't have a session for it though."* (Consultant Nephrologist)

Table 32 Job planned time and Vascular Access services

Unit 1

VA work was described as being counted within the overall vascular surgery consultant job plan, including operating time and one hour per month for MDT discussions. It was reported that this was not reflective of the time actually spent visiting the RDU and liaising with VAN and others.

There are two whole-time equivalent VANs. There was no job planned IR time for VA. The nephrologist who acted as de facto nephrology lead for VA was a member of the team largely because his office's proximity to RDU, meaning he was frequently asked VA related questions; this meant however that no formal clinical time was allocated for VA and this was absorbed within his overall allocation of clinical time. He estimated spending around 4 hours per week on VA work.

Unit 2

The MDT was said to be job planned but was timed to begin before normal working hours for some attendees. If individual clinicians were on leave their role in the MDT was not backfilled. This had caused previous problems in the event of prolonged sickness absence.

VAN was employed nominally on a 0.5 whole time equivalent basis, with another unconnected 0.5 time commitment in another role in the unit. In reality however, it was said that the vast majority of her time was spent attending to VA, possibly to the detriment of the other role.

Unit 3

There was no formal clinical time allocation for IR to attend MDT meetings, perform procedures, or otherwise participate in the VA service.

The VA coordinator estimated spending 5 hours per week dealing with VA work, including clinical and administrative functions along with attending meetings. There was however a significant degree of unmeasured activity that is likely to greatly exceed this time commitment including clinic attendances to meet new patients, ad hoc scheduling enquiries and so on. She described having to anticipate and plan ahead during periods of annual or study leave, providing clear instructions for nephrologists and surgeons to follow in her absence. She sometimes struggled to find a nephrologist willing to backfill her role during planned absences, in part because they would have little experience of coordinating the service.

The degree of formally allocated time for VA surgery was unclear. Surgeons reported slotting VA work into their general vascular theatre lists to prevent lengthy waiting lists developing and thus impacting upon other elements of their service.

Unit 4

The clinician interviewed in this unit was unclear about how much clinical time was formally job planned for VA services, or how much time was routinely needed to deliver the service.

Unit 5

The Unit 5 VA team had a clear idea of the available and required time allocation to maintain their current level of working. There was one nephrology session per week allocated to TCVC insertion, plus around 0.5 sessions allocated for MDT discussions and administration. It was reported that the TCVC list usually had spare capacity; this effectively provided a buffer for procedures that would otherwise go to IR, meaning the available IR time was then protected for AVF maintenance.

While IR time was not formally job planned there was an informal designation of specific slots for VA work in the department, with several operators performing the procedures. The flexibility of this approach was welcomed by IR but did mean there was no formal measurement of clinical activity at an organisational level.

Vascular surgeons have 0.5 sessions per week to attend the VA clinic and MDT. Operating time was included within their general operating job planned time, and they estimated this equated to approximately 0.5 sessions per surgeon per week.

VAN has a 0.8 whole time equivalent time commitment, but found she often required to work significantly beyond this to achieve the necessary results, often in her own time.

Unit 6

While there was no formally job planned vascular surgery time for VA, there was relative freedom to book VA cases during an allocated endovascular theatre day. There was no formal nephrology time allocation. There was no radiologist employed within the board who could perform VA work. IR procedures were usually conducted by the vascular surgeon, who was also trained in endovascular procedures more traditionally performed by a radiologist. It was considered normal practice that VA work would be fitted around other clinical commitments, whether by VAN, sonographers or surgeons.

Unit 7

MDT attendance was job planned for radiologists and nephrologists. It was said that some nephrologists could not reliably attend MDT meetings in view of geography and other commitments, but colleagues tended to discuss patients on their behalf in this case.

VA was considered part of caring for HD patients and was hence accounted for within this part of nephrologists' job plans. There was no reference to time allocations for managing VA issues in the low clearance clinic cohort, nor for strategic service development.

Surgeons reported recent success using electronic job planning tools. This was said to allow more specific allocations of time that reflected their usual clinical commitments. It was hoped this would reduce the impact of ad hoc VA scheduling that would sometimes require utilisation of emergency theatre space for elective or semi-elective VA work.

Unit 8

Nephrologists reported that some job planned time was designated for MDT attendance, but not for the associated administration or clinical activity. It was estimated that each nephrologist spent 1-2 hours per week attending to VA related issues, including inpatients, outpatients and HD patients. They estimated there was probably one WTE nephrologist spread across the whole unit by the time all the access issues are dealt with, but no individual had sufficient time to properly attend to VA. It was common for nephrologists to circumvent established pathways in an effort to expedite a particular patient's case. There was a strong perception that VA work was largely “done as a favour”.

It was considered best to focus the available time allocation for one or two clinicians to take ownership of the service, rather than spreading this among all nephrologists in the centre.

Nephrologists considered that several additional VAN roles were necessary for the service to be adequately resourced. There was one whole-time equivalent VAN for the whole service.

RDU VA link nurses were considered a highly valuable resource within RDUs and by VAN. Link nurses reported rarely having time at work to devote to VA, and in fact could not recall the last shift that had been genuinely protected for VA work alone. They were expected to absorb VA into their already full working day, and attendance at MDT meetings or strategic involvement with the service had to be done in their personal time.

A significant proportion of the overall inpatient workload was attributed to VA emergencies and other VA problems. Ward nurses and inpatient nurse practitioners were said to spend a lot of time managing the associated logistical issues, but this had never been formally measured. The designated VA theatre lists were insufficient to meet the clinical demand, and surgeons tended to utilise emergency theatre to get through the necessary VA work.

Radiologists had job planned time to attend the VA MDT, but no protected time to deal with the subsequent clinical workload. It was suggested that significant proportions of clinical IR time was spent on activities that could be performed by other members of the team, for example by sonographers. There were often logistical problems impacting upon radiologists' ability to cover VA work in practice, in view of their requirement to cover multiple clinical sites and provide an emergency on-call service.

Unit 9

There was some ambiguity as to the available job planned VA time in Unit 9. Surgeon's operating time was job planned, and the VA clinic was also thought to be job planned although this was unclear.

The only nephrology job planned time for VA was a nominal TCVC insertion list. The clinician who usually performed this list did not have any other role within the VA team and the list was often cancelled. It was also reported that nephrologists already had fully committed job plans and thus had no spare capacity for VA issues.

IR reported having job planned time to attend a VA MDT but not for the resulting clinical activity. It was unclear if this was job planned time specifically for VA MDT since this was said to almost never go ahead in practice. The radiologist stated that VA clinical work was performed almost exclusively within their professional development time, meaning procedure lists were unreliable and not backfilled in the event of absence.

Scheduling and tracking

This section considers the means of scheduling and tracking VA clinical activities (table 33).

Unit	Transcript Data
1	*"We do everything within a day, like you know the same day the Vascular Access Nurse gets details, on the same day the access form is done … and we fill in the request on [electronic requesting system] on the same day, but then it stops there until you hear from the interventional team, so that depends on how free they are and how busy they are."* (Associate Specialist Nephrologist) *"I would say they would be once every fortnight [there is] a situation where you have to prioritise somebody"* (Associate Specialist Nephrologist)
2	*"…our sonographers, if they notice that there's a critical stenosis or there may be thrombus within the fistula or what have you, they will just bring the card directly to one of the interventionalists… we just get on with it. Sometimes we get them done that day."* (Consultant Interventional Radiologist) *"They certainly get priority over, well the venous work, some of the ischaemic legs, so it usually works out okay. We're usually able to fit them in at very, very short notice because most of our vascular work is that sort of same thing that will come – ischaemic legs, aneurysms needing to be worked up. So it works quite well."* (Consultant Surgeon) *"Theatre time is definitely an issue, but we have times where there have been issues about theatre space and it has impacted, as we might have had to wait three weeks to get a fistula and you know [surgeon] and [surgeon] are both about and we still can't get space in theatre to do it."* (Consultant Nephrologist)
3	*"We have got two main interventionalists… if one of the experienced ones are off it is problematic to get them in, and the person who organises it all is away for three weeks… it is the organisational aspects that can be difficult in getting messages to somebody who, you know there is nobody sort of taking that over then it can be difficult."* (Vascular Access Coordinator) *"I think having one person in charge of that is the key, and I think also having flexibility so that I trust that [she] will arrange for my patient to get a fistula just as much as any of my other renal colleagues… she talks to us all about it: 'can I cancel this one and do this one', … so it is done on a clinical need for the population."* (Consultant Nephrologist)
4	*"I am not sure how frequently their lists are, but there is certainly we have access to a list once a week at least… it would be at least once a month because we never have difficulty getting people on to those lists really."* (Consultant Nephrologist)

	"Incident access doesn't generally come through [the MDT] meeting unless prioritising the waiting list for PD access and fistula creation which is a very small part of the meeting." (Consultant Nephrologist)
5	*"You talk about job planning time – there isn't any, but that makes it more efficient for me because I can then you know put two fistulas into three lists for every three weeks, depending what… who is around, so you just get swallowed up by the rest of the work. There's no official time."* (Consultant Interventional Radiologist) *"We feel, or I feel, it's the renal physicians that need to advise us of the running order of how we should and when we should do operations … we just are unaware of what priorities and pressures [there] are."* (Consultant Surgeon) *"One of our patients had a fistula planned for Tuesday and he got called for a transplant on Sunday night. So then on Monday when I came in, I was scrambling about in my low clearance… who, because we have to swap like for like, so if the surgeon was going to do a [radiocephalic fistula] I can only put a [radiocephalic fistula] in that space because that's all he's got space to do."* (Vascular Access Nurse)
6	*"We get a reasonably good service from the radiology department wherein [they] can find a slot within 48 hours or so. Occasionally it might take 3 – 4 days. It is usually because of multiple things like me not being free when they are free and vice versa. But usually it's ok. We feel quite comfortable, you know, screening when doing the procedure and things."* (Consultant Nephrologist)
7	*"There is some slack built into the system towards the end of the week. We don't book electives in every single slot…. we recognise that by the end of the week you are going to accrue a various amount of emergency work. That's across the board – that's vascular, hepatobiliary, all of those things."* (Consultant Interventional Radiologist) *"What I would love to happen is, I see a patient in clinic… and I could offer him a date for surgery… I'd love to say, 'these are the dates we've got, you choose what suits you'."* (Vascular Access Nurse) *"It's very fragmented because there is a waiting list office and they will say 'we can give you so many slots', and it's out of, I mean it's out of my control. I don't know what I am going to do, you know, I'm at the mercy of the waiting list coordinator, and so Vascular Access will say 'well we have only been given, you know, two or three slots, this is what we… can you add another patient in?' So then they come up to myself or any of my colleagues to just add it on to that, and then they will email the waiting list office to say 'right I've added more fistulas'. It's not ideal."* (Consultant Surgeon)

	"The problem is it's not a priority, because what's happening is these patients get their fistulas, and a lot of it is through my colleagues' good will. You know, 'yeah we will do it, stick it on the end of the list', and in fact the priority is this three-month target that's come up, and that's actually swung things to the detriment of the renal patients. And that's a real issue, and you can fight with it till you go blue in the face, but you know, 'no sorry this is our priority, this is, you know the patient, this patient's gonna trip' and you know the politics behind that!" (Consultant Surgeon)
8	*"I go down to try and get a space for a renal patient and I go down, I'm a nurse and I'm standing next to one of the consultant vascular surgeons down asking to have an angioplasty done, and I want an angioplasty done. Who do you think the radiologist is going to do? Who are they going to give that space to?"* (Vascular Access Nurse) *"There's so little spaces, and it was robbing Peter to pay Paul a little bit, you know. 'So and so's name is more important than someone else's name', so they are going to take you off the list, or put [you] down the list because you have got nothing but you can wait. And even though your [fistula] is about to actually collapse and fail dramatically, you might need yours first cause you need [procedure], it's one of those scenarios."* (RDU Nurse) *"[Some surgeons] will only put renal patients on when they've got an empty list, cancellations, and it's last minute, and then trying to get patients last minute – they don't want to come, or there's a problem, they need to dialyse or whatever."* (Nurse Practitioner) *"There's usually an immediate referral made to radiology probably, quite timely – I would say within the sort of first hour of the patient being there it's established what the problem is and if it needs to be referred to radiology… and is it a clotted fistula? And that's where the hold-up then really happens, because if radiology can't fit them in then the patient sits all day waiting to hear. Because radiology will often tell us, 'we'll try and fit them in' … and then the patient sits all day and quite often at 4 or 5 o'clock when a phone call comes to say, 'we've ran out of time', and then that leaves us to deal with the problem late on into the on-call hours because either then we need to get a temporary line put in if their bloods aren't safe, or they have to be admitted, or they get discharged. They go away and come back the next day, and they have to revisit and then we go through the whole performance again of waiting while the patient sits in a room."* (Nurse Practitioner) *"The radiologists, certain ones won't speak to nurses, they have a wee bit of an issue… I had an issue with [radiologist] where I went down, and the radiologist turned up and said 'I don't speak to nurses'. And I said, 'well there is nobody else'. I kind of stood my ground and eventually he spoke to me but that's not always the case… [VAN], because they're familiar with her, they maybe won't discuss the case but they'll allow the [radiology nurses] to kind of liaise with her and sort things out you know. Usually if it's an emergency, something that needs done in a hurry [VAN] will often say it will have to be a medic that goes down to discuss it if you want it done there and then."* (Nurse Practitioner)

	"Some individuals seem to be really focused on this, and for other individuals this is clearly not a priority and I know that I see the same faces come down to speak to me or engage with me and then for other faces, you don't see them at all… and I don't know whether that's because they have other commitments, it could well be, I don't know that, but you just don't see them so you don't get that engagement. The more engagement you get, the better, particularly when you get into the marginal cases." (Consultant Interventional Radiologist) *"They may say 'come speak to us', but it's not easy because I've done it. I've really tried to do it and as you know I'm quite happy to wander round and speak to anybody I can find in order to get things done, so it's not that I'm averse to it, but I cannot find them. Now if you've got an emergency or whatever, then you know you're forced use your phone and stamp your feet! But there isn't somewhere I can go and think, how can I speak to a radiologist and say this is the situation, what can we do."* (Consultant Nephrologist) *"One of the problems when you do a list of just fistulas is if you have, say five or six fistulas on the list, you know that one of them is going to have awful vessels and just won't work, that the other one that you do that doesn't work very well and you fiddle around with it for a bit to try and get it going better, and the other three will probably be fine. But if the two bad ones, the first and second patients on the list, your day is ruined, and the rest of the day is entirely miserable! So, for that reason I don't like a list with five fistulas; I like to put a bit of general surgery in too, for my own sanity."* (Consultant Surgeon) *"A one-step [clinic], that would be ideal, but even if there is a 2-step, there's no point in seeing the surgeon before they get mapped. They will see the surgeon first of all, then they get vein mapping, then they see the surgeon again, then another surgeon does it and does something completely different!"* (Consultant Nephrologist) *"So that depends which route you want to use. So, either you fill in the screen in the same way that I usually do and set them off into dialysis in whatever unit they're doing, and then wait, wait, and wait – or you go and nobble a surgeon! And say 'come down, this person's got reasonably good veins. Do you think you can fit them in sometime!'"* (Consultant Nephrologist) *"There's a handful get referred informally, particularly people who are currently inpatients on [the renal ward], someone will speak to us and you can fit them in somewhere. And that creates a problem in that we don't, there's no-one tracking that and there's no prioritisation of that so that's a particular problem area."* (Consultant Surgeon)

9	*"Yeah, I'd go back into my head and jiggle about, and obviously I've got people sitting on the waiting list, so I'd look at that and try and see, well, who can I see"* (Vascular Access Nurse) *"We have our waiting list, so I then get emails from those secretaries to say [name] is on annual leave, study leave, etc. So I know what planned dates we have, I know what procedures they are going for and whether it's a one slot or two slot. So I then just have to try and… and also we work at the moment with, one theatre session is in day surgery and it's day surgery protocols, the other two sessions are in the main theatres, so the protocols are slightly different …. it affects the patient as in, they are being, sometimes their diabetic status etc, so I do have to do a wee bit of juggling around to see which patient actually goes where."* (Vascular Access Nurse) *"The way that we sell 'come to [another campus]' is that that's where our vascular surgeons are; if something were to go wrong, you're better… it's safer for you to be there and vascular surgery theatre is right beside us, so it is, there's that connection."* (Consultant Interventional Radiologist) *"And again, that's what having someone whose job it is to look after the kind of quality clinical part of it and somebody to co-ordinate. They're different things. We try to make it…. we're asking one person to do everything and she's doing the best she can but it's plate spinning."* (Consultant Interventional Radiologist)

Table 33 Scheduling and tracking Vascular Access clinical activity

VA scheduling was viewed as a cumbersome process requiring knowledge of the clinical priority, decision making as to the specific procedure to be scheduled, with the clinical (and technical) authority to book slots within the surgery or radiology system. Multiple convoluted steps were often involved in scheduling a specific procedure and it was common for multiple administrative staff to be involved in the process.

Effective scheduling required available slots designated for VA work, and where VANs or other members of the VA team were afforded direct booking rights to allocate specific slots to named patients.

It was apparent that no unit had designated clinical slots or formally protected time for VA services across nephrology, surgery and interventional radiology. Most centres had some formally protected surgery slots, but relied upon additionally unprotected slots to manage clinical demand. There were no formally protected radiology slots in any centre.

It was highly uncommon for procedures to be scheduled directly within the MDT meeting; just one centre routinely did this, and only for IR procedures. In several centres formal radiology requests would require to be submitted following MDT discussion, and the requests were subsequently vetted and processed through waiting lists and other back office administration. In some centres MDT discussion was required before a request would be considered, but MDT meetings were reported to occur too infrequently for this to be practical.

Scheduling procedures and the associated logistical arrangements tended to occupy considerable amounts of clinical time for VANs, particularly in units with high TCVC usage or where the renal unit was not geographically co-located with vascular surgery or radiology.

It was also said to be common for theatre lists to be cancelled at short notice, for operators to be redirected to performing an alternative clinical activity, or for there to be mismatches between operator and theatre space availability. These issues all required VA procedures to be rescheduled. It was also apparent that processes were necessary to manage technical failure of a procedure, for example AVF that failed to mature. Most centres recognised the importance of being able to reschedule procedure lists to accommodate emergency cases at short notice, but practice between units varied considerably: some described proactive planning to counteract anticipated AVF problems, while others were reliant upon reactive last-minute approaches that often precipitated unscheduled hospital admission.

Unit 1

In Unit 1 there was reported to be a day surgery list available for VA procedures, and this was heavily utilised for elective work. There was said to be a considerable additional surgical workload that required to be slotted around other commitments into non-protected slots. The surgeon found considerable benefit from regularly visiting the RDU but this was not during designated clinical time, and so was not backfilled when he was on leave, on-call, or otherwise unable to attend. VAN could allocate surgical theatre slots to named patients within broad parameters.

There were no designated IR slots for VA work and no allocated time for MDT discussion. The VA team described having almost no ability to influence the scheduling process for IR procedures, the majority of which related to TCVC insertion.

The logistics of transferring patients from the renal unit on one site, to either the surgical unit or radiology service on another site, occupied a lot of VAN time. While inpatient VA problems were not formally part of VAN's role, they did tend to become involved with these cases too in view of the common logistical challenges.

It was said to be common for clinicians to be asked to reprioritise waiting lists to accommodate emergency clinical problems or to utilise newly available slots. This typically meant displacing an existing planned VA procedure in favour of one that was more clinically urgent.

Unit 2

The ethos in Unit 2 was clearly to focus upon patients' individual needs to provide optimal VA. They adopted a team approach and held a weekly MDT meeting where forthcoming surgical and IR slots were allocated. They were flexible such that urgent clinical problems could be addressed without waiting for the next MDT meeting.

Patients who lived in geographically remote areas tended to need customised 'one stop' approaches, but this was not seen to be a significant problem. All VA cases were afforded 'urgent' priority status, and there was willingness to accommodate cases at short notice.

There was no formal protection of IR or surgical slots for VA work. Enthusiastic operators in both departments meant slots were readily available when required, although there were sometimes mismatches between operator and theatre space availability. Surgeons tended to allocate patients to ‘vascular’ rather than ‘general’ theatre spaces to ensure a vascular anaesthetist would be present.

VAN booked patients for procedures following the weekly MDT meeting. She had authority to prioritise the waiting list, and maintained an overview of surgeons’ availability. It was normal to create a follow-up plan at the point of planning an intervention, to facilitate rescheduling when required. The weekly MDT meeting agenda consisted of an ‘active patient list’, which served as a means of tracking ‘active’ patients. There was also a policy to actively discuss any patient currently dialysing with a TCVC until they had successfully moved over to using an AVF or AVG.

Unit 3

There were reported to be designated theatre slots for VA work, and it was perceived by other team members that these were readily accessible for VA patients. Surgical on-call commitments would occasionally result in a cancelled VA list, since the operator would be unavailable to perform the procedures.

The nephrology team (and the VA coordinator in particular) scheduled all VA procedures, in liaison with a named surgical secretary. A nephrology secretary would book an inpatient bed where required. The VA coordinator was empowered to allocate specific surgical slots to named patients, without them needing to meet the operating surgeon until the day of surgery. There tended to be a reliance upon one administrator, and a small number of operators with the technical skills to perform procedures, which could occasionally cause difficulties.

Patients seen in the VA clinic are allocated a specific surgical slot. Patients who present late tended to have VA creation surgery scheduled before leaving hospital during the index admission, for a date as soon as possible thereafter. The VA coordinator matches operators with cases based upon their relative experience and case complexity, taking account of their general workload and any planned absences. She maintains a running order of patients awaiting procedures, to facilitate scheduling and reorganisation if a patient could not utilise a particular slot. Her overview of the active patient cohort, coupled with empowerment and ability to prioritise, were considered a key element of success.

Unit 4

In Unit 4 the MDT was the forum for decision making, prioritisation and scheduling of VA procedures, including the placement of PD catheters where appropriate. There was uncertainty as to the number or availability of protected slots, but it was considered that patient throughput was prompt and appropriately timed for the clinical context. It was noted that Unit 4 and Unit 5 operated a shared surgical and IR network for the purposes of VA.

Unit 5

Unit 5 had easy, rapid access to a TCVC insertion list designated for renal VA work. This was performed by a nephrologist and was considered an effective means of limiting NTCVC use.

The weekly VA clinic appeared to function well, although it was not backfilled in event of planned or unplanned staff absence. Clinic attendance was prioritised by VAN, and it was possible to directly allocate specific IR slots to named patients at the MDT meeting. Some IR slots were informally designated for VA work, with an intended three-week turnaround period such that patients were appointed at one MDT meeting, and their IR procedure outcome discussed at the subsequent meeting three weeks later. IR think this works well albeit the lack of protected slots could make the service vulnerable to external pressures.

It was not possible to directly allocate patients to surgical slots, and instead their names would be added to a surgical waiting list from the clinic or MDT meeting as appropriate. There was no dedicated surgical theatre time for VA work; this was considered a key problem by VAN and surgeons alike since VA cases could be usurped by other patients who required their theatre slot for an unrelated clinical problem.

Once a patient had been added to the surgical waiting list it was not possible for VAN to further influence the timing of their procedure, beyond swapping one case for another on an already published theatre list. This could only be done on a like-for-like basis, meaning only patients awaiting the same procedure could be swapped. The surgeons were comfortable with this process and would perhaps have welcome further flexibility with their lists, based upon the clinical imperative indicated by other members of the team.

Individual surgeons were flexible as to which patients they operated on; it was not necessary that they had personally met the patient in the clinic before the scheduled theatre date.

It was noted that VA procedures were given ‘routine’ priority for the purposes of the surgical waiting list, while procedures for other non-VA indications were afforded ‘emergency’ priority despite having a similar level of clinical urgency.

Surgical and IR rescheduling tended to be reactive, and there was no described process for maintaining a ‘reserve list’ of patients on standby for a late availability slot.

Unit 6

Unit 6 described having adequate capacity to schedule VA procedures at short notice, without requiring designated slots to be available for this purpose in advance. It was usual for duplex ultrasound to be performed within one day, and for theatre cases to be listed either as emergency procedures or electively scheduled within 1 month. While the weekly endovascular theatre list was not formally designated for VA procedures, this was the usual list for VA cases and the surgeons were enthusiastic about listing them.

Difficulties in obtaining IR imaging or procedures tended to reflect a lack of slot availability at short notice, but the workload was not judged sufficient to justify the designation of specific slots for VA work.

Unit 7

A major component of the VAN role was to prioritise and reschedule theatre lists, and optimising slot utilisation by maintaining an overview of active patients. They maintained a ‘control room’ with various whiteboards to facilitate this aim.

There were no designated slots for VA work in IR, although VAN tended to use this as a means of limiting TCVC use within the unit. There were some slots informally available for VA use, although these were in the form of slots at the end of each week that were purposely left vacant to accommodate emergency work from earlier in in the week.

Radiologists found VAN very helpful in prioritising VA patient throughput, although when patients were directly referred to them by a nephrologist (for example as an inpatient) they had difficulty assessing the degree of urgency of the requested procedure. There were also some inefficiencies identified in that individual nephrologists would request IR procedures for their patients following an MDT meeting, rather than these being allocated directly during the meeting.

Surgery slots were available with at least 1 month notice and VAN allocates individual patients to slots. It was not possible to allocate specific theatre dates to patients during their clinic consultation, but this was something they aspired towards doing. VAN was reliant upon the surgical waiting list office providing an appropriate number of slots, a process which could be frustrating for the whole VA team.

The only dedicated access slots were in a peripheral centre, and surgeons wanted additional protected theatre time. It was common for surgical cases to be postponed because (non-VA) cases required the theatre space, often because of an impending waiting list target rather than for clinical reasons. There was little dialogue with the waiting list administration, and despite informal agreement that patients could be listed onto any available surgical list, many cases were said to rely upon goodwill to be done within a clinically appropriate timeframe.

There was local agreement that a patient did not require to be seen in an outpatient clinic by a surgeon in order to be listed for an AVF creation procedure. Instead, VAN could assess the patient in their clinic and then list for a specific procedure, or in the event that adequately sized vessels were not identified on imaging, they would be booked for an exploratory procedure. This was said to be highly successful.

Unit 8

Unit 8 reported having a regular nurse-led TCVC insertion list. While this list was often oversubscribed, there were said to be strict criteria defining the patient cohort suitable for the service and in practice many patients were deemed ‘unsuitable’. There were no other protected slots in IR for VA associated procedures relating to TCVC or AVF. The lack of slots was described as having reached a critical juncture where crisis management had become the normal day-to-day experience for staff in the unit.

IR did try to accommodate VA cases amongst their other workload, but frequently had to deal with other (non-VA) clinical emergencies, displacing VA cases. They maintained a diary and whiteboard with the names of ‘priority patients’, but considerable difficulty was reported in persuading radiologists to prioritise VA cases above the other clinical problems of the day and it seemed many people awaiting IR VA procedures had already reached ‘emergency’ status hence it had become impossibly difficult to genuinely prioritise urgent cases.

There were some scheduled VA surgical theatre lists, but these were said to be insufficient to cope with the clinical need. Other slots often become available at short notice, but many patients were not available to attend with such little warning. It was also common for non-VA cases to usurp renal patients, particularly for ‘higher profile’ procedures like transplant surgery. It was felt that VA cases would only become a priority when it was impractical for other sorts of cases to utilise the available theatre space. This meant there was variable patient throughput and at times operators with limited AVF experience would be performing most of the necessary procedures.

Nobody across the clinical team had any certainty about the available clinical time for VA work, and it was therefore said to be difficult to ‘demand’ spaces for their patients’ cases. Nobody had job planned time to attend the VA MDT, which was often cancelled or poorly attended. When the MDT did happen, patients would be added to a surgical waiting list for a named procedure, but it was unknown at the point of the MDT meeting how long it would take for a slot to become available. The uncertain lead time for procedures also led to uncertainty, if a patient was thought likely to receive a transplant in the near future, perhaps soon after AVF creation.

The convoluted scheduling processes, involving test requesting, waiting for slot allocation from a waiting list, and no real-time tracking or allocation, meant it was difficult for anyone to maintain an overview of the service, or track individual patients’ journeys. When procedure slots did become available there was no organised means of identifying the next patient on the waiting list. This seemed chaotic, particularly since a significant proportion of the overall VA workload was scheduled in this way.

It was felt that AVF had not been afforded the urgency of other procedures, and that this was increasingly necessary. It was recognised that AVF procedures often failed, but there was little fall-back planning for this occurrence.

Convoluted booking processes were described for both surgical and IR procedures. For IR cases technical difficulties with the booking system that meant VAN could not personally request VA procedures, as these required to be ordered by a doctor. Listing a patient for a procedure required liaison between the radiology booking office, VAN and RDU, to coordinate logistics. Without allocated slots, and with low priority being given to emergency access issues, it was felt that patients' needs were not well served by IR.

It was apparent that last-minute scheduling was a significant challenge, and often an element of luck was needed for a referral to be accepted. It also appeared that urgent cases were more likely to be prioritised by radiologists if they were presented and discussed with them by a doctor rather than by a nurse.

Radiologists felt detached from the clinical decision-making process, with little involvement unless another clinician specifically sought their opinion. Nephrologists however expressed frustration at the difficulty in finding a radiologist to discuss VA cases.

Access surgery was considered technically frustrating by some surgeons, and they were at times uncomfortable performing procedures that had been listed by colleagues. Some were also uncomfortable with day surgery arrangements where they would not have met the patient before the day of surgery. Nephrologists, however, questioned the utility of patients routinely meeting a surgeon in clinic before theatre.

The convoluted VA referral systems had made it common for nephrologists to make informal referrals that circumvented the usual process. Surgeons found this frustrating and considered that it ultimately hindered the service.

Unit 9

In Unit 9 the lack of protected radiology time, and the need to transfer patients to another campus for IR or surgery procedures, were cited as key challenges. Radiologists reported performing VA procedures exclusively during professional development time rather than clinical time. VAN reported significant variability in whether procedures would occur on any given week, which led to considerable difficulties. There were further difficulties in that VA cases would be given similar priority to other cases, despite the potential time-sensitivity of VA cases. Many slots that did become available were used for TCVC insertion as there was a high proportion of patients dialysing in this way. This meant that almost no IR time was used for AVF maintenance, and so there was a reluctance to invest in the IR service.

There were protected slots for surgical procedures and a scheduled VA surgical clinic. These were usually on another campus from the renal unit, and the surgeon who usually conducted the clinic did not personally perform any VA surgical procedures. The operating surgeon would only hear about the patient upon their arrival on the day of surgery, although it was unusual for an operation to be cancelled at that stage. Neither surgeon had an overview of the whole patient cohort including those waiting for clinic or operation appointments, and those who had recently had an operation. The standard surgical TTG was applied to AVF surgical referrals, but it was acknowledged that this was a ‘routine’ surgery target that was often not clinically appropriate for patients requiring VA.

Nobody had an overview of the current waiting list size or lead times for procedures. The allocation of individual patients to specific slots relied mostly upon VAN’s memory rather than an organised and accessible waiting list system. VAN was unable to allocate named patients to specific theatre slots beyond a small number that were made available at short notice. There was no formal or informal managerial involvement in this process, and little acknowledgement of the difficulties generated by multi-site working.

There was an awareness that the VAN workload was unrealistic for one individual. It was acknowledged that mutual trust and agreement was needed between different members of the clinical team to facilitate optimal utilisation of the available clinical slots.

Unscheduled care

The approach to managing unscheduled care was significantly different between units. In some centres the discussion focused upon emergency access presentations, while others were more concerned about other, non-renal, unscheduled clinical work, and its impact upon displaced VA work (table 34).

Unit	**Transcript data**
1	*“We don’t have emergency services over the weekend so that is another thing that an additional pair of hands would probably be helpful for”* (Associate Specialist Nephrologist)
2	*“I can’t remember a fistula requiring de-clotting since I’ve been here, presumably because of the surveillance. You know if someone has a problem.”* (Consultant Surgeon)
3	*“There is no Vascular Access clinic this week but if there is somebody I desperately need seen, I will buttonhole a surgeon and take the patient to them or do something”* (Vascular Access Coordinator) *“Usually within 3 or 4 hours we will get a vascular person over to have a look and they could be in theatre that night if it’s starting to fail. They usually do try and attempt to see, even if it was stopped completely they will go to theatre and try and rescue if it’s just happened.”* (RDU Nurse) *“A lot of the challenge is in the out-of-hours work in ensuring that the cases are appropriately assessed, and the correct decisions are made and people, you know bear in mind just the long term and not just the short-term fix…. We don’t always have adequate cover out-of-hours in interventional radiology and it causes a huge logistic problem in terms of the staff because we need staff from theatre, so when you do that it stops the emergency list, and you need the interventional staff, including the nurses who also cross-cover cardiology, their interventional suite, so you have got three different lots, four different lots of on call people all trying to get into the same place at the same time and not being somewhere else”* (Consultant Surgeon)
4	*“So out of hours or if there’s holiday cover things then sometimes patients will go up to [neighbouring board]. Mostly it gets done here.”* (Consultant Nephrologist)
5	*“I am very aware of Vascular Access theatre slots having to be postponed if emergencies happen. You know, because we are on the receiving end of that. That will be the one to go if a vascular emergency comes in, it will be Vascular Access that gets [postponed]”* (Vascular Access Nurse) *“It’s more what’s coming in through the doors that can bump Vascular Access patients, sadly.”* (Consultant Surgeon)

	"As I said, one of the things is because of surveillance, fistulas just turning up thrombosed is not that often for us. Unexpected thrombosis of fistulas which is what I have seen in other centres where I was training, where they more often than not, the fellow used to do the last fistuloplasty thrombectomy of the day – it doesn't happen here. It's very rare." (Consultant Interventional Radiologist)
6	*We [have a] contingency plan [for clotted fistulas] that we would either wait until the Monday or we will try and deal with it on emergency theatre at the weekend. Yeah. It doesn't happen that often."* (Vascular Access Nurse) *"If it is urgent, urgent, then [surgeon] tries to squish them in, even in the emergency theatre list he will try and do them for us."* (Vascular Access Nurse)
7	*"You know, you can be in clinic and you've got the bleep going off continuously, you've got a blocked fistula coming in from [satellite centre], and when a blocked fistula comes in that's my responsibility to sort out."* (Vascular Access Nurse)
8	*"It's like crisis management, so people who have got the most need get the space and somebody who maybe isn't, I don't mean is not important but their access is still ticking along and you know, it's not failed yet. They will not have the priority over someone whose access has fell out, the fistula's collapsed and it's not working and it needs to go back to theatre, you know, wait to get new access in to plan, so it was a bit of a vicious circle the whole month I was there, plans were changed and changed and changed every day."* (RDU Nurse) *"Occasionally interventional radiology wouldn't be able to do what we should be able to do with a fistula, like a fistuloplasty. And I think salvaging the fistulas, you know, is a big effort."* (Consultant Nephrologist) *"They put them on a list and then an emergency does come in, and radiology will tell us to make a choice: that you've got two routines booked in tomorrow or two patients on the waiting list, but if you want your fistula that's clotted done, you're going to have to postpone them and reappoint. So, then they get bumped, and they might get bumped for 2 weeks or 3 weeks, so that the emergency can get done. So it can be at the end of that time most of them reappear and they become the emergency and then the patients get bumped so the circle… the vicious circle goes on."* (Nurse Practitioner)
9	*"You can be operating in theatre and then someone phones you, and you feel very, very bad about it because you can be in an aneurysm that can take 3 hours or so and they are waiting for you and the patient might have had the dialysis already and needs to wait sometimes, not very common. By the time I go across to see them, maybe it's about 4 o'clock – 5 o'clock and they are waiting for me. So it's not the ideal situation."* (Associate Specialist Surgeon)

Table 34 Unscheduled Vascular Access care

Unit 1

There were no emergency cover arrangements at weekends. There was no additional data around unscheduled VA care in this unit.

Unit 2

There was often a reliance upon an individual surgeon to deal with AVF problems out of hours, but when a new patient presented or an AVF thrombosed at the weekend it was normal to insert an NTCVC in the first instance. The need for unscheduled care among existing VA patients was said to be very uncommon, and this was attributed to the achievements of the close-knit MDT team.

Unit 3

There was a focus upon managing problems as rapidly as possible. Surgeons considered that out-of-hours there could be inconsistency of approach, where clinicians who are not normally part of the VA team could encounter AVF problems.

Unit 4

Emergencies arising out-of-hours would be sent to the neighbouring health board, with which they shared surgical and IR services for VA. Most VA problems were considered to be managed locally however, although there was no audit data to support or refute this.

Unit 5

It was said to be common for non-VA emergencies to displace VA cases.   Radiologists noted that emergency fistula procedures were uncommon and attributed this to a robust surveillance programme that preventing this from arising.

Unit 6

Unscheduled care was not reported to present a significant problem. It was normal to slot additional emergency cases into the normal working day if clinically required.

Unit 7

The main challenge was reported to be the need to juggle emergency issues during the working day around the existing ‘routine’ workload. As described earlier, there was additional radiology capacity made available for VA (and other) emergency cases, to prevent significant delays in their management.

Unit 8

There was a sense of crisis, with the service felt to be operating at the very limit of its capacity. Nephrologists did not feel they had sufficient IR support to maintain fistulas, and it was reported that a large proportion of IR referrals related to unscheduled emergency care rather than routine maintenance activity. The feeling of crisis was said to be perpetuated by an inability to fix clinical problems within an appropriate timescale, resulting in problems escalating.

Unit 9

There was a nominal on-call IR service, but in practise VA patients tended not to have rapid access to it. There was reasonable access to an on-call surgeon, but they were based off-site hence any clinical review tended to be delayed by several hours.

Knowledge of timelines and processes

It was apparent that nobody had a complete overview of the VA service within their unit. Most clinicians had an appreciation of the processes relevant to their specialty, and most VANs and equivalents had a command of the other operational aspects of the service such as slot availability, pathways, and workarounds required to get things done. However, there was no managerial oversight of the service or strategic overview of the overall VA service, its use of resources and the outcomes delivered.

Most clinicians assumed that VAN had access to an array of VA metrics and statistics, but in reality this was not available. The operational components of the VAN job appeared to occupy the whole working day, often significantly beyond contracted hours, and there was little potential to add strategic components to the role without substantially increasing staffing complements.

> *I am 30 hours but 30 hours officially, but I'm here a lot more than that… I kind of probably work an extra day in amongst all that…. Just hours over my time coming in on days off to facilitate Vascular Access." (Vascular Access Nurse, Unit 5)*

It was clear that waiting times and clinical processes were almost never discussed across the broader VA team, and almost never with a management representative. There was no internal or other publication of waiting times, which created difficulty in accurately timing when patients should be referred for VA creation, and anticipating how long a patient was likely to wait for a requested test or procedure. There was a lack of data about postponed or cancelled tests and procedures. Individual clinicians referred to 'being able to dig out the data' when asked about their local throughput and service statistics, but it was clear that this information was not routinely reviewed or used to improve service performance.

Procedure outcomes, morbidity and mortality discussion

There was a lack of discussion around VA clinical outcomes, and there appeared to be no formal managerial oversight of VA care in any centre.

There was no agreed definition of 'morbidity' relating to VA. Individual specialties would occasionally discuss cases relating to VA work at a local meeting, for example in the event of a theatre mishap which happened to occur during an AVF procedure. There was no VA-specific morbidity and mortality meeting held in any centre, and discussion of major adverse events was typically limited to a once-off review.

It was striking that IR and surgical operators were often unaware whether their interventions resulted in a positive subsequent clinical course for the patient concerned. Their view on the utility of VA procedures was governed mostly by the volume of repeat work they were asked to perform on the same patients. No units routinely measured their volume of clinical procedures or their outcomes. Only a few surgeons and radiologists could produce logs of their VA clinical workload, and where these existed they were not tethered to outcome data, for example the survival of a new AVF.

> *"We were doing a fair bit of de-clotting and, you know, it was soul destroying. We had to look at it and just say right, what difference are we making here with this? Considering this procedure takes 4 or 5 hours to do, takes out pretty much the whole day in intervention to do one patient. Let's have a look at our figures. And our figures were just appalling. This is not worthwhile doing. Let's have a look. Let's see which, let's try and decide which patients would be worth attempting to open it and which ones are [not]." (Consultant Radiologist, Unit 2)*

It was highly unusual for VA complications to be associated with morbidity and mortality data. Unscheduled care episodes, unusable AVF and similar episodes were not routinely recorded or discussed. Similarly, NTCVC use was not normally recorded in any searchable database. Associated complications were not routinely considered 'morbidity' or logged for regular review. There was some awareness of the approximate proportion of patients within the centre who dialysed via TCVC, but there was no means of tracking which specific patients used them, or their status with regard to AVF or AVG planning. The one exception was Unit 2, where the weekly MDT meeting did feature a real-time list of all patients currently dialysing with TCVC. Part of the standing agenda at this meeting was to plan an exit strategy from the TCVC for these individual patients, and their names would remain on the meeting agenda until the TCVC was removed.

Across most centres, the role of tracking clinical outcomes and individual patient journeys was considered a part of the VAN portfolio. It seemed however that the VAN, who was often a solo clinician, typically funded for less than one whole-time equivalent salary, couldn't realistically hope to achieve this in addition to their multiple other roles.

A further striking finding was the ad hoc nature of any clinical audit relating to VA. Typically this was performed in the context of a medical student project or equivalent. VA clinical audit was not taken seriously by any health board, and no administrative or analytical support was available to help achieve this. This was at odds with the support that was said to be available for other areas of practice such as 'infection control', and the detailed analyses reported to took place when patients developed VA-associated SAB episodes.

Chapter 9: Service Development Needs

This study aims to delineate the structure, function and workload of VA services in Scotland, in the context of unwarranted variation in AVF use for haemodialysis. Moreover, it aims to highlight inconsistencies between ‘work-as-imagined’ and ‘work-as-done’, using these to generate recommendations for practice that are then used to stimulate QI activity.

Earlier chapters have contextualised the study and its systems-based methodology (chapters 1 and 2). Results chapters 3-7 described the structure, function and workload of VA services from an operational perspective. Chapter 8 considered strategic findings from the thematic analysis related to how VA services perform, from a systems perspective. This chapter relates further strategic findings from the thematic analysis, about VA services’ development needs. The findings reported here reflect clinicians’ perspectives on the strengths and vulnerabilities of their service; barriers they face to working effectively; their use of EHRs; and strategies they have adopted to preserve veins for AVF creation. The chapter is particularly important in view of the final research aim of this study – to present recommendations for practice to the clinical community in a manner that facilitates ongoing QI. Creating these recommendations in light of clinicians’ own reflections about their aspirations for service development will surely enhance the likelihood of their implementation.

Self-reported strengths

Clinicians in all centres recognised several strengths and weaknesses of their service (table 35).

Unit	Transcript data
1	*"We usually write two or three options, you know [fistula approaches] so if what we do doesn't know, we are happy with the blood pressure and all that sort of stuff, they just get listed for the next procedure."* (Consultant Surgeon) *"I quite like the surveillance programme over here. The nurses are doing a very good job over here so that I think is a good thing that other units can learn from that."* (Associate Specialist Nephrologist) *"We recently started one patient who… had a fully working fistula you know before he started dialysis, so that story is quite welcome and we are happy to see that but unfortunately that is not very often."* (Associate Specialist Nephrologist)
2	*"It's because we all play a part. A small part, a large part of this and we work together. And we work quite well together."* (Vascular Access Nurse) *"I think we can do it quite well because the number – we do roughly I think it's about 140 fistuloplasties a year… we're doing it with a number of interventional radiologists that is less than a lot of places, but then if you look at somewhere like [large unit] you'll be having to do a helluva lot more fistuloplasties which makes it more sort of difficult to fit it into the working week."* (Consultant Radiologist) *"I can't imagine us doing this sort of work without an MDT. It organises the work, it brings everyone together to give an opinion so I think that is key to have an organised and well attended MDT*." (Consultant Surgeon)
3	*"I think if you are going to work together it is absolutely crucial that you have a good working relationship and excellent communication so that, you know, we can pick up problems and you know with each others work and try aim for the best for the patient."* (Vascular Access Coordinator) *"We are not too big so the whole thing is kept under the control of [VA coordinator] and me really, they are the main players in making sure things happen and without that it would probably all fall to pieces, you would have to formalise everything. If the [unit] gets too big then we won't be able to cope with the numbers anymore without being more formal arrangements"* (Consultant Surgeon) *"If there is failing fistula, early intervention I suppose, and people who are dealing with the fistulas they pick up problems quickly…I think most of the fistulas that we deal with, the failing fistulas, or even the clotted failed fistulas we deal with, we do have pretty good results"* (Consultant Radiologist)
4	*"I think what works well here is that we get on with and speak frequently with the Vascular Access surgeons and interventional radiology, and the surgeons and interventional radiology are committed to our service. So we never have a problem convincing them of the importance of procedures and access and part of that, I think mostly, that is the personalities involved because they seem to enjoy*

	the renal service and patients enjoy their interaction with the surgeons and particularly with interventional radiology." (Consultant Nephrologist)
5	*"I think the fact that we meet and we talk and, you know, I certainly feel that we're a team. I think having access to a vascular laboratory is fab and even if we're struggling to get needles in and we can't see why, [sonographer] will take the nurse and the patient along and scan the patient with the nurse there."* (Vascular Access Nurse) *"We seem to have been maintaining a large number of fistulas by repeat angioplasties or stents, and creating less."* (Consultant Surgeon) *"It works very well having a specific [MDT] to only discuss Vascular Access cases, having a surveillance programme with interested sonographers running it."* (Consultant Radiologist)
6	*The major advantage for us is we have a really friendly approachable surgeon… this is a small hospital wherein the theatre space and the surgeons availability… even if there is no space, [surgeon] finds a space and people will go out of their way to help him because he helps them*." (Consultant Nephrologist) *"We're a happy family, we talk to each other, it's I don't think the rules… we don't need quite so many rules because you know we've got more flexibility."* (Consultant Surgeon)
7	*"I think the main thing is you are quite comfortable with your colleagues of what, how they do things"* (Consultant Surgeon)
8	*"The referral process in is fairly good. I think that the units outwith know how to contact in now because I think in the past it was all a bit up in the air about who they contacted, but certainly having a Vascular Access nurse on site they will either contact her directly or they will contact the nurse practitioners."* (Nurse Practitioner) *"There are surgeons now who will keep going in theatre until they make something and that is very commendable… I think someone like [surgeon] should be viewed as an expert and we should be referring people in for you know end stage access transplant requests and Vascular Access requests because there probably is a role for people building up experience in these sorts of things."* (Consultant Nephrologist)
9	*"We've done a lot of work on SAB reduction; we've not had a … SAB in a temporary line for over 3 years. And we've not had one in a tunnelled line for over 2 years."* (Vascular Access Nurse)

Table 35 Self-reported strengths

Unit 1

Significant benefit had been found by their surgeon's willingness to anticipate future difficulties when designing a VA strategy for a given patient. It was normal to explicitly document several potential surgical approaches to AVF creation, facilitating early relisting of the patient for a further attempt in the event that an AVF failed to mature. This was said to have prevented many delays.

The surveillance programme and attempts to pre-emptively detect AVF problems was said to be highly effective. Similarly, they reported having an effective patient education programme about AVF care.

Curiously, it was also suggested that a recent patient who had begun haemodialysis treatment with a functioning AVF in-situ was a 'success story'; it appeared unusual for this to occur.

Unit 2

There was a strong sense of team working, and individual clinicians worked semi-autonomously without requiring colleagues' approval to escalate clinical problems.

It was clear that all clinicians felt responsible for patients' VA, and the MDT format appeared collegial and functional. The success of the weekly meetings, routine use of detailed clinical records, and proactive approaches to VA problems, had substantially reduced unscheduled care episodes associated with VA.

Clinicians felt that the workload was well balanced to enable operators to maintain their skills, without being overwhelmed such that other services were adversely impacted.

Unit 3

In Unit 3 good relations between nephrology and surgery were seen as the key to success, with nephrology mostly directing patient flow through the service, supported by surgeons with technical expertise and a willingness to fit VA cases around their other workload. They also saw significant benefit in having a nominated individual, equipped with the appropriate clinical knowledge, skills and authority, to coordinate the service. It was recognised that this worked well with the current patient cohort size but could potentially fall down in the event that patient numbers were to substantially expand.

A further strength was recognised in their usual approach of early and aggressive intervention whenever a clinical problem was detected with VA. This was seen to helps maintain the prevalent fistula numbers within the patient cohort, by avoiding access failure and prolonging secondary AVF patency.

Unit 4

Effective communication between team members was regarded as enabling the service to function optimally. The vascular lab was seen to act in a flexible manner that provided rapid access to imaging for patients, and prompt escalation of problems to IR.

Unit 5

Regular MDT meetings were said to enable scheduled AVF intervention planning. The meetings were held with sufficient frequency that additional cases rarely required discussion between meetings. The use of a dedicated VA MDT forum, with sufficient clinical autonomy to directly appoint patients into timed slots, both reduced the risk of VA being displaced by other issues and prevented VA from disrupting other clinical activities.

The vascular lab was considered especially useful in providing practical help with needling AVF and for surveillance imaging. The degree of accuracy from the USS imaging was said to have effectively removed the need for diagnostic fistulography in IR. Their surveillance programme was considered highly effective in extending AVF secondary patency, in part because of the high quality, responsive sonography service. Radiologists also considered that having a regular, nephrology-led TCVC list, was a significant strength: it effectively focused IR VA time on AVF rather than TCVC.

Unit 6

The small, local feel of the hospital was said to enable collaborative working without the need for formal processes and meetings to facilitate this happening. Regular renal unit business meetings, and relative autonomy from senior management over budget control, were said to enable the optimisation of resource use. This, combined with a flexible approach from all clinicians who contributed to the service was said to enable efficient patient care without the need for regular, formal MDT meetings.

It was felt that having one, dual trained operator who could perform both surgical and interventional radiology procedures had eliminated any potential disputes as to who should manage a particular clinical problem. It was recognised however that with this strength came the limiting factor that this individual had to be present in the hospital for any VA interventional activity to occur.

Unit 7

The VAN team was said to be highly visible within the unit, with delegated authority to manage most aspects of VA, and with sufficient staffing to cope with staff planned and unplanned leave.

MDT working was credited with facilitating good communication between clinical specialties and had fostered an environment where clinicians felt comfortable with one another’s judgement and decision making.

Unit 8

A key reported strength was the presence of significant expertise in the surgical team, which enabled management of complex patients. There was also said to be better access to ‘emergency transplantation’, which was unlikely to be so forthcoming in other (non-transplant) centres.

RDU staff enjoyed considerable autonomy in their ability to directly refer VA problems to a clinic without requiring VAN to first review the patient. The single point of contact (VAN) was also considered a strength by RDU staff, albeit the VAN felt overwhelmed with the vast number of referrals and enquiries she received.

The presence of a day area was also considered a strength; this provided a reservoir of beds that limited the impact of bed capacity problems on day case VA activity.

Unit 9

Patient engagement was cited as the reason for substantial reductions in SAB episodes. There was otherwise a striking sense of underachievement among transcripts from this centre, with surprisingly little cited as a positive example of good practice.

Self-reported weaknesses

Many weaknesses were perceived by clinicians in every unit (table 36).

Unit	Transcript data
1	*"I think that if everyone bought into the referral form and the Duplex scanning happened quite reasonably in terms of time and we actually had a bit more access to theatre, then the way the service is set up would run quite smoothly. It would work very well. But it doesn't quite run as smoothly as we would like. Even if I stopped and thought about it and tried to get a handle on it."* (Consultant Surgeon)
2	*"We don't have on-call intervention. We can't have patients staying around in our department after 5 o'clock. And everyone knows that here, so they'll just, they usually come back here and [VAN] will assist with transport. Sometimes it's a taxi and… It can make it difficult for organising stuff. We don't like to do a fistuloplasty as the last case for the afternoon unless they're an inpatient just because of that reason."* (Consultant Radiologist) *"We'd like an audit base, a database."* (Consultant Surgeon)
3	*"The posts are there, we just can't get anybody to apply, it is the same with all our registrars and trying to get staff to come up here is not easy"* (Vascular Access Coordinator) *"[VA coordinator] retires next year, so I think for our service you know… there are many things [she] does for the renal unit that I don't even know I suspect! And when she goes there will be a whole load of stuff on everyone's desk, for want of a better term, which hasn't been recorded."* (Consultant Nephrologist) *"I am worried when [VA coordinator] goes because she plays such a key role"* (RDU nurse) *"A lot of the challenge is in the out-of-hours work, in ensuring the cases are appropriately assessed and the correct decisions are made and people, you know bear in mind just the long term and not just the short term fix."* (Consultant Surgeon) *"So it is also an issue for seccession planning when she retires next year, we will have to replace [VA coordinator] with about 3 specialist nurses I think."* (Consultant Surgeon)
4	*"I would have more robust team planning rather than individual clinicians maintaining their own lists. That is our intention. And that will rely on the new IT which we can't deal with currently, not easily. We have tried with various Excel lists but they tend to duplicate and be overwritten."* (Consultant Nephrologist)
5	*"[I would use additional resources for] dedicated theatre time, where our patients wouldn't get bumped for complex vascular cases, so that our access could happen smoothly… and a vascular anaesthetist who would, you know, take on these crumbly patients that, you know, require block or GA. Maybe another Vascular Access nurse. I'm only me and I've got 185 haemo patients and all the low clearance clinic patients that we're dealing with as well."* (Vascular Access Nurse)

	"Well, there's one thing that we don't have and that's some sort of central intelligence on Vascular Access. We don't have a Vascular Access manager so … renal manages its own bit. Vascular lab manages its own bit, we manage our own bit and radiology manages its own bit. Nobody actually has an overview" (Consultant Surgeon) *"I'm towards the end of my career, need to get other people involved to take that over so there isn't a dip when I do go, whenever I do. And I suppose the same applies to the vascular lab as well. I think that's a big challenge."* (Consultant Radiologist)
6	*"Paradoxically, we are about to build a new hospital and the renal unit is not going to be in it!"* (Consultant Surgeon) *"I think it will be massively crippled when [surgeon] retires unless they get a proper replacement."* (Consultant Nephrologist) *"We want [a] vascular interventional radiologist to be honest with you, wherein, if we had a difficult line or a difficult fistula, which needs immediate attention, so we can go to somebody to do it."* (Consultant Nephrologist)
7	*"And I also realise that as I have been talking I have been focusing on fistulae and the management of [them], and I think [what works much less well] is permcath placement."* (Consultant Nephrologist) *"I prefer a written letter anyway. A sticker's not appropriate at all. I mean that's just ridiculous. And I think stopping me in the corridor, you know, I forget, you know I prefer something documented. We do sort of try and insist that all referrals come in properly you know, so we've got a trail back and you can look."* (Vascular Access Nurse) *"I used to do a lot of fistulas in the [emergency] theatre, if it was empty I would just do it and then I got my knuckles wrapped saying I really shouldn't be doing this because this is for kind of true emergencies. So that doesn't happen as much."* (Consultant Surgeon)
8	*"I come in and I've got 60, 70 emails after a weekend. And I've got a clinic on Monday morning. (laugher) I'm like that, okay, that all waits until I've been to clinic. I've got an MDT, I've got to action the MDT for 3 pm before I even start answering any emails."* (Vascular Access Nurse) *"Yeah that's the problem because see if I get somebody that comes in with 'Oh their fistula's clotted'. 'Oh that's a medical problem'. And we're like that, 'well no it's a surgical problem'. And you're like that, it's the patient's problem – they've now got no access, could somebody do their access please!"* (Vascular Access Nurse) *"We're all in a slightly difficult situation because when you go complaining to someone else that their service is not good or our service is not good, then there's a tendency for that to be taken personally."* (Consultant Nephrologist)

	"I think smaller [satellite RDUs] have more time to give. I think the bigger units struggle because they've just got so many patients and their staffing levels are different… we certainly seem to see less referrals coming in from [smaller units] … I don't think the surveillance is as good in [larger] units. Patients often get here, and they look back and [they've had] months of high venous pressures and needling problems and low pump speeds and you think 'well why were they not referred'? It's a kind of frustration that you think why have they got left to this point?" (Nurse Practitioner)
9	*"We have no dedicated radiology time whatsoever for our patients, which is a problem. I would say that is probably the weakest part of our service. They are great, don't get me wrong. They would do emergency stuff and they are very helpful on the phone, we've got no problems with the radiologists themselves and it's just that we have no time dedicated for when we need it. The more fistulas we have, you know yourself, the more problems there are going to be."* (Consultant Nephrologist) *"My view, this has to be a surgical lead, a radiology lead and a nephrology lead. At the moment, the renal service is compartmentalised. Each compartment is sequestrating in their own compartment. Surgeons, fistula, do the fistula, nice operation, do it. But what are we trying to achieve? Where are we going ahead with it? Where are we among the rest? No. Physician, nephrologist, refer. See, anaesthetist yes, we do this, we don't do that. It's compartmentalised and that's a problem."* (Associate Specialist Surgeon) *"I think, to be honest, we are doing the bare basic for a fistula… I don't think we are providing a service that I should be really proud of."* (Associate Specialist Surgeon) *"We are slightly dislocated from the surgical side of the things unless there's a hybrid procedure requiring to be done or the surgeons wish some ancillary investigation prior to creating a fistula. If we are speaking candidly I would say that we perhaps need to improve that…"* (Consultant Radiologist)
10 (Paediatrics)	*"I don't think [management] really knows how difficult it is dialyse a 4 month year old child or a 5 year old child, I don't think they have any concept of, you know, as soon as the dialysis is finished we can move this nurse to them, that would be finished, are you sure can't manage with less nurses?"* (Nurse Practitioner)

Table 36 Self-reported weaknesses

Unit 1

There was a notably nihilistic tone in the interview transcripts: the surgeon asserted that he was unable to change anything; the nephrologist felt that his unit was underperforming, and the radiologist stated he was unsure that his unit had any good practice to share with others. Passivity and lack of interest from colleagues were cited as particular problems, in addition to the significant waiting time for any investigations or theatre slots to become available, and the geographical separation of the renal unit from vascular surgery and IR.

Unit 2

A major difficulty in this unit was the coordination of logistics for patients who lived in rural areas and required an IR or surgical procedure. It was also noted that despite high AVF utilisation, there was very limited data available relating to clinical outcomes of VA creation and maintenance procedures in the centre.

Unit 3

The team was heavily dependent upon two individuals to fulfil most of the VA workload: the VA coordinator and one surgeon who performed the bulk of access surgery. There was concern about difficulties in succession planning, in a broader context of challenges recruiting staff at all levels across the wider medical and nursing workload. This was a particular concern as the VA coordinator had indicated they were planning to retire in the near future.

Concern was also voiced about the limited capacity of the surgical service, as one surgeon performed the bulk of the work, but this was increasingly impractical given the required time to attend clinic, have MDT discussions and perform the operations, when there was little formally allocated time to do this. Out-of-hours the approach to VA problems was said to be very variable, based largely upon the degree of interest in VA held by whoever happened to be on-call when a patient presented to hospital.

It was recognised across the service that most VA work was done outside of formal job plans and so there was difficulty in reconciling the time and skill requirements for any individuals being recruited to replace incumbents.

Unit 4

Clinicians in this unit did not typically take a team approach to the VA service, and instead individual clinicians were said to refer, manage and navigate their own patients through the access creation and maintenance pathways. Service data recording was said to be unreliable and a robust IT solution was wanted to improve this.

Unit 5

Lack of protected clinical time was a concern, particularly when this meant that relatively urgent VA work could be displaced by non-urgent (but protected) clinical activity.

The vascular lab was a key element of their service, but little succession planning had been done prior to the recent retiral of one of the sonographers. Similarly, one radiologist was anticipating retirement in the next few years, and it was proving difficult to plan for this.

There was little strategic overview of the VA service. This role had historically fallen to VAN, but in reality her 0.8 WTE job was already overwhelmed by operational clinical work, and it had become normal for her to work an additional (unpaid) day per week to cope with the volume of work.

Unit 6

There was awareness that low patient numbers and relative lack of VA-related complications could reduce RDU nurses' vigilance. It was felt that education was important to prevent this, but the available time to deliver this was limited.

Since one individual surgeon performed both the surgical and IR service there were occasional delays in accessing either service, albeit this was not said to be a significant problem.

A future challenge was anticipated in that a proposed new hospital development would lead to radiology and surgery moving to an offsite location; this was expected to hamper the strong sense of teamworking the unit currently enjoyed.

Unit 7

The VAN team was key to the VA service in Unit 7 but had no interaction with inpatients; this was said to cause difficulties whenever an inpatient required a TCVC placed.

There was said to be considerable variation between clinicians as to their VA referral practice, and many referrals were very informal and circumvented the published referral pathway. For example, it was not uncommon for VAN to be given an addressograph label in a brief corridor discussion, and for no additional details to be forwarded about the patient and their requirements.

There was little theatre time allocated to VA surgery in the main centre, and surgeons reported being censured previously by management when they attempted to utilise emergency theatre space for this work.

Unit 8

A lack of resources was a key challenge in this unit. The individual VAN reported having a workload far in excess of what one person could reasonably be expected to contend with, with limited support for professional development and no real contact with the board management structure. Technical issues with the test ordering system also prevented VAN requesting some routine investigations that formed a key part of her role.

The large size of the unit was also considered a barrier to some clinical activity. It was difficult for clinicians to attend MDT meetings due to the geography of the unit and its outlying satellites. Some were disinclined to attend due to a perception that much of the time would be spent discussing patients for whom they were not directly responsible.

There was uncertainty relating to when patients should be referred for VA creation, particularly when the timescales varied significantly without any apparent clinical reason. It was unusual for follow-up plans to be documented at the point of AVF creation, so in the event of primary (or secondary) AVF failure it was difficult to expedite a further procedure.

There was a reported tendency for RDU staff to ‘nurse problems along’ rather than escalating them when first identified. When problems were highlighted, staff reported it being normal to lose the AVF during the excessive waiting time before a maintenance or salvage procedure. There was a substantial mismatch between IR capacity and clinical demand, in part because the regional renal unit relied upon an IR department that was only resourced for a local hospital's needs, rather than to support a regional service.

There was little team cohesion within the centre. Nephrologists report difficulty finding radiologists to speak with, while radiologists reported frustratingly little contact with nephrologists. VAN and nurse practitioners often feel usurped by doctors when requesting emergency IR procedures, and some radiologists were said to be unwilling to speak with nurses about clinical matters altogether.

Unit 9

A lack of designated surgery and IR resource was compounded by the geographical separation of these departments from the renal unit. This hampered attempts to hold MDT meetings, which were held irregularly if at all; consequently, the team lacked cohesion, with individual clinicians working largely independent of one another with no genuine lead surgeon, radiologist or nephrologist.

The lack of IR time was said to delay inpatient discharges and led to increased NTCVC use in patients awaiting TCVC. Staff described having to 'beg' for IR space, and considered that procedures were done as personal favours, rather than as properly scheduled clinical activities. There was also said to be reluctance from a sonographer with expertise in AVF imaging to share this expertise with VAN or other RDU staff.

The non-co-location of renal, surgical and IR services created challenges in identifying a bed and nominating a responsible clinician whenever a patient required to move outside the renal unit for a procedure to be performed. Surgery was commonly cancelled due to patient illness, and last-minute surgical spaces were hard to utilise as there was no easy way to identify the next patient waiting in the queue. There was said to be a relatively high procedure cancellation rate because of confusion around patients' inpatient or outpatient status, particularly when 'day surgery' theatres were being utilised for inpatient VA procedures.

The surgeon who runs the VA clinic does not personally perform the subsequent operations and plays no other part in the service.

Unit 10 (Paediatrics)

The low clinical workload made it difficult to justify regular, programmed VA activity, but the potential value of formal pathways was recognised. Clinicians had very limited awareness of VA complications, especially those that emerged in the longer term such as central venous stenosis. There was little management insight into the complexity and logistical requirements of VA.

Vein preservation

An adequately sized artery and vein are required for the surgical fashioning of an AVF. Without these, the procedure is technically impossible. Veins can be damaged by repeated venepuncture, so limiting their potential use as an AVF. In this study it seemed very common for surgeons to have encountered patients whose veins had been rendered unusable by recent venepuncture. In some cases, it was suggested that alternatives had been available but not utilised for phlebotomy or intravenous cannulation. This was an almost universal source of frustration amongst VA clinicians.

Many units reported issuing patients with ‘alert wristbands’ that identified the arm where an AVF was planned, maturing or in use. These were typically funded from charitable funds rather being directly provided by the NHS organisation. It was also uncertain whether anyone outside the renal services recognised these wristbands, or their significance.

Most units reported ‘educating’ patients about vein preservation but there were no formal policies in relation to this. It was reported to be extremely common for veins that were potentially useable for AVF creation to be rendered inoperable by clinic venepuncture or intravenous cannulation. Patients requiring venepuncture outside the renal ward were said to be at the highest risk. (Table 37.)

Unit	Transcript data
1	*"They get their wee red bangles now and stuff like that, so I mean we still get people fistulas about 2 weeks before they've had IV therapy put through the labelled vein"* (Consultant Surgeon)
2	*"It is very, very difficult and we try to educate medical students, because the renal educator goes and does talks to medical students… Phlebotomists, we try to teach and we also try to educate GP practices as well, but obviously some people are quite set in their ways."* (Vascular Access Nurse)
3	*"[I] tell the patient [which arm to 'protect'] and we put it in the computer system and when the junior doctors start here you tell them, try and use the veins at the back of the hand, unless if it is a cardiac arrest they can put a venflon in that [arm]"* (Vascular Access Coordinator) *"All patients have got a white board beside their bed with their fluid restriction and no needles in whichever arm"* (Consultant Nephrologist)
4	*"We have had quite a few problems with cannulation of things, usually A & E, but other admissions: medical admissions, surgical admissions, they usually identify the patients that need to preserve veins and so it has not been too bad a problem…we have input to the doctors' induction, so all grades, and that includes A & E, surgical and so we explain to them about dialysis patients and venous access so that they all get that and we haven't had major problems with it."* (Consultant Nephrologist)
5	*"We educate the junior medical staff but no, not the phlebotomists really. I suppose we rely on the patients…I think the patients are generally clued up [about preserving veins]"* (Consultant Nephrologist)
6	*"When I see somebody in the Vascular Lab I usually say we're going to make a fistula on this side. If anybody wants to take blood we ask them to use the other side. So it's usually addressed when I meet the patient"* (Consultant Surgeon)
7	*"…that is purely because veins have been battered. They have that band thing, 'fistula, do not use', but still in the community it happens…two or three weeks ago I had a patient who had like…..you know….who'd come in for a [AVF] and they had just been recently, the day before, in the community they had blood taken from the vein"* (Consultant Surgeon)
8	*"…in general terms really we don't [discuss vein preservation] because you're going to have to embark on the discussion about renal replacement therapy. Which is pretty time consuming and very upsetting for them."* (Consultant Nephrologist)

	"The difficulty is, a lot of our patients are frail and have cognitive impairment and they're not going to remember! ... The difficulty is they don't get admitted to our unit, they get admitted to half a dozen other hospitals. I think it's really hard." (Consultant Nephrologist)
9	*"We do have the red rubber wrist bands… elderly people are not that keen about wearing them; I would say [60% of our patients] will wear them. If they are on the ward for any reason they have the band on, or they have on their board above their bed 'do not use', we find a bit more of an issue if they are outliers"* (Vascular Access Nurse)

Table 37 Vein preservation

Unit 1

Red armbands are issued to patients to signify which arm to avoid for venepuncture. Despite this it is said to be common that patients attend for AVF creation surgery, whose veins have been needled in the recent past. There is no formal patient education programme, although efforts are made informally to tell patients about protecting specific vessels. This is most commonly done at the point of AVF creation or when a patient is established on haemodialysis, rather than in the earlier pre-dialysis and clinic stages.

Unit 2

There had been some problems with staff engagement in vessel preservation, which limited efforts aimed at staff education. Problems with primary care phlebotomy had been partly negated by the renal team supplying smaller butterfly needles for venesection, to reduce the risk of large needles being used in an antecubital fossa vein.

Unit 3

Renal inpatients have a whiteboard at the bedside which includes a description of which arm to avoid for venesection. Attempts are made to identify the most likely vessels for AVF creation at an early stage, and patients are taught to protect this arm from venesection. The proposed or existing AVF site is referred to as the patients' 'lifeline'.

Unit 4

There was a reliance upon staff education and patient empowerment to protect vessels. There was little formal thought as to which vessel was most likely to accommodate an AVF, and it was said to be common to find that a 'preserved' vein is inadequate at the point of requiring AVF creation.

Unit 5

The key strategy for vein preservation was to inform the patients about which arm they should avoid having blood taken from. This was felt to be as successful as more extensive strategies would be.

Unit 6

Vein preservation efforts were focused around empowering patients to protect the specific vessels from venepuncture. It was common for patients who attended the renal service to be accommodated within the renal ward whenever they were inpatients for any reason; vein protection for VA purposes was an unintended benefit of this policy.

Unit 7

The VA team anticipate the need for AVF creation and use wrist bands to assist vein preservation. It was very common to encounter a patient with essentially unusable veins.

Unit 8

There was a reluctance among nephrologists to discuss vein preservation with patients early in the course of CKD. It was considered that holding this discussion “too early” might cause unnecessary distress and lead to difficult discussions about future needs for RRT, when this may not realistically occur for many years.

There had been some effort to informally train ward and clinic phlebotomy staff about vein preservation. However, many patients were exposed to other settings where there was no oversight of vein preservation: non-renal clinics, inpatient admissions under other specialties, or attending for blood tests in primary care.

Unit 9

Wristbands are offered for vessel preservation, but it was reported that many patients declined to wear them.

Electronic Health Records

EHRs are seen to have considerable potential to improve clinical quality in nephrology and other areas of practice[277–279]. Little has been written specifically about EHR use in the setting of VA. Across Scotland every renal unit reported using an EHR, but none was seen to utilise this to more effectively to manage the VA service. Various software programs were in use, and most were unable to effectively interface with software used by other specialties. All centres were seen to rely heavily upon email communication, with subsequent copying/ pasting of information into a clinical record. In practice, most 'EHRs' were really collections of static data points such as copied email chains, rather than live records that could practically be used to assist decision making or facilitate detailed clinical audit. There was variable IT support available within units to develop EHRs or to generally support the VA team. No unit consistently recorded the insertion of NTCVC, and it was highly unusual to consistently record other VA episodes of care, clinical outcomes or adverse events in an auditable, electronic database (table 38).

Unit	Transcript data
1	*"I know of [EHR]s existence and my information gets put on it but not by me. So, I mean I think I was given a code, a password, a long time ago. But I just bring the information to [VAN] and she just plonks it on to her vascular operations. I don't use it for any sort of audit."* (Consultant Surgeon)
2	*"Some of it is on an electronic record. A lot of it is on my computer, where I keep electronic records. But here isn't a named database as such."* (Vascular Access Nurse) *"We make up a list, you know, simple spreadsheets for the MDT. That information… there isn't really a fool-proof system."* (Consultant Surgeon)
3	*"We have got a space now [on the EHR] and we have been doing that maybe for a year or two… it comes up at the top of the report, Vascular Access plan."* (Vascular Access Coordinator) *"The trouble is [peripheral unit A] are on [national EHR linkage system] but I think we have now got that linked. We are trying to get [peripheral unit B] linked to our [national EHR linkage system] as well so that we can run the reports and pick up [peripheral unit B] patients and we haven't managed that."* (Vascular Access Coordinator)
4	*"We have had [electronic] low clearance lists but around about 2008… it was abandoned as too chaotic and that never got replaced."* (Consultant Nephrologist) *"We have never [consistently] recorded [clinical data] and so that's because of the way other individuals use IT, so it's actually quite difficult."* (Consultant Nephrologist)
5	*"I copy and paste the clinic letter into [EHR] and then when they're going to theatre, I get that from the waiting list secretary so that goes into [EHR]… once we get the discharge letter from the surgeon that goes into the patient's record on [EHR] as well"* (Vascular Access Nurse)
6	*"I receive an email, the system is called [name] … as soon as there's something in the [EHR] there's an email in my account … it just shows me a list of people who have been referred to me."* (Consultant Surgeon)
7	*"We have got a database and we do keep a list of all the patients we've put on [waiting lists], but we are very much in the office, we have got like three massive big white boards and all the information's on there. A bit of both really [paper and electronic record keeping]"* (Vascular Access Nurse) *"At the moment, not very much because [old EHR] hasn't been developed in a very long time because as you know, we are moving over to [new EHR] [soon]."* (Consultant Nephrologist)
8	*"The idea [is] that anybody, everybody puts the information in the same place… individual access episode specific, all the information and that no matter where you are in the service, even if you're at home, you can read the latest information about the Vascular Access, whether it's from the surgeon, [VAN], nephrologist, nurse, I think that's a real strength … that's involved a big culture change over several years."* (Consultant Nephrologist)

	"We have got a paper and an electronic diary because paper is much easier to use than electronic diaries." (Consultant Radiologist) *"We have… an electronic kind of spreadsheet, but everybody that's referred goes on to the front page which is just the referral and all the waiting list dates and as they're appointed they move on to whatever date, and then [VAN] does her MDT list she just pulls through all the dates in the last week to look up the last and see who's all been seen by radiology"* (Nurse Practitioner)
9	*"We did have what was all in my head basically, but now we put it on to this waiting list on [EHR separate to main renal EHR]"* (Vascular Access Nurse)

Table 38 Electronic Health Record systems

Unit 1

The EHR was viewed primarily as an audit tool, and the VA surgeon didn’t routinely use it. VAN kept records on the EHR but had to manually enter data into the EHR, rather than using the EHR to generate a referral. An electronic test requesting system was used for VA procedures; this was considered more robust than previously used paper referral forms. Unfortunately, the renal unit campus used a different system to the one used on the campus where IR and surgery were based, and no interface between the systems existed. This was said to cause confusion, and it was common for procedures to be mistakenly requested on the wrong system

Unit 2

An EHR was reported to be in use for the general care of renal patients, but not specifically for VA. A simple spreadsheet was used to track ‘active’ VA patients and to guide MDT discussions. VA issues weren’t formally documented in the main renal EHR, but there were plans to move onto an updated EHR in the near future.

Unit 3

The VA plan appears at the top of the electronic patient report. Access creation and significant events were recorded, but the process for doing so was relatively labour intensive and relied upon manual data input. There had been technical difficulty utilising the EHR for patients who lived in other health board areas, for whom they provided renal services.

Telemedicine is used to support remote RDUs, for example photographs of AVFs could be send by email for review in the main unit.

Unit 4

Electronic patient tracking had previously been in use, but its widespread use had been abandoned a number of years ago. This was attributed to inconsistent recording of data by different clinicians within the unit, and the emergence of a chaotic database that was not practically useful.

Unit 5

The EHR was a compendium of access-related activities and decisions. The data was almost all manually input by VAN, who copied/pasted clinical letters and other relevant data. This amounted to a large volume of work, and the resulting database was not practically usable for audit purposes or for strategic review of the unit activities.

Unit 6

New referrals to the VA surgeon were made electronically. These would generate an email alert to the surgeon, and the patient was usually allocated a specific theatre slot within a day of referral. This system helped facilitate rapid attention for emergency cases.

Unit 7

The team used a mostly paper-based tracking system, but also maintained an electronic patient database and inserted MDT outcomes as free-text comments within the main EHR. There was no centralised recording of NTCVC insertion.

Unit 8

The EHR has a VA section that is used to refer patients for VA creation; an accompanying letter, email, telephone call or other message to VAN prompts her to read the referral. The VA screens could be updated in real time but there was no software functionality to track 'active' patients. A VA spreadsheet is used for this purpose, but this data seemed to be accessible only to VAN, and there were questions as to the accuracy of the data. The EHR was widely used by nephrology, VAN, RDUs, surgery and radiology, albeit mostly as a reference tool rather than for active scheduling of appointments. There were no clinical decision aids within the EHR, for example predictors of when a patient should be referred for incident VA creation.

Unit 9

An electronic clinic management system was used to organise a VAN clinic. This did not interface with the main renal EHR and could not be used to carry clinical details or otherwise assist in patient prioritisation. No other use was made of the EHR for VA purposes.

Barriers to effective working

It was acknowledged across every unit that there were several barriers to providing an effective VA service for patients. There was variable insight into the challenges faced by each unit, but in general the units who appeared to have the most significant hurdles to overcome tended to have more insight into their difficulties than others. A nihilistic perspective was frequently encountered when discussing these barriers, and there was often a clear sense that 'nothing can be done'. Phrases like "sadly this happens…" were used frequently to lead into this part of the discussion (table 39).

Unit	Transcript data
1	*"If you were a surgeon taking on an operation then you should be looking after the patient at the time of surgery and after the operation. I struggle to do that because I'm not on site… having your vascular service and your interventional radiology service in different hospitals is not good planning… having a single handed surgeon providing the service is not good either."* (Consultant Surgeon) *"I don't think the nephrologists really had much interest in access. It was somebody else's problem… they didn't seem to take a really big interest in what happens, or liaise closely with the access nurse"* (Consultant Surgeon) *"We do everything within a day, like you know the same day the Vascular Access Nurse gets details on the same day, the access form is done on the same day and we fill in the request on [IR system] the same day, but then it stops there until you hear from the interventional team so that depends on how free they are and how busy they are."*(Associate Specialist Nephrologist) *"Me , [surgeon], all of the nephrologists are asked [to the MDT meeting], [specific nephrologist] is probably the best attender; the rest don't bother."* (Vascular Access Nurse) *"The logistics of getting people across from [campus A to campus B] is such that we can't really meet that requirement. And there are a number of temporary lines going in, sadly, for that reason."* (Consultant Interventional Radiologist) *"We have all the problems of a small centre really and I am not sure we have got any key excellent points. Unfortunately, I would only see the downsides of the geography and relatively small numbers of procedures and IRs offering intervention. I am not sure we have a lot to teach the rest of Scotland."* (Consultant Radiologist)
2	*"Probably the biggest challenge I suppose is the interventional radiology, whether you can fix that. It's a sort of small hospital but I always get the impression that they are most pressurised within the whole system."* (Consultant Nephrologist)
3	*"There is one [surgeon] who it is very difficult to get him to do anything. It is not his area of interest so he will do about two a year, but it causes problems if he is on when an emergency happens. The chances are that [the fistula] won't be retrieved. So it is trying to get consistency, so that the same thing happens when there is a problem every time isn't easy"* (Vascular Access Coordinator) *"I think we are highly dependent on individuals in vascular surgery and radiology"* (Consultant Nephrologist) *"We have a huge problem with our interventional radiology service here in terms of capacity and recruitment and retention of radiologists"* (Consultant Surgeon)

	"The only grief I get [from surgical colleagues] is when I tell them that they need to sort their own ones out, so if they are on call and they have an access problem I say right you sort it out. You sort out the definitive access don't dump it back on me, that's the only grief I get!" (Consultant Surgeon)
4	*"We're still getting late presentation of patients even from other specialties who hold on to patients until they're at the brink of dialysis and there's maybe nothing we can do other than put plastic in them. And GPs also, some of them refer late which is frustrating"* (Consultant Nephrologist)
5	*"Vascular access patients – if we have emergency vascular, urgent fistula, major arterial cases coming in, we don't have dedicated Vascular Access theatre, so these patients will be knocked out of their theatre slots just as varicose vein patients are in order to make space… It's more what's coming in through the doors that can bump Vascular Access patients, sadly."* (Consultant Surgeon) *"If you get an anaesthetist outside our usual 4 vascular anaesthetists, you can run into problems with inexperience for putting blocks or being uncomfortable with anaesthetising patients close to or in renal failure."* (Consultant Surgeon) *"With the former PD surgeons we had a problem in that they were always leaking. We tried to set up a meeting with them and it's really difficult."* (Consultant Nephrologist) *"Having let maybe three members of staff hit retirement with nothing relating to succession planned for these individuals… you have to grow your own vascular lab technician, as we can't find them (laughter) in the papers, we are a bit under pressure"* (Consultant Surgeon)
6	*"Putting a graft in, I haven't really been able to do that very a-traumatically. Let's put it that way. People have often ended up with quite a lot of bruising… they're used immediately in some places but, maybe we'll get around to [that] some day"* (Consultant Surgeon) *"I have spoken to [administrator] and she promises she will email me, but I mean she has got loads of other things to do as well, and you can't always rely on her, so yeah, I do a bit of chasing."* (Vascular Access Nurse) *"Most of our community team or the support team are part-time. So that's when the problem comes, wherein they are not been followed up and things are not getting done purely because nobody is there to do it"* (Consultant Nephrologist)
7	*"A lot of academic consultants will, you know, will refer the patients about 2 years before they need a fistula"* (Vascular Access Nurse) *"[Interventional radiology] is a side of our service that runs less well. Definitely. Now that is because the pressure is on their system"* (Consultant Nephrologist)

8	*"The renal service is regional in [this centre], but the interventional radiology service is not, so that's part of the issue where the capacity is at. I am very aware that there are units around [this area] who don't provide fairly basic imaging support for fistulas…we are faced with fistulae coming in from other areas for venography… and those other centres are really capable centres, … so you know, a bit of re-distribution wouldn't go amiss."* (Consultant Interventional Radiologist) *"All of them have got interventional radiology that could probably do some of these things. They argue that they've got no back up vascular surgeon if something goes wrong."* (Vascular Access Nurse) *"We are always displacing people and I am not judging one against the other, but I think, no I would be reticent to improve the service for one area, on patient group, if it would but impacted very adversely on another patient." (Consultant Interventional Radiologist)* *"Honestly, it never stops. It never stops. Because it's like: I tried to phone you and couldn't get you so I've emailed you. You know? I'll come in, and I've cleared my emails, and when I go back there'll probably be about 30 emails and I'm not kidding."* (Vascular Access Nurse)
9	*"When we drew up the plan to re-vamp the Vascular Access service, everything was in it, so there was [VAN]'s post, there was a fistula clinic planning clinic, the fistula surveillance programme. Everything that we thought we might need, including, we worked out how many sessions of theatre we would need based on the guidelines that we used at the time, and also there were guidelines for how much radiology time you would need, and there was a number of functioning fistula and patients on dialysis. And we would put that in and it made this, the budget, the business case so expensive that the managers just took that out. So we have no dedicated radiology time whatsoever for our patients, which is a problem. I would say that is probably the weakest part of our service. They are great, don't get me wrong. They would do emergency stuff and they are very helpful on the phone, we've got no problems with the radiologists themselves and it's just that we have no time dedicated for when we need it. The more fistulas we have, you know you yourself, the more problems there are going to be."* (Consultant Nephrologist) *"If we had a system in place to stop the guys getting on the treadmill, we wouldn't have to try and catch them as they're falling off. So if we get this part sorted out, we will able to save in that part, but we can't do that, because we can't do that. We've got to invest to look after these patients."* (Consultant Radiologist) *"It would be defining what, in terms of resources, to find out what we need to support a good quality service and I think there's a gap between what we need to support the service. Because we've got a gap, we've come up with all these compromises and fill-ins etc."* (Consultant Radiologist)

	"No, I think the last time [any radiologists and nephrologists in this unit] met [in person] was at a meeting [organised by a third party]" (Consultant Radiologist)
10 (Paediatrics)	*"My last emergency cases, you are phoning around various different people coordinating, if you can't get hold of someone or you're leaving voicemails, messages, then you have to wait for them to get back. You can't plan until you have everybody in place. So it certainly could be smoother but that's the way it is."* (Consultant Nephrologist) *I think as long as the service is progressing and moving on and there's not too many issues, people don't look too far beyond and that's where I feel that we could do with some more audit too"* (Nurse Practitioner)

Table 39 Barriers to effective working

Unit 1

Several problems were reported in this unit. Fundamentally there was a lack of clinical time allocated to the service and no designated procedure slots for VA, compounded by multi-site working and a perceived lack of buy-in from the wider nephrology team.

The VA team consisted almost exclusively of individuals who had no formal job planned time to participate in the service. There was no named radiologist to liaise with the VA team, and any contact between VAN or surgeon with radiology was reserved for 'special' cases. The radiologist interviewed for the study was unable to name any nephrologists and could not recall having ever met a nephrologist in person. One surgeon performed all VA procedures with no provision for backfilling his time in the event of absence. One staff grade nephrologist attempted to contribute to the team but had no time or administrative support to fulfil this role.

It was perceived that nephrologists were disinterested in VA, while the broader surgical, radiology and sonography teams perhaps failed to appreciate the complexity of the VA service beyond the technical aspects of the relevant clinical procedures.

There were no scheduled MDT meetings besides informal discussions between the surgeon and VAN in the RDU. These were fitted around the surgeon's other commitments and in practice it was not possible for patients attached to some haemodialysis shifts to see the surgeon during their scheduled haemodialysis sessions.

The non-co-location of nephrology, surgery and radiology on one campus caused substantial inconvenience to patients and the service. Specific challenges include the logistics of moving patients between sites, ambiguity as to who was clinically responsible for the patient at different stages of the VA journey, and managing clinical uncertainties when patients with complex renal illness require to stay as inpatients on the other campus (with no on-site nephrology cover), and ambiguity as to who is clinically responsible for the patient at any given stage of their VA journey. Most surgical intervention was scheduled offsite as bed pressures prevented patients from having their operation and being accommodated in the renal unit. The lack of onsite surgery or IR meant it was not possible to aggressively manage patients who presented with an acute VA problem such as AVF thrombosis. The difficulty accessing IR was said to result in high NTCVC use.

VAN appeared overwhelmed with the workload involved in organising the logistics of patient transfers to the IR site, coupled with the need to book beds, issue instructions for patient care (e.g. regarding the administration of peri-procedure antibiotics), and attending to the vast array of enquiries about these patients' care. VAN was also unable to order some VA-related tests and needed a nephrologist to countersign requests, which added to delays in pushing patients through the system. There were two parallel interventional radiology requesting systems in use (one on each campus) and it was said to be common for miscommunication to result in tests being requested on the wrong system and therefore being missed.

Referrals for new VA creation were said to be haphazard. Clinicians varied in their thresholds for referring patients, and variably bought into using the referral documentation. It was typical for referral to be deferred until a crisis point was reached, with little acknowledgement of the timelines involved in new AVF creation. Much of this delay was outside the control of the VA team, but was not routinely measured or published internally.

Patients were not actively discouraged from TCVC use, and staff felt that using TCVC early in a patient's experience of RRT might reduce their enthusiasm for transiting onto an AVF.

It had become normal for patients to wait over three months for 'urgent' VA procedures, sometimes remaining an inpatient for large proportions of this time. New patients had almost no hope of having an AVF in place they required haemodialysis, and when this did happen it was lauded as a major achievement rather than being considered normal practice.

Unit 2

The major barrier to optimal working was said to be a lack of designated IR resources for VA. There was a highly enthusiastic radiologist in post in the unit, but most of the VA related activity was seen to be discretionary. There was some concern that if IR ceased to continue providing their current, intensive, level of service, this would have serious consequences for patients and would impact greatly on surgical and nephrology services.

Unit 3

The main active challenges related to capacity in the radiology department, which was a particular challenge due to difficulties in recruiting and retaining consultant radiologists. It was acknowledged that while the service functioned well, there was a dependence upon one or two key individuals in each unit. Out-of-hours it was difficult to ensure consistency of approach to managing access problems, and there was at times a tendency for any VA problems to be referred back to one or two clinicians who were not resourced to provide the whole unit's VA service.

Unit 4

Late referral into the renal service was said to be a major problem, frustrating efforts to create timely VA. There was limited data to support this assertion, and it seemed that a lack of audit data to support practice was perhaps a more important barrier. This was partly because of reluctance among the wider renal team to effectively utilise the EHR system, hence limiting the ability to collect meaningful data.

Unit 5

A major reported challenge here was in succession planning, as several established members of the VA team were planning to retire in the coming year or so.

There was also some difficulty in maintaining 'urgent' status for VA work, and other clinical problems frequently usurped VA cases for non-clinical reasons. Occasionally there were also difficulties encountered when anaesthetic staff who were unfamiliar with VA work were asked to help in a theatre case: non-vascular anaesthetists tended to be less comfortable with renal patients' comorbidity, so were more likely to cancel the surgery.

Historical difficulties with PD catheters had proven particularly difficult to address; the high frequency of PD fluid leaks had been thought partly a function of operator technical skill. In the absence of robust local (or national) audit data it had been impossible to raise this issue with the surgeon concerned.

Unit 6

The major challenge in this unit related to AVG. Their insertion was considered a significant technical challenge by surgeons, and there was considerable uncertainty as to how they should be monitored thereafter. RDU also struggled to needle grafts, which was said to reflect a general need to improve skills with AVF cannulation. Educational opportunities were relatively lacking in view of their geographical situation and low patient numbers.

A large part of VAN's role involved chasing administrative staff to push patients through clinical pathways; there seemed to be sufficient work for a part time VA administrator role alongside that of VAN.

The VA team collaborated informally with one another; while this worked well in the existing setup, the lack of formality and designated clinical resource was a risk that staff changes, or other external events, could impact upon the service.

Unit 7

The major challenge reported here was the variable timing of referrals into the service for VA creation. While some clinicians tended to refer patients very early, others would refer significantly later in the illness trajectory. There was little appreciation within the nephrology group as to the likely timescale of creating a functioning AVF. There was concern that patients referred too early in the course of their CKD may occupy slots that would be better used for more urgent cases. They may have an AVF created and require considerable ongoing maintenance work prior to its eventual use, or it may ultimately not be required.

There were several technical barriers, for example VAN was unable to directly request several imaging tests and procedures; these had to be countersigned by a nephrologist. In addition, there was a reliance upon administrative staff who were not part of the VA team, who controlled access to theatre slots. This was a particular issue when urgent AVF creation was required.

There were no designated IR slots for VA, which could cause delays. TCVC insertion was not considered 'urgent' hence an inpatient with NTCVC may wait a considerable time before this can be converted to a TCVC. The designated VA surgery slots tended to be offsite, but patients were often unwilling to travel there for their procedure.

Unit 8

There were several major challenges in Unit 8, principally focused on the IR service, AVF surveillance and VAN workload.

There was a significant lack of IR slots for VA, and limited buy-in from senior radiologists to enable service development. This was partly because of a mismatch between the IR department funding (for the needs of one local hospital) versus the regional catchment of the renal unit, which generated a disproportionate volume of IR work. This generated considerable discontent and was possibly perceived by some team members as disinterest in patients, rather than inability to accommodate the large volume of requests.

It appeared that no one in the centre had an idea of the likely timeline for a given procedure, which could sometimes be done within hours of the request and other times would require several months wait. Many clinicians reported having a sense of radiology ‘doing them a favour’ whenever a VA case was performed.

It was reported to be common for semi-elective IR referrals to evolve into clinical crises. Urgent procedures that required out-of-hours radiology would only be considered once the out-of-hours period began, which caused further uncertainty and delay. A consequence of the inability to maintain AVF was a large patient cohort with longstanding TCVC use resulting in central venous stenosis, which brought a further large workload to the IR department.

Significant chunks of IR resource were utilised performing routine ultrasound vein map scans, as there were no sonographers available to do this work. It was said to be common for this imaging list to be cancelled at short notice if the radiologist was required elsewhere. The vascular lab was a separate entity from radiology, with no capacity to record images on a central database, and with no direct interface with IR in the event of a problem being encountered. Radiologists also had a high TCVC-related workload: the nurse-led service’s exclusion criteria effectively excluded most potential (renal) patients, and when the nurse-led service was operating a radiologist was required to be in close proximity, further limiting their capacity for other clinical tasks.

IR feel disengaged from the renal and VA teams and feel a duty to consider all renal and non-renal patients equitably.

VAN and RDU staff encountered significant difficulty in maintaining surveillance or education programmes in view of the high patient numbers, large numbers of satellite units spread across a wide geographical area, and high staff turnover. Staff were often reluctant to discuss VA with patients, particularly since they had little confidence that a candid discussion of AVF benefits would then be supported by the service being able to create an AVF for that patient. Many RDU staff were also underconfident cannulating AVF.

It had become common for clinicians to circumvent the usual VA clinical pathways for patients with urgent clinical problems, in part because the routine pathway was not considered credible by the wider clinical team. The difficulty accessing IR encouraged ‘just in case’ referrals instead of waiting until it was clear a patient needed a particular procedure.

There were various governance problems within the unit. Nephrologists worked on a ‘team’ rather than ‘named patient’ basis, and colleagues often struggled to identify the nephrologist responsible for a given patient. It was said to be difficult to obtain senior surgical opinion during the working day, and decision making tended to be deferred until ward rounds in the late afternoon when there was then little prospect of actioning any decisions that day.

VA was not afforded ‘urgent’ priority status. It was regularly displaced by transplant and other vascular emergencies, as there are no designated VA slots and these procedures were performed by the same group of surgeons.

The workload for the solitary VAN in the centre was far in excess of what could realistically be achieved. The flow of incoming enquiries seemed overwhelming, and the lack of dedicated surgical or IR resource limited her options for addressing any identified problems. In common with other centres, it was reportedly common for referrals to contain inadequate clinical information, while technical issues prevented VAN requesting radiology tests or procedures which were fundamental to her role. There was also very limited training or clinical support available for VAN, which frustrated efforts to develop the service.

Unit 9

A key challenge in this centre was the lack of designated clinical time for VA work. It was reported that a business case had previously been submitted to senior management in an effort to secure dedicated IR resources, but for cost reasons this has been declined. All IR on the renal unit site was said to be performed during the radiologist’s professional development time, hence it was unreliable and not backfilled in the event of absence. Offsite IR was more reliably operational, but logistical difficulties made this extremely difficult to access.

Sonography availability was also variable, and there were reported personality clashes that impeded development of this service in the RDU.

Surgical time was similarly under-resourced. Besides a fortnightly theatre list, the surgeon had no other clinical time to attend to VA problems, and was not otherwise based on the renal unit site. He would see urgent referrals effectively in his own time at the end of the working day. There was interest in increasing the use of AVG as a strategy to reduce TCVC use, but the lack of infrastructure to maintain grafts had frustrated this.

There was very little formal nephrology involvement in the VA service, which predominantly relied upon VAN. The lack of regular MDT meetings, and the situation of IR and surgery on another campus meant that the VA team almost never met with one another. There was no insight into the volume of pending clinical activity or the current waiting times for procedures.

Clinical pathways seemed inadequately designed. The VA team was not made aware of a patient until they had chosen haemodialysis as an RRT modality; this decision was often made late, without due regard for what was technically possible for that patient, and without awareness of the timelines involved. The VA clinic was run by a surgeon who did not actually perform any access surgery; it was common for the surgical assessment to effectively be repeated by the operating surgeon on the eventual day of surgery. It was also very common for patients to be referred for anaesthetic pre-assessment, which typically resulted in their planned surgery being cancelled, even when general anaesthesia was not being contemplated.

Unit 10 (Paediatrics)

It was apparent that the logistical difficulties involved in arranging a VA procedure were very time consuming; this was ultimately seen as a barrier to doing things unless absolutely necessary. Little effort was made to audit clinical activities and there was very limited awareness of patient outcomes, particularly later outcomes that became apparent once the patient had transited from paediatric into adult care.

Chapter 10: Recommendations for practice

This study sought to explore the structure, function and workload of Scottish VA services, in the context of widespread variation in AVF use between centres (see chapter 1). Principles of sociotechnical systems theory and healthcare resilience engineering were used to design a mixed-methods model that was then used to explore the structure, function and workload of VA services across Scotland, and comparison of 'work-as-imagined' and 'work-as-done' from the perspectives of all key VA stakeholders in Scotland (see chapter 2). The findings collectively enable the generation of recommendations for practice: practical steps units could take to improve their VA service, with an overarching aim of improving AVF use.

This chapter reports the results associated with the final two research aims of this study: to illuminate gaps between 'work-as-imagined' and 'work-as-done', and to present recommendations for practice in a manner that facilitates ongoing QI. These results are presented in two main sections: recommendations for practice, which reflect the identified gaps arising from the data; and VA scorecards, the means of presenting the recommendations and stimulating QI. The subsequent chapters discuss the study and suggest avenues for further study.

Recommendations

The recommendations were generated from the study findings, which arose from detailed thematic analysis of interview transcripts (chapters 3-6, 8-9), consideration of field notes, and analysis of the six-week clinical activity census data (chapter 7). These findings were contextualised in the sociotechnical systems and healthcare resilience engineering literatures, and a Safety II perspective focusing on 'why things go well' rather than 'why things go wrong' was adopted.

In writing the recommendations a balance had to be struck between providing a sufficiently detailed statement of recommendation, with the need for this to be practically useful to the VA community. Similarly, there was a need to accommodate a mixture of large and small, rural and city-based units, accepting that a 'one size fits all' approach was unlikely to be helpful. The language used was judged accessible to clinicians and managers alike, while each recommendation was written in a way that its implementation could be gauged objectively using the scorecard tool (see below).

The recommendations, and their rationale, are presented in table 40.

	Recommendation	Explanation
1	'Haemodialysis with TCVC', 'haemodialysis with AVF', 'haemodialysis with AVG' should be considered as three discrete RRT modalities with varying associated burdens of morbidity, mortality and financial cost.	The data suggested clinicians considered different VA modalities as merely technical considerations of how haemodialysis was delivered. The literature suggests significant divergence in the morbidity, mortality and financial costs profile of each modality. This recommendation seeks to reframe VA modality selection and enable patients to make better informed choices about RRT. (See chapters 3 and 4.)
2	Variation in TCVC use should be used to study variation in VA between centres.	The data suggested clinicians were interested in increasing usage of PD and transplantation. Current guidelines recommend 'maximising AVF use' as an audit standard for VA services; this perhaps fails to recognise the potential benefits for patients of other RRT strategies. This recommendation suggests 'minimising TCVC use' – encompassing greater use of PD, transplantation, AVF and AVG – would provide a much clearer picture of quality in VA services, and potentially stimulate greater use of other RRT modalities. (See chapter 4.)
3	Efforts should be made to understand and measure patients' experience of Vascular Access services.	Chapters 3 and 5, and appendices 4-6, suggest markedly variable clinical pathways, uncertain waiting times, and a frustrating clinical course for many patients. Chapter 7 suggests patients are also subjected to large numbers of tests and procedures. This recommendation seeks to encourage units to consider their patients' experience of the VA service, in keeping with Scottish Government strategy[103].
4	Clinical time should be allocated to delivering patient education about Vascular Access modalities, and vein preservation strategies, to	The data suggested some patients are unable to have AVF created due to overzealous venepuncture (see chapter 9). This recommendation seeks to acknowledge and address this challenge, being mindful that this issue is not necessarily within the gift of the local VA service to fix.

	all patients for whom haemodialysis is being contemplated.	
5	Patient education about Vascular Access should continue throughout their time on haemodialysis treatment. Patients should be encouraged to self-report potential access problems.	The data suggested patient education was delivered as a once-off session prior to commencing haemodialysis, and variable surveillance activity (chapters 3, 6). This recommendation seeks to empower patients regarding their Vascular Access in the hope this will facilitate smoother entry and processing through VA maintenance pathways.
6	A ‘personal access strategy’ should be documented by nephrologists for each patient who may plausibly require haemodialysis treatment. This should be done with mindfulness of local timelines for access creation, which should be published regularly.	The data suggested variable clinician opinion about using AVF, late referral for AVF creation, shared clinical responsibility for patients, and uncertain internal timelines for VA creation (chapters 3, 4, 8). This recommendation encourages nephrologists to anticipate the need for Vascular Access, to document a clear plan about this, and to initiate referral into the local VA creation pathway with sufficient time for there to be a realistic chance of commencing haemodialysis using an AVF.
7	A written clinical pathway for Vascular Access creation and maintenance should exist in each renal unit. This should include clear processes for referral into the pathways for both new access creation, and when problems are identified with existing access.	The data suggested poorly defined clinical pathways, and poor clinician awareness of local pathways (chapters 3, 5, 8). This recommendation arises from these findings, and is in keeping with the Safety II emphasis on “why things usually go well” to design and document a clear, unambiguous pathway.

8	Electronic health records should be routinely used to streamline and track patient flow through Vascular Access pathways.	The data suggested all units had access to EHRs but did not routinely use them for VA purposes (chapter 9). This recommendation arises from this and mindfulness of the sociotechnical systems literature around 'information flow' (see chapter 1B).
9	A suitably trained sonographer, with adequate clinical time and resources, should be available to all Vascular Access services.	The data suggested a clear lack of clinical imaging facilities for Vascular Access creation and maintenance purposes (chapters 3, 5). This recommendation aims to reduce the reported reliance upon consultant radiologists to perform such imaging, which was said to reduce their available clinical time for other VA activities.
10	Patients with a clear option for AVF creation should be listed directly for their operation without requiring additional clinic attendances. If there is uncertainty about the best AVF creation approach, patients should have access to a one-stop clinic for access planning. Appropriate clinical review, imaging and a decision for theatre should be available at a single appointment.	The data suggested decisions about AVF creation were regularly delayed or thwarted by patients having to attend multiple outpatient appointments. There were also difficulties in tracking patients' progress through the pathways, and it was said to be common for patients to be lost in the process. Units in which patients could be directly listed for surgery by VAN or equivalent, or who operated a one-stop clinic for this purpose, tended to report higher AVF use. (See chapters 3 and 8.) This recommendation aims to share these areas of good practice from the study findings.
11	AVG should be available to any patient with a clinical requirement for one. This may require regional or national collaboration to provide a tertiary specialist service.	The data suggested AVG were only practically available in centres where there was an interested and technically skilled surgeon, supported by responsive interventional radiology services to maintain graft patency. Patients who did not have access to AVG would otherwise dialyse using TCVC. (Chapters 3 and 4.) This recommendation seeks to reverse this finding and is in keeping with clinical guidelines[3,89].

12	Designated vascular surgery and interventional radiology slots should be available for Vascular Access procedures. These should be available to book on both a routine and emergency basis.	Clinical activity data suggested a substantial workload associated with VA services, while interviewees almost universally complained of inadequate slot provision for surgical or IR VA procedures. Access to the available slots was limited by difficulties booking elective or emergency cases with sufficient notice. (See chapters 3, 5, 7, 8). This recommendation seeks to resolve this problem.
13	Vascular access procedures should be afforded ‘urgent’ or ‘emergency’ status. They should not be subject to displacement by other cases for non-clinical reasons	The data suggested VA cases were usually given ‘routine’ status and were often subject to displacement for non-clinical reasons. This was said to commonly mean VA cases were not managed within clinically acceptable timeframes. (Chapters 3, 8). This recommendation seeks to resolve this problem.
14	A plan for further intervention should be documented at the time of any access creation or maintenance procedure. This should guide further action in the event that the procedure proves to be unsuccessful.	The data suggested many VA procedures were unsuccessful, but patients had to then join a waiting list for a clinic visit before further procedures could be scheduled. One unit routinely documented the next steps to take with each access procedure, expediting listing for a follow-up procedure if the first attempt failed. (Chapter 3.) This recommendation seeks to share this good practice and resonates with Chern’s model in relation to ‘information flow’ (see table 4).
15	All patients should be assessed by a suitably trained clinician between 2-4 weeks following an access creation or maintenance procedure. This review should be supported by provision of designated procedure slots	Variation in postoperative review practice was described between centres. All sought to review patients within 4 weeks of AVF creation, but in one centre this review was performed six times within a two-week time window. Steps to remedy identified problems were said to be practically difficult in view of the lack of available urgent surgery or IR slots. (Chapters 3, 5, 6.) This recommendation seeks to address these challenges by focusing clinical resources upon a single postoperative

	for further work that is found to be needed.	review followed by direct access to a procedural slot for any required maintenance procedure.
16	Vascular Access Coordinators should be empowered to directly request tests and allocate slots to named patients for Vascular Access procedures, in keeping with the clinical confidence of other team members.	Interviewees suggested that key VAN roles were to request VA tests and prioritise procedures for patients. It was said however that they often lacked authority to book tests without a doctor's countersignature, and often had to defer to a third-party administrator to procedure slots to patients. This recommendation takes account of these findings in light of Chern's model, in relation to 'power and authority' (see table 4).
17	Units should maintain 'priority lists' that identify the next patient to have a procedure performed, should additional capacity become available. This should be accessible by all relevant members of the team.	The data suggested chaotic patient flow tracking and reliance upon memory, or databases that were inaccessible to key team members. It was said that 'spare' procedure slots were often 'wasted' as staff had difficulty identifying the next patient on the waiting list. (Chapters 3, 8, 9.) This recommendation seeks to resolve these challenges.
18	Patients should have access to vascular surgery and interventional radiology services that are co-located with the renal unit.	The data suggested non-co-location of renal, surgical and IR services often impeded patient care (chapters 3, 5, 8, 9). This recommendation is made to resolve this problem, mindful that its implementation is likely to be challenging within the wider hospital context.
19	A vascular-access specific morbidity and mortality meeting should be held on a regular basis, with	The data suggested an almost complete absence of clinical audit, discussion and publication of VA outcomes, morbidity and mortality. There was also sporadic awareness within centres of other barriers to effective

	involvement from all members of the team. Meetings should discuss procedure outcomes and cancellations; administrative delays; deviation from normal clinical pathways; emergency Vascular Access provision in patients with established kidney failure; access patency; unanticipated failure of existing access; complications including central venous stenosis, steal syndromes and infections.	clinical care (such as deviation from the usual clinical pathway, administrative delays and so on). (Chapters 3, 5, 8, 9.) This recommendation seeks to provide scrutiny of VA clinical outcomes. It is also hoped that a morbidity and mortality meeting would provide a helpful forum to discuss other relevant service issues such as administrative delays, or where colleagues appeared to be deviating from the usual clinical pathway.
20	A Vascular Access-specific multidisciplinary team meeting should be convened on a regular basis, with a frequency and duration reflecting the patient cohort size. All clinicians with responsibility for patients receiving haemodialysis should have clinical time to contribute to this meeting. At least one nephrologist, surgeon, interventional radiologist and VAN should attend, and administrative support	The data suggested that multidisciplinary teamworking was necessary for effective VA care. Reported barriers to this process included the inadequate provision of clinical time, no administrative support and poor attendance from colleagues. (Chapter 5.) This recommendation seeks to equip units with the reported prerequisites for effective multidisciplinary working.

	should be provided for each session.	
21	The Vascular Access service should be adequately resourced with job planned time. This should include backfilling in the event of long-term absence.	The data suggested almost no VA clinical work was performed during formal job planned time, rendering services vulnerable to staff absences. (Chapter 8). This recommendation seeks to remedy this issue.
22	A meeting to discuss strategic aspects Vascular Access services should be held on a regular basis. This should be kept separate from clinical discussions about individual cases.	There was a striking lack of strategic overview of VA services, with no formal managerial involvement and little clinical time for strategic (rather than clinical) discussions. This issue was conspicuous in its absence from interview transcripts. This recommendation seeks to provide VA clinicians with the opportunity to consider their service performance in a separate forum from clinical discussions.
23	RDU nurses should be formally trained to assess and use AVF and AVG, to record their findings at each haemodialysis session, and to identify potential access problems. Patients with challenging Vascular Access should be identified and cared for in an appropriately staffed area of RDU.	The data suggested a lack of training for RDU staff in the assessment and routine use of VA. Interviewees said it was common for clinical problems to be unrecognised and opportunities for corrective action missed. (Chapter 5.) This recommendation seeks to share good practice and encourage formal training programmes for staff.
24	Units should develop educational programmes that provide secondments for RDU nurses to work with VAN, to enhance	The data provided several examples of successful RDU engagement in Vascular Access care through the provision of a secondment programme. (Chapter 9.) This recommendation seeks to share good practice.

	Vascular Access knowledge and skills.	
25	Units should maintain an ‘access intervention history’ as part of the haemodialysis patient record. This should be used to inform decisions about problematic access.	The data suggested clinicians in the wider VA and RDU teams lacked awareness of patients’ previous access problems. One unit had a highly successful strategy for record keeping, which was seen to reduce futile interventions and reduce unanticipated failure of existing access. (Chapter 5.) This recommendation seeks to share good practice.
26	Vascular access at risk of failure should be afforded ‘clinical emergency’ status and managed as such.	The data suggested poor recognition of impending Vascular Access failure as a clinical emergency. This was said to reduce the likelihood of expediently dealing with problems while there was a realistic prospect of salvaging the AVF. (Chapter 5, 6, 8.) This recommendation seeks to address this problem.
27	There should be a clearly articulated, written policy describing the management of clotted Vascular Access. For clotted AVF or AVG this should include urgent access to combined surgical and interventional radiology declotting procedures.	The data suggested inconsistency within and between centres around the management of patients who presented with a clotted AVF or AVG, although this was said to be common. Centres with streamlined approaches tended to report more successful salvage procedures. They also anecdotally encountered the problem much less frequently, perhaps reflecting enhanced awareness and greater preventative action. (Chapter 5.) This recommendation seeks to reduce this variation.
28	A clearly articulated, written description of the roles and responsibilities of each Vascular Access team member should available to patients and members of the wider clinical team.	The data suggested considerable ambiguity as to who was responsible for different elements of the VA service. (Chapters 8, 9.) This recommendation seeks to address this.

29	The Vascular Access coordinator role requires clinical credibility and expertise. The coordinator complement within a centre should be proportional to the patient cohort size. Their primary responsibility should be the efficient processing of patients through Vascular Access pathways. The post demands an individual with a clinical background, but administrative elements of the job could be performed by a non-clinically trained individual.	The data suggested a central role for the Vascular Access coordinator, but a significant volume of administrative work was said to distract from important clinical issues. (Chapters 3, 5, 6.) This recommendation suggests an equivalent to a 'cancer tracker' administrator role may relieve administrative burdens to free up clinical time.
30	The broader Vascular Access community should develop service performance metrics that facilitate comparisons between centres and provide a national overview of productivity.	The literature and individual units had a striking absence of data relating to clinical workloads, outcomes and financial costs of operating VA services. It was apparent that the clinical activity census in this study was the first attempt to systematically collect this data. This recommendation seeks to embed and standardise this data collection process to facilitate further QI.
31	A named senior manager (e.g. the medical director) should be nominated by NHS boards to provide strategic oversight of the Vascular Access services. This should include	The data suggested an absence of managerial oversight from Vascular Access services. Interviewees reported difficulty navigating different areas of the service that had different budgets and priorities. (Chapters 4, 9.) This recommendation intends to provide a single senior manager with strategic oversight of VA services across all relevant directorates within the NHS board, to manage these challenges.

	stewardship of the overall financial costs.	
32	Recruitment exercises should anticipate the needs of Vascular Access services	The data suggested a lack of succession planning amongst Vascular Access services. The absence of job planned time also rendered services 'invisible' when recruitment exercises were planned. (Chapter 8.) This recommendation seeks to address these gaps.
33	The specialty training curricula for renal medicine, vascular surgery and interventional radiology should include formal training in Vascular Access as a core competency. This should include technical and non-technical elements of service delivery.	The absence of formal Vascular Access training from specialty training curricula appears incongruous, given the volume of work associated with Vascular Access, and the significant associated potential for morbidity and mortality. This also hindered attempts to recruit clinicians with Vascular Access skills, in the absence of a recognised training qualification in the field. This recommendation seeks to address these gaps.
34	All clinical staff involved in the peri-procedural care of patients undergoing Vascular Access procedures should be appropriately trained in these patients' specific needs.	The data suggested patients accommodated outside renal units for VA procedures were vulnerable to suboptimal care, including under-recognition of the need to preserve veins, and other aspects of perioperative management specific to patients with kidney failure. (Chapter 3.) This recommendation seeks to address this problem.

Table 40 Recommendations for practice

Vascular Access Scorecards

The background to the ‘scorecard’ tool is discussed in chapter 2. The scorecards intend to fulfil the final aim of this study: to present the recommendations for practice in a manner that facilitates ongoing QI efforts.

The scorecards (appendix 3) present the recommendations as a series of questions about the respondent’s local service. Each question can be answered ‘yes’, ‘no’ or ‘don’t know’. The intention is to facilitate engagement with the recommendations; to encourage clinicians and managers to consider the position of their local service both at the point of completing the questionnaires and with the subsequent benchmarking provided by the complete dataset; and to stimulate QI activity using the questions as prompts to develop elements of the local service. The questions were written in a manner sympathetic to the structure of the preceding results chapters, but using language more commonly used in clinical management circles. Table 41 outlines the scorecard domains and their contents.

Domain	**Inclusions**
Governance	Questions related to governance of the service. These include integration with corporate structures; definition of individual roles and responsibilities; written policies for managing VA creation, maintenance and unscheduled care.
Job planning	Questions relating to the provision of clinical time for the VA service
Service performance	Questions relating to local strategies for measuring, auditing and discussing service productivity, clinical outcomes, morbidity and mortality.
Education	Questions relating to education and training of staff and patients
Patient experience	Questions relating to processes focused upon patients' experience of the VA service
Clinical Processes	Questions related to elements of VA creation and maintenance considered important to the overall success of the service.

Table 41 Vascular Access Scorecard domains

Results

A total of 42 scorecards were submitted using the online data collection tool. No paper responses were received.

Responses were received over a broad timescale, from December 2015 – November 2016. While individual responses were anonymised at the individual level, the submitted demographic data made clear whether a representative of a given VA stakeholder group had completed the scorecard from a particular centre. Reminder invitation emails were sent twice during the data collection period if a centre had not responded; where reliance was made upon snowballing[254] to identify a particular stakeholder (e.g. a service manager) the reminder was sent to the lead nephrologist in the centre, with a request that this invitation be passed to the most relevant colleague.

The respondents represented all specialties across all nine adult renal units in Scotland, with a broad range of responses from each unit (tables 42 and 43).

Main Vascular Access role	**Respondents**
Nephrologist	12
Interventional radiologist	6
Sonographer	4
Vascular surgeon	6
Vascular access coordinator	8
Clinical manager	2
Non-clinical manager	3
Anaesthetist	1

Table 42 Scorecard respondents by main Vascular Access role

Scorecards responses were received from a broad range of clinicians and managers. Respondents' demographics broadly reflected those of the VA teams working in each Scottish renal unit. Those holding dual roles, for example nephrologist clinical managers, were categorised according to what they stated was their 'main Vascular Access role'. The term 'Vascular Access coordinator' was used instead of 'Vascular Access nurse' in recognition that in some units this role was performed by someone who was not from a nursing background.

Unit	Respondents
1	4
2	6
3	2
4	5
5	4
6	4
7	5
8	8
9	4

Table 43 Scorecard respondents by unit

Responses were received from every adult renal unit. The number of responses from each centre was broadly representative of unit size. The paediatric centre was not invited to participate in the scorecard exercise, since the clinical processes and workload were seen to be significantly different from the adult units earlier in the study.

All recommendations had been implemented in at least one unit, no units had implemented every recommendation, and no single recommendation was universally in place. Respondents within each centre disagreed with one another about whether some recommendations were in place.

The following tables 44-46 respectively describe the scorecard responses according to respondents' main VA role, respondents' unit and the scorecard domain in question.

Role	**Yes**	**No**	**Don't know**
Nephrologist	31.9	24.8	5.4
Surgeon	23	31.5	7.8
Radiologist	24.3	17.6	20.3
Sonographer	9.5	4.75	48.5
VAN	28.8	30.25	3.6
Anaesthetist	10	41	12
Clinical manager	15.5	15	31.5
Non-clinical manager	28.3	9.6	24

Table 44 Scorecard responses by Vascular Access role

Values are expressed as the mean number of 'yes', 'no' and 'don't know' responses respectively. There was surprising variation between respondents, perhaps reflecting variable awareness and engagement with their local VA service. VANs, nephrologists and surgeons responded with the fewest 'don't know' responses; while sonographers, clinical managers and radiologists responded with the most 'don't know' responses.

Unit	**Yes**	**No**	**Don't know**
1	31	28	3.75
2	37.8	15.8	8.1
3	25	32.5	5.5
4	24.6	15.6	22.2
5	34	18	10.7
6	16.5	21	25.2
7	23.6	18.6	20.6
8	20.3	26.3	15.2
9	13.7	36	12.2

Table 45 Scorecard responses by unit

Values are expressed as the mean number of 'yes', 'no' and 'don't know' responses respectively, across every respondent from that unit. There was significant variation between units in the number of recommendations that had and had not been implemented. There were also significant differences in the number of 'don't know' responses between units.

Domain	**Yes**	**No**	**Don't know**
Governance (7 questions)	9.4	22.1	10.4
Job planned time (2 questions)	14.5	15	12.5
Service performance (13 questions)	14.3	20.6	6.6
Education (7 questions)	17.1	9.7	15.1
Patient Experience (2 questions)	21	11	10
Clinical Processes (32 questions)	19.3	12.8	9.1
Total	40.3	91.2	63.7

Table 46 Scorecard responses by domain

Values are expressed as the mean number of 'yes', 'no' and 'don't know' responses respectively across each domain. Most recommendations had not been implemented; those in the domains 'clinical processes' and 'education' were most commonly implemented, whereas those in the domains 'governance' and 'service performance' were least commonly implemented.

The number of ‘yes’, ‘no’ and ‘don’t know’ responses for each recommendation were considered and used to determine whether a recommendation was in place. Across all responses a median of 22.5 recommendations were implemented, 23 were not implemented, and 9.5 had a ‘don’t know’ response.

There was variation between centres as to which recommendations had been implemented, as calculated by amalgamation of ‘yes’, ‘no’ and ‘don’t know’ responses within each centre.

Discussion

The data shows wide variation in the implementation of the recommendations arising from the study. Those relating to ‘clinical processes’ and ‘education’ were most likely to be in use, whereas ‘service performance measures’ and ‘clinical governance’ measures were least likely to have been implemented.

The recommendations were a product of the thematic analysis; it is therefore unsurprising that all were in use in at least one centre. The distribution of ‘yes’ and ‘no’ answers resonates with the findings of the study and reflects the conspicuously inadequate clinical governance and performance measure arrangements surrounding VA practice.

Variation in responses within a given unit was interesting, perhaps reflecting uncertainty as to whether normal practice was according to a formal policy, or alternatively being uncertain about how other elements of the service ran on a routine basis. The large number of ‘don’t know’ responses was also intriguing. These could reflect apathy towards the service, although it would seem unlikely that someone would be apathetic towards their local VA service but prepared to spend time completing the scorecard tool. It is perhaps more likely that these responses are a surrogate for the respondent’s sense of detachment from the wider VA team. The demographic groups most likely to provide ‘don’t know’ responses were sonographers, radiologists and managers; this resonates strongly with the thematic analysis, which suggested detachment of these groups from others in the local VA team in many centres.

The main aim of the scorecard exercise was to present the findings of this study in a manner that facilitated ongoing QI within VA services. The manner in which the scorecards were written and presented intended to provide a degree of self-awareness to those with responsibility for VA services; to provide suggested next-steps for local quality improvement initiatives (based upon scorecard questions to which the answer was 'no'); and to provide a pictures of strength and vulnerability across VA services. These aims are in keeping with the principles of Safety II and healthcare resilience engineering, and have a practical focus aligned with the quality improvement and change management literatures.

It was not asserted that implementation of the recommendations would necessarily improve service performance metrics, particularly the traditional audit standard measures of incident and prevalent haemodialysis VA modality. However it was intriguing to note that the unit whose published registry data indicates they have the highest AVF use in Scotland[13] was also the unit with the most implemented recommendations; conversely, the unit with the lowest published AVF use according to registry figures[13] was also the unit with fewest recommendations in place.

Resilient Vascular Access

In adopting a 'resilient healthcare engineering' approach to this study, one remaining unanswered question related to the degree of 'resilience' seen in Scottish VA services. In this context, the term resilience is taken to mean the capacity of a system to continue functioning normally in expected and unexpected circumstances[195]. Resilience is a characteristic of system functioning, not a discrete structural element of the system. Those seeking to measure resilience have therefore considered the types of structural elements that could serve as enablers of this system characteristic[280]. Perhaps the best known is the 'resilience analysis grid' (RAG); it questions systems' ability to respond to challenges, to monitor the need to respond, to learn from the past, and to anticipate the future[280]. The specific questions used must be contextually appropriate for the system in question, and responses are given on a Likert scale. It is acknowledged that the output does not provide an absolute measure of system resilience; instead it gives a window into the system from the perspective of resilience, providing a basis for future comparison.

The VA scorecards are a measure of whether the various findings from the current study have been implemented within a given centre. These findings are recommendations for good practice and service development in VA, based upon comprehensive appraisal of VA practice across Scotland. While the RAG asks questions according to the domains specified in the paragraph above, the scorecards use the domains expressed in table 41. Instead of a Likert scale, the scorecards used ‘yes’, ‘no’ and ‘don’t know’ responses. For the purposes of statistical analysis, these were allocated a score as follows:

- Yes = 3 points
- No = 2 points
- Don’t know = 1 point

This scoring system was somewhat arbitrary but intended to capture the following issues:

- A ‘yes’ scorecard answer represented the presence of a positive VA system element;
- A ‘no’ scorecard answer represented the absence of a (positive) VA system element;
- A ‘don’t know’ scorecard answer represented the potential absence of a (positive) VA system, and/or a respondent who was disengaged with that element of the service in spite of their position as a key stakeholder within the VA system.

Mean ‘resilience scores’ were thus calculated for each centre, using the mean ‘yes’, ‘no’ and ‘don’t know’ responses submitted. These were compared with the registry published incident and prevalent AVF utilisation data. These figures were similar to those presented in figures 1 and 2 (chapter 1A), but the updated registry data for 2016 was used for the scorecard calculations[8]. These data are not reproduced here to avoid risking unit anonymity.

There appeared to be a subtle statistical correlation between the number of implemented recommendations and the respective incident and prevalent proportions of AVF utilisation within each centre. Correlation coefficients were r=0.74 for incident AVF use, and r=0.67 for prevalent AVF use (figure 12).

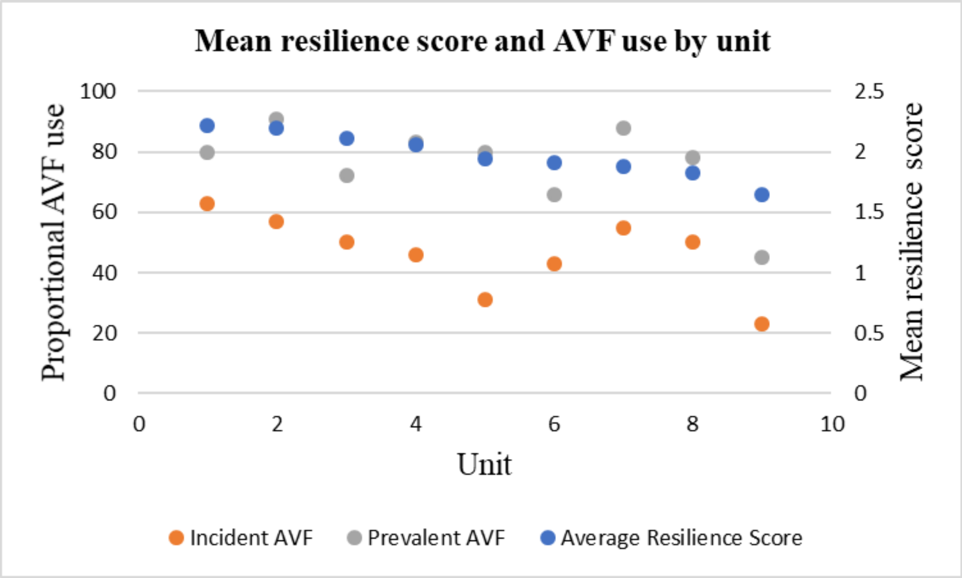

Figure 12 Mean resilience score versus incident and prevalent AVF use by centre

Scores were calculated as follows: values of 1, 2 and 3 were allocated respectively to 'don't know', 'no' and 'yes' responses, and an average score was calculated for each renal unit. Correlation coefficients were calculated, with comparison to published incident and prevalent AVF use in each centre (2015 audit data)[13]. Correlation coefficients were r=0.74 for incident AVF use, and r=0.67 for prevalent AVF use.

This apparent correlation may reflect bias in data analysis, or emphasis being placed in the recommendations on quirks of services that appeared to be performing ‘better’. It seemed unlikely that the recommendations simply favoured larger or smaller hospital infrastructures, since the units with the highest and lowest AVF use (from the registry data) have similar RRT and haemodialysis cohort sizes. These results must also be interpreted with some caution in view of the lengthy scorecard data submission period: it’s possible that responses were given from the same unit across a longitudinal time period, therefore not truly representing a ‘snapshot’ of unit status at a given moment. Similarly, there was not a uniform number of responses from each centre, and it is possible that the presence or absence of a particular staff group in one centre unduly biased the results. Nonetheless this observation provides a basis for future study and should stimulate services to recognise potential vulnerabilities highlighted by the data. Further work should revisit the scorecard exercise after an appropriate time interval and consider the specific questions and domains, changes in the pattern of responses, and how this may reflect service characteristics including resilience.

Strengths and weaknesses

There were several strengths offered by the ‘scorecard’ approach to the dissemination of findings and implementation of recommendations. The online scorecard data collection tool was inexpensive, straightforward to use and did not require a significant time commitment from those providing local data. The format lends itself well to repeated data entry to enable comparisons over time, and to provide benchmarking data at regional and national level.

It was intended that the process of completing the scorecard would afford respondents a degree of self-awareness in relation to their local VA setup, and serve as a prompt for ongoing quality improvement efforts. Indeed, many recommendations were written with this specific point in mind. Further study after an appropriate time interval will demonstrate whether this ambition has been realised.

It is acknowledged that scorecard data entry was ultimately incomplete, with underrepresentation of some clinical specialties from some units. Submissions were received over a long period, and therefore cannot strictly be directly compared. This was not, however, an exercise in comparison between centres; instead the intention was to facilitate local quality improvement activities while gaining a baseline understanding of how many measures were already in place in each centre.

The study did not seek to evaluate the acceptability or practicality of implementing each recommendation arising from the data analysis. No measurement was made of the financial, clinical or opportunity costs associated with implementing any recommendations; this should be the subject of further study. Nonetheless, the large number of responses could be seen to indicate a general acceptance of the recommendations amongst the Scottish VA community. It remains unclear whether the active implementation of these recommendations would lead to improvements in service metrics; further study after an appropriate time interval will determine whether this is the case.

Chapter 11: Discussion

This was a comprehensive appraisal of VA services across NHS Scotland. The study was conceived to investigate longstanding, marked variation between centres in the proportions of patients receiving haemodialysis treatment using AVF. The study sought to delineate the structure of VA clinical pathways, explore their routine functioning, and quantify the associated clinical workload. The study intended to highlight misalignments between 'work-as-imagined' and 'work-as-done', drawing upon the socio-technical systems and healthcare resilience engineering literatures. The aim was to present the findings in a manner that facilitated ongoing QI, using a novel 'scorecard' approach that enabled units to benchmark their clinical pathways against other centres.

A novel, mixed-methods approach was designed, based upon both the systems literature and a working clinical knowledge of the area of investigation. It involved semi-structured interviews supplemented by a six-week census of all VA-associated clinical activity. All ten adult and paediatric renal units in Scotland were visited, and interviews conducted with 42 clinicians representing all aspects of Scottish VA practice. Almost 28 hours of interviews were recorded, amounting to over 257,000 words of audio-transcript; these were quality assured before being subjected to detailed thematic analysis. The first reported census of VA clinical activity was undertaken, with data gathered from across the spectrum of VA clinical practice including nephrology, vascular surgery and interventional radiology.

The study illuminated a vast array of issues spanning VA services and highlighted genuine potential to improve clinical care while enhancing the efficiency of resource utilisation. Findings included the existence of two discrete clinical pathways concerned with VA creation and maintenance respectively, with significant associated workload. Multiple barriers to idealised VA care were identified; these included a lack of designated clinical resources and uncertainty around timelines for VA creation and maintenance activities. Dysfunctional multi-disciplinary team working was compounded by significant differences in clinicians' opinions around 'optimal' VA for a given patient and the utility of VA surveillance. There was an absence of data relating to clinical workloads, while procedural outcomes and VA-associated morbidity and mortality was never routinely discussed. There was a lack of managerial involvement in VA services, and several educational gaps were identified.

The data was presented alongside a novel ‘scorecard’ tool, which each renal unit was invited to complete. This was designed to operationalise the recommendations arising from the study, facilitating their implementation and providing a baseline for further study.

Qualitative work has been used before to assist clinical service development[281], but this was the first study to characterise VA as a complex socio-technical system, and to use systems thinking to explore this highly complex area of clinical practice. It provided a thorough understanding of VA services from the perspectives of clinicians across the multidisciplinary team, patients who depend upon the service for their survival, and strategic managers with responsibility for funding and otherwise resourcing the service.

The study analysed VA services’ function from a Safety II, healthcare resilience engineering perspective. This differs from the traditional Safety I approach to PS and QI, using an epistemological approach that seeks to maximise positive outcomes rather than simply minimising negative outcomes. The findings expose considerable variation in processes and practice. The potential of this approach to stimulate positive change in complex healthcare systems has been described by others[156,193,195,196]; this is the first work to highlight the advantages of understanding the routine workings of VA services from PS, QI, financial planning and resource allocation perspectives.

Linkage with published registry data provide clues as to the impact of such variation in practice, particularly with regard to the proportions of patients who receive haemodialysis with an AVF or TCVC. Areas of strength and vulnerability are revealed at local, regional and national levels, and an impetus has been created for change among domains including ‘education’, ‘governance’, ‘resource allocation’ and ‘clinical pathways’. An implementation ‘scorecard’ tool has been developed and made available to the renal community; it is anticipated that this will provide a basis for QI activity, and further work will explore its potential to measure resilience in VA services.

The following sections contextualise the study findings in the sociotechnical systems literature. The full set of recommendations arising from this work are in table 40.

Theoretical constructs

Several theoretical constructs informed the methodological approach and data analysis in this study.

Sociotechnical system design

Cherns' model and its various adaptations provided a helpful conceptual approach to considering the function of a complex sociotechnical system[178,207,208,210]. This aided interview design by highlighting issues that might influence system function, rather than interviews simply seeking to explore VA service structure. In the data analysis stage, it acted as a lens through which VA system function could be considered. Strengths and weaknesses of each service could be identified by considering interview transcripts in light of the Cherns principles. Table 47 considers how these principles could be applied to VA.

Compatibility	The capacity of the VA team to create, utilise and maintain VA must adapt to accommodate newer means of VA as they become available.
Minimum critical specification	VA clinical pathways should have freedom to create the most appropriate VA for a given patient. MDT function should be appropriate for the organisation's needs; it should facilitate optimised patient care and provide a forum for open discussion of VA problems.
Variance control	A degree of standardisation and discipline is necessary to optimise the timing of patients' referral into VA pathways. Designated time should be available within IR and surgery to create and maintain VA within a clinically appropriate timeframe.
Boundary location	Managerial and financial oversight of VA services should be unified, rather than sitting between three separate (nephrology, surgery, radiology) departments that do not otherwise routinely interact. Corporate service configuration should not impede clinical scenarios where resources are required from one department to manage a problem in another (eg investment in radiology equipment to manage nephrology clinical problems).
Information flow	Electronic health records should be utilised to keep track of patients with active VA problems, including all those currently active within any of the VA clinical pathways. An access / intervention history should be maintained for all patients, and used to plan further VA clinical procedures. When a new AVF is created, a fallback plan should also be documented to guide clinical thinking in the event that it fails to mature.
Power and authority	VANs (and others) should have the necessary authorities – technical and otherwise – to request tests and allocate procedure slots to patients. Individual team members should be able to directly raise urgent clinical problems with the most appropriate team member regardless of hierarchical rank within the team.
Multifunction	All possible VA modalities should be practically available within each VA service, to accommodate the changing needs of the patient cohort. This includes the technical expertise and capacity to create,

	maintain and use variations of AVF, AVG, TCVC, PD and other technologies as they become available.
Support congruence	Service configuration should allow procedures to be performed with the minimum of logistical and governance challenges. Relevant scheduling and other administrative functions within IR and surgery should be harmonised with the VA team, and vice versa.
Transitional organisation / Incompletion	The development of new clinical pathways and increasing AVF use will require staff development. As patterns of RRT requirement and delivery change, strategic oversight of service development will be required to ensure it remains adequately resourced and fit for purpose.

Table 47 Socio-technical system design principles applied to Vascular Access services

Consensus

Reason's published work provided a helpful means of understanding how opinions and assumptions at strategic level filter down to influence operational activity and decision making[186]. In the context of Wennberg's model of unwarranted variation[143] (see chapter 1B) and the potential for clinicians' opinions to modify variations in practice, this seemed especially important. Using Reason's language of 'source types', 'function types' and 'condition tokens' enabled recognition of data linkages in the transcripts that would not otherwise have been apparent.

The data illustrated marked differences in clinicians' opinions about the merits of AVF over alternative VA or other RRT modalities. When clinicians believed in the clinical and service benefits of AVF, their service tended to support AVF creation and maintenance. Conversely, when clinicians do not enthusiastically support AVF use, other factors tended to obstruct clinical pathways necessary for AVF creation and maintenance, and patients were less likely to utilise an AVF for haemodialysis. In this context, attitudes towards the merits of AVF could be considered a 'source type'. Other factors, some of which may be tethered to the source type, could be considered 'function types', which describe the translation of strategic direction into operational ('functional') forms that then disrupt the goal in question. Such factors could include decision making around referring patients for VA creation or the establishment of a regular, adequately resourced MDT meeting. Using the same nomenclature, a 'condition token' represents the contextual situation that can lead to an unwanted outcome: for example, a patient receiving HD via a TCVC. Such tokens could include the provision of clinical time within job plans, the designation of procedural slots for VA work, and the availability of administrative support to facilitate MDT meetings and attend to other administrative and logistical work associated with the VA service. This fits well with Reason's published work[185,186].

Fischbacher-Smith frames Reason's work as the 'consensus' that underpins sociotechnical system function[178]. This emphasised the key importance of these findings, providing a rationale for their exploration in detail, as presented in Chapter 4. Many of the findings related there suggest that many VA clinicians in Scotland hold views that are at odds with published VA guidelines. No other publications have been identified that explore the issue of clinicians' opinions about VA modalities in any detail.

Wicked problems

Much of the language encountered in this study was nihilistic in tone. Several interviewees expressed a sense of disempowerment and a feeling that little could be done to change the status quo. In many ways this language was alluding to a sense that VA was in fact a 'wicked problem'[180]. Table 4 (earlier) described the components of a wicked problem; table 48 considers these criteria in the setting of the current study. It is clear that while VA services represent a highly complex area of clinical care, they do not meet the recognised definition of a wicked problem.

1. It has no definitive formulation	The parameters of the VA service are clearly defined. The service exists to provide optimal VA for patients who require haemodialysis treatment. The available options are AVF, AVG, TCVC, and in broader terms the options of PD, transplantation or conservative care may also be considered. Clinicians have varying perspectives on the clinical challenges associated with service delivery, but these do not impact on the parameters of the system.
2. It has no stopping rule	The context and practice of clinical medicine will continue to evolve, but theoretically it should be possible to reach a point where all patients within a VA service are being treated with optimised VA.
3. Solutions are 'good' or 'bad', not true or false	It is possible to objectively measure the productivity of a VA service, and to evaluate its impact with respect to clinical outcomes.
4. It has no immediate or definitive test of a solution	Changes to VA system configuration and function could result in (relatively) rapid, measurable changes: for example, the proportions of patients receiving treatment using each VA modality. In the longer term it will become apparent whether this translates into financial, mortality and other clinical benefits.
5. Every attempted solution has consequences	It is possible to change practice within the system, in a relatively controlled manner: for example, changes in referral practice, or the allocation of additional resources or clinical time. These changes may be reversed in the short-term without necessarily creating a lasting impact on future system function.
6. They do not have a finite set of potential solutions	Potential solutions to VA service problems can be defined in terms of necessary clinical processes and requirements for human and other resources.
7. They are unique	VA represents a niche area of clinical practice, and one of the few areas where nephrologists, surgeons and radiologists interface. It is not unusual however in clinical medicine for such services to be jointly managed by clinicians representing different specialties and disciplines.

8. They can be considered a symptom of another problem	VA is a relatively well-defined system, albeit one that is influenced by competing clinical activity across nephrology, surgery and radiology. It is also subject to influence from other peripheral and external factors including geographical concerns and bed availability within the hospital. Nonetheless it is possible to at least partly modify these external factors in favour of the VA service.
9. Perspectives on the problem govern the attempted solutions	There are competing perspectives on what constitutes 'best' VA for a given patient, but it is generally accepted that services should generally aim to deliver most haemodialysis via AVF or AVG.
10. Those proposing solutions are compelled to be correct	This study has demonstrated the willingness of the VA community to consider new technologies and alternative ways of working. There does remain an overriding need to provide optimal, safe patient care.

Table 48 Characteristics of wicked problems, in the context of Vascular Access services

Vascular access services: a normal accident?

Perrow's work describing the evolution of the 'normal accident'[174] is also highly relevant to this argument. Perrow considers the normalisation of suboptimal practice over time, such that a poor outcome becomes an expectation rather than a surprise. This study suggests some of the reasons why TCVC use has become 'normal' for many patients receiving haemodialysis treatment in Scotland despite clear evidence of a better alternative in the form of AVF, AVG or PD. Suboptimal care has become 'normalised' in this area of practice. The data suggests that clinicians' attitudes towards TCVC versus alternatives; the existence of designated clinical time and resources (or lack thereof); the physical and functional juxtaposition of the renal service in relation to vascular surgery and IR, all influence the likelihood that a patient will receive a TCVC rather than an alternative. Moreover, it is clear that efforts to maintain AVF are thwarted at several levels: RDU staff have limited training and little practical support to optimise the lifespan of a patients' VA, and when a problem is identified and escalated to VAN or equivalent, there are often limited options available within a clinically appropriate timeframe.

The findings also suggest a disappointing lack of organisational memory within VA services, perhaps in part due to the informality of the VA team in each centre. Despite the high volume of clinical work, significant financial expense, and clear impact on patients' lives, it was surprising to find that no renal unit in Scotland had a named 'VA manager'; indeed, there appeared to be no managerial oversight of the VA service. This was possibly a contributory factor towards the conspicuous absence of scrutiny towards VA-associated morbidity and mortality. This is at odds with efforts to develop a degree of organisational memory recommended several years ago by a wide ranging Department of Health review[117,118]. Similarly, there was a startling lack of structured clinical audit relating to VA, which is surprising given the degree of interest in other aspects of haemodialysis care with arguably less potential contributions to morbidity and mortality.

Healthcare resilience engineering

Hollnagel characterises dissonance between how one perceives a system to operate, as opposed to how it 'should' or 'could' function, in the frame of 'work-as-imagined versus 'work-as-done'[196]. He argues that contradictions in these two perspectives of a system are key to understanding the system's potential to cause harm. He asserts that misunderstanding of reality by those with strategic responsibility facilitates the design of ineffective policies and encourages a culture where operational staff routinely make use of workarounds in order to get the job done. One may also argue that operational staff misunderstanding of strategic planning and service orientation is partly responsible for the divergence between both groups and perspectives. This was quite apparent throughout Scottish VA services, where there is a striking absence of managerial involvement, oversight and regulation.

Hollnagel's work also challenges normal practice in relation to improving safety and quality in healthcare and other industries. He characterises the traditional focus upon adverse events and retrospective, reductionist approaches to their investigation, as 'Safety I'[193]. He asserts that in the context of highly complex sociotechnical systems there is limited value in understanding the specific circumstances that led to the generation of a particular incident[108]. Given the nature of emergence from sociotechnical systems, which arises as a function of often unpredictable system component interaction, attempts to 'fix' factors that contributed to one accident are not likely to render the system any safer. Reductionist approaches to socio-technical systems analysis are widely discredited in the literature.

In a broader sense the need to analyse the whole system, rather than just one isolated set of circumstances, has been recognised for many years. Leveson speaks of the need to recognise complexity and its requirement for more sophisticated analytical tools; simple approaches to (historical) simple problems do not provide the required complex approach to complex problems[104,175]. The 'Safety II' approach of Hollnagel and others aims to focus upon normal system function rather than narrowing understanding to the events surrounding specific adverse events. He argues that attempts to maximise good outcomes are potentially more helpful than efforts to understand historical problems and implement solutions that may ultimately prove ineffective or actively harmful.

This work used a Safety II perspective in attempting to understand normal VA system function. This represented an alternative approach to most studies seeking to reduce variation in areas of care – in this case, variable AVF use for haemodialysis despite their morbidity and mortality advantages (see chapter 1A). Most published VA literature concerns clinical trials comparing the use of different modalities[60,282]; recognised complications of VA[34,275,283]; and less commonly, comment about patients' experience of VA[284–288]. There are no prior studies taking a comprehensive, systems-based approach to understanding the function of VA services, but other works have demonstrated the clear utility of such Safety II approaches[206,289,290]. More traditional Safety I approaches are considered unlikely to have yielded such a rich tapestry of information about VA systems function.

Every study participant described multiple interacting factors that influenced their ability to provide an effective VA service. Seeking to understand 'how things normally work' yielded a vast array of findings that enabled the creation of recommendations for practice. The Safety II approach also guided the development of the 'scorecard' tool, which aimed to operationalise the study recommendations in a way that facilitated local VA QI work. In essence, the scorecards invited clinicians and managers to consider 'how things usually work' in their service, using the questions as a prompt to design improvements.

Methodology

The study methodology added several strengths to the project. The sampling strategy achieved the involvement of key stakeholders across all Scottish VA services. The use of snowballing, and interviewing until saturation was reached, ensured the full range of perspectives were gathered about each service, within the confines of practicality. Unexpected challenges arose: some units shared surgical and IR resources to an extent that had not been fully appreciated when the study was being designed. The geography of Scotland and multi-site working meant that visits to 12 separate campuses were required, in some cases returning on a further date to conduct a further interview. Visiting sites engaged many clinicians in the process; it seems very unlikely that this breadth of data could reasonably have been achieved were interviews all conducted on one site or by telephone (see also chapter 2).

The flexibility of the semi-structured interview format, aided by the use of interview guides, an interview panel, and the constant comparison technique, facilitated optimal data capture. The face validity study appears to confirm that study participants, who themselves form the backbone of VA services, considered the study 'valid'; this will be borne out by subsequent efforts to implement the study recommendations.

A further strength involved the six-week census of clinical activity. This quantified the substantial workload associated with VA services. It is acknowledged that an arbitrary six-week data collection period, where some centres under-reported activity, is not necessarily fully representative of annual workload. Nonetheless the available data suggest that this small patient cohort is subjected to a huge volume of IR tests and surgical procedures. This lends credibility to the recommendations that data concerning procedure volume, outcomes and associated morbidity should be systematically collected, analysed and published. This finding also provides a clear mandate to improve clinical pathways and optimise resource use in providing a VA service.

The development of a scorecard tool provided a unique means of engaging the VA community with a large number of recommendations, and providing a basis for further study in terms of QI and the measurement of resilience. This should proceed after an appropriate time interval has elapsed. (Scorecards are discussed in more detail below.)

Comparison with other services

This study sought to explore VA services in the context of unwarranted variation in AVF use across Scotland. In other areas of healthcare similar variation has already been identified and steps taken to investigate and attenuate its impact. It is unclear why this has not happened until now in the setting of VA. One possible explanation lies in this study's findings of absent managerial oversight from VA services, and VA services distribution across multiple clinical specialties, directorates and budgets. Despite the significant workload associated with VA care, the relatively small number of patients may go unnoticed in the broader context of large NHS organisations in which thousands of clinical interactions occur each day.

It is hoped this work will illuminate VA care to senior health service managers, emphasising its costs in financial, resource and clinical terms. Questions must also be asked regarding the existence of other services with similar characteristics: niche clinical needs, met by a varied multidisciplinary team coming together across specialty, organisational and financial boundaries, without clear managerial involvement or oversight. It is possible further service appraisals following the methodology of this study would benefit these areas too.

Impact on clinical guidelines

Many clinical practice guidelines have described the optimal VA that should be provided for patients receiving haemodialysis treatment[3,86–89]. The recommended strategies for VA utilisation, surveillance and maintenance are specified in some detail. In many ways these could be considered in the frame of 'work-as-imagined', while this study provides a contrasting 'work-as-done' perspective[197]. Study findings include the configuration of VA services and how they routinely function, providing significant insight as to how the guidelines are seen and implemented in practice.

Guidelines universally recommend prioritising AVF above other VA modalities, but clinicians' opinions (see chapter 4) are less clear cut. It is seen that access to AVG is not universal throughout Scotland. Guidelines mandate "early referral" for VA, some specifying a time or eGFR threshold for doing so, but in practice many issues complicate this: uncertainty about the rate of eGFR decline, unknown internal timelines for VA creation, and inadequate tracking of patients throughout the process. These issues, and others described in this thesis, all represent barriers to meeting the audit standards regarding the proportion of incident and prevalent patients who should dialyse with an AVF.

The data also illustrate why VA maintenance also fails to live up to guideline standards. There was disagreement among clinicians as to the utility of VA surveillance. No centre had formally allocated clinical time or resources to performing maintenance activity within a clinically appropriate timeframe. TTGs were cited as a frequent cause for other clinical activity to displace VA cases for non-clinical reasons. A large volume of clinical time was seen to be distracted by unnecessarily complex logistical arrangements, particularly where IR was not co-located with the renal unit or where large numbers of TCVC were in use.

Many of the identified system performance problems (chapter 8) and VA service development needs (chapter 9) resonate with the latest European Society for Vascular Surgery guidelines[89]. This study also raises questions over concordance with published quality standards, including the need to routinely discuss morbidity and mortality issues and to record procedure numbers and outcomes[86].

Overall, this work complements existing literature and guidelines by providing a practical view of VA, which as not hitherto been described in this level of detail. This will assist individual centres seeking to implement guidelines, and provides insight to guideline writers about the practical limitations on their use. Future guidelines should benefit from this 'unfiltered' view of frontline working[197].

Vascular Access Scorecards

In an effort to extend the current work beyond simply understanding VA, a novel 'scorecard' tool was created to facilitate dissemination of the results to clinicians and managers in VA services across Scotland. This was designed using the principles of healthcare resilience engineering, providing the means by which managers and clinicians could understand the function of their local service. There was significant interest in this exercise and responses were received from managers and clinicians representing all specialties in every Scottish adult renal unit.

At an operational level the scorecards enabled units to reconcile 'work-as-imagined' with 'work-as-done'. This should illuminate opportunities for local service development. Given the nihilistic tone emerging from the thematic analysis, and the lack of significant time, resource or managerial involvement in VA services, it was hoped that the provision of practical 'things to do' via the scorecard exercise would stimulate this work.

At a strategic level the data suggests opportunities for regional and national collaboration. It can also be considered an attempt at measuring vulnerability and resilience across a national service. As discussed in chapter 10, 'resilience' in a systems sense reflects the capacity of a system to continue functioning in the face of expected and unexpected circumstances. In the context of VA unexpected circumstances could be considered at patient and service level; some examples are given below:

- Patient level issues could include infection or thrombosis of existing VA, the need to commence haemodialysis earlier than anticipated, or veins being technically unsuitable for AVF creation at the point of surgery;
- Service level issues could include staff absence, unusable operating theatre space, postponed or cancelled MDT meeting.

Curiously, a number of such 'unexpected events' were noted during the conduct of the study. During the six-week clinical activity census a number of ad hoc theatre session cancellations, unanticipated clinical presentations, and staff absences were noted. More surprising were the anecdotal reports about staff absence and changes within local services, that were encountered during the process of data checking, and liaising with colleagues around the time of the national feedback event in November 2015. It was also very common for clinicians, particularly nephrologists, to regard a large proportion of their patients who required emergent haemodialysis to have had an unanticipated, or "unpredictable" catastrophic fall in their eGFR. Quantifying these episodes was beyond the scope of this study but it is conceivable they could serve as a test on local service resilience, or indeed hamper the ability of the service to cope with other events. Further work is required to explore this issue.

As a characteristic of system function, resilience is a difficult property to measure. The scorecards seek to measure elements of the VA system that may promote resilience, for example the presence of clearly defined clinical pathways, the provision of adequate clinical time for VA work, the use of EHRs to track patient flow. It remains to be seen whether these or alternatives represent the most optimal measures of resilience for VA services.

Relation of thematic analysis to scorecard findings

The 'resilience scores' indicated a possible moderate correlation with published registry data relating to incident (r=0.74) and prevalent (r=0.67) AVF use. Further work, including interval reanalysis of scorecards in conjunction with contemporary registry AVF data, may show whether this apparent correlation has changed as units progressively implement the recommendations.

Perhaps the key finding from the scorecards was the pattern of 'don't know' responses. While most respondents gave this answer to at least one question, there were some respondents for whom almost all responses were 'don't know'. They were either managers, sonographers or radiologists. The thematic analysis suggested these professional groups tended to be detached from the rest of the service, which may explain this answer. This exercise seems to present an opportunity to engage with colleagues who have taken the time to respond to the scorecard, yet 'don't know' about many elements of their local service.

The 'governance' questions asked about the presence of defined pathways and processes for managing elective and unscheduled VA care. Most of these questions were answered 'no'. The thematic analysis suggested smaller units may be less vulnerable in the absence of clear pathways, but this relied upon close MDT working. This is difficult to measure objectively, but the degree of teamworking could perhaps be inferred by the consideration of scorecard 'governance' results juxtaposed with incident and prevalent AVF rates for a given centre: the hypothesis being that units with few governance arrangements, yet high AVF use, manage to compensate for this through close teamworking. Further work is needed to address this question.

A predominantly negative response to 'service performance' questions confirms the finding from the thematic analysis that timelines for VA creation and maintenance procedures were uncertain in most units. It is likely that larger units would benefit most from the provision of this internal data, with the presumption of higher patient numbers and hence longer waits for procedures. Conversely, it may be that larger units have more capacity to manage variable clinical demand for procedures. Again, further work is needed to establish the impact of providing such data internally within a unit, and whether this positively (or otherwise) influences incident and prevalent AVF use.

The finding that 'education' and 'patient experience' questions were predominantly answered 'yes' is reassuring. This is in keeping with the thematic analysis findings, which suggested a universal wish from individual interviewees to improve their patients' experience and overall wellbeing. In many units the convoluted clinical pathways, dysfunctional MDT working and lack of clinical resource frustrated these efforts, and this was clearly expressed in many of the interview transcripts. It's unsurprising however that steps are being taken across all units to establish patient education programmes and begin to measure patient experience, and this finding sets a tone of optimism for ongoing VA QI activity.

Educational outcomes

A wide range of educational outcomes arise from the data.

The specialty training curricula for renal medicine[291], vascular surgery[292] and IR[293] respectively define the requirements to practice as an NHS consultant in these specialties. Review of these documents demonstrates a conspicuous lack of VA-related competences:

- IR trainees are obliged to become technically competent in fistuloplasty, but there is little other requirement relating to renal VA;

- Vascular surgery trainees must be familiar, but not necessarily competent, with AVF-related procedures;
- Nephrology trainees have no formal training requirements whatsoever for VA, and the subject does not appear in the blueprint for the Renal Medicine Specialty Certificate Examination[294].

Moreover, there are no specific training requirements for individuals wishing to work as a VAN (or equivalent) or an RDU nurse. The current work highlighted one Scottish unit with an informal training programme for newly recruited RDU nurses; it had no associated formal qualification, and it was not subject to external audit or quality assurance, and it had not been shared with other centres in Scotland or further afield. Anecdotally it is believed there are renal units elsewhere in the United Kingdom using similar training programmes for RDU nurses (personal communication); these are also informal practice development initiatives, rather than forming part of any compulsory training requirement to practice in this area.

There is a clear need for formal VA training and credentialing for clinicians wishing to work in VA services. The need seems most acute among nephrology training programmes, given the substantial contribution of VA to morbidity, morality, hospitalisation and financial cost among the patients for whom nephrologists typically have primary responsibility. Training programmes should include issues relating to MDT working, familiarity with other disciplines' potential contributions to VA problems, and strategies for optimising VA services as well as attending to the more technical aspects of VA. This would benefit training grade clinicians and could also serve as a guide for continuing professional development and revalidation needs for established clinicians working in this area of practice.

Projects seeking to meet these training needs are beginning to emerge, for example a surgically-led training programme based in Glasgow, and an NHS England sponsored initiative intending to upskill RDU nursing staff who deal with AVF and AVG.

Resource implications

The large number of recommendations arising from this study may raise concern about the resource implications and practicalities of their implementation.

Key recommendations relate to the designation of adequate clinical time for VA creation and maintenance. At first glance this means additional resource for both surgical and IR services, but in reality the patients are already consuming substantial clinical resources to maintain some form of VA, often TCVC rather than VA. It is hoped that reallocation of existing resources, rather than investment of additional resource, is all that is required. Similarly, several recommendations relate to the collation, publication and discussion of VA clinical activity and procedure outcomes. This is in keeping with existing guidelines[86] and it is possible such data is already collected within organisations, but not presented in a way that lends itself to VA service needs.

It is acknowledged that considerable work would be associated with actioning every recommendation, but is should also be recognised that not every recommendation would be appropriate in every centre. The provision of a menu-based approach – where recommendations are made in granular detail, and benchmarked in comparison with other centres (via the scorecard tool) – intends to facilitate iterative QI by interested individuals without requiring inordinate investments of time or other resources in order to be realised.

Strengths and weaknesses of this study

This study was the first to attempt to explore a complex clinical system such as VA across such a large scale. Its methodology inexpensively attained a comprehensive view of Scottish VA services, while the Safety II perspective provided valuable insights into 'work-as-imagined' and 'work-as-done' from the perspectives of all key VA stakeholders. The study enjoyed strong clinical engagement, and the data highlighted strengths, vulnerabilities and potential opportunities to improve for all centres. A number of positive outcomes arose from the project, including a publicly available report that has provided services with the ability to recognise their areas of strength and vulnerability. A momentum for change has been generated, not least through the creation of a de facto network of interested clinicians who agreed to be interviewed for the study. The dissemination of the findings and recommendations for change, along with a toolkit to assist in their implementation, is an attempt to ensure the longevity of the study outputs and maximise the positive impact for the wider community. Time will ultimately tell how successful this endeavour has been.

There are limitations in the study, both in terms of its design and in its ability to influence change within VA systems. The volume of data collected throughout the project was limited by financial and logistical considerations, and on a pragmatic basis there was a limit to how much data one researcher could reasonably analyse within a sensible timeframe. While acknowledging the ‘system of systems’ concept discussed in chapter 1B[173], pragmatism dictates than arbitrary boundary of VA systems had to be set for the purposes of this study. For this purpose, VA services were taken to concern all haemodialysis-associated VA modalities; this is in keeping with the author’s professional experience. However, it would be remiss to ignore the significant influence of PD, transplantation and conservative care programmes within any given centre; these surely have some impact on the VA service too. Further work should explore these interfaces and their influences on clinical outcomes.

A key limitation lies in the absence of a patient perspective from the data. It would have been preferable to interview patients representing each centre, but sampling concerns suggested this would have involved a large number of additional interviews that were not feasible within the scope of this study. Further work should address this gap. A further challenge arose from the finding that no Scottish renal unit had a clearly identified ‘Vascular Access service manager’ or equivalent; as a result the data focused on front line staff rather than those senior members of staff who held strategic responsibility for the service. Further work should address this gap, and indeed the nomination of an adequately resourced ‘VA manager’ is a recommendation arising from this study.

The interview process was designed to enable free and unbiased discussion of all relevant issues, however the nature of the topic under discussion and the makeup of the interview panels almost certainly coloured the discussion. To some extent this was controlled by ensuring that the same researcher led all interviews, while the anonymous face-validity questionnaire confirmed interviewees had felt able to speak freely, and that a neutral tone had been maintained throughout the interviews. This was borne out in the candid nature of the interview transcripts. Data analysis was necessarily undertaken by a single researcher; to minimise the potential for bias the transcripts were coded in random sequence, and the coded dataset and subsequent thematic analysis was sense-checked by others who had been present during the interviews, and who also had access to the audio files and audio transcripts. Chapter 2 explains in some detail the steps taken to avoid bias in the methodological approach.

The six-week clinical activity census provided rich insights into the volume of clinical activity performed by VA services, the nature of the activity and the marked variation between centres. Data collection for this element of the study was limited to six weeks, again for financial and logistical reasons. It is possible that the data was incorrectly recorded or that cases were missed, and it is known that data submitted from one centre was incomplete at the time of the final analysis. It is unclear how representative those six weeks were in relation to the rest of the year, and further work should address this topic. Nonetheless the available dataset illuminated the realities of VA system function, highlighting the significant clinical time occupied by VA procedures and the enormous disruption this must cause to patients' lives. The volume of work emphasises the importance of formalising VA pathways and encouraging managerial involvement in the running of the system. The potential for collaboration between the nine adult renal units must also be considered: a regional or national approach could provide more effective care for patients, particularly during out-of-hours periods. This census exercise should be repeated on a larger scale and over a broader time period, and ideally these data should be systematically collected, analysed and published as a matter of routine.

Chapter 12: Conclusions

This study was conceived in the context of significant unwarranted variation in AVF use for haemodialysis in Scotland. The study aimed to delineate the structure, function and workload associated with Scottish VA services; to identify potential for improvement using a systems approach that contrasted ‘work-as-imagined’ and ‘work-as-done’ from the perspective of key VA stakeholders; and to present recommendations for practice to the clinical community in a manner that facilitated ongoing QI.

The preceding chapters have reported the detailed context, methods, results, recommendations and their presentation. Processes for creating and maintaining VA have been explored alongside service performance issues, development needs, and a six-week clinical activity census. The recommendations for practice have been presented (table 40), as has the scorecard tool used to disseminate them to the community.

The mixed-methods model developed through this study was simple, effective and inexpensive to use. The methodology proved acceptable to clinicians, who were extremely candid in discussions about their services. These generated significant insights into a highly complex area of clinical practice and illuminated many areas for improvement. The ‘scorecard’ approach to results dissemination generated significant engagement from clinicians and managers across Scotland and created an impetus to implement the findings.

This study has shown the worth of systems approaches to healthcare, and the particular merit of Safety II approaches seeking to understand normal system function. The mixed-methods model was sympathetic to the resilient healthcare engineering literature and was designed to be practical and accessible to everyday practising clinicians.

There was a striking absence of published data accounting for VA staffing levels and the volume of clinical activity associated with providing a service. This study provides some insight as to VA service workload in Scotland; while it is not asserted that these data represent ‘optimised’ numbers, they are taken to represent current practice and provide a starting point for further clinical and health economic study.

The recommendations arising from this study concern aspects of VA creation, maintenance, service performance review, and opportunities for service development. These were written in light of the thematic analysis and clinical activity census. It was recognised that ‘standardising’ VA across Scotland was not necessarily the best solution, given the very different contexts in which the services exist. Optimal resource utilisation looks different between larger, city hospitals and smaller, more rural clinical settings; it is expected therefore that some recommendations will be a better fit for larger centres, while others will be more suited to smaller settings. Instead of seeking to achieve a standard service configuration in every centre, the recommendations centre around patients’ needs and seek to provide a balance of high quality care at a local level, while recognising the need for regional and national collaboration in areas requiring highly specialised care. Many recommendations were made, enabling a spectrum of QI activities across various clinical settings including larger, smaller, rural and urban units. They were written in language judged accessible to practising clinicians and healthcare managers. It is hoped they will provide a practical means of improvement within the context of busy clinical roles where there may be limited time for service development.

The 'scorecard' tool proved a useful way to rapidly and inexpensively disseminate the recommendations to the clinical community. The scorecards effectively engaged clinicians and managers, enabling appraisal of which recommendations were being implemented and benchmarking between centres. The scorecard responses can be seen to provide a map of service engagement, a guide to future quality improvement needs, and a benchmark as to the arrangements in each Scottish VA service across an array of relevant domains. It is anticipated that the scorecards will continue to prompt local service improvement alongside regional and national collaboration. Updates over time will inexpensively provide a view of how these services are evolving. The scorecard approach could easily be applied to VA, and other clinical services, in other health services further afield.

At the heart of the recommendations lies a need to more formally recognise VA as a clinical subspecialty. NHS boards should formally integrate VA into their corporate structures and provide managerial oversight, allocated clinical time and designated technical resources. The vulnerabilities of person-dependent services, and strengths of MDT working have been highlighted. The need for organisational learning, with routine audit, discussion and publication of clinical outcomes has been emphasised. A range of educational opportunities are identified, with the potential to improve clinical standards and provide those who work in this area with better recognition and credentialing of their skills.

A detailed report was published containing summarised VA clinical pathways along with extensive discussion of the strategic and operational findings from this study[295]. This was written in language that was judged accessible to practising clinicians and was presented in a format that encouraged further service development. A national meeting was additionally convened at the Teaching and Learning Centre, Queen Elizabeth University Hospital, Glasgow, to convey the study results to the VA community.

The recommendations provide practical suggestions for enhancing VA service design and function across multiple domains. It is intended that this will serve as a baseline for service development in Scotland and further afield. They were provided in various formats: contextualised within the main text of the report, as a full list in an appendix to the report, and in the accompanying ‘Vascular Access Scorecard’ document.

The study has achieved its aims of delineating VA service structure, function and workload; identify and presenting recommendations for improvement. It provides the first comprehensive description of VA service configuration and forms an evidence-base as to how services could operate, the workload associated with different configurations, with insights as to how they may improve. The methodology used to achieve this has proven highly effective, and this thesis serves as a starting point for others wishing to replicate this work in other areas of clinical practice.

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Appendix 1 – Interview Guides

An appraisal of vascular access provision for patients requiring renal replacement therapy in Scotland

1. Information for interviewee
    a. Purpose of study
    b. Format of interview
    c. Confidentiality
    d. Dissemination of results
    e. Agreement to participate
2. Study demographics
    a. Title, investigators, sponsor
    b. Date/time/location of interview
    c. Interviewee name/title/contact
    d. Interviewers present
3. Questions and probes
4. Closure

Information for interviewee

<u>Purpose of study</u>

The purpose of this study is to describe and appraise the current state of vascular access provision for patients requiring renal replacement therapy (RRT) in Scotland. A mixed-methods quantitative-qualitative approach is employed to gather:

1. Quantitative data that may explain / define / describe:
    a. The adequacy of vascular access provision
    b. The incidence / prevalence of complications
    c. The patient-centeredness of current service provision
2. Qualitative narrative that may explain / define / describe:
    a. Positive and negative vascular access practices across Scotland
    b. Rationale for adopting a particular approach over an alternative
    c. Variation between units and opportunities for improvement

Data collection

Quantitative data is being gathered using a questionnaire that has been supplied separately. This interview focuses upon collecting qualitative data that provides context, insight and meaning to the quantitative data.

Data analysis

A constructivist grounded theory epistemological approach is being utilised to conduct and analyse this study. This means we do not believe that any one vascular access setup represents a gold standard to which others should be compared; rather we acknowledge that real-world clinical systems exist within a complex, changing context and each system has its own strengths and weaknesses. We aim to gather quantitative and qualitative data from each renal unit in Scotland, and analyse the data in order to determine current practice and identify opportunities for improvement across the country.

Ethical approval

This project is being conducted under the auspices of the Scottish Renal Registry. No intervention is proposed during this study, which is categorised as a "service evaluation". Formal ethical approval has therefore not been sought.

Format of this interview

A semi-structured interview schedule will be followed. Notes will be taken during the interview, and the discussion will be audio-recorded for later transcription. The interview is intended to last between 20-30 minutes.

Confidentiality

All patient and participant data will be held confidentially, and will be destroyed securely once data analysis is complete. Audio is being directly recorded onto a password-protected NHS computer, and will be backed-up using a password-protected, encrypted, USB memory stick.

Dissemination of results

The results of this study will be disseminated nationally via the Scottish Renal Registry. The lead author (SO) intends to include this project in his forthcoming PhD thesis. It is also intended that the data will be presented at relevant scientific meetings and subsequently published in a peer-reviewed journal.

Agreement to participate

Please sign the attached consent form.

Consent to participate in Scottish Vascular Access Appraisal interview

I understand:

- The purpose of the interview is to gather qualitative information about the current status of vascular access for patients who require renal replacement therapy in Scotland;
- Interviews will last up to 20-30 minutes, and questions will focus upon the processes involved in obtaining and maintaining appropriate vascular access;
- To facilitate data analysis, notes will be taken and interviews will be audio-recorded for later transcription and the audio data destroyed once transcribed;
- I can refuse to answer any question at any time, or end the interview, without giving reasons;
- All patient data will be treated in strict confidence, and will be anonymised for analysis and/or publication;
- All unit-specific data will be anonymised for publication according to Scottish Renal Registry policy;
- Information disclosed during this interview will be used only for the purposes described above.

I have read and understand the above information, and have had the opportunity to ask any questions. I consent to participating in this interview.

Signature:

Print:

Date:

<u>**Interview record**</u>

Date

Time

Hospital

Location

Interviewee name

Interviewee job title

Interviewee consent form?

Interviewers

Audio recorded?

Question 1

Who is involved in vascular access here, and what are their roles?

Nephrologist / Surgeon / Interventional radiologist / Sonographer / Vascular access coordinator

How much allocated time do they have?

Who is responsible for the process / for the individual patient?

Question 2

What's the process for obtaining vascular access pre-emptively?

How are patients identified?

How do you time referral?

What is the mechanism of referral?

What is the timescale for each part of the pathway?

Is there a means of documenting and keeping track of the process?

Question 3

What's the process for obtaining vascular access in patients who present late with end-stage renal failure?

What are the timescales?

Who are the operators performing the procedures? How available are they?

How are these patients upgraded to more permanent access?

Question 4

How do you identify problems with vascular access?

Is there routine surveillance of access?

Is there any communication with primary care or phlebotomy or ward staff about preservation of access?

Is there any established patient or staff education programme?

Question 5

What could other units learn from the way things work here?

What changes have you made to the way things work?

What have your biggest challenges been?

Is there a memorable patient who stands out as a particular success story?

Question 6

What would you change about the current setup?

If money was no object, how would you make things better?

What would you change about current governance arrangements?

What do your patients think of the current setup?

Question 7

Is there anything else you would like to tell us?

Closure

Thank you for taking part in the interview.

Could we contact you again for further information?

Contact phone

Contact email address

Patient scenarios

1. CKD in low clearance clinic – no live donor

48 year old man with progressive IgA Nephropathy and no other comorbidity, diagnosed on biopsy 3 years ago. No potential live donors. eGFR 20ml/min/1.73m2 and declining at 10ml/min/1.73m2/year.

2. CKD in low clearance clinic with potential live donor

48 year old man with progressive IgA Nephropathy and no other comorbidity, diagnosed on biopsy 3 years ago. Live donor being actively worked-up. eGFR 12ml/min/1.73m2 and declining at 10ml/min/1.73m2/year.

3. Late presentation with end-stage renal failure

62 year old man, new patient, presenting with likely diabetic nephropathy, eGFR 10ml/min/1.73m2 and likely to need to start RRT within 4 weeks.

4. Failing transplant

39 year old female, ESRF end-stage renal failure secondary to autosomal dominant polycystic kidney disease, who received a cadaveric transplant 9 years ago. Several episodes of acute rejection

treated with steroid / ATG / rituximab since transplantation, and eGFR declining by 8-10ml/min/1.73m2/year. Current eGFR 17ml/min/1.73m2. No potential live donors.

5. Difficult vascular access

64 year old man with end-stage renal failure secondary to diabetic nephropathy, who attends thrice weekly for hospital haemodialysis via right brachio-cephalic fistula. Transplantation contraindicated in view of comorbidity. Admitted as an emergency with clotted fistula.

Appendix 2 – Clinical Activity Census data collection spreadsheet

Surgery

Chi	Date Referred	Date Listed	Date of procedure	Procedure (RCF/BCF/BBF/AVG/other - specify)	HD Stage HD / PreD	Complication of procedure

Interventional radiology

Chi	Date Listed	Date of Procedure	Procedure	Complication of procedure

Admissions and complications

Chi	Date Admission	Date Discharge	Reason/s For Admission	Out of hours admission?

Unexpected events

Date	Description

Appendix 3 – Vascular Access Scorecard questions

What health board do you work in? [multiple choice]

What is your job title? [free text]

What is your main role in relation to vascular access? [free text]

Is the vascular access service formally integrated into the corporate structure of the NHS board through the presence of a nominated board-level stakeholder? [yes / no / don’t know]

Is there a named service manager who collates the financial cost data on all vascular access related activity from across nephrology, surgery and radiology? [yes / no / don’t know]

Are the roles and responsibilities of each member of the VA team clearly defined in a written description of the VA service, which is accessible to patients and members of the wider clinical team? [yes / no / don’t know]

Is there a clearly articulated, written pathway that describes and governs the referral mechanisms and patient flow through the access creation and maintenance pathways? [yes / no / don’t know]

Is there a written policy describing and governing the escalation of potential access problems? [yes / no / don’t know]

Is there a written policy that describes and governs the management of clotted arteriovenous fistulae or grafts? [yes / no / don’t know]

Does the NHS Board have a policy designed specifically to prevent inappropriate venepuncture and other such practices that create a hazard for patients who require or already have native arteriovenous fistula or graft vascular access? [yes / no / don’t know]

Do the lead VA clinicians from nephrology, vascular surgery and interventional radiology have at least job planned time to attend to strategic aspects of the VA service? [yes / no / don’t know]

Do all clinicians responsible for the care of patients receiving HD have job-planned time allocated to attending at the vascular access MDT proportionate to their haemodialysis case load? [yes / no / don’t know]

Do you know how many vascular access surgical procedures are conducted per year? [yes / no / don’t know]

Do you know how many interventional radiology procedures are conducted per year? [yes / no / don’t know]

Do you know how many vascular access ultrasound examinations are conducted per year? [yes / no / don’t know]

Do you know how many patients require an overnight inpatient hospital stay for an elective vascular access procedure? [yes / no / don’t know]

Are current waiting times for vascular access creation procedures available and accessible to the clinical team? [yes / no / don’t know]

Are all cases where patients require emergency access routinely audited or discussed in the setting of a vascular access morbidity and mortality meeting? [yes / no / don’t know]

Are vascular access procedures that are cancelled for non-clinical reasons routinely audited or discussed at a vascular access morbidity and mortality meeting? [yes / no / don’t know]

Are administrative delays routinely audited or discussed at a vascular access morbidity and mortality meeting? [yes / no / don’t know]

Are informal referrals for vascular access routinely audited or discussed at a vascular access morbidity and mortality meeting? [yes / no / don’t know]

Is primary and secondary arteriovenous access patency routinely audited or discussed at a vascular access morbidity and mortality meeting? [yes / no / don’t know]

Are all cases of clotted arteriovenous fistulae or grafts routinely audited or discussed at a vascular access morbidity and mortality meeting? [yes / no / don’t know]

Are all cases of central venous stenosis routinely audited and discussed at a vascular access morbidity and mortality meeting? [yes / no / don’t know]

Is there a regular meeting, separate to the discussion of individual patient cases, where strategic elements of the vascular access service are discussed? [yes / no / don’t know]

Are RDU staff formally trained in the basic assessment of fistulae, to identify potential fistula problems, and to cannulate arteriovenous fistulae and grafts? [yes / no / don’t know]

Are all members of the vascular access team trained in the optimal use of the electronic patient record and associated electronic health records? [yes / no / don't know]

Has appropriate training been given to nurses and other clinical staff who provide periprocedural care for patients undergoing access creation or maintenance procedures? [yes / no / don't know]

Is there formal clinical time set aside for staff to educate patients about vascular access? (New patients) [yes / no / don't know]

Is there formal clinical time set aside for staff to educate patients about vascular access? (Prevalent patients) [yes / no / don't know]

Has education been provided to all clinicians who refer patients for vascular access creation to enable the clinical identification of vessels that are suitable for AVF creation? [yes / no / don't know]

Is there an educational secondment programmes that enables RDU nurses to have protected time to working with the vascular access coordinator? [yes / no / don't know]

Are steps being taken to measure patient experience around the creation and maintenance of vascular access? [yes / no / don't know]

Do patients have access to arteriovenous graft procedures as a potential access modality? [yes / no / don't know]

Do all prospective haemodialysis patients with eGFR <=15ml/min within the centre have a documented "personal access strategy"? [yes / no / don't know]

Is the patient's "personal access strategy" documented in the patient's case record? [yes / no / don't know]

Are electronic health records used to refer patients into the access creation and maintenance pathways? [yes / no / don't know]

Are electronic health record used to tracking the patient journey through access pathways? [yes / no / don't know]

Is there access to a suitably trained sonographer to perform ultrasound vein mapping? [yes / no / don't know]

Is USS duplex vein mapping available for all patients within two weeks of referral? [yes / no / don't know]

Is there a one-stop clinic (or equivalent) where ultrasound scanning, clinical review and a decision for theatre may all be undertaken at a single attendance? [yes / no / don't know]

Do operation notes for all arteriovenous access procedures include a statement directing subsequent action in the event that the access does not mature? [yes / no / don't know]

Are all patients who have arteriovenous access creation or revision surgery seen between two to four weeks postoperatively? [yes / no / don't know]

Are there protected slots for interventional radiology and surgical vascular access procedures? [yes / no / don't know]

Are slots for elective vascular access creation and maintenance procedures available to book with at least four weeks' notice? [yes / no / don't know]

Are slots for emergency interventional radiology maintenance procedures available with 48 hours' notice? [yes / no / don't know]

Are all vascular access procedures are given 'urgent' or 'emergency' priority on waiting lists? [yes / no / don't know]

Does the Vascular Access Coordinator have the clinical authority and technical / administrative ability to directly allocate specific surgery or interventional radiology slots to named patients for the creation or maintenance of vascular access? [yes / no / don't know]

Can the Vascular Access Coordinator re-order existing vascular access surgery and radiology procedure lists? [yes / no / don't know]

Are named administrative staff available during normal working hours to liaise with vascular access coordinators? [yes / no / don't know]

Is there a regular vascular access MDT meeting at least every three weeks? [yes / no / don't know]

Does the minimum time allocated to the vascular access MDT meeting per week equate to the same number, in minutes, as the number of patients in 10-15% of the prevalent HD population? [yes / no / don't know]

Is an attendance register taken at the MDT meeting? [yes / no / don't know]

Is it possible to directly book interventional radiology procedures at the MDT meeting? [yes / no / don't know]

Are MDT outcomes recorded on the electronic health record? [yes / no / don't know]

Do sonographers have direct access to an interventional radiologist to discuss cases outwith the MDT meeting? [yes / no / don't know]

Is a 'priority list' maintained, that identifies which patient is next in line to have a procedure performed? [yes / no / don't know]

Do renal services have access to 'Day surgery' beds for elective/semi-elective arteriovenous access work? [yes / no / don't know]

Are co-located nephrology, vascular and interventional radiology services available for patients undergoing complex access work or who require an overnight stay? [yes / no / don't know]

Is there a proactive approach to identifying the failing arteriovenous access? [yes / no / don't know]

Are 'threatened' arteriovenous fistulae or grafts considered medical emergencies and managed accordingly? [yes / no / don't know]

Do patients have access to a combined surgical / interventional radiology declotting procedure within 48 hours of presentation with a clotted AVF or AVG? [yes / no / don't know]

Is an 'intervention history' recorded in the patient's record for every arteriovenous access? [yes / no / don't know]

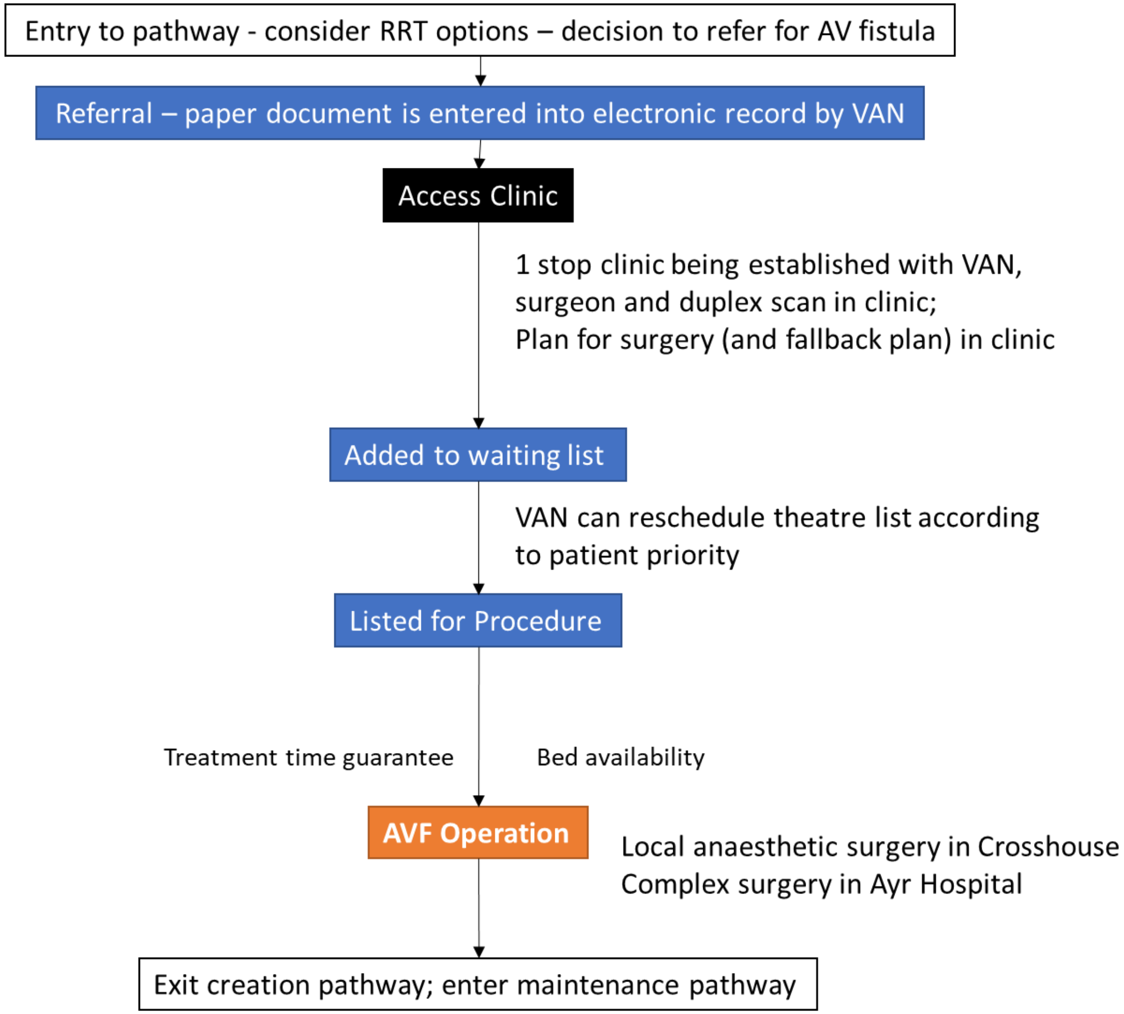
Is there a tracking system that allows team members to determine where an individual patient is in their vascular access journey? [yes / no / don't know]

Is there a named lead vascular access nephrologist, vascular surgeon, interventional radiologist and service manager? [yes / no / don't know]

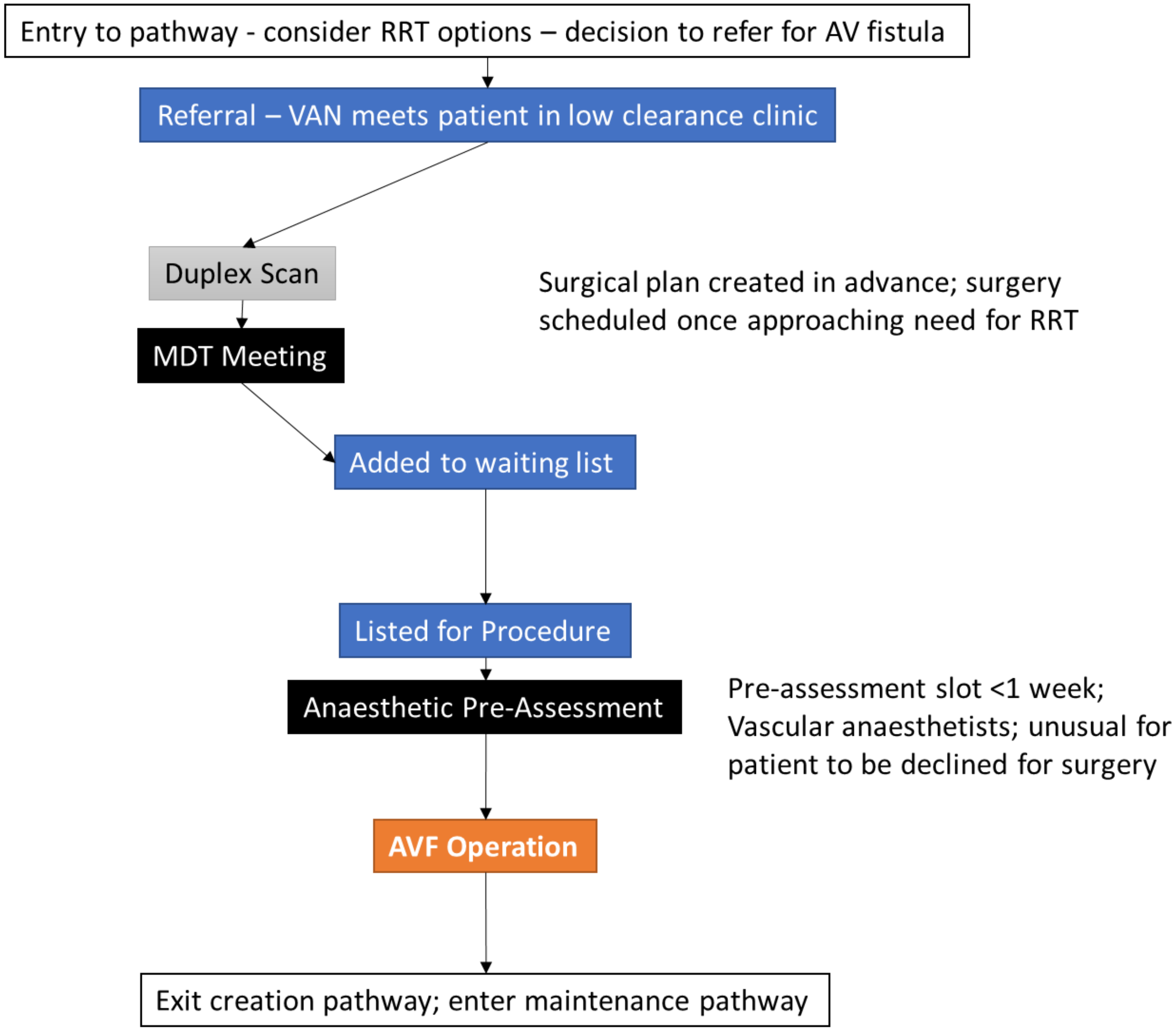
Is there a vascular access coordinator role, staffed equivalent to a minimum of 0.75 WTE coordinators per 100 prevalent HD patients? [yes / no / don't know]

Do you have any comments to add? [freetext]

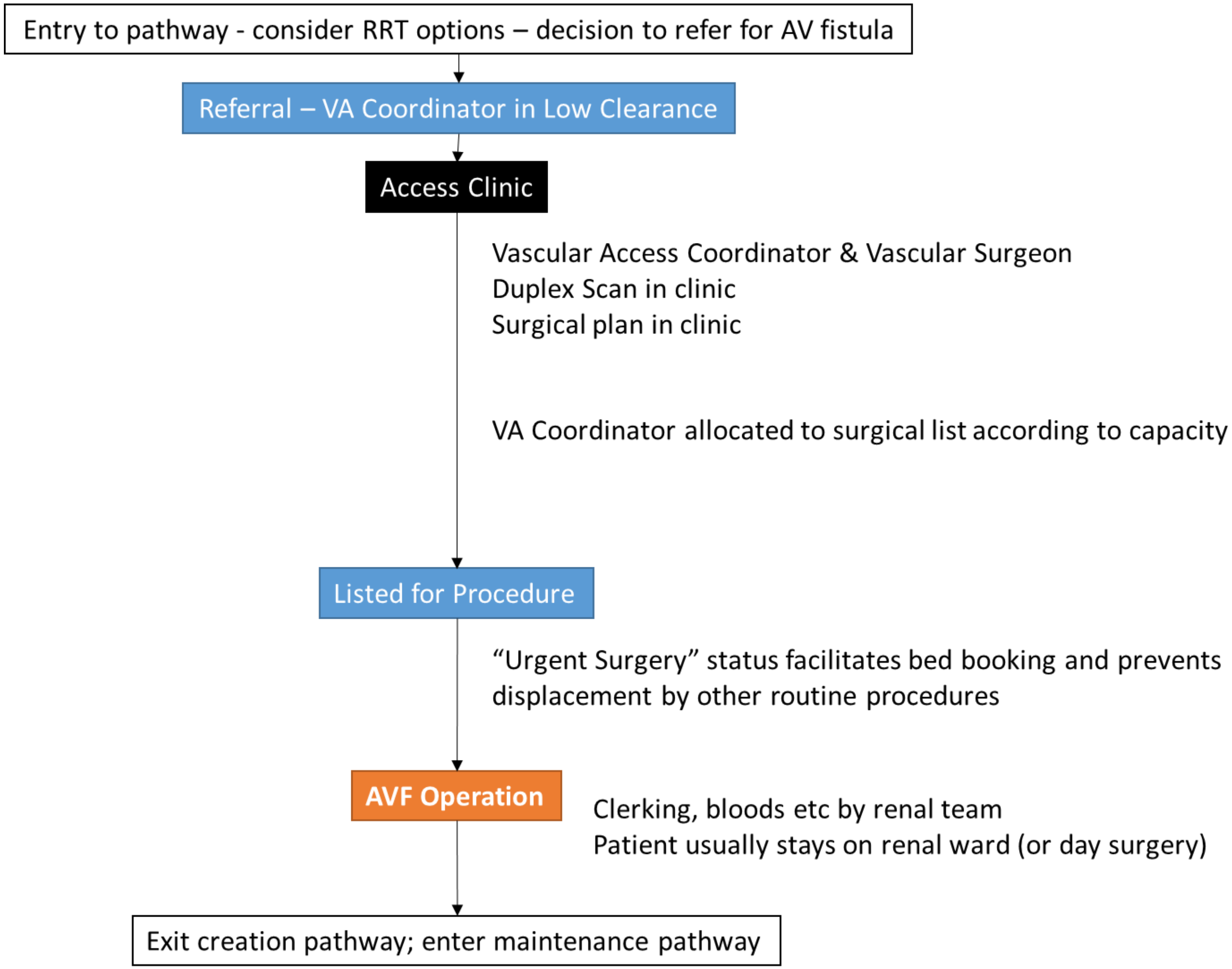
Appendix 4 – Vascular Access creation pathways by unit



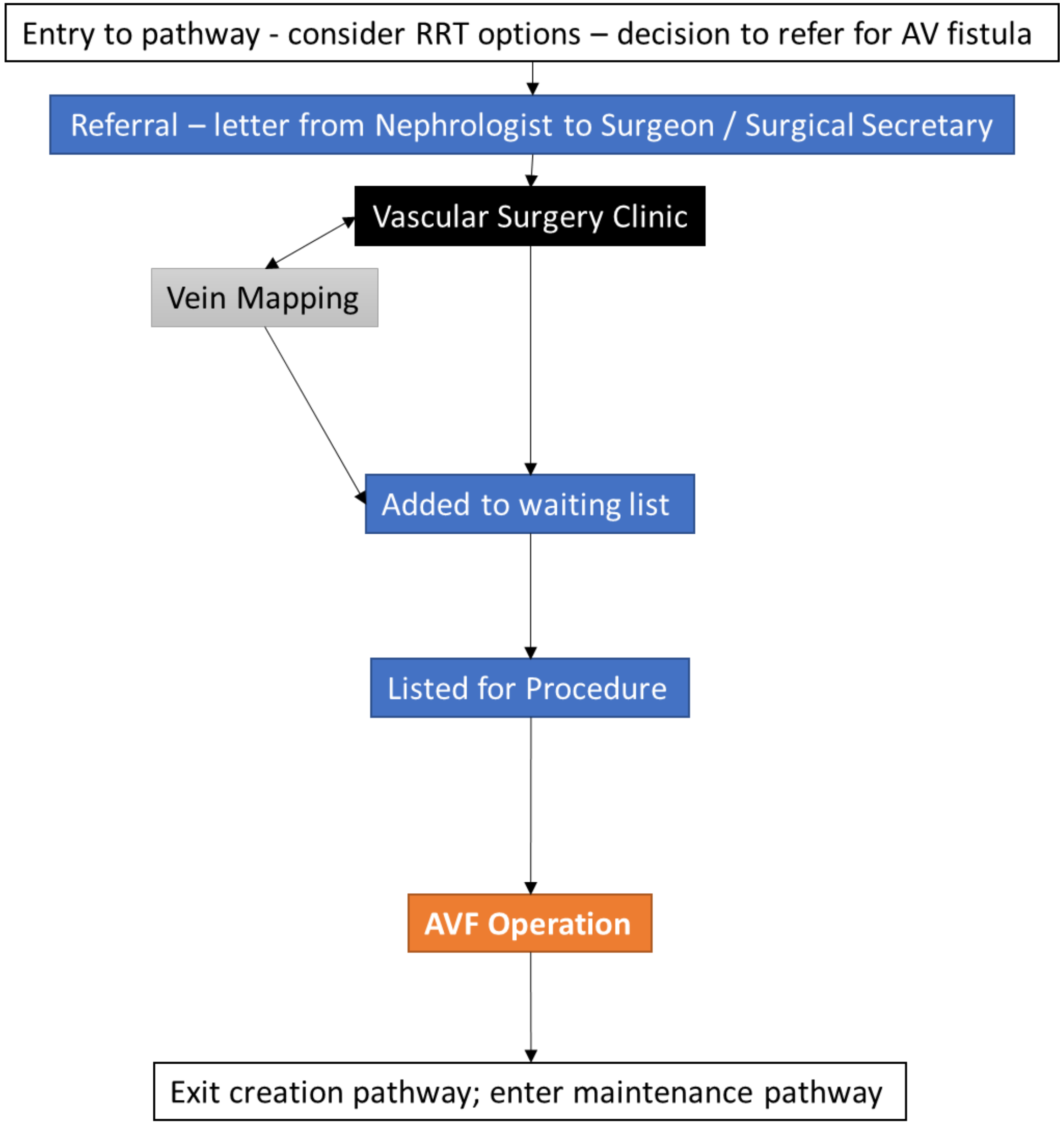
Unit 1


Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – VAN meets patient in low clearance clinic
Duplex Scan
MDT Meeting
Surgical plan created in advance; surgery scheduled once approaching need for RRT
Added to waiting list
Listed for Procedure
Anaesthetic Pre-Assessment
Pre-assessment slot <1 week; Vascular anaesthetists; unusual for patient to be declined for surgery
AVF Operation
Exit creation pathway; enter maintenance pathway

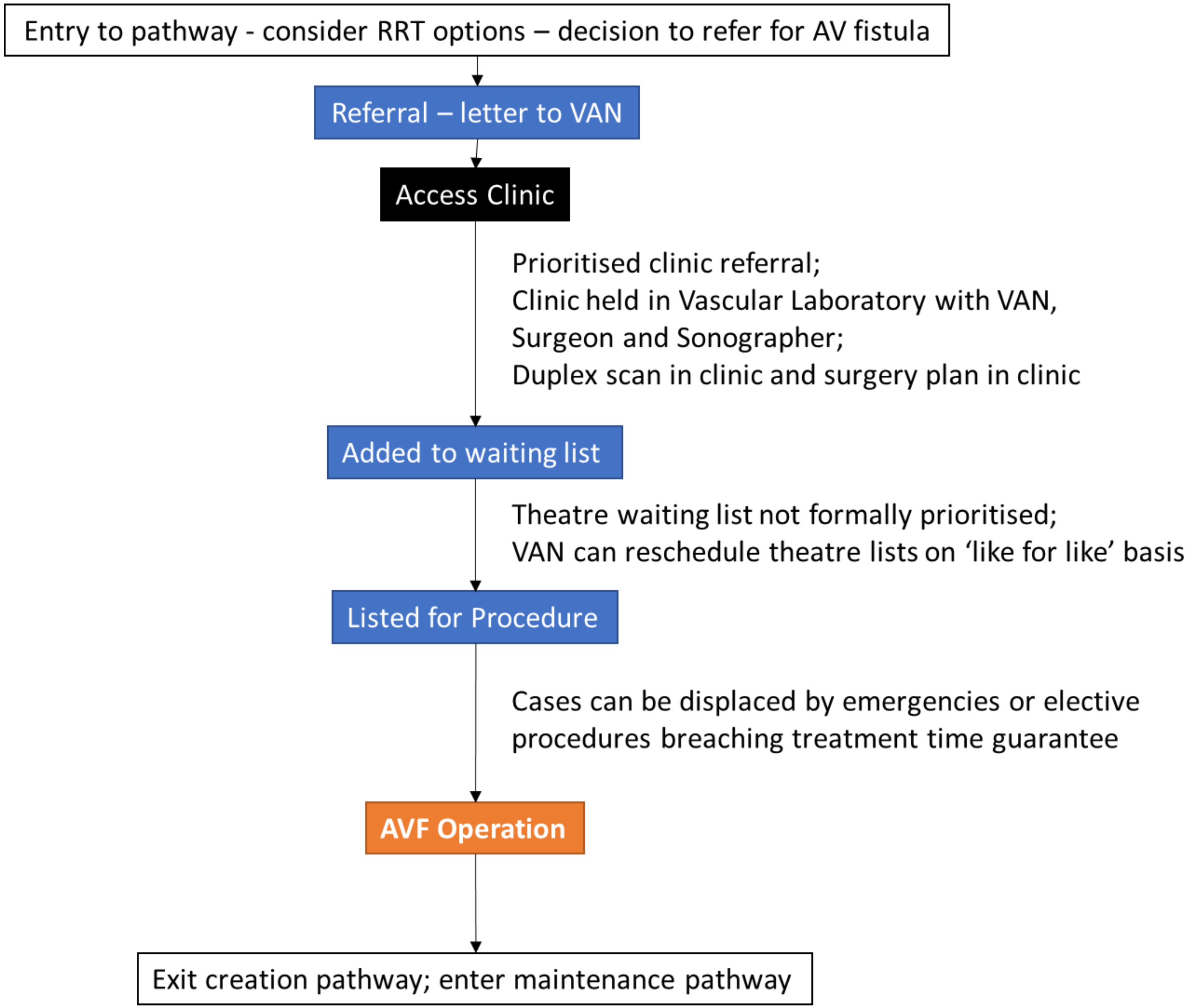
Unit 2


Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – VA Coordinator in Low Clearance
Access Clinic
Vascular Access Coordinator & Vascular Surgeon
Duplex Scan in clinic
Surgical plan in clinic
VA Coordinator allocated to surgical list according to capacity
Listed for Procedure
“Urgent Surgery” status facilitates bed booking and prevents displacement by other routine procedures
AVF Operation
Clerking, bloods etc by renal team
Patient usually stays on renal ward (or day surgery)
Exit creation pathway; enter maintenance pathway

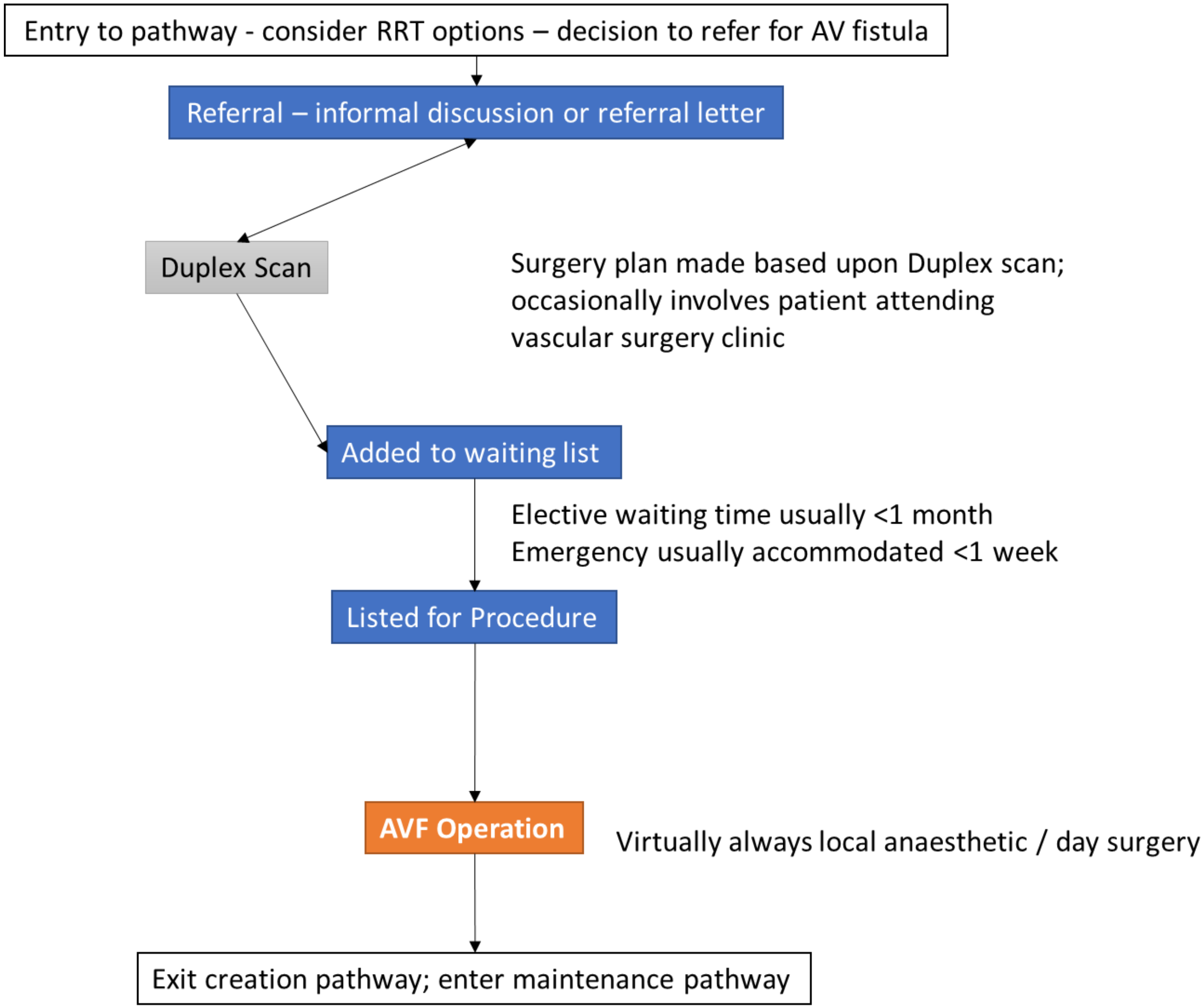
Unit 3


Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – letter from Nephrologist to Surgeon / Surgical Secretary
Vascular Surgery Clinic
Vein Mapping
Added to waiting list
Listed for Procedure
AVF Operation
Exit creation pathway; enter maintenance pathway

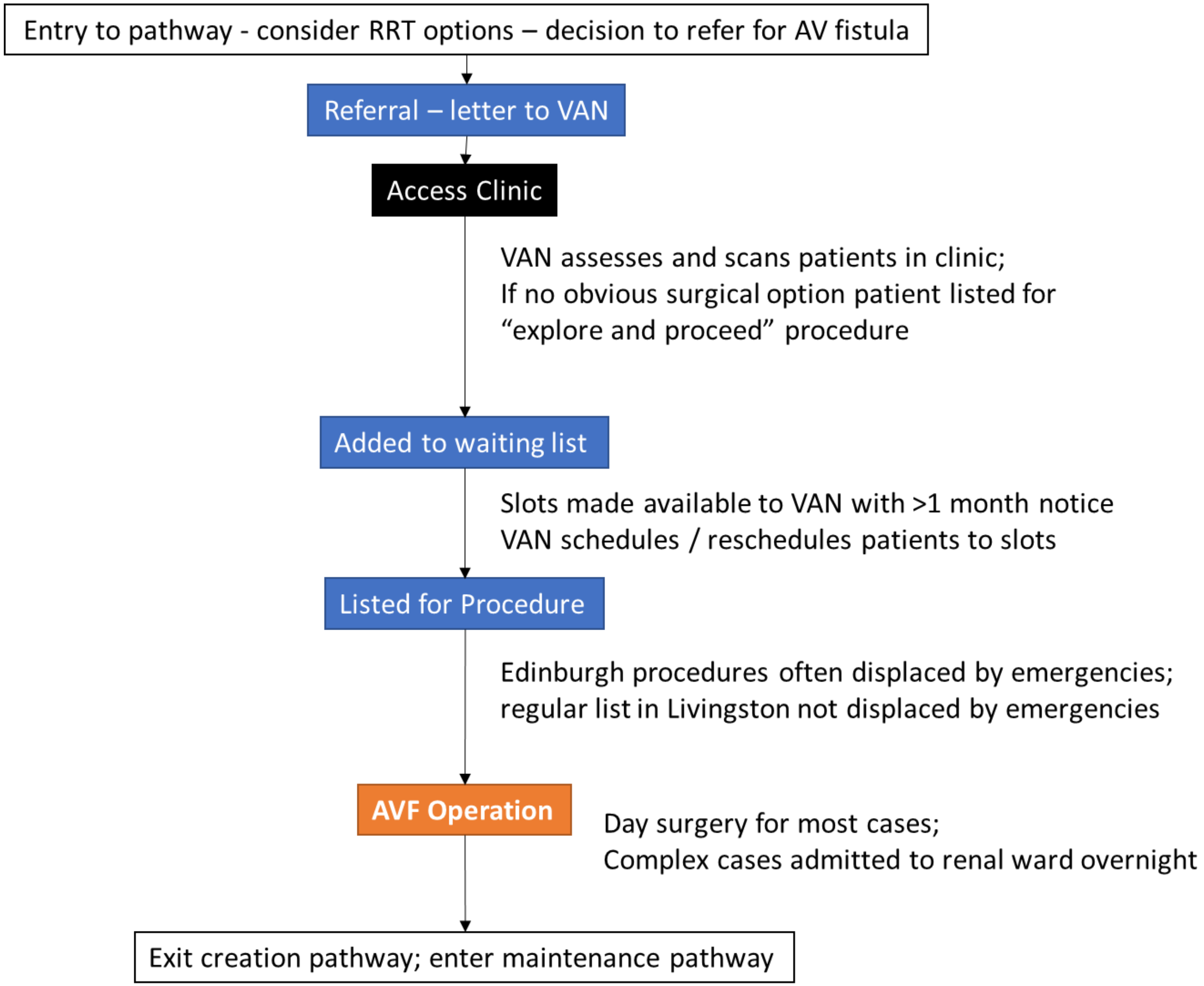
Unit 4


Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – letter to VAN
Access Clinic
Prioritised clinic referral;
Clinic held in Vascular Laboratory with VAN,
Surgeon and Sonographer;
Duplex scan in clinic and surgery plan in clinic
Added to waiting list
Theatre waiting list not formally prioritised;
VAN can reschedule theatre lists on 'like for like' basis
Listed for Procedure
Cases can be displaced by emergencies or elective
procedures breaching treatment time guarantee
AVF Operation
Exit creation pathway; enter maintenance pathway

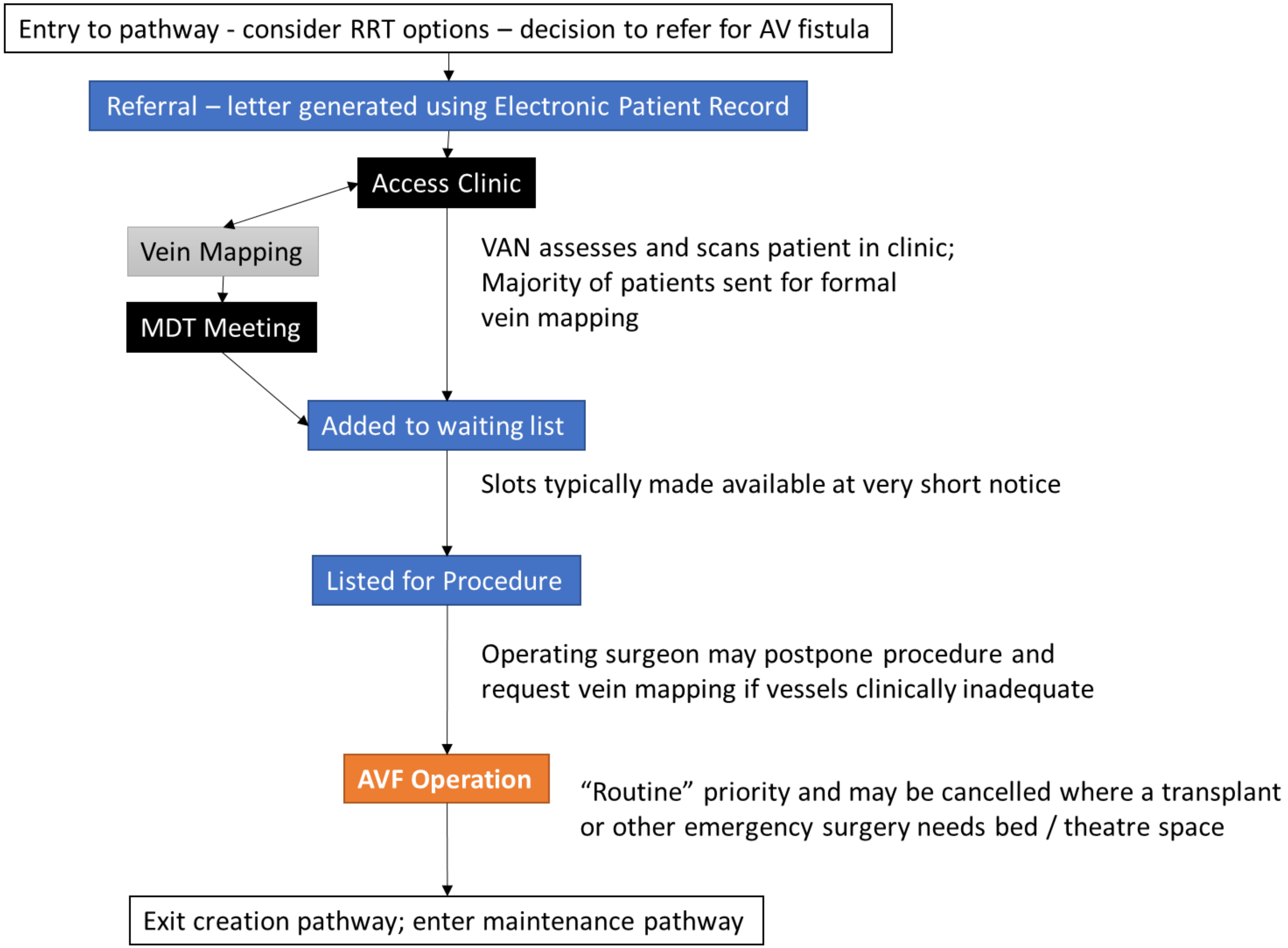
Unit 5


Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – informal discussion or referral letter
Duplex Scan
Surgery plan made based upon Duplex scan; occasionally involves patient attending vascular surgery clinic
Added to waiting list
Elective waiting time usually <1 month
Emergency usually accommodated <1 week
Listed for Procedure
AVF Operation
Virtually always local anaesthetic / day surgery
Exit creation pathway; enter maintenance pathway

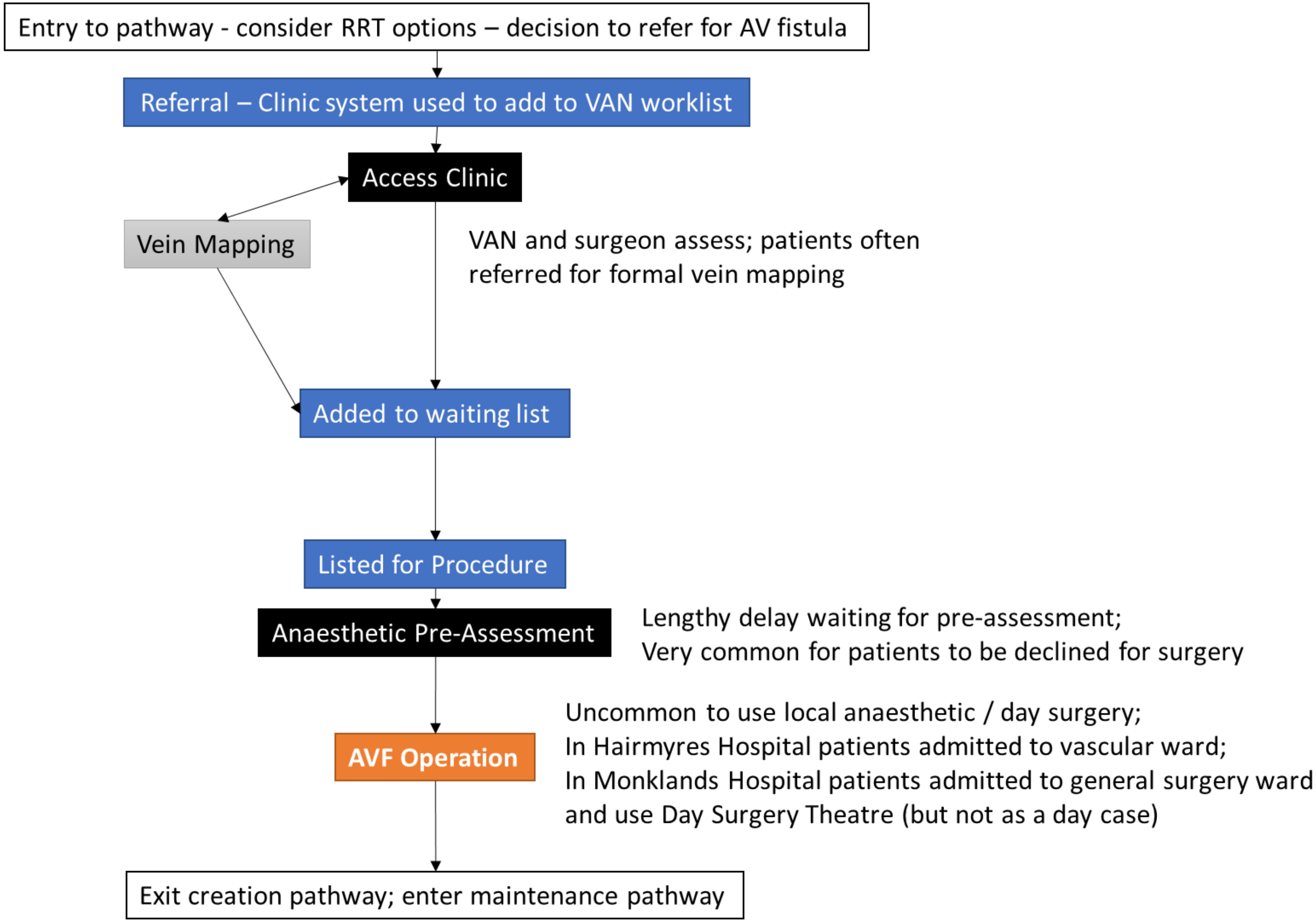
Unit 6


Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – letter to VAN
Access Clinic
VAN assesses and scans patients in clinic;
If no obvious surgical option patient listed for
“explore and proceed” procedure
Added to waiting list
Slots made available to VAN with >1 month notice
VAN schedules / reschedules patients to slots
Listed for Procedure
Edinburgh procedures often displaced by emergencies;
regular list in Livingston not displaced by emergencies
AVF Operation
Day surgery for most cases;
Complex cases admitted to renal ward overnight
Exit creation pathway; enter maintenance pathway

Unit 7

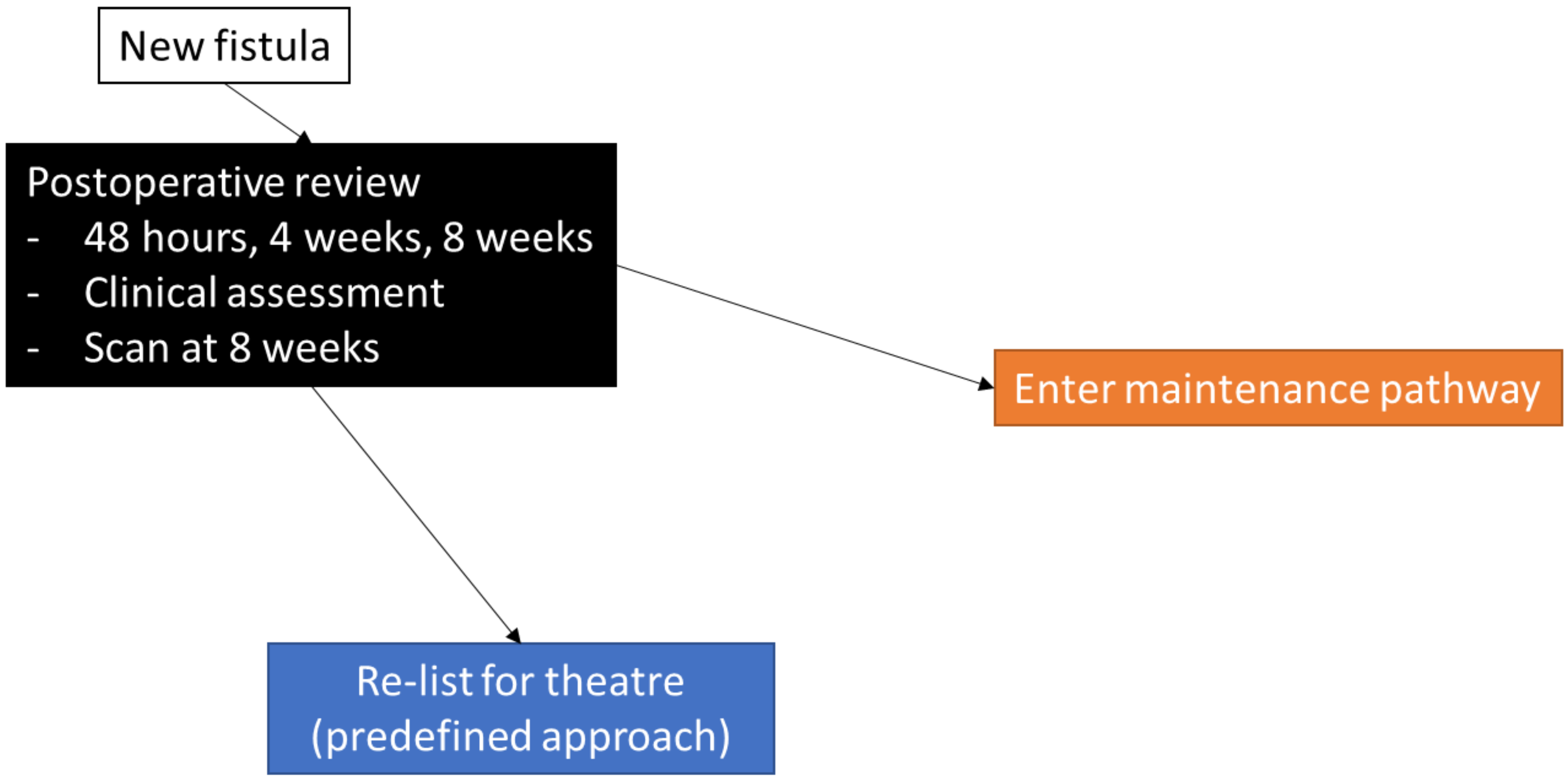

Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – letter generated using Electronic Patient Record
Access Clinic
Vein Mapping
MDT Meeting
VAN assesses and scans patient in clinic; Majority of patients sent for formal vein mapping
Added to waiting list
Slots typically made available at very short notice
Listed for Procedure
Operating surgeon may postpone procedure and request vein mapping if vessels clinically inadequate
AVF Operation
"Routine" priority and may be cancelled where a transplant or other emergency surgery needs bed / theatre space
Exit creation pathway; enter maintenance pathway

Unit 8

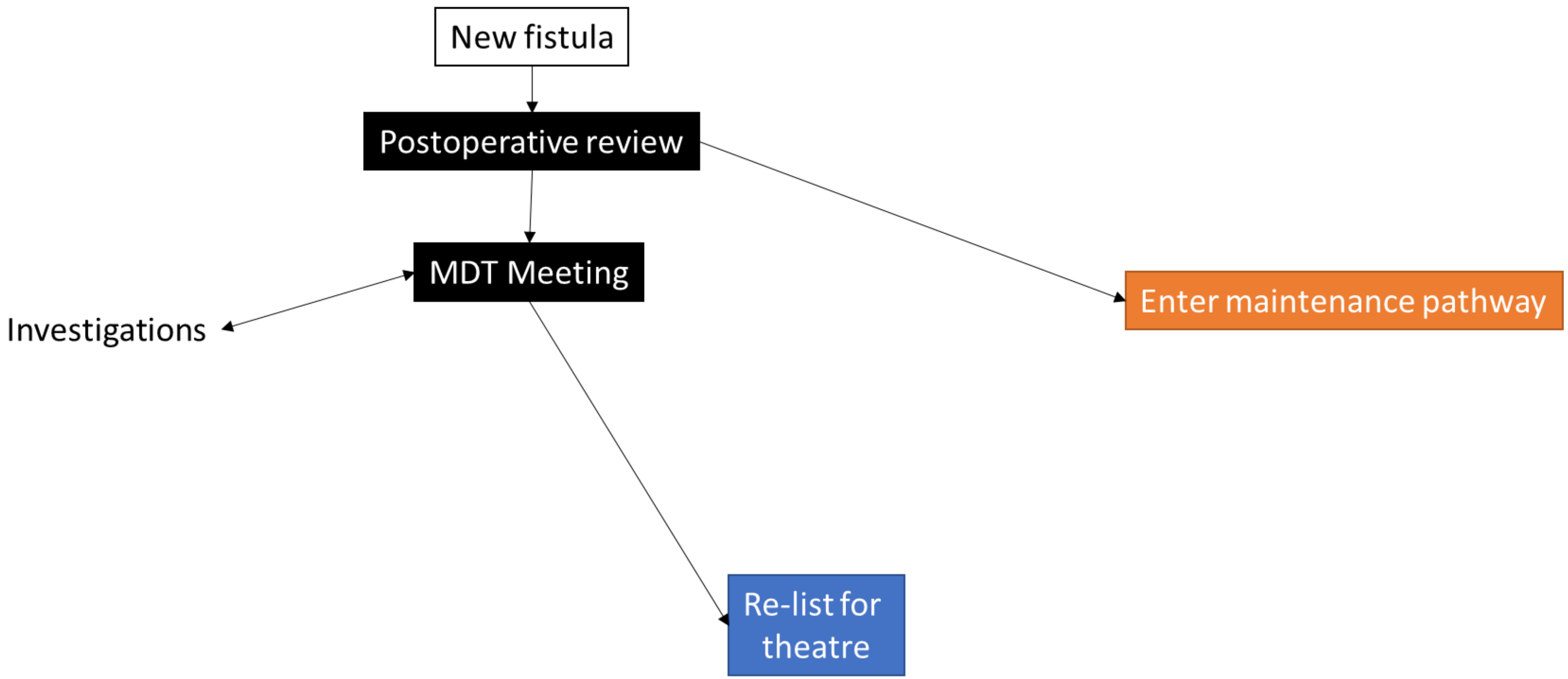

Entry to pathway - consider RRT options – decision to refer for AV fistula
Referral – Clinic system used to add to VAN worklist
Access Clinic
Vein Mapping
VAN and surgeon assess; patients often referred for formal vein mapping
Added to waiting list
Listed for Procedure
Anaesthetic Pre-Assessment
Lengthy delay waiting for pre-assessment;
Very common for patients to be declined for surgery
AVF Operation
Uncommon to use local anaesthetic / day surgery;
In Hairmyres Hospital patients admitted to vascular ward;
In Monklands Hospital patients admitted to general surgery ward and use Day Surgery Theatre (but not as a day case)
Exit creation pathway; enter maintenance pathway

Unit 9

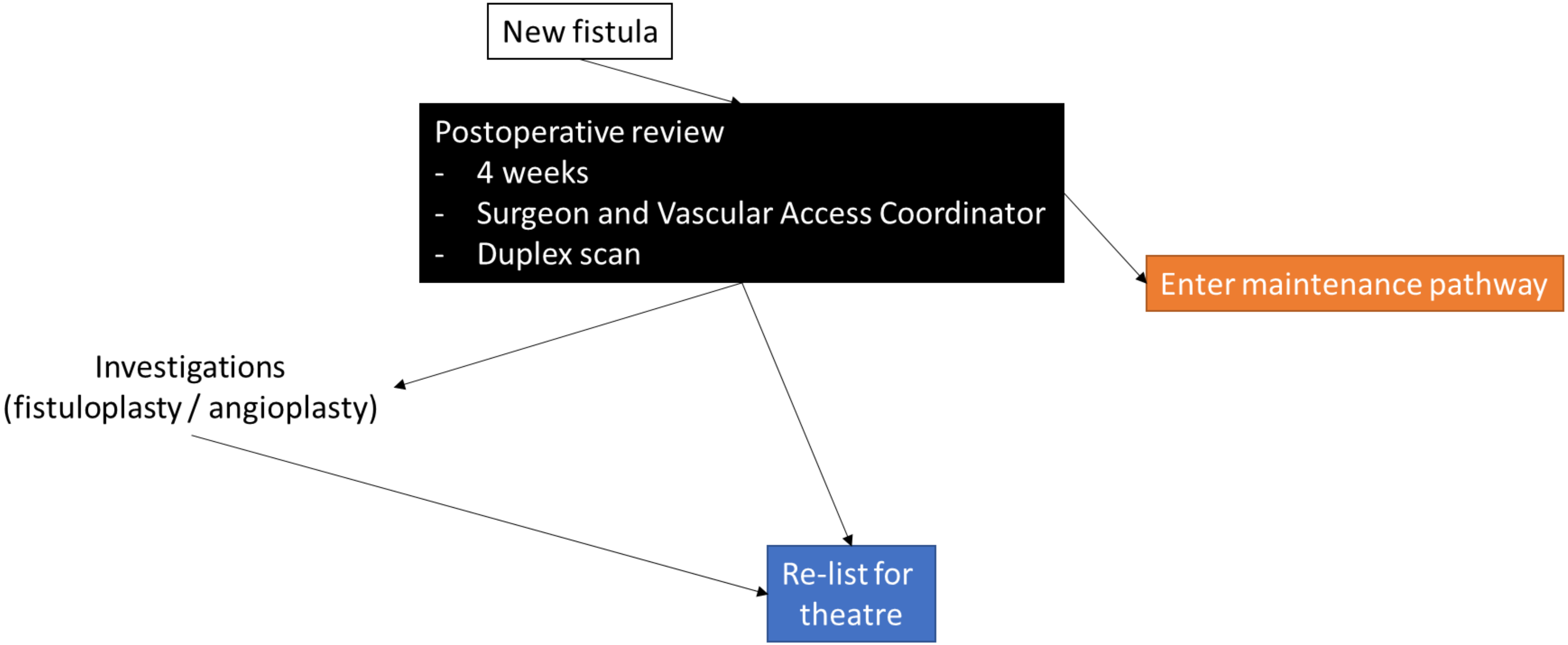
Appendix 5 – Vascular Access postoperative pathways by unit



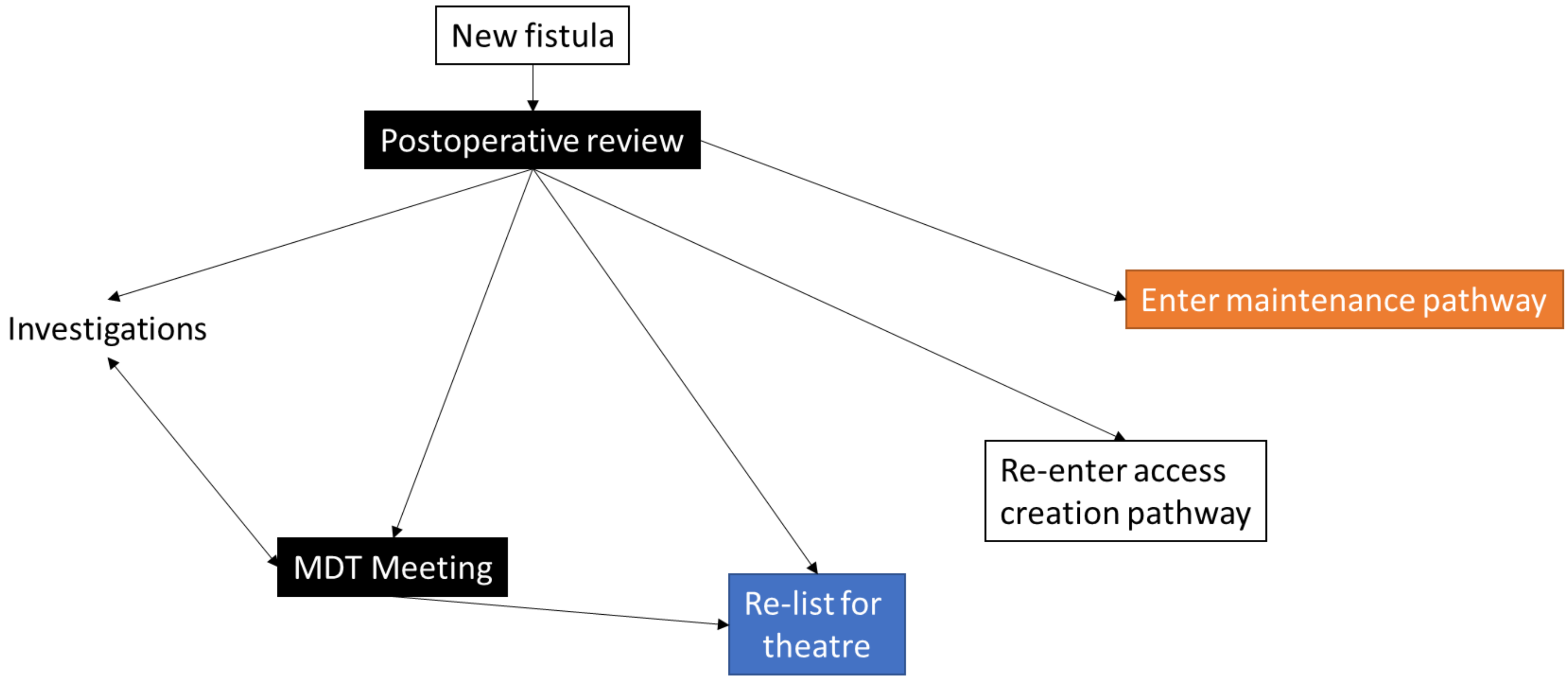
Unit 1


New fistula
Postoperative review
MDT Meeting
Investigations
Enter maintenance pathway
Re-list for theatre

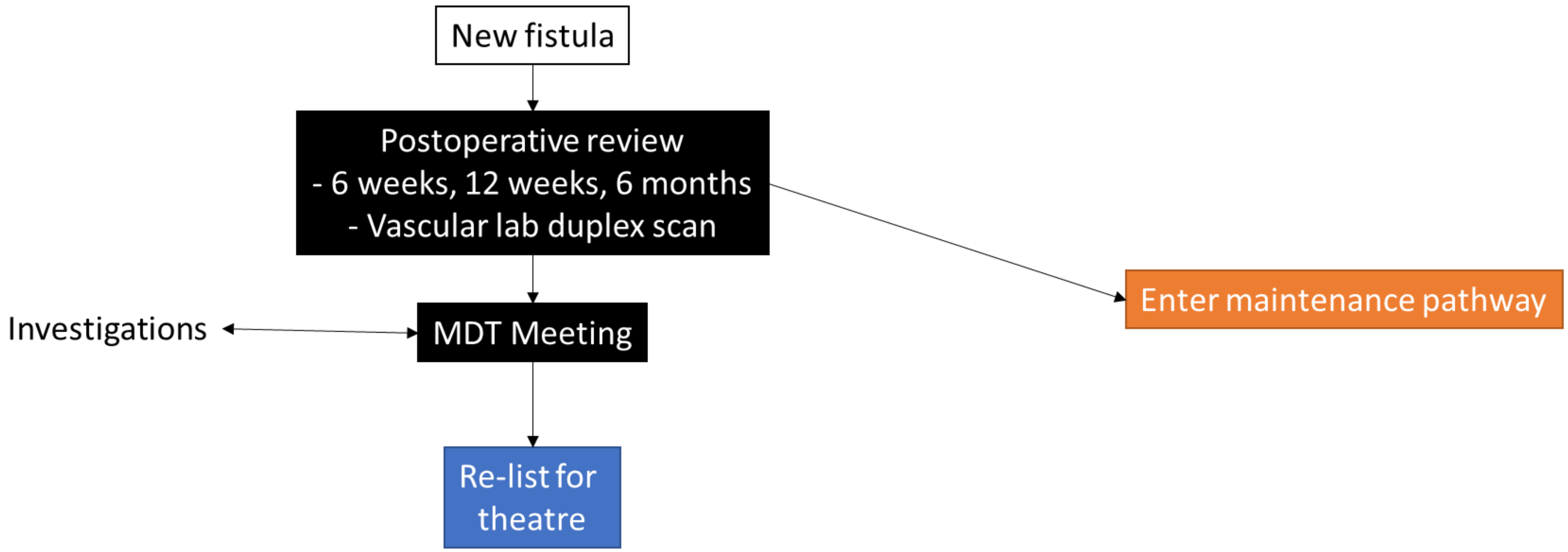
Unit 2


New fistula
Postoperative review
- 4 weeks
- Surgeon and Vascular Access Coordinator
- Duplex scan
Enter maintenance pathway
Investigations
(fistuloplasty / angioplasty)
Re-list for theatre

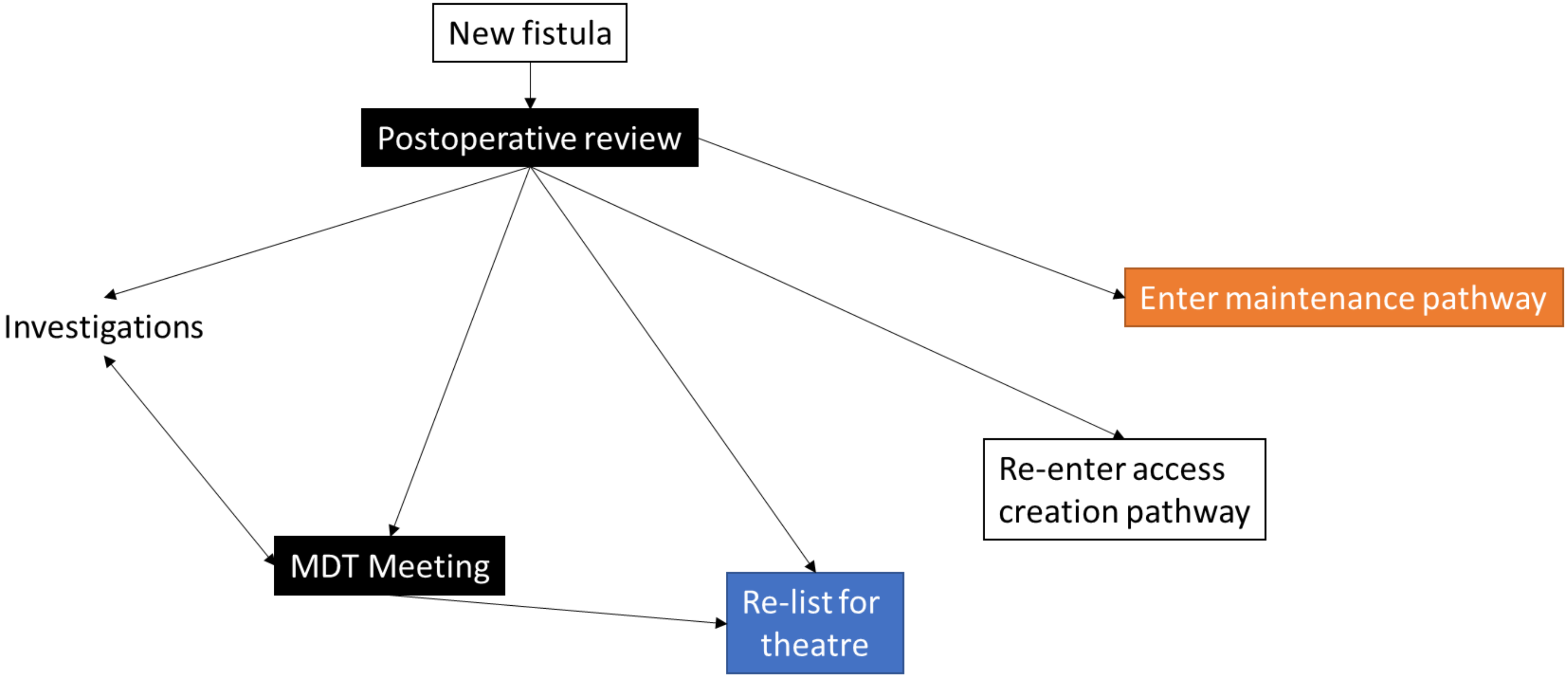
Unit 3


New fistula
Postoperative review
Investigations
Enter maintenance pathway
Re-enter access creation pathway
MDT Meeting
Re-list for theatre

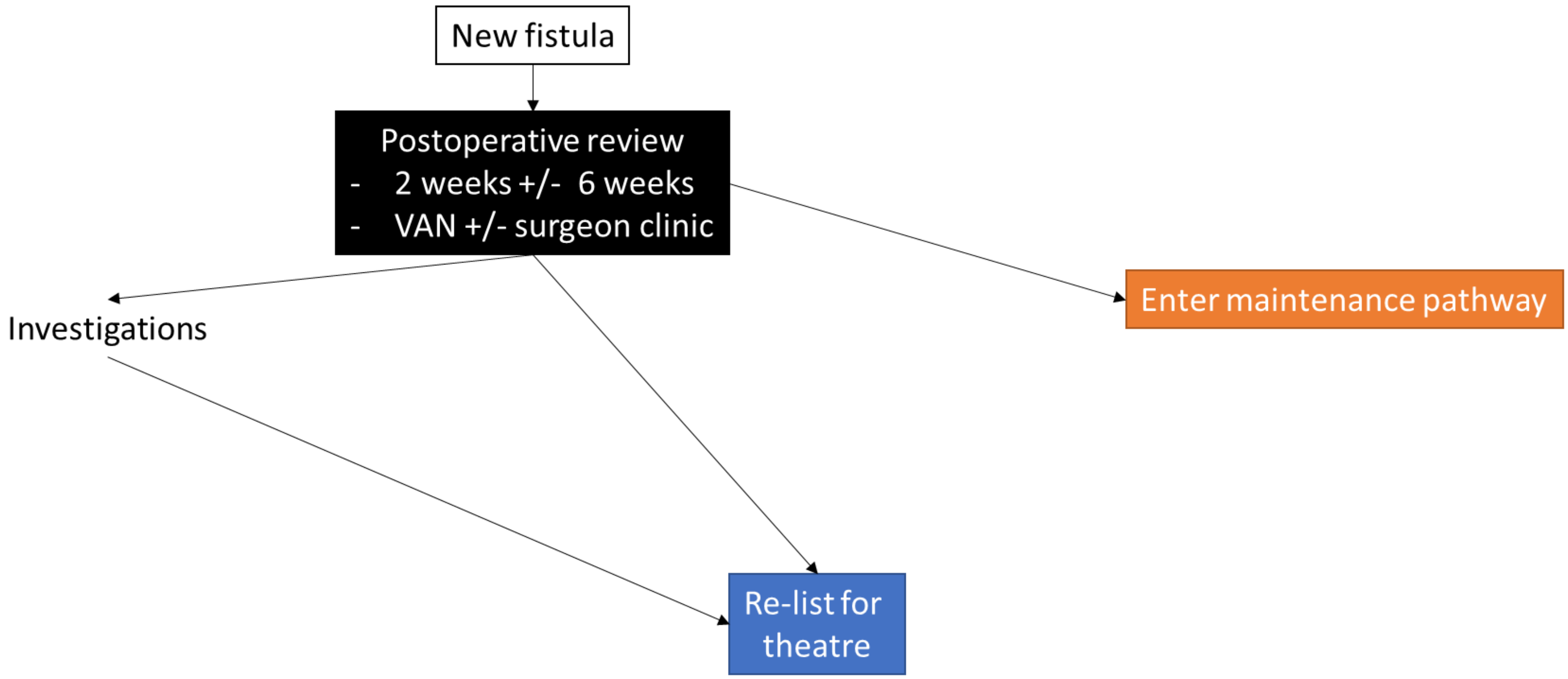
Unit 4


New fistula
Postoperative review
- 6 weeks, 12 weeks, 6 months
- Vascular lab duplex scan
Enter maintenance pathway
Investigations
MDT Meeting
Re-list for theatre

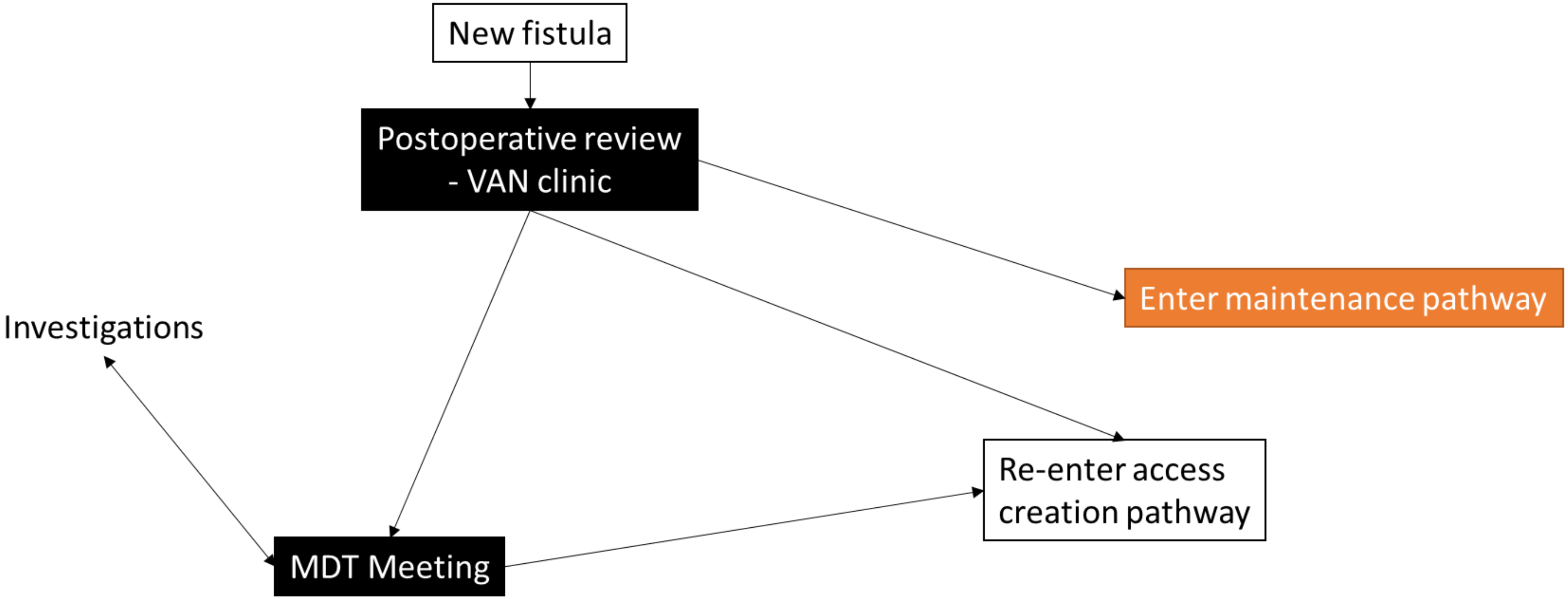
Unit 5


New fistula
Postoperative review
Investigations
MDT Meeting
Re-list for theatre
Re-enter access creation pathway
Enter maintenance pathway

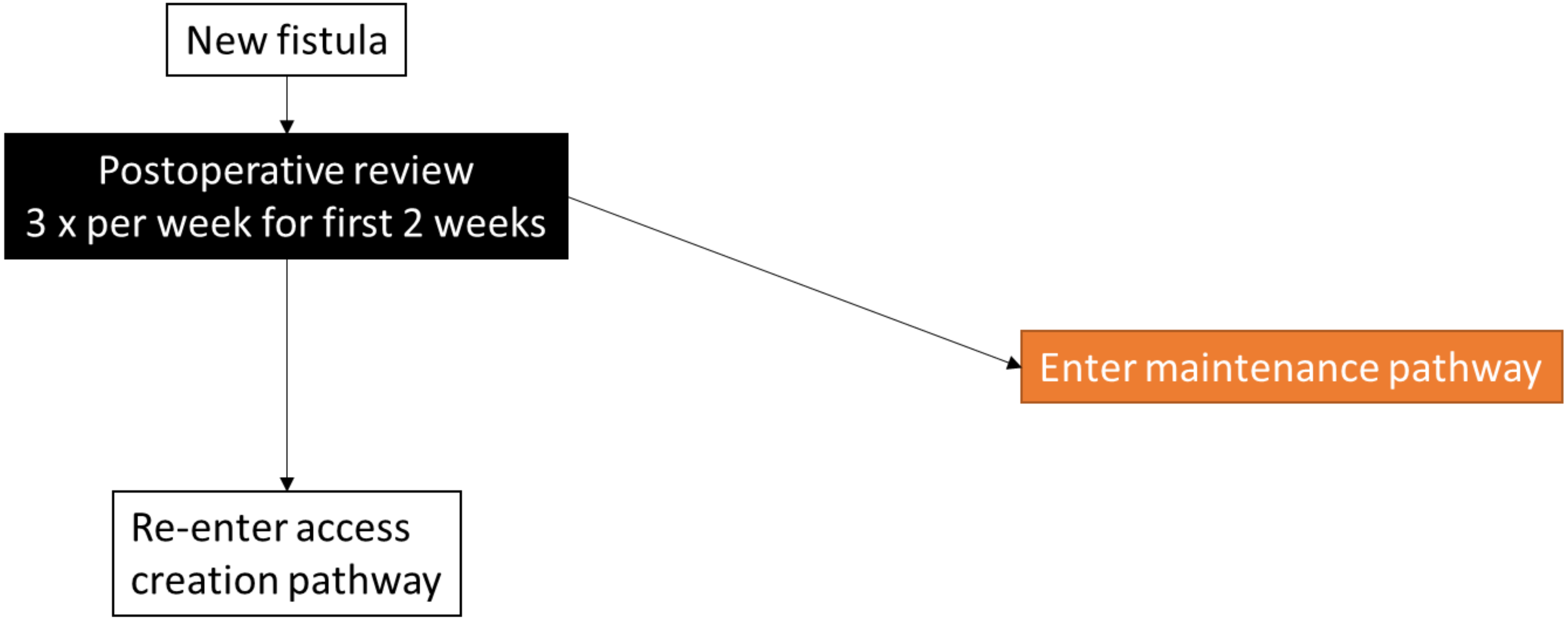
Unit 6


New fistula
Postoperative review
- 2 weeks +/- 6 weeks
- VAN +/- surgeon clinic
Investigations
Enter maintenance pathway
Re-list for theatre

Unit 7

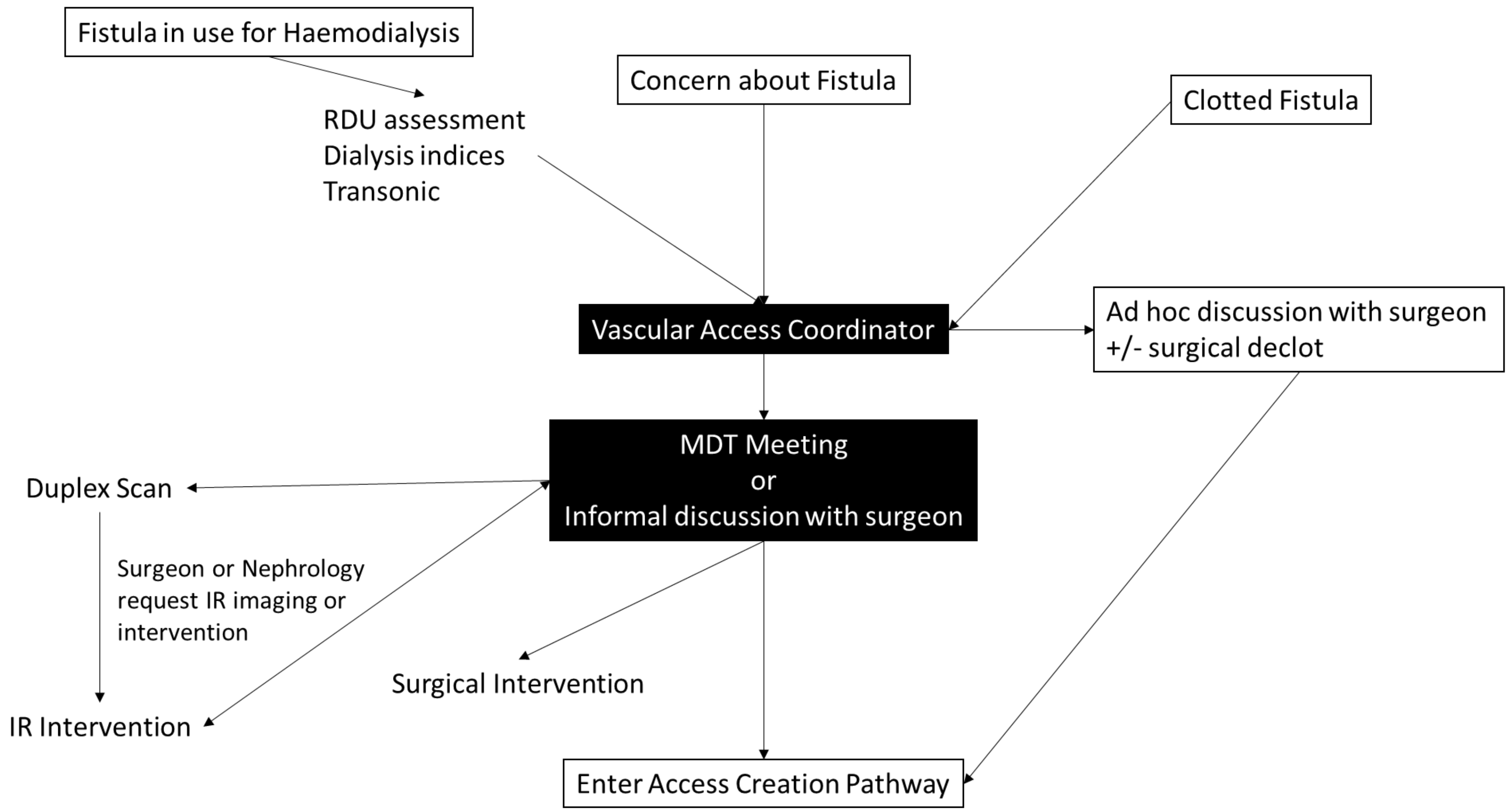

New fistula
Postoperative review - VAN clinic
Enter maintenance pathway
Investigations
Re-enter access creation pathway
MDT Meeting

Unit 8

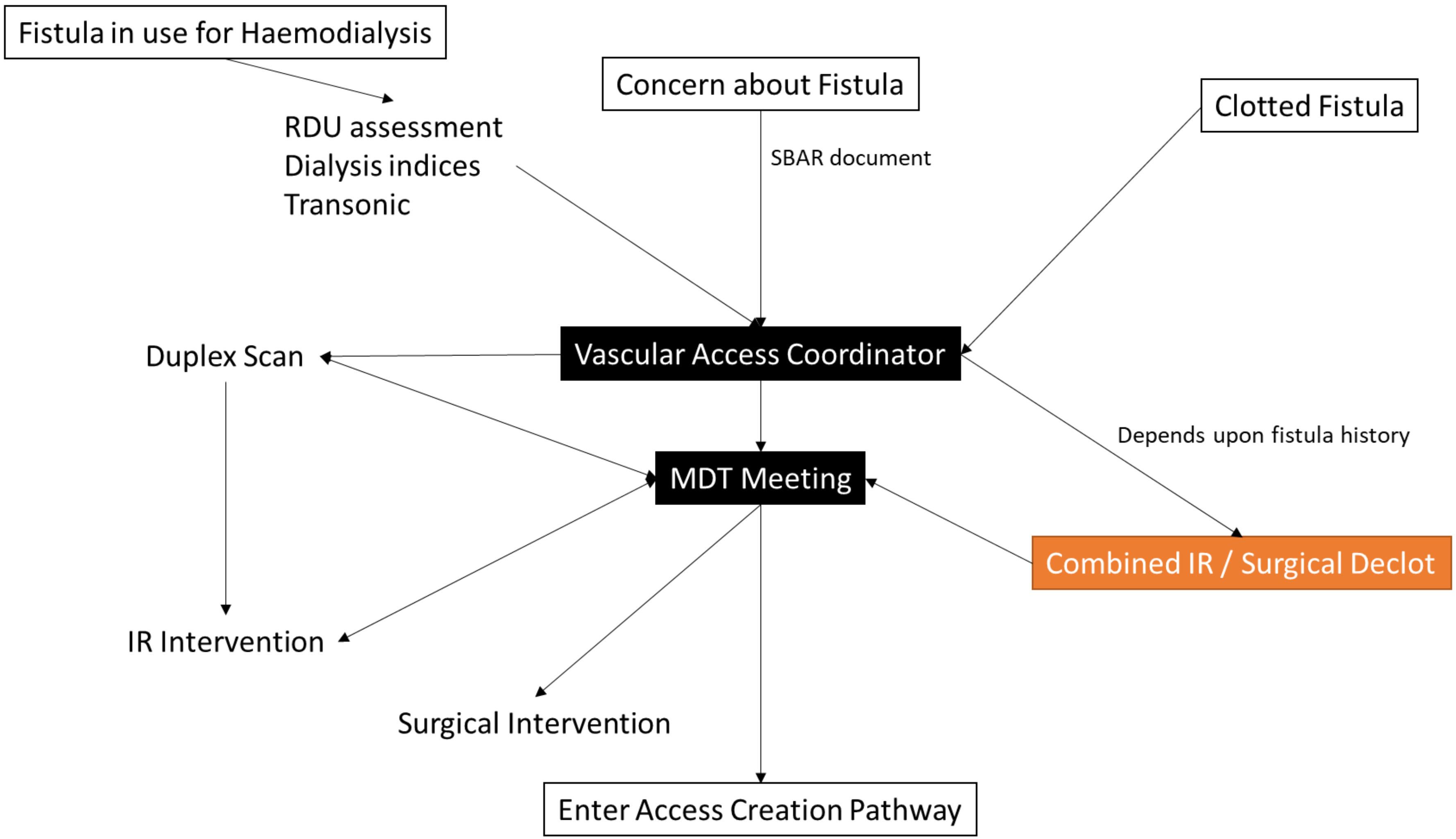

New fistula
Postoperative review
3 x per week for first 2 weeks
Enter maintenance pathway
Re-enter access
creation pathway

Unit 9

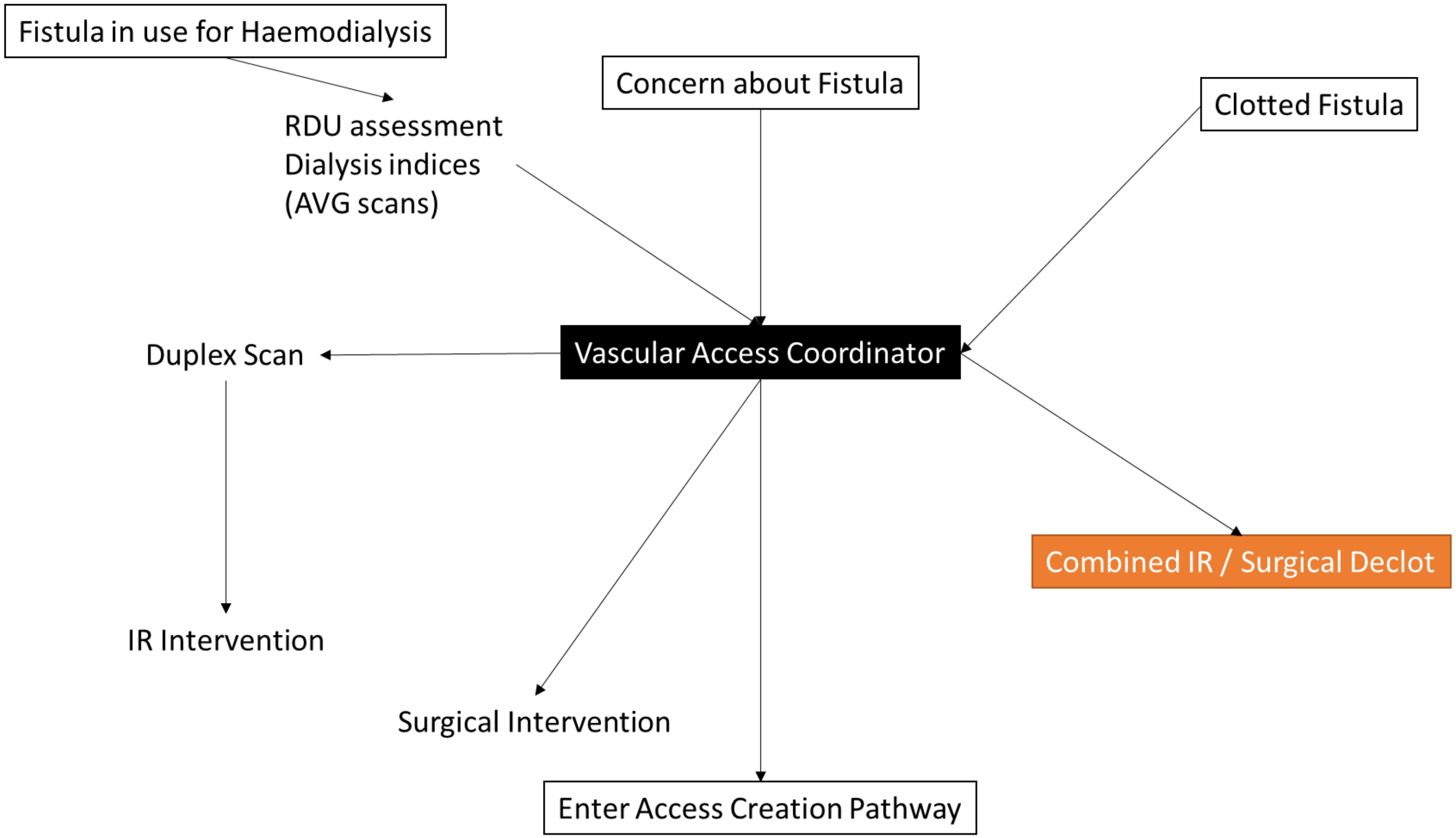
Appendix 6 – Vascular Access maintenance pathways by unit



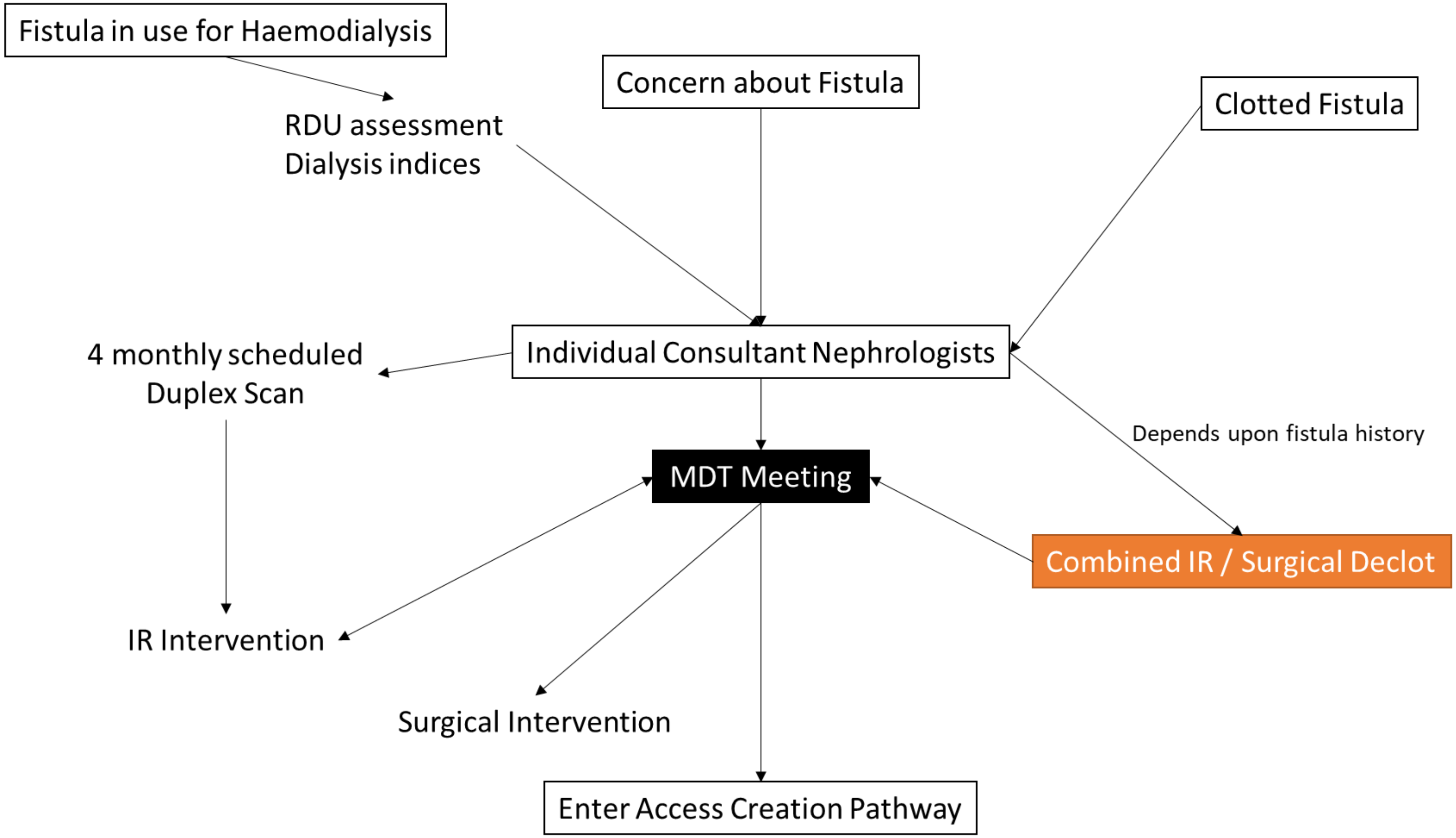
Unit 1


Fistula in use for Haemodialysis
RDU assessment
Dialysis indices
Transonic
Concern about Fistula
SBAR document
Clotted Fistula
Duplex Scan
Vascular Access Coordinator
MDT Meeting
Depends upon fistula history
Combined IR / Surgical Declot
IR Intervention
Surgical Intervention
Enter Access Creation Pathway

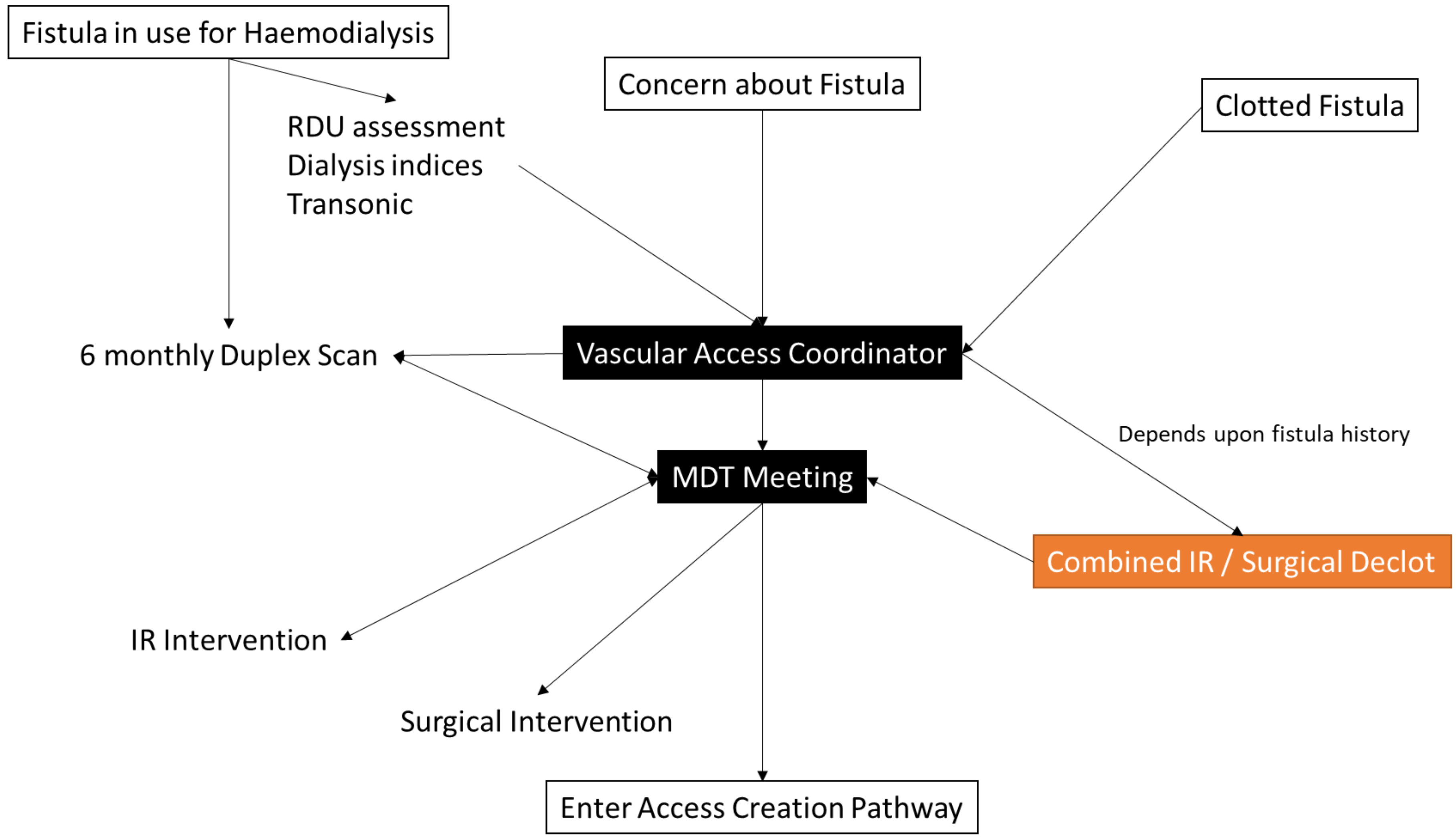
Unit 2


Fistula in use for Haemodialysis
Concern about Fistula
Clotted Fistula
RDU assessment
Dialysis indices
(AVG scans)
Duplex Scan
Vascular Access Coordinator
IR Intervention
Surgical Intervention
Combined IR / Surgical Declot
Enter Access Creation Pathway

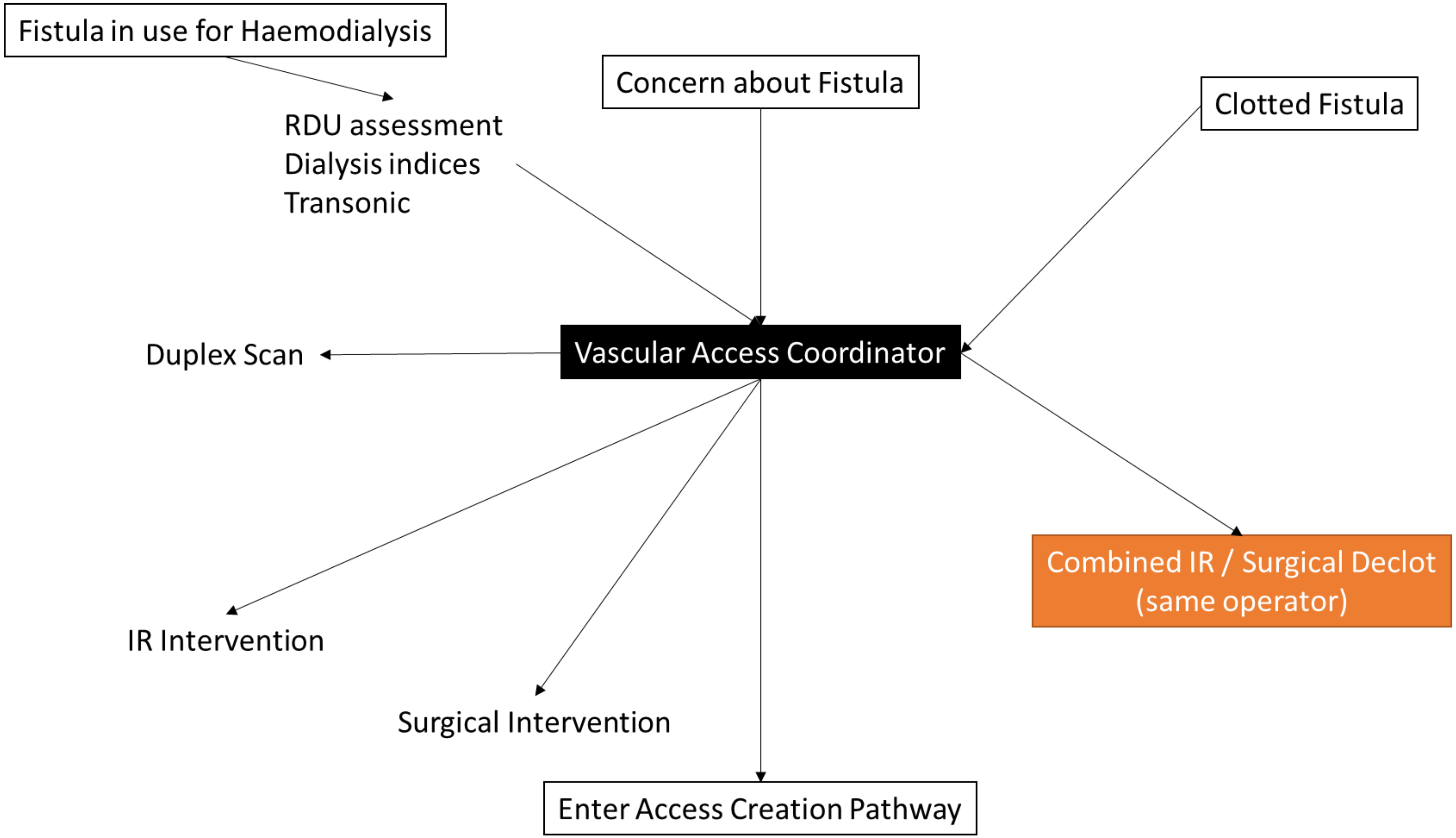
Unit 3


Fistula in use for Haemodialysis
RDU assessment
Dialysis indices
Concern about Fistula
Clotted Fistula
4 monthly scheduled
Duplex Scan
Individual Consultant Nephrologists
Depends upon fistula history
MDT Meeting
Combined IR / Surgical Declot
IR Intervention
Surgical Intervention
Enter Access Creation Pathway

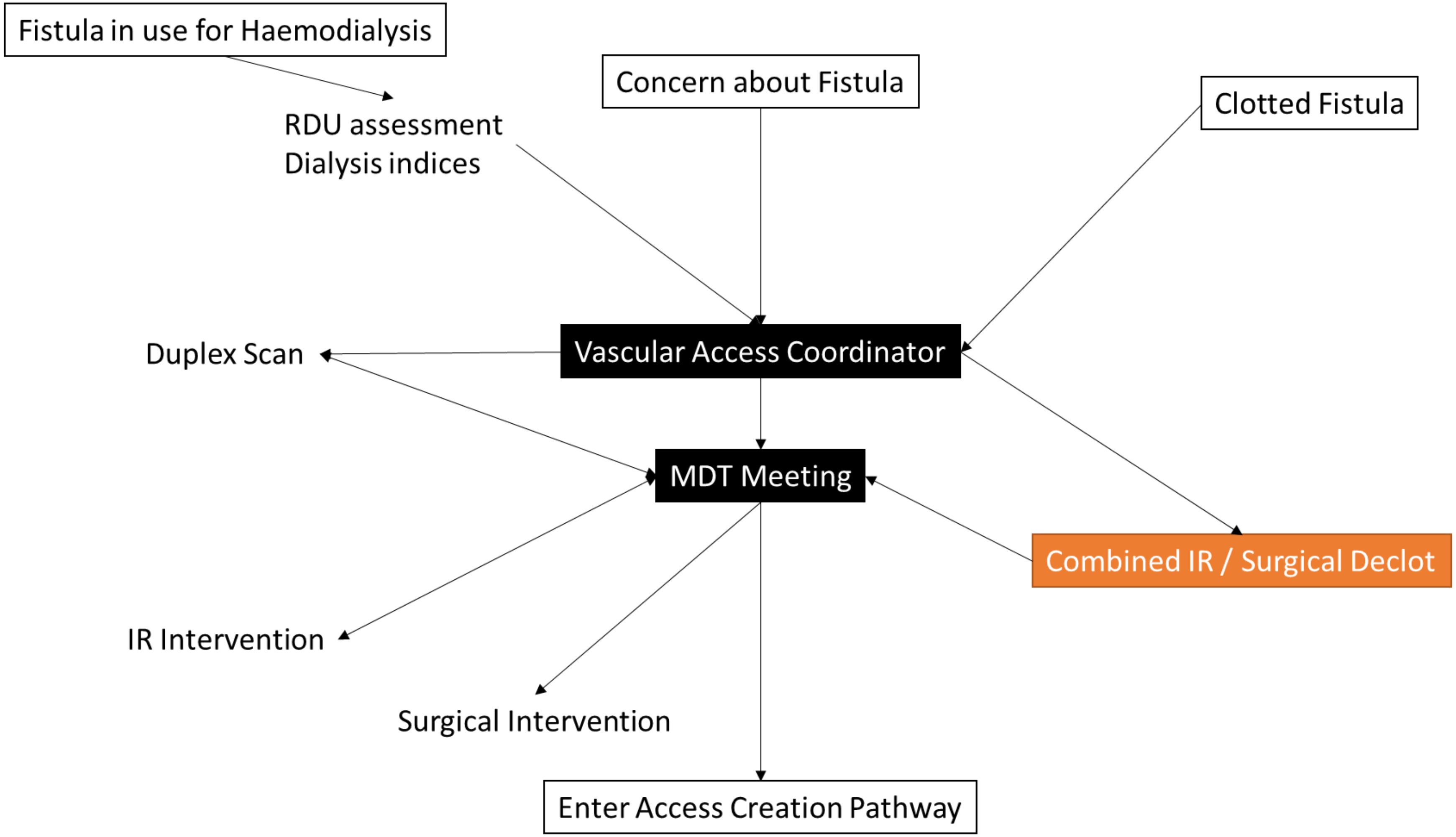
Unit 4


Fistula in use for Haemodialysis
Concern about Fistula
Clotted Fistula
RDU assessment
Dialysis indices
Transonic
6 monthly Duplex Scan
Vascular Access Coordinator
Depends upon fistula history
MDT Meeting
Combined IR / Surgical Declot
IR Intervention
Surgical Intervention
Enter Access Creation Pathway

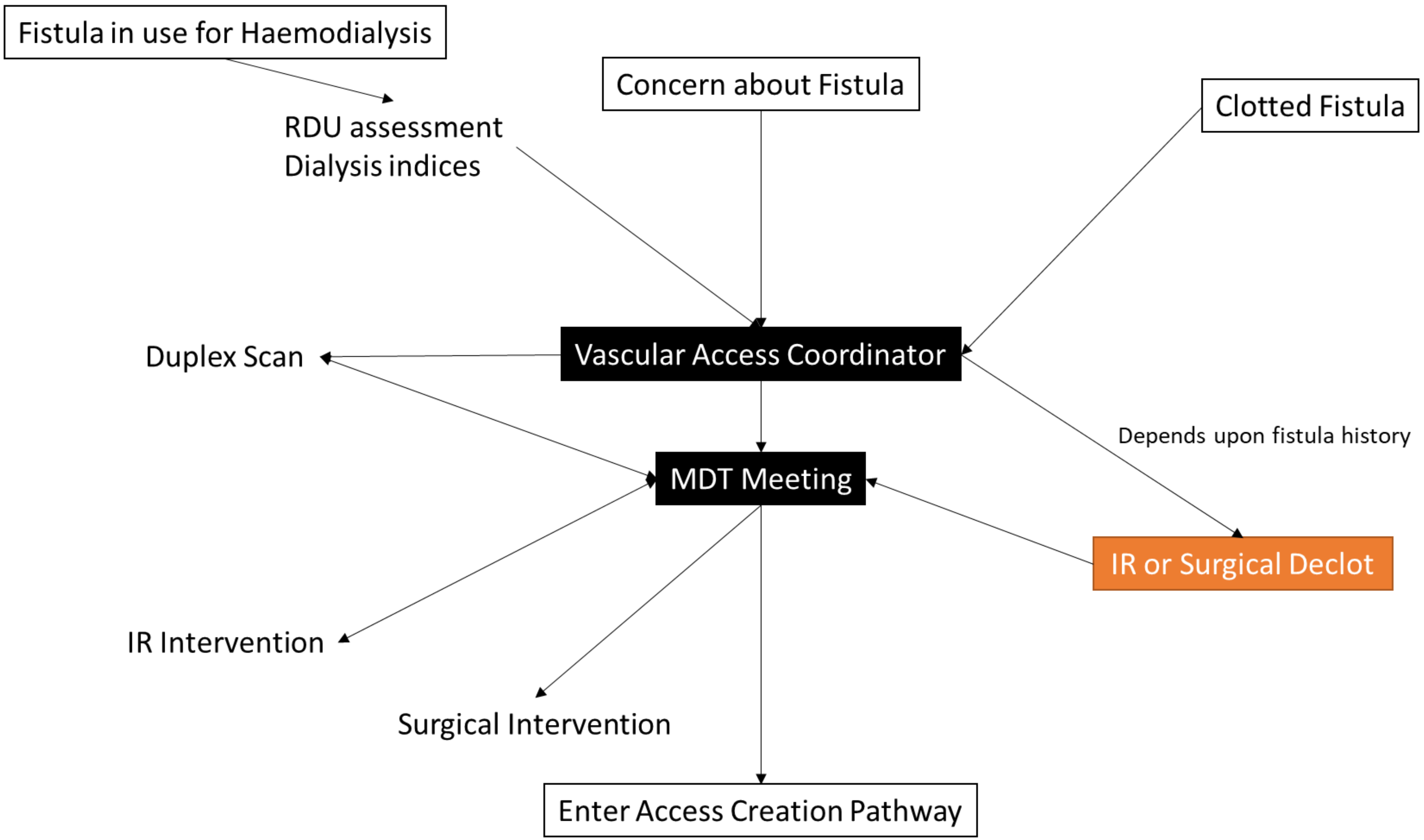
Unit 5


Fistula in use for Haemodialysis
RDU assessment
Dialysis indices
Transonic
Concern about Fistula
Clotted Fistula
Vascular Access Coordinator
Duplex Scan
Combined IR / Surgical Declot (same operator)
IR Intervention
Surgical Intervention
Enter Access Creation Pathway

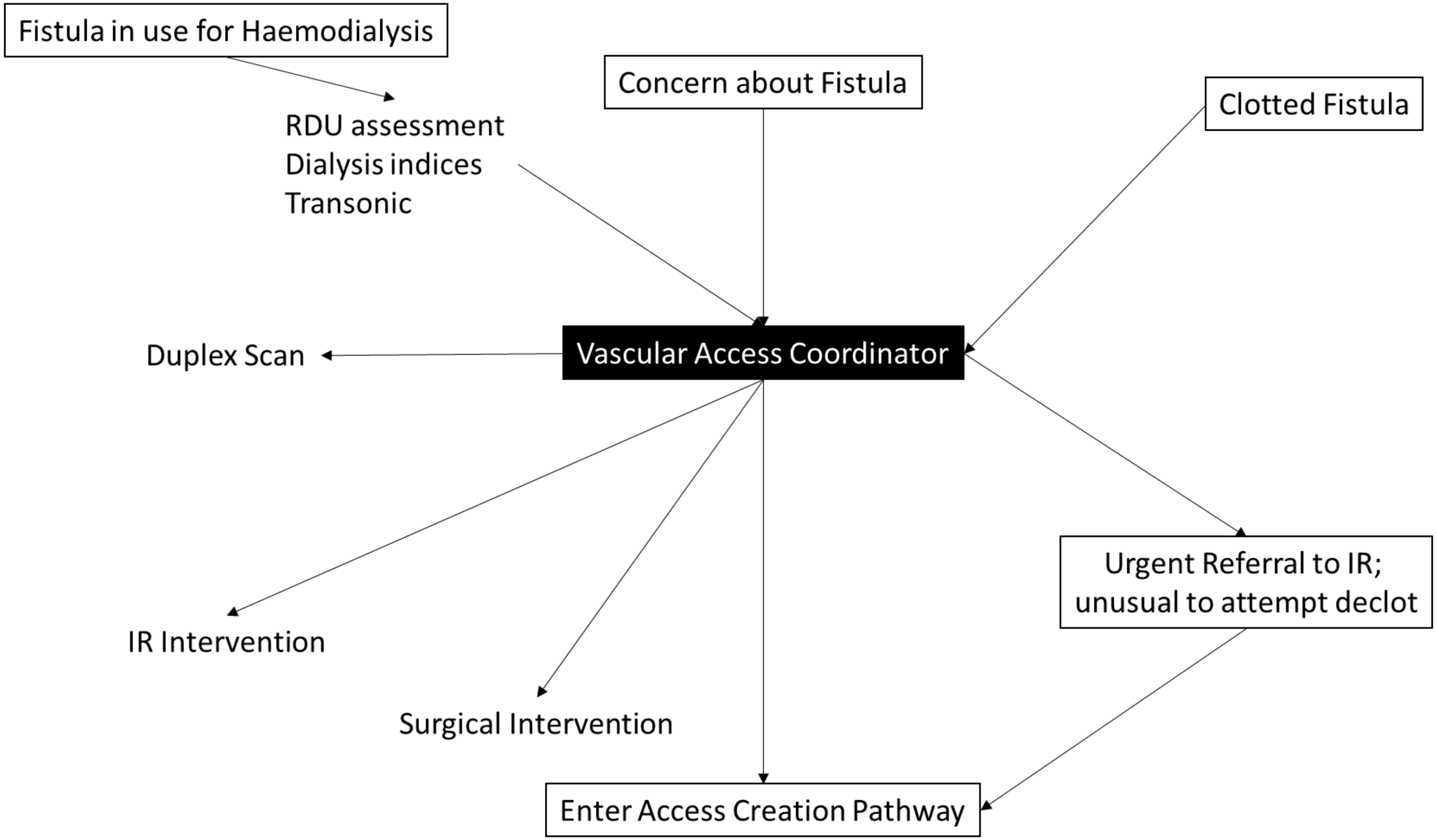
Unit 6


Fistula in use for Haemodialysis
RDU assessment
Dialysis indices
Concern about Fistula
Clotted Fistula
Duplex Scan
Vascular Access Coordinator
MDT Meeting
Combined IR / Surgical Declot
IR Intervention
Surgical Intervention
Enter Access Creation Pathway

Unit 7


Fistula in use for Haemodialysis
Concern about Fistula
Clotted Fistula
RDU assessment
Dialysis indices
Vascular Access Coordinator
Duplex Scan
MDT Meeting
Depends upon fistula history
IR or Surgical Declot
IR Intervention
Surgical Intervention
Enter Access Creation Pathway

Unit 8


Fistula in use for Haemodialysis
Concern about Fistula
Clotted Fistula
RDU assessment
Dialysis indices
Transonic
Duplex Scan
Vascular Access Coordinator
Urgent Referral to IR; unusual to attempt declot
IR Intervention
Surgical Intervention
Enter Access Creation Pathway

Unit 9