RENAL BIOPSY AS AN AID TO DIAGNOSIS IN THE CAT AND DOG

by

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CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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To Him be all the glory.

Andrew S. Nash,
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DECLARATION

I confirm that I have carried out the work presented in this thesis. Interpretation of biopsy and necropsy material has been performed in collaboration with Professor N.G. Wright. Radiological examinations in the experimental studies were supervised by Dr. J.S. Boyd.

Information embodied in this thesis has already been presented in the following publications:

Nash, A.S., Wright, N.G., Spencer, A.J., Thompson, H. and Fisher, E.W. (1979). Membranous nephropathy in the cat: A clinical and pathological study. Vet. Rec., 105, 71-77.

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Wright, N.G. and Nash, A.S. (1983). Glomerulonephritis in the dog and cat. Irish Vet. J., 37, 4-8.

Nash, A.S., Boyd, J.S., Minto, A.W. and Wright, N.G. (1983). Renal biopsy in the normal cat: An examination of the effects of a single needle biopsy. Res. Vet. Sci., 34, 347-356.

Nash, A.S. and Wright, N.G. (1983). Membranous nephropathy in sibling cats. Vet. Rec., 113, 180-182.

SUMMARY

During the last 30 years needle biopsy has become a standard procedure in the diagnosis of human renal disease, particularly diffuse disorders like glomerulonephritis. The technique of percutaneous renal biopsy has been proved safe and reliable in many thousands of patients in the hands of experienced operators. The major post-biopsy complications are severe haemorrhage, subcapsular haematomata and arteriovenous fistulae.

Renal biopsy has been used much less in other species. Indeed, in the chimpanzee, horse, ox, pig, sheep and rabbit, sparse reports have been confined almost entirely to pilot studies and experimental investigations.

In the dog, major experimental studies in the technique and effects of renal biopsy were conducted in the USA between 1967 and 1971, and during the same period 66 dogs with clinical renal disease were also biopsied. In 1982, a 10 year retrospective survey of renal biopsy in 163 dogs indicated that using a small laparotomy ("keyhole") approach to the right kidney the technique is safe and reliable under general anaesthesia. Franklin-Silverman, Metcoff paediatric Franklin-Silverman and "Tru-Cut" needles were all used in this study. The major post-biopsy complications were self-limiting haematuria, severe haemorrhage and renal subcapsular haematomata.

Evaluation of renal biopsy in the cat, has, by comparison with the dog, been very limited. Although the "blind" percutaneous approach is simple to perform in the cat, the only substantial series of biopsied clinical cases hitherto reported contained 34 cats. Moreover, experimental studies into the effects of renal biopsy on the cat kidney, with its unique presence of subcapsular veins, have not been reported.

In this study, 131 biopsy specimens were obtained from 53 dogs and 50 cats referred as clinical cases to the University of Glasgow Veterinary School over a 10 year period. In every case 4½ inch "Tru-Cut" needles were used.

The majority of dogs were deeply sedated with the reversible neuroleptanalgesic drug "Immobilon". On 39 occasions the direct percutaneous approach to the left kidney was used, with favourable

results in terms of the number of biopsy attempts per adequate sample, lengths of samples obtained and glomerular content, when compared with the less frequently used "keyhole" and laparotomy approaches to the right or left kidney. One severely anaemic dog died without recovering from anaesthesia and 9 dogs were euthanased immediately following biopsy. On 47 occasions recovery was normal while in 7 others it was prolonged. The major post-biopsy complication was self-limiting haematuria on 33 occasions. Renal tissue was present in all 64 specimens (84.1 per cent). A disease diagnosis was made on 54 occasions out of 64 (84.4 per cent), with a biopsy diagnosis to necropsy diagnosis positive correlation in 32 out of 36 dogs (91.4 per cent). At necropsy, severe post-biopsy damage to kidneys and related structures was rare. Chronic nephropathy was diagnosed in 20 dogs and glomerulonephropathies in 14, while diseases resulting from infection, toxins and neoplasia were diagnosed infrequently.

On 59 occasions, cats were anaesthetised with ketamine hydrochloride and biopsied using the direct percutaneous approach to the left kidney on 66 occasions. Recovery from anaesthesia was normal on 55 occasions and prolonged only twice. Ten cats were euthanased immediately after the procedure. Self-limiting haematuria was recorded on 47 occasions. Renal tissue was present in all 67 specimens and glomeruli were present in 59 out of 66 recorded specimens (89.4 per cent). A disease diagnosis was made on 57 occasions out of 67 (85.1 per cent), with a biopsy diagnosis to necropsy diagnosis positive correlation in 34 out of 36 cats (94.4 per cent). At necropsy, severe post-biopsy damage, including large areas of infarction and fibrosis were found in the biopsied kidneys of 7 cats (20.5 per cent). Glomerulonephropathies were diagnosed in 29 cats and chronic nephropathy in only 7.

Idiopathic membranous nephropathy was diagnosed in 27 cats, representing the largest number of cats with clinically apparent membranous nephropathy hitherto reported in one series. Affected cats were all domestic and ages at onset ranged from one to 8 years with an average of 3.5 years. Twenty-two cats were male and 5 female. Twenty-five cats developed the nephrotic syndrome and 2 others were presented in renal failure and were never nephrotic. No aetiological agent was implicated. Initial and subsequent biopsy

specimens examined by routine histology, immunofluorescence and transmission electron microscopy were graded according to the severity of the lesions as "mild", "moderately severe" and "advanced". At necropsy 100 glomeruli were examined from the non-biopsied kidney in order to give a controlled assessment of the overall state of the disease and a comparison with the biopsy grading. Nine cats originally placed in the "mild" or "moderately severe" groups were later transferred to the "moderately severe" or "advanced" groups, indicating the progressive nature of the disease. Five of the 6 cats originally placed in the "advanced" group were dead within 6 weeks of the initial biopsy, suggesting a relationship between the severity of the lesions and the clinical course. Most nephrotic cats treated with frusemide made a good initial response, although 13 cats relapsed and required further diuretic therapy during the course of the illness. Corticosteroid preparations given to 5 cats for periods up to 8 weeks did not appear to alter the course of the disease. Surviving cats were followed for periods of up to 4 years. Fifteen cats developed chronic renal failure. Four cats are still alive, of which 2 are siblings. Three remain proteinuric, while the fourth has been in complete clinical remission for more than 2 years.

Two investigations were conducted into the effects of percutaneous renal biopsy on the kidney of normal cats.

In the first, 11 cats were subjected to a single biopsy and thereafter monitored until euthanasia at intervals up to 2 months after biopsy. At necropsy, radiographic studies following infusion of a contrast gel demonstrated vascular changes in the biopsied kidneys. Histological examination of these kidneys revealed lesions varying from barely discernible linear scars to extensive haemorrhage and wedge-shaped infarcts. A direct relationship was established between the severe renal lesions in 7 cats and biopsy specimens containing medullary tissue and major renal blood vessels.

In the second investigation, 3 consecutive biopsy punctures were made in the left kidneys of 3 cats which were then monitored until euthanasia one month later. A further 3 cats were biopsied at monthly intervals on 3 occasions and then monitored until euthanasia one month after the third biopsy. At necropsy, radiographic and histological examinations revealed similar but less severe changes

to those encountered in the first investigation. More cautious biopsy sampling reduced vascular damage at the corticomedullary junction but also reduced the overall quality of specimens for diagnostic purposes.

Two disadvantages of the "Tru-Cut" biopsy needle became apparent in the course of these studies. First, the 20 mm. long specimen notch is too long to be safe in the average sized adult cat kidney. Second, the 6 mm. leading tip may cause unrecognised trauma to blood vessels at the corticomedullary junction. In an attempt to overcome these disadvantages, a third investigation was undertaken.

Standard 4½ inch "Tru-Cut" biopsy needles were modified so as to reduce the length of the obturator tip and the exposed length of the specimen notch by half. Four normal adult cats were each subjected to 4 biopsy punctures of each kidney using the modified needles. Satisfactory samples were obtained in 28 out of 32 biopsy attempts and the needles were shown to be more adequate and probably safer for use in the cat than the standard "Tru-Cut" instrument.

ABBREVIATIONS, TERMINOLOGY AND SOURCES

Abbreviations in the text are introduced in parentheses following first use of the abbreviated words in full.

Abbreviations in the Tables and Appendices are explained in footnotes.

Haematological and plasma biochemical estimations are reported in Système International d'Units (SI units).

Normal values given are those currently issued by the service laboratories of the University of Glasgow Veterinary School.

Haematuria estimations are recorded in abbreviated form as negative (-); trace; small (+); moderate (++) and large (+++), as judged by colour changes on "Lab-Stix" (Ames Company, Division of Miles Laboratories Limited, Slough, England).

In this study, the term uraemia, in dogs and cats, is defined as plasma urea in excess of 20 mmol/l.

Abbreviations of journal titles given in the References are those used in Serial Sources for the Biosis Data Base, Volume 1981, Biosciences Information Service, 2100 Arch Street, Philadelphia, Pa. 19103-1399.

INTRODUCTION

Although needle renal biopsy is a standard procedure in the diagnosis of human renal diseases, its application to domestic animals has been very limited.

In the dog, techniques of needle biopsy and its resultant effects on the normal kidney have been investigated, using Franklin-modified Vim-Silverman needles.

Renal biopsy has been used in the clinical situation in both the dog and cat but there are reports of only 4 series in which biopsy techniques and results in these species have been critically assessed. All of these studies were carried out in the United States of America and 3 of the reports overlap one another to a considerable extent. The majority of dogs were biopsied under general anaesthesia using a small laparotomy ("keyhole") approach to the right kidney. Cats were biopsied under sedation and local anaesthesia using the blind (direct) percutaneous approach to the left kidney. Franklin-Silverman, Metcoff paediatric Franklin-Silverman and disposable "Tru-Cut" needles have all been used. These reports indicated that the techniques were safe and reliable and the results obtained proved that the procedure is worthwhile, particularly in the diagnosis of diffuse renal diseases such as glomerulonephropathies.

This thesis includes a report of the first British study of renal biopsy applied to clinical cases of canine and feline renal disease. As a departure from previous studies, a majority of the dogs were deeply sedated with a reversible neuroleptanalgesic drug and biopsied via the direct percutaneous approach to the left kidney, while cats were anaesthetised with ketamine hydrochloride.

Throughout the present study, "Tru-Cut" needles were used. This is the first critical study of this needle to be reported and allows comparison with an earlier study in which only the Franklin-Silverman needle was used.

Idiopathic membranous nephropathy was diagnosed in more than half of the cats biopsied, comprising the largest single series of cases hitherto reported, warranting a special study of the condition. The progressive nature of the disease was demonstrated by subsequent biopsy and necropsy examinations and a simple classification for the assessment of the severity of the disease was devised. Two novel features of the natural history of feline membranous nephropathy were

encountered: first, 2 sibling cats from the same household became nephrotic; and second, one of these cats subsequently went into full clinical remission and has remained minimally proteinuric for more than 2 years.

During the course of the clinical studies, a number of cats which came to necropsy showed evidence of severe renal damage in the vasculature of the biopsied kidneys. In view of these findings and the absence of any previous studies into the effects of renal biopsy on the cat kidney, 2 investigations were designed to examine these effects in healthy cats, using "Tru-Cut" needles. It was shown that penetration of the corticomedullary junction by the biopsy needle led to moderate or severe haemorrhage and infarction, while avoidance of over-penetration increased the chance of obtaining an inadequate specimen. It became apparent that the "Tru-Cut" needle is too long for safe use in the cat and a prototype modification was designed so as to halve the length of the penetrating tip and specimen storage components of the needle. Favourable results were obtained using modified needles in a limited investigation in normal cats.

CHAPTER ONE

REVIEW OF THE LITERATURE

1. RENAL BIOPSY IN MAN

Historical background:

The earliest attempts at renal biopsy were made during the course of abdominal surgery (Gwyn, 1923; Russell, 1929) but it was not until 1943 that Castleman and Smithwick reported the first systematic study of the technique. In their investigation into the pathogenesis of hypertension, they removed renal tissue from 100 patients undergoing splanchnic sympathectomy operations. Representative samples, measuring 6mm. x 5mm. x 4 mm., were excised from one kidney in 75 patients and from both kidneys in 25 others. Criticism that their samples were too small to be representative (Goldblatt, 1947), was answered decisively in a further report summarising the results obtained from 500 renal biopsies (Castleman and Smithwick, 1948).

The use of needles in obtaining renal biopsy specimens followed successful needle aspiration sampling of other organs and tissues, particularly in relation to tumour diagnosis (Ball, 1934). Iversen and Roholm (1939) described a technique for aspiration needle biopsy of the liver and this method was later adapted for use in renal biopsy (Iversen and Brun, 1951). The latter workers were able to make a definitive diagnosis in all of 5 patients with renal disease. At the time of reporting these cases, they had previously attempted renal biopsy in 66 patients, although only 42 samples contained sufficient tissue for histological examination. They also intimated that they had not encountered any serious complications, which was reassuring, as they were aware of the earlier work of Alwall (not reported until 1952), who ceased performing renal biopsies after one of a series of 13 patients had died. Iversen and Brun (1951) were satisfied that the amount of tissue obtained by needle biopsy was sufficient to be "fairly representative in diffuse renal disorders" and emphasised their conviction that the technique was valuable in both diagnosis and monitoring the progression of renal disease.

Since then, renal biopsy has become a standard procedure in the investigation of renal disease in man and results of large series of renal biopsy cases have been reported (Schreiner and Berman, 1957; Kark, Muehrcke, Pollak, Pirani and Kiefer, 1958; Muth, 1965; Bohle, Eichenscher, Fishbach, Kronenberg and Wehner, 1972; Beregi and Varga, 1978).

Development of techniques:

Needle biopsies were first performed under local anaesthesia with the patient in a sitting position (Iversen and Brun, 1951). This position was soon discarded because of patient discomfort, excessive mobility of the kidneys and consequent inadequate samples obtained (Parrish and Howe, 1953; Brun, 1954). Kark and Muehrcke (1954) evaluated the benefits of the prone position and obtained good specimens of renal tissue in 48 of 50 attempts. The patients were at rest throughout the procedure and the use of a sand-bag placed under the abdomen, giving slight elevation of the buttocks, enabled the right kidney to be fixed against the structures of the back. The right kidney was preferred in order to avoid the risk of puncturing the spleen. The prone position has remained the one of choice for needle biopsy (Colodny and Reckler, 1975; Row, Cameron, Turner, Evans, White, Ogg, Chantler and Brown, 1975).

In most cases, light sedation and local anaesthesia have provided sufficient relaxation and analgesia. However, in children, general anaesthesia with ketamine or halothane has been used in the majority of cases (Colodny and Reckler, 1975).

The use of serrated hypodermic needles to excise kidney tissue, with suction applied by means of a syringe to retrieve the sample, (Iversen and Brun, 1951), was soon discarded. A number of aspiration and non-aspiration types of needle were developed (Table 1.1) and the Franklin modified Vim-Silverman needle (Kark and Muehrcke, 1954) gained the greatest popularity (Kark and Smith, 1974; Beregi and Varga, 1978). This instrument consists of an outer cannula and inner cutting tongs (Figure 1.1a). An end stop in the cutting tongs prevents the biopsy sample from slipping out on withdrawal of the instrument, so rendering aspiration unnecessary (Figure 1.1b).

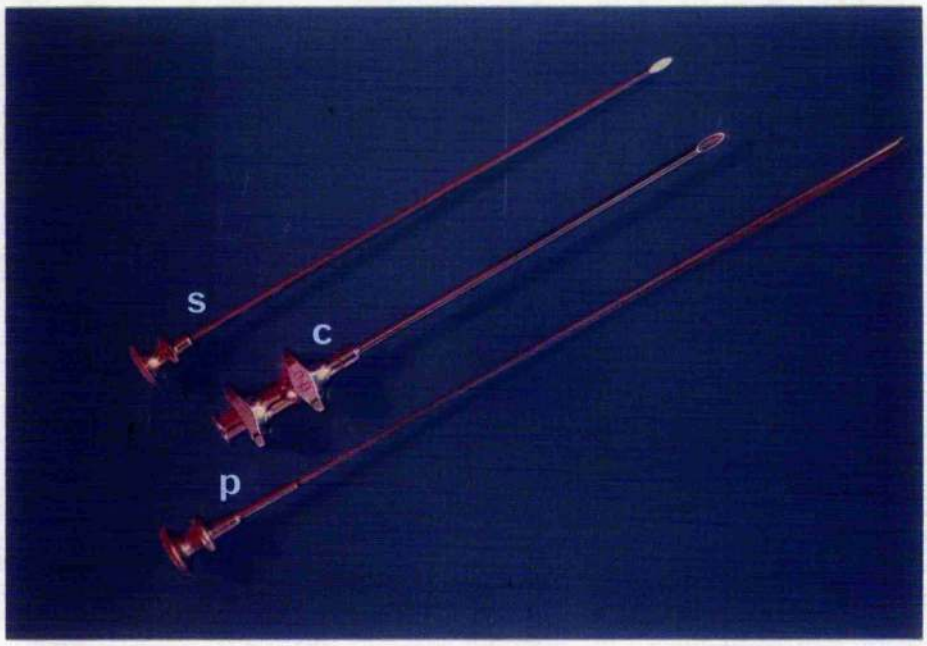


FIGURE 1.1a. Franklin-modified Vim-Silverman needle.
(s) Stylet; (c) Outer cannula;
(p) Inner cutting prongs.

FIGURE 1.1b. Enlarged view of hollow cutting prongs to show solid end-stop.

Later, disposable needles of both aspiration and non-aspiration type were introduced and of these, the non-aspiration "Tru-Cut" needle (Travenol Laboratories, Inc., Deerfield, Illinois 60015, USA) would appear to be the most widely used (Alderman and Becker, 1968; Kark, 1968; Kark and Smith, 1974). (Figure 1.2). Some reports have indicated equally effective use of both "Tru-Cut" and Franklin-Silverman needles (Bolton, Tully, Lewis and Ranniger, 1974; Row et al, 1975) and these would appear to remain the needles of choice. However, occasional reports refer to the continued use of the Menghini aspiration type needle (Pierides, Malasit, Morley, Wilkinson, Uldall and Kerr, 1977).

TABLE 1.1

TYPES OF NEEDLE USED IN HUMAN RENAL BIOPSY

NEEDLE TYPE	FIRST REPORTED	AUTHOR
Iversen-Roholm (A*)	1951	Iversen & Brun
Turkel (A)	1953	Parrish & Howe
Franklin-Silverman (NA+)	1954	Kark & Muehrcke
Franseen (A)	1954	Joske
Gillman (A)	1957	Lofgren & Snellman
Vim-Silverman (NA)	1958	Bohn, Ackles, Drew & Urwiller
Modified Menghini (A)	1960	Kerr
White-Silverman (NA)	1962	White
"Tru-Cut" (NA)	1968	Lavastida, Musil & Hulet
Parker (NA)	1969	Parker

*A - aspiration type; +NA - non-aspiration type

Various aids to localisation of the kidney for percutaneous biopsy have been introduced in order to reduce the risk of biopsy-induced complications and improve the quality of samples obtained. These aids have included: intravenous pyelography (Kark and Muehrcke, 1954); image-amplification fluoroscopy (Lusted, Mortimore and Hooper,

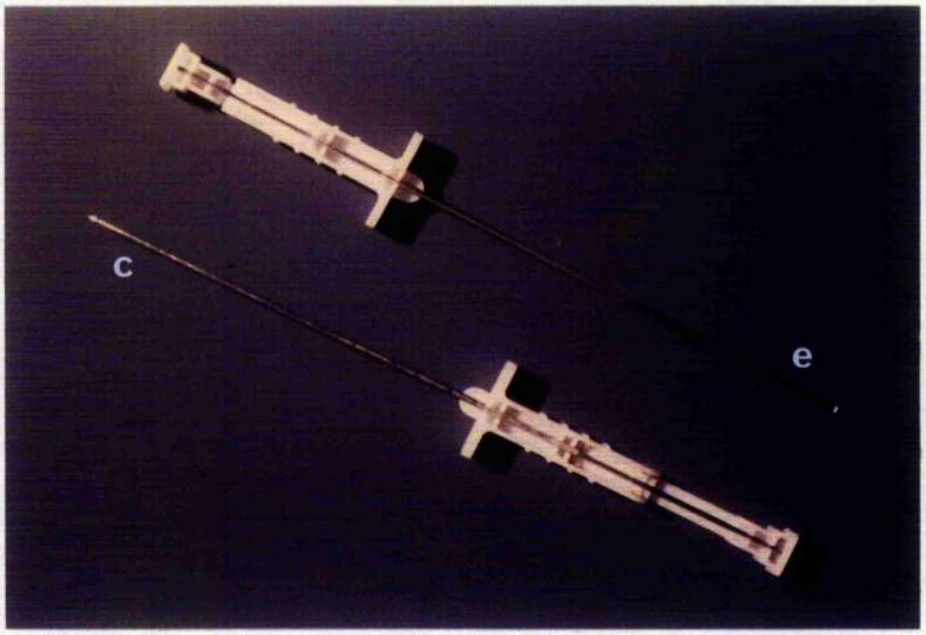


FIGURE 1.2a. "Tru-Cut" disposable biopsy needle.
Specimen notch exposed (e) and closed (c).

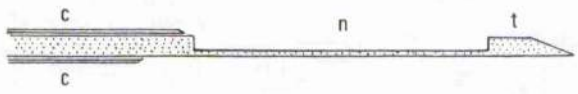


FIGURE 1.2b. Longitudinal section of "Tru-Cut" needle.
Outer cannula (c) retracted to expose 20mm. specimen notch (n), behind the 6mm. obturator tip (t).

1956); radio-nuclide scanning (Allen and Riley, 1963); and ultrasonography (Berlyn, 1961). Nevertheless, simple percutaneous biopsy with the patient in the prone position, without ancillary aids, has continued to be the method of choice of many workers (Kark and Smith, 1974).

2. RENAL BIOPSY IN ANIMALS

Renal biopsy has been described in a number of species but apart from the dog and cat, reports are sparse and most refer to pilot studies or experimental work.

Chimpanzee:

In 1967, Moser, Kurtzman, Van Riper, Kratochvil and Prine, developed a technique for percutaneous puncture of the kidneys in chimpanzees. The position and method was very similar to that in man. Pre-biopsy excretory urograms from 3 animals indicated a remarkable consistency of renal position, and this finding made sampling much easier.

Using an exploratory 20 gauge needle as a guide, the biopsies were taken with a Franklin-Silverman needle. Thirteen successful biopsies were obtained from 15 chimpanzees and no complications were encountered.

Horse:

Osborne, Fahning, Schultz and Perman (1968) successfully performed 2 percutaneous renal biopsies on one horse under epidural anaesthesia with a Franklin-Silverman needle. The operator immobilised the left kidney against the left flank, using his right arm per rectum. No complications ensued.

Bayly, Paradis & Reed (1980) reported the results of renal biopsies from 3 horses suspected of having renal disease. These authors used the technique described by Osborne et al (1968) but used local anaesthesia in conjunction with sedation and manual restraint. Biopsies were performed using "Tru-Cut" disposable needles. One biopsy specimen was made up of haemorrhagic fragments and was unsuitable for examination. The other 2 samples were suitable for

examination but no firm diagnosis was made in either case. In one case, sampling resulted in the development of a perirenal haematoma.

Although the technique in this species appears to be straightforward, it would appear to have limited clinical application.

Ox:

In 1968, Gudat performed biopsies on 21 cattle, obtaining 36 samples, some by blind percutaneous puncture and others by percutaneous punctures visually directed by means of an endoscope.

Osborne et al (1968) also performed percutaneous biopsies on the left kidneys of 8 cows under epidural anaesthesia and took a second sample from each animal either immediately or after varying intervals of up to 19 days.

Ramkuma, Kwatra, Kalra and Tyagi (1972) investigated the feasibility of open renal biopsy of the right kidney in 7 buffalo calves. Six of the animals were biopsied on 3 occasions at 10 day intervals.

The combined results of these workers indicate that there were no inherent difficulties in the techniques, nor were the possible after-effects any different from man or other domestic species.

The lack of reports of the use of renal biopsies in the investigation of clinical cases of bovine renal disease indicates that this field has yet to be developed but may also be a measure of the comparative rarity of clinical renal disease in this species.

Pig:

An experiment conducted by Hatfield, Cameron and Cadenhead (1975), to induce crystalline nephropathy in pigs was aided by serial renal biopsy. The authors gave an excellent account of their method and biopsy sites, together with a formula for gauging the depth of the kidney, according to bodyweight. Apart from post-operative haematuria there were no complications. "Tru-Cut" needles were used in these animals and the authors commented on the fact that they were able to sterilise the needles with ethylene oxide and re-use them on up to 3 occasions.

Sheep:

Welsh and Smith (1972) mentioned the use of renal biopsies taken prior to and during experimental induction of proliferative glomerulonephritis in sheep but gave no details of the methods used.

Mitchell and Williams (1975) in their study of naturally occurring glomerulonephritis in Finnish Landrace sheep, discarded needle biopsy techniques in favour of open surgical sampling, because early attempts to obtain samples via needles resulted in inconsistencies in the quality of samples so obtained. They used general anaesthesia and a right side paracostal approach which not only enabled them to choose the site for sampling, but also overcame difficulties due to variation in position of the kidney; their open technique was without complications.

Rabbit:

Natusch and Ditscherlein (1965), using a Menghini needle, described a percutaneous aspiration renal biopsy technique in rabbits. Fourteen experimental rabbits were anaesthetised with ether and underwent a total of 27 biopsy attempts at intervals of 3 to 32 days. Twenty-two yielded renal tissue and 19 of these samples contained glomeruli, of which 18 were suitable for histological analysis. There were no deaths or complications.

In an investigation into the value of electrocoagulation following renal biopsy (Lazarus, Rosenberg and Weinberg, 1969), 9 rabbits were anaesthetised with intravenous pentothal and maintained on open-drop ether. A single biopsy attempt was made on each kidney using a Vim-Silverman needle. Electrocoagulation was carried out on one kidney of each rabbit by means of a teflon-sleeved coagulating tip which was passed down the outer sheath of the biopsy needle. The opposite kidney was not treated in this way and when the rabbits were killed at intervals ranging from one to 21 days post-biopsy, comparisons were made between the appearance of the biopsy tracts in the coagulated and non-coagulated kidneys. These authors found that healing in the coagulated kidneys was more rapid and complete and with less scarring. Although the technique was successfully applied to 3 human patients there are no major reports to indicate that the additional procedure gained popularity.

A fine needle aspiration technique for harvesting glomeruli was developed by Pasternack, Helin, Törnroth, Rantala, Väisänen and Rahka (1978) and studied in 6 rabbits prior to use in 26 human patients. The technique is of limited application as renal parenchyma was not obtained and those glomeruli harvested were stripped of Bowman's capsule.

Dog:

It is in this species that renal biopsy techniques have been applied to the greatest extent both clinically and experimentally.

The first report of needle renal biopsy in the dog appeared after successful biopsy attempts in 14 normal dogs using a laparotomy approach and a Turkel needle (Stanski and Lugowski, 1953). These authors studied the healing of the renal wounds and showed that this was complete within 14 days and that the biopsy technique did not result in generalised post-biopsy complications.

In an account of attempts to induce glomerulonephritis in dogs by injecting rabbit anti-dog-placenta serum and rabbit anti-dog-kidney serum, Bevans, Seegal and Kaplan (1955) stated that 3 dogs were subjected to renal biopsy 30 days after injection but no details were given as to the method or approach.

In a detailed study of the renal changes associated with canine pyometra, Obel, Nicander and Asheim (1964) performed renal biopsies on 23 out of 27 affected and 5 normal bitches; the open wedge technique was employed.

Knecht and Reynolds (1967) examined in some detail the technique of needle biopsy under general anaesthesia of the kidney, liver and certain superficial lymph nodes of normal dogs. They removed specimens from both kidneys of 8 dogs and from the right kidney of 22 dogs, using a Franklin-Silverman needle and a blind percutaneous approach. Initial failure to obtain any suitable kidney samples was attributed to inexperience in handling the needle and in later attempts 16 samples were successfully obtained. Dogs were killed immediately after biopsy and at necropsy the renal artery of one dog was found to have been ruptured by the biopsy needle with resultant severe peritoneal haemorrhage. A further study designed to determine the character

and extent of tissue damage and the clinical effects resulting from a single renal biopsy in 5 dogs was included in the same report. The left kidney was biopsied, and the blood and urine changes monitored for up to 10 days following biopsy. Only 2 of the 5 biopsy samples were suitable for examination but necropsy examinations carried out on the second, fourth, sixth, eighth and tenth days post-biopsy indicated that the procedure was well tolerated. The only clinical complications were mild, transient haematuria in all 5 dogs and proteinuria in 3. The authors concluded that kidney specimens adequate for the detection of generalised renal disease in the dog could be obtained successfully by needle biopsy but drew attention to the danger of penetrating the major blood vessels in and near the kidney and stated that care, dexterity and experience were required of the operator.

At this time several workers indicated the use of renal biopsy in the course of various experimental investigations in dogs. In most cases the procedure was performed under general anaesthesia and a laparotomy approach employed so that wedges of kidney tissue could be removed. Thus Reutner (1956) referred to biopsies in 800 dogs, while Cale, Parks and Jenkins (1962) biopsied 66 dogs after methoxyflurane anaesthesia. Nayman (1964) referred to at least 2 biopsies after inducing chronic renal failure in dogs using uranium nitrate, but gave no description of the method. Mattenheimer, Pollak and de Bruin (1964) examined wedge biopsies from 5 dogs in the course of a study of renal enzyme distribution and activity, while Wertlake, Hill and Butler (1965) performed needle and wedge biopsies on the left kidneys of 35 dogs under general anaesthesia before and after receiving toxic doses of Amphotericin B. Details of the biopsy technique were not reported in either case. Kersting and Neilsen (1966) used a high flank laparotomy incision to gain access to kidneys of 18 dogs experimentally poisoned with ethylene glycol. In this study samples were taken with a Franklin-Silverman needle and some dogs were biopsied up to 3 times.

A preliminary report by Osborne, Finco, Low and Perman (1967) gave details of renal biopsy of the left kidney in 4 dogs under general anaesthesia via the blind percutaneous approach and in a further 17 dogs biopsy of the right kidney via a small paralumbar incision - the "keyhole" approach. In 6 of these dogs the left kidney was also biopsied at the same time using the same approach on the left side.

General anaesthesia was used in some cases while in others, morphine sedation and local infiltration anaesthesia was used, with encouraging results in both cases. Franklin-Silverman needles were used in all these attempts and the procedure was successful on all occasions. The animals were monitored post-operatively for several weeks and apart from haematuria observed for a few days post-biopsy in most animals, the only problem encountered in one dog was a palpable perirenal haematoma which regressed after a few days. The animals in this series were suspected of having renal disease and diagnoses made after examination of biopsy specimens included: chronic interstitial nephritis, renal amyloidosis, hydronephrosis, renal cell carcinoma and pyelonephritis.

Gudat (1968) reported performing 24 renal biopsies on 16 normal dogs under general anaesthesia using a Franklin-Silverman needle, and a small laparotomy incision. After inducing pneumoperitoneum he directed the needle using a small endoscope which he had inserted through a lower paracostal incision. Twenty adequate samples were obtained. The only complication was transient post-operative haematuria.

Sweet, Davidson and Hayslett (1969) examined the effects of needle biopsy on the renal vasculature in 6 normal dogs. Five samples at various sites were taken from each kidney with a Franklin-Silverman needle. Bilateral selective arteriography was performed in each dog and arteriograms obtained before biopsy, 24 hours and one week post-biopsy and thereafter fortnightly for 8 weeks. Lesions were demonstrated at approximately 50 per cent of the biopsy sites and these consisted of linear infarcts, retention cysts, vascular occlusions and subcapsular haematomata. Intrarenal arteriovenous fistulae, as described in man (Meng and Elkin, 1971; Leiter, Gribetz and Cohen, 1972) were not demonstrated.

The technique of post-biopsy electrocoagulation in rabbits described by Lazarus et al (1969) was also tested in 3 dogs which were similarly anaesthetised and underwent the same procedure. Comparisons made between lesions in the coagulated and non-coagulated kidneys indicated that there was more rapid and complete healing in the former. There are no reports that this technique was pursued further in dogs or applied in the clinical situation.

Perhaps the most important contribution concerning renal biopsy in the dog is embodied in the Ph.D. Thesis of C.A. Osborne (1971a) and in subsequent communications based on that work. Osborne (1971b) summarised the clinical aspects following renal biopsy in 66 dogs, most of which had clinical or laboratory evidence of renal disease. Clinical and haematological examinations were carried out prior to biopsy. Anaesthesia varied from sedation and local infiltration anaesthesia to general anaesthesia, and throughout the study, Franklin-Silverman needles were used. Biopsies were taken either by blind percutaneous puncture or via the "keyhole" approach. Detailed clinical and laboratory examinations were made post-biopsy.

Anaesthesia by the various methods was considered to be satisfactory . The author preferred the "keyhole" approach for reasons of ease and reduced patient risk, even though it took longer to perform. Specific details of the biopsy technique were given and it was noted that the faster the needle was inserted, the better were the samples obtained. Fibrotic kidneys yielded smaller specimens. Post-biopsy observations indicated that uraemic animals were depressed for up to 48 hours whereas most non-uraemic animals remained bright. Apart from severe haematuria in 2 cases there were no complications but 3 animals had slight post-biopsy elevations of rectal temperature for 24 hours. A note of caution was introduced in view of the risk of serious complications and it was suggested that only dogs in which a biopsy might be of real help to diagnosis or therapy should be subjected to the procedure (Osborne 1971b).

Osborne and Low (1971a) reported the results of experiments carried out on healthy dogs from which a total of 125 renal biopsy samples were obtained. They noted that good specimens were obtained with the correct use of the biopsy needle and that failure to observe the correct procedure resulted in a reduced quality of samples. The degree of renal damage induced appeared to depend upon the size and number of renal vessels penetrated. Less damage resulted from biopsies in which only the cortex had been penetrated. Compression of the edges and base of samples was regarded as a normal artifact,

as was some degree of intraluminal desquamation of tubular epithelial cells. The presence of amorphous debris in tubular lumina, distortion of apical portions of tubular epitheial cells and collapsed tubular lumina were also regarded as artifacts occurring as a result of formalin fixation. Thin sections fixed in formalin for 3 to 4 hours were recommended.

Osborne and Low (1971b) reported experiments designed to evaluate the possibility of obtaining serial renal biopsy samples containing iatrogenic lesions caused by previous biopsies. It was found that most serial samples from the same pole of the same kidney included lesions from earlier sampling. It was concluded that repeat cortical samples should be taken at least 25 mm. distant from previous tracts and that cortico-medullary material should be taken from the opposite pole of the kidney or even the other kidney, to avoid previous tracts and resultant vascular damage.

A further report on the renal parenchymal response to experimental needle biopsy (Osborne, Low and Jessen, 1972) indicated that biopsy tracts per se comprised less than one fifth of the renal damage. Vascular damage was responsible for much larger lesions as a result of ischaemia and infarction. The changes so caused were regarded as irreversible. Biopsy tracts which penetrated the renal pelvis remained patent and were lined by transitional epithelium. Some medullary cystic lesions were observed, similar to those reported by Sweet et al (1969).

Reviews of the techniques, contraindications and clinical value of renal biopsy in the dog have been published by Osborne, Low and Finco (1972); Osborne, Stevens and Perman (1974); Osborne (1975) and Osborne, Finco and Low (1975). Reports of individual and small series of cases of renal disease in the dog have included statements that renal biopsies have been performed but few specific details have been given (Table 1.2).

TABLE 1.2

SUMMARY OF ADDITIONAL CASE REPORTS OF DOGS
IN WHICH DIAGNOSTIC RENAL BIOPSY WAS PERFORMED

AUTHOR AND DATE	NUMBER OF DOGS	APPROACH	NEEDLE
Osborne, Johnson, Perman & Schall, 1968	2	Keyhole (1) Percutaneous (1)	Franklin-Silverman
Osborne, Johnson & Perman, 1969	1	Keyhole	Franklin-Silverman
Slauson, Gribble & Russell, 1970	2	NR	NR
Osborne, Johnson, Perman, Fangmann & Riis, 1970	1	Keyhole	Franklin-Silverman
Osborne, Stevens, McClean & Vernier, 1973	1	Keyhole	Franklin-Silverman
de Schepper, Hoorens, Mattheeuws & Van Der Stock, 1974	1	Laparotomy	Franklin-Silverman
Stuart, Phemister & Thomassen, 1975(a)	13	NR	NR
Easley & Breitschwerdt, 1976	1	Keyhole	NR
Osborne, Hammer, Resnick, Stevens, Yano & Vernier, 1976 (a)	1	Keyhole	Franklin-Silverman
Osborne, Hammer, Stevens, O'Leary & Resnick, 1976(b)	2	Keyhole	NR
Finco, Duncan, Crowell & Hulsey, 1977	NR	NR	NR
DiBartola, Spaulding, Chew & Lewis, 1980	13	NR	NR
O'Brien, Osborne, Yano & Barnes, 1982	1	NR	NR

* NR - Not recorded

More recently a 10 year retrospective study of needle biopsy of the kidney in 163 dogs has been reported by Jeraj, Osborne and Stevens (1982). While this study includes some of the 66 dogs previously reported by Osborne (1971b) it provides the only up to date and comprehensive details of the clinical value of renal biopsy and post-biopsy complications in the dog. Sedation and local infiltration anaesthesia was used in the earlier cases but insufficient anaesthesia of the sensory nerve endings in the parietal peritoneum was encountered in some and general anaesthesia became the method of choice. The keyhole approach was used in all cases, the majority on the right side. Up to 3 specimens were obtained per biopsy, and Franklin-Silverman, Metcoff paediatric Franklin-Silverman and "Tru-Cut" disposable needles were all used on different occasions throughout the period of study. Glomeruli were present in all but 2 specimens and there was a 97.5 per cent correlation in diagnosis in 82 biopsied dogs which were followed through to necropsy. Post-biopsy haematuria was the major complication. In 4 dogs there was severe haemorrhage as a result of: puncture of a large adrenal carcinoma (one case); laceration of the kidney by scissors caused by the inadequately anaesthetised dog struggling as the abdominal wall was opened (one case); and in one case each of chronic end-stage renal failure and acute ethylene glycol nephrosis. One dog died and the other 3 were euthanased soon after biopsy in view of the hopeless prognosis. Three dogs out of 82 which were necropsied showed evidence of hydronephrosis associated with the presence of post-biopsy blood clots in the renal pelvis. The authors concluded that needle renal biopsy is a valuable aid to specific diagnosis, choice of specific therapy and prognosis. However, they repeated the earlier cautionary note (Osborne, 1971b) that the procedure is not innocuous and as serious iatrogenic complications can occur, it should only be used when information obtained is likely to be of direct benefit to the patient.

A laparoscopic technique for renal biopsy similar to that of Gudat (1968) has been described recently by Grauer, Twedt and Mero (1983). Thirty seven dogs suspected of having renal disease were biopsied under general anaesthesia and pneumoperitoneum using 6 inch "Tru-Cut" disposable needles directed by a laparoscope. The cranial pole of the right kidney was biopsied in most cases and adequate specimens were obtained on 36 occasions. Post-biopsy haemorrhage occurred in one dog and macroscopic haematuria in 3 dogs. Eleven

dogs were followed through to necropsy and the biopsy diagnosis was confirmed in 10 cases (91 per cent). The authors pointed out the advantages of laparoscopy in visualisation of the kidney, selection of the biopsy site and monitoring post-biopsy haemorrhage. In spite of these, their overall results were no better than those recorded by Jeraj et al (1982) without the use of laparoscopy.

Cat:

By contrast with the dog, cats have taken second place in the field of renal biopsy, both in clinical and experimental studies. Osborne et al (1967) described successful blind percutaneous biopsy of the left kidney in 3 cats with clinical renal disease using Franklin-Silverman needles and drew attention to the relative ease of access to and immobilisation of the more mobile cat kidneys compared with the dog. The method of anaesthesia was not stated.

In a similar fashion, Gudat (1968) performed renal biopsies on 5 normal cats under general anaesthesia using Franklin-Silverman needles, after immobilising the kidneys by external palpation. Results were also satisfactory.

In a more detailed account of his method, Osborne (1971b) reported biopsies in 9 cats, using sedation and local anaesthesia in 7 cats, local anaesthesia only in one cat and general anaesthesia in one other cat which was biopsied via laparotomy. Short ($3\frac{3}{8}$ inch) Franklin-Silverman needles were used in all cases and the blind percutaneous approach in 8 cats. All samples were taken from the left kidney and one subsequent sample was taken from the right kidney. The author reported ease of sampling and obtained adequate samples at each attempt. In all but one case the biopsy and necropsy diagnosis were the same (89 per cent). Six of the biopsy specimens (67 per cent) contained transitional epithelium and the author was not sure whether this was a result of faulty technique or relative oversize of the needle. At necropsy 2 cats were found to have blood in the renal pelvis and in one case the blood clot had caused a moderate hydronephrosis of the right (biopsied) kidney.

Direct percutaneous biopsy under local or general anaesthesia using Franklin-Silverman needles was described by Finco, Kneller and Crowell (1975), while Osborne et al (1974) recommended the use of Metcoff paediatric Franklin-Silverman needles for cats (and also small

dogs and animals with small kidneys), possibly because the shorter length rendered it safer. However, Osborne (1975) pointed out that its high cost (twice that of the standard Franklin-Silverman needle) made its use unattractive. In reporting the use of the "Tru-Cut" disposable needle these authors described the method recommended by the manufacturer for human breast biopsy and not the method given for other soft tissues biopsies. The former method was the recommended instruction for use for a short period of time and then the manufacturer reverted to the original recommendation as it gave better results and placed less strain on the obturator (R.K. Ausman, Travenol Laboratories Inc., (1979), Personal communication).

To date, the most comprehensive study of renal biopsy in the cat has been reported by Jeraj et al (1982). Thirty three cats were biopsied by blind percutaneous punctures and one other by the "keyhole" technique. Sixteen of 22 cases for which records were available were biopsied on the left side and the other 6 on the right side. Specific details of anaesthesia were not given. Franklin-Silverman, Metcoff and "Tru-Cut" needles were used in the course of the study but details as to their frequency of use were not given. However, the authors did state that, excluding length (Franklin-Silverman and Metcoff needles are capable of some adjustment) no needle offered any technical advantage over the others and adequate samples were obtained with each one. Transient haematuria was a common post-biopsy occurrence and in one case hydronephrosis was discovered in the biopsied kidney at necropsy, associated with a blood clot in the renal pelvis. No cats died as a result of the biopsy procedure and a positive correlation between biopsy and necropsy diagnosis was obtained in 17 out of 19 cats necropsied (90 per cent).

Grauer et al (1983) used a laparoscopic technique to visualise the right kidney of one cat under general anaesthesia and successfully obtained a biopsy specimen using a 6 inch "Tru-cut" disposable needle. Other details were not given.

Renal biopsy has been mentioned in a few case reports of cats with renal disease but although diagnostic information was obtained, no attempt was made to evaluate the method or results of the techniques employed (Table 1.3).

Apart from the pilot study by Gudat (1968) using 5 normal cats, there are no reports of experimental investigations into the nature and effects of renal biopsy on the feline kidney.

TABLE 1.3

SUMMARY OF ADDITIONAL CASE REPORTS OF CATS

IN WHICH DIAGNOSTIC RENAL BIOPSY WAS PERFORMED

AUTHOR AND DATE	NUMBER OF CATS	APPROACH	NEEDLE
Slauson, Russell & Schecter, 1971	1	Laparotomy	NR*
Scott, Hurvitz, Ehrenreich & Derr 1975	1	NR	NR
Northington & Juliana, 1977	1	Percutaneous	NR
Drazner & Derr, 1978	1	Keyhole	Franklin-Silverman
Thornburg, Kinden & Digilio, 1979	1	NR	NR
Evans, 1981	1	Laparotomy	(Wedge)
Lucke, 1982	16	NR	NR

NR* - not recorded

From the foregoing it is clear that needle renal biopsy has become established as an important aid to the diagnosis of renal disease in man and to a lesser extent in the dog. However, while the procedure is easier to perform in the cat, far fewer reports exist of its diagnostic value in this species. Moreover, there has been only one report of a large series of renal biopsy cases in dogs and cats (Jeraj et al, 1982) since that of Osborne (1971b) and renal biopsy in these species has not hitherto been studied in Britain.

The majority of reports of renal biopsy studies in the dog and cat have involved the use of the Franklin-Silverman needle or Metcoff paediatric modification. There are no reports of any critical study of the "Tru-Cut" disposable needle.

The effects of renal biopsy in the normal dog have been thoroughly explored (Osborne and Low, 1971a; Osborne and Low, 1971b; Osborne et al, 1972; Sweet et al, 1969), but in the cat have never been investigated. In view of the relatively small size of the feline kidney and its unique structure, with the presence of subcapsular veins, it cannot be concluded that the effects of renal biopsy in the cat will follow the same pattern as in the dog. Furthermore, reservations still exist with regard to the technique in the dog. In Chapter 2 a detailed account of renal biopsy methods and results in 53 dogs and 50 cats will be presented.

CHAPTER TWO

RENAL BIOPSY AS AN AID TO DIAGNOSIS IN CANINE AND FELINE RENAL DISEASE

INTRODUCTION AND REVIEW OF THE LITERATURE

Renal biopsy techniques in the dog and cat have been developed (Osborne et al, 1967) and their effects in normal dogs thoroughly investigated (Sweet et al, 1969; Osborne and Low, 1971a; 1971b; Osborne et al, 1972). However, there are only 4 reports of large series of dogs and cats with clinical renal disease in which renal biopsy methods have been evaluated and of these, the first 3 overlap each other (Osborne et al, 1967; Osborne 1971b; Jeraj et al, 1982; and Grauer et al, 1983). There is, therefore, a need for further cases to be studied and documented, especially in cats. Moreover, to date there is no report of a study of renal biopsy methods or a documented series of biopsied clinical cases of renal disease in dogs and cats in Britain.

The author has had the opportunity to make such a study of clinical cases admitted to the University of Glasgow Veterinary School over a 10 year period. In order to be fully aware of the methods and results of earier workers, a thorough review of existing reports of clinical renal biopsy surveys in the dog and cat has been undertaken. The following information has been obtained.

1. Pre-biopsy considerations.

(a) Indications.

Renal biopsy has evolved as an important adjunct to the clinical evaluation of patients with generalised primary renal disease, particularly as it may enable a specific diagnosis to be made in life, so giving the clinician greater certainty in assessing the severity and potential reversibility of the condition in that patient and the choice of suitable treatment. Therefore renal biopsy is indicated if:

(i) a diagnosis can be established;
(ii) the severity and prognosis of the condition can be assessed;
(iii) the choice of treatment can be enhanced; and
(iv) the patient can tolerate the procedure without undue risk of serious complications (Osborne, 1975).

(b) Contra-indications.

Renal biopsy should not be considered if there is a risk of:

(i) Excessive haemorrhage.

Gross haematuria and perirenal haematoma are among the most common potential post-biopsy complications in man (Slotkin and Madsen, 1962; Colodny and Reckler, 1975) and dog and cat (Osborne, 1971b; Jeraj et al, 1982). This may be of renal origin but can also result from the biopsy needle penetrating other organs, e.g. the renal artery (Knecht and Reynolds, 1967) or adrenal adenocarcinoma (Jeraj et al, 1982).

(ii) Unco-operative patient.

This factor has been stated in reports of human patients undergoing renal biopsy, in which sedation and local anaesthesia have been used for convenience and also because some patient co-operation is useful at the moment of taking the biopsy (Kark et al, 1958; Dodge, Daeschner, Brennan, Rosenberg, Travis and Hopps, 1962). General anaesthesia is used routinely in children and any adult expected to be unco-operative (Colodny and Reckler 1975). Jeraj et al (1982) reported the necessity of changing from sedation and local anaesthesia to general anaesthesia after a number of dogs had struggled during abdominal incision.

(iii) Inexperience of the operator.

Evaluation in both the human and animal fields has shown that the prevalence of post-biopsy complications decreases as clinicians gain experience in using the technique (Dodge et al, 1962; Jeraj et al, 1982).

(iv) Other factors.

Features listed as contra-indications to renal biopsy in man, including pre-existing infection, renal abscesses, hydronephrosis, renal cysts, neoplasia and uraemia (Colodny and Reckler, 1975), have been discussed by Osborne et al (1974) with reference to the dog. Their experience showed that there was no evidence of exacerbation of pre-existing infection. Moreover, renal abscesses, cysts and hydro-nephrosis could be satisfactorily investigated by fine needle aspiration techniques. In their view, early diagnosis of a renal neoplasm was preferable to the unlikely risk of biopsy induced metastasis. More important still was their assertion that uraemia did not consitute an undue anaesthetic risk.

2. Anaesthesia.

(a) Dog.

(i) Local anaesthesia.

Osborne (1971b) used sedation with morphine sulphate and atropine followed by local infiltration with lignocaine hydrochloride prior to biopsy in 70 dogs with suspected renal disease. Uraemic dogs received a post-biopsy dose of the morphine antagonist, levallorphan tartrate. Inadequately anaesthetised peritoneum occurred in a sufficient number of cases biopsied under this regimen to warrant a change to general anaesthesia (Osborne et al, 1974; Jeraj et al, 1982).

(ii) Neuroleptanalgesia.

Thirty seven dogs with suspected renal disease were heavily sedated with intravenous oxymorphone hydrochloride, acetylpromazine and atropine (Grauer et al, 1983). Relaxation was satisfactory and post-biopsy recovery was without complications.

(iii) General anaesthesia.

Osborne (1971b) reported using sodium thiamylal in 8 dogs and 2 cats and methoxyflurane in 3 other dogs. However, the same author later recommended inhalation general anaesthesia in preference to intravenous anaesthetics because variables associated with drug metabolism and renal excretion are eliminated (Osborne, 1975).

(b) Cat.

(i) Local anaesthesia.

Osborne (1971b) sedated 7 cats with pethidine and promazine hydrochloride prior to local infiltration with lignocaine hydrochloride. A further, severely depressed cat was given lignocaine alone.

(ii) General anaesthesia.

Sodium thiamylal was used in one cat (Osborne, 1971b) while an un-named inhalation anaesthetic was used in the one cat reported by Grauer et al (1983). Details of anaesthesia in the 34 cats biospied by Jeraj et al (1982) were not given. General anaesthesia in cats in renal failure using ketamine hydrochloride was discouraged, since, it was stated, the drug is excreted in active form in the urine (Osborne et al 1974).

3. Biopsy needles.

Franklin-Silverman needles (3 $\frac{3}{8}$ inch) were used in dogs and cats by Osborne et al (1967) and Osborne (1971b). The shorter Metcoff paediatric modification of the Franklin-Silverman needle was recommended by Osborne (1975) in spite of its high cost, for use in small dogs, cats and animals with abnormally small kidneys.

Since the indroduction of the "Tru-Cut" disposable biopsy needle (Lavastida, et al, 1968), they have been used in dogs and cats (Jeraj et al, 1982; Grauer et al, 1983). While there has been no reported critical or comparative evaluation of this needle, Jeraj et al (1982) stated that equally satisfactory renal specimens were consistently obtained with Franklin-Silverman, Metcoff and "Tru-Cut" needles and Grauer et al (1983) reported that compression of samples which had been encountered with the Franklin-Silverman needle (Osborne and Low, 1971a) had not occurred with the "Tru-Cut" needle.

4. Methods of approach

(a) Blind percutaneous.

Osborne (1971b) reported the successful biopsy of the left kidney in 7 dogs and 8 cats and the right kidney in one cat after immobilising the kidney by digital pressure. He pointed out that this was an easier procedure in the cat since both kidneys could be easily palpated and immobilised whereas in dogs only the left kidney is usually palpable and capable of immobilisation. The same percutaneous route was used in 33 cats, and of 22 recorded sides, 16 were from the left and 6 from the right kidney (Jeraj et al, 1982).

(b) "Keyhole" technique.

This route was first described by Osborne et al (1967) following successful biopsy of 17 dogs and was performed on the right kidney in 11 dogs and on both kidneys of 6 other dogs. Later, Osborne (1971b) reported taking 79 biopsy samples from 61 dogs using the "keyhole" technique, 63 from the right and 16 from the left kidney. The technique was described as follows:

An incision just large enough to accommodate the index finger was made in the paralumbar fossa over the caudal pole of the kidney ventral to the sublumbar muscles. The long axis of the incision was approximately equidistant between the caudal border of the last rib and the ventral border of the lumbar muscles. The underlying

subcutaneous tissue, muscles and peritoneum were then bluntly dissected with scissors. Following incision through the abdominal wall, the index finger was inserted into the peritoneal cavity. A separate, smaller incision was made in the body wall through which the biopsy needle was passed. The index finger was used to guide the needle to the caudal pole of the kidney. When a satisfactory specimen had been obtained and there was no evidence of continuing haemorrhage, the body wall incisions were closed.

The "keyhole" approach seemed to have the advantage over the blind percutaneous route of permitting the operator to make a direct digital examination of the kidney to be biopsied. Under certain circumstances this might help in the selection of a specific biopsy site.

The right side was preferred because its position is more constant due to the fact that the right kidney is more firmly attached to the body wall than the left and its cranial pole is closely apposed to the liver. For these reasons, Osborne used the left side only if there was a particular need to biopsy the left kidney.

(c) Laparoscopy.

Grauer et al (1983) described the following technique after using it successfully in 37 dogs and one cat. Pneumoperitoneum was established with a Verres needle and injection of compressed carbon dioxide. A 180 degree 8mm. laparoscope with a 150-W halogen light source was then introduced via its cannula through a one cm. skin incision approximately 5 cm. caudal to the 13th rib and 3-5 cm. ventral to the border of the sublumbar muscles. When the kidney was visualised, a 6 inch "Tru-Cut" biopsy needle was introduced into the abdomen through a separate incision and the cranial pole of the kidney biopsied. The needle was directed away from the hilus of the kidney at an oblique angle to the kidney capsule. Post-biopsy haemorrhage was monitored and if prolonged beyond 3 minutes, pressure was applied to the site with the tip of the laparoscope. After satisfactory results, the laparoscope was removed and the abdominal incision closed.

(d) Laparotomy.

This approach was used in 2 dogs and 1 cat (Osborne, 1971b) but no details were given about the operative technique. Osborne (1975) stated that this approach could be usefully employed for renal biopsy in cases of canine pyometra where there was evidence of associated primary renal failure, at the time of ovarohysterectomy.

5. Sampling techniques.

(a) Franklin-Silverman needle.

The technique of operation in the dog and cat has been described in great detail by Osborne (1971b). According to this author, the needle should be positioned so that the cutting prongs only pass through the renal capsule once. The tip of the needle should then be brought into contact with the renal capsule with the stylet in position and the cutting prongs advanced rapidly through the renal capsule into the renal parenchyma. The hub of the cutting prongs is held firmly by an assistant in order to keep them in the same position. The outer cannula is then advanced over the blades to a point just beyond a landmark scratched on the shaft of the cutting prongs. The cutting prongs are then withdrawn into the cannula for a short distance and the unit removed.

(b) "Tru-Cut" disposable needle.

The technique of operation in the dog and cat was briefly described by Osborne (1975) and Grauer et al (1983). Both authors described the method whereby the needle assembly was advanced to the renal capsule in the closed position and then the obturator thrust into the renal parenchyma while the cannula was kept stationary. The obturator was kept firmly in position, the cannula quickly advanced over it to cut the specimen and close the specimen notch, and the instrument subsequently withdrawn (Figure 2.1).

6. Post-biopsy management.

Osborne et al (1974) recommended observation of patients for evidence of excessive haemorrhage and warned against manipulation of the biopsied kidney for an unspecified time after biopsy, in order to avoid disturbance of the clot at the biopsy site. The presence of blood clots in the renal pelvis leading to urinary stasis had occurred in several dogs and cats and this had been overcome in later cases by the administration at the time of biopsy of sufficient Ringer's lactate

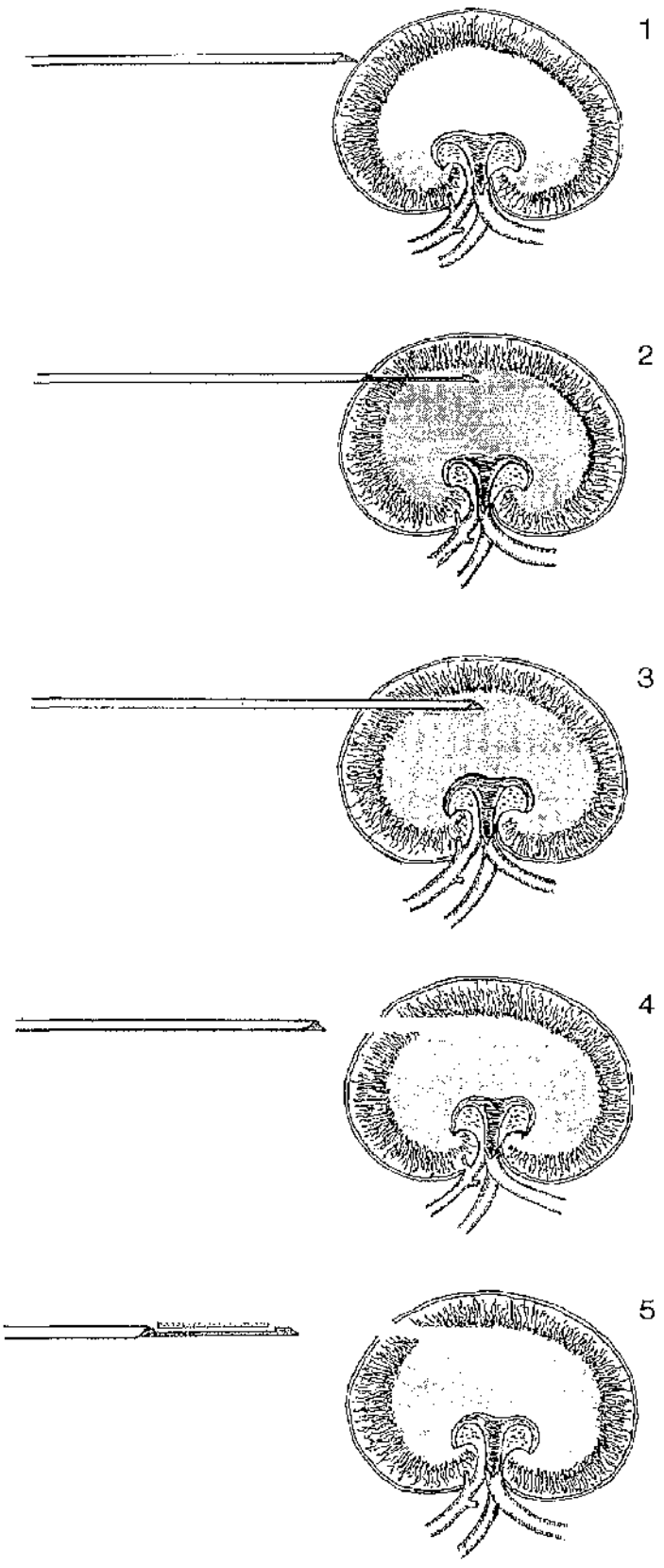


FIGURE 2.1. Method of operation of the "Tru-Cut" disposable biopsy needle as described by Osborne (1975) and Grauer et al (1983).

solution to induce a mild diuresis. Antibiotic therapy was only given if an animal was debilitated or showed evidence of renal or other infection. The use of potentially nephrotoxic antibiotics in animals in renal failure was avoided.

7. Post-biopsy complications.

Self-limiting haematuria occurred in most cases for up to 3 days following biopsy in nearly all patients (Osborne, 1971b; Jeraj et al, 1982; Grauer et al, 1983). Severe macroscopic haematuria occurred in only one dog in 98 biopsy attempts (Osborne, 1971b). Severe renal haemorrhage occurred in one dog out of 37 (Grauer et al, 1983) and in 4 dogs out of 163 (Jeraj et al, 1982). One of these dogs died as a consequence of post-biopsy haemorrhage. This was after Osborne (1975) reported that no deaths had occurred as a direct result of needle renal biopsy in more than 400 dogs and cats at the University of Minnesota.

8. Processing of biopsy specimens.

Osborne (1971b) recommended that prior to fixing, biopsy specimens should be examined for their colour and consistency. The latter were then fixed in 10 per cent formalin solution prior to processing for routine histological examination. On 2 occasions samples were prepared for cytological examination as imprints on glass slides, which were then stained with new methylene blue.

Jeraj et al (1982) reported that one specimen from each patient was fixed in 10 per cent buffered formalin solution prior to processing for routine histological examination. If amyloidosis was suspected, Congo red stained sections were examined by polarising light microscopy. If membranous glomerulonephropathy was suspected the sections were stained with silver methenamine. Another specimen was "snap frozen" in isopentane immersed in liquid nitrogen prior to preparation for immunofluorescence studies. A further specimen was fixed in buffered glutaraldeyhyde solution prior to electron microscopic examination.

9. Biopsy results.

In the first clinical renal biopsy studies in the dog and cat, (Osborne et al, 1967), material adequate for histopathologic examination was obtained from all of 21 dogs and 3 cats but no further details were given.

In a later report (Osborne, 1971b), no details of the size or glomerular content of the biopsy specimens were given. However, it was stated that there was a 91 per cent correlation between the biopsy and necropsy diagnosis in 64 out of 70 biopsied dogs and cats.

More details of biopsy specimens were given in the report by Jeraj et al (1982). In 194 biopsy specimens from 197 dogs and cats there were from one to 10 glomeruli in 101 specimens and more than 11 glomeruli in 93 specimens. In only 3 specimens (1.5 per cent) were glomeruli absent. There was a 96 per cent correlation between biopsy and necropsy diagnosis in 82 dogs and 19 cats.

Grauer et al (1983) took laparoscopically directed specimens from 37 dogs and one cat and found that in 37 cases (97 per cent) the samples were adequate for morphologic diagnosis. They reported that most of the biopsy cores contained cortical tissue at each end and corticomedullary tissue in the centre, which was in accordance with the oblique angle at which the needle was directed. One specimen contained pelvic transitional epithelium, which previously had been reported in samples from cats by Osborne (1971b). There was a correlation between biopsy and necropsy diagnosis in 10 out of 11 dogs (91 per cent) but no details as to actual diagnoses were given.

10. Follow-up studies.

Osborne et al (1967) reported that, following biopsy, 14 dogs and one cat were observed for several weeks and apart from transient microscopic haematuria in all cases and a spontaneously resolved perirenal haematoma in one dog, there were no untoward effects. These authors also reported that 2 dogs had serial biopsies 3 weeks apart and apparently suffered no ill-effects. Osborne (1971b) stated that he had re-biopsied 15 dogs and one cat at different time intervals. Ten dogs and the cat were biopsied twice, 4 dogs on 3 occasions and one other dog on 5 occasions. In the same study, 42 dogs (64 per cent) and 5 cats (56 per cent) were followed through to necropsy.

Jeraj et al (1982) did not give details of long-term follow-up studies on repeated biopsies but stated that 82 dogs (50 per cent) and 19 cats (56 per cent) were followed through to necropsy.

Likewise, Grauer et al (1983) reported that 11 dogs (38 per cent) were necropsied but gave no information about any follow-up studies.

MATERIALS AND METHODS

1. Clinical cases.

The 53 dogs and 50 cats in the following series were referred by veterinary surgeons and admitted to the Department of Veterinary Medicine of the University of Glasgow Veterinary School between February 1974 and December 1983. Wherever possible, a detailed case history was obtained from the owner and a thorough clinical examination of the animal carried out at the time of admission. Subsequently clinical and laboratory examinations were performed at intervals during the period of hospitalisation and observations and results were recorded. Haematological, plasma and urine biochemical, bacteriological, virological, immunological and radiological investigations were performed by the appropriate service departments of the Veterinary School using accepted procedures employed at the time. Indications for renal biopsy were based on the tentative clinical diagnosis, supported by laboratory evidence of probable primary renal disease and observations of the patient for evidence of polydipsia and polyuria.

2. Anaesthesia.

(a) Dogs.

On 31 occasions dogs were heavily sedated following intravenous injection of combined etorphine hydrochloride and methotrimeprazine ("Small Animal Immobilon", C-Vet Ltd., Bury St. Edmunds, England) at a dose rate of one ml. per 20 kg. bodyweight. In 2 of these a further intravenous injection of 5 per cent sodium thiopentone was given to effect, and one was later intubated and maintained on a halothane and oxygen mixture. On 12 occasions dogs were sedated with intramuscular acetylpromazine (0.5 mg per 5 kg bodyweight) and anaesthetised with intravenous 5 per cent sodium thiopentone given to effect. On 15 other occasions anaesthesia was similarly induced and then maintained with halothane and oxygen. On 4 occasions, 5 per cent sodium thiopentone alone was used and on 2 other occasions, acetylpromazine sedation preceded local infiltration with lignocaine hydrochloride.

Following the biopsy procedure dogs which had received "Immobilon" were given an intravenous injection of the morphine antagonist diprenorphine hydrochloride ("Revivon", C-Vet Ltd., Bury St. Edmunds, England), with the exception of 4 animals which were euthanased.

(b) Cats.

On 59 occasions cats were given an intramuscular injection of ketamine hydrochloride ("Vetalar", Parke Davis Ltd., Pontypool, U.K.) at a dose rate of 30 mg. per kg. bodyweight. Four cats were given intravenous injections of 2.5 per cent sodium thiopentone to effect and 2 of these were then intubated and anaesthesia maintained with halothane and oxygen. Four other cats were given 2 per cent lignocaine hydrochloride by local infiltration.

3. Biopsy needles.

Throughout this study 4½ inch "Tru-Cut" disposable biopsy needes were used. In the majority of cases a new needle was used but occasionally needles were re-used after sterilisation with ethylene oxide. Before use, all needles were examined to ensure freedom of movement and complete closure; faulty ones were discarded. When multiple biopsy attempts were necessary the needle was placed in an alcoholic solution of povidone-iodine ("Pevidine" Surgical Scrub, Berk Pharmaceuticals Ltd., Eastbourne, England) prior to re-use.

4. Preparation of biopsy site.

Hair or fur was machine clipped in an area approximately 4 cm. square on the left or right paralumbar fossa and then prepared for surgery with a scrub consisting of an alcoholic solution of "Pevidine". Sterile drapes were placed around the site in cases where the "keyhole" approach was used.

Animals biopsied while undergoing laparotomy were prepared for ventral midline abdominal incision with sterile drapes placed over the site.

5. Approach.

(a) Dogs.

The direct percutaneous route was used on 37 occasions on the left kidney and twice on the right kidney. The "keyhole" technique was used on 18 occasions, 13 on the left kidney when it could not be palpated externally, rendering the percutaneous route inadvisable,

and 5 on the right kidney. Seven dogs were biopsied while undergoing exploratory laparotomy, 6 from the left and one from the right kidney.

(b) Cats.

The direct percutaneous route was used on all occasions; on 66 the left kidney was used and on one the right kidney.

6. Sampling technique.

When a kidney could be palpated, it was held against the lateral body wall and a small stab incision made through the skin and muscles over the caudal pole. The biopsy needle was inserted vertically through this incision towards the caudal pole in larger dogs, while in smaller dogs and cats, it was inserted at a shallow angle to the body wall at the caudal pole and directed cranially (Figure 2.2).

When the "keyhole" method of approach was used, a small incision in the paralumbar fossa on the appropriate side was made through the skin and abdominal wall muscles using first a scalpel and then blunt dissection with scissors. The right index finger was inserted through this incision and placed medial to the caudal pole of the kidney, so as to fix it against the body wall. A small stab incision was made a little anterior to the first incision and through this the biopsy needle was directed downwards towards the kidney, guided if required by the index finger in the abdomen. The needle was placed in a vertical position against the caudal pole of the kidney (Figure 2.3).

In dogs biopsied while undergoing laparotomy the kidney was exposed by the surgeon and the site for biopsy selected. The biopsy needle was directed towards the kidney through the laparotomy incision.

The biopsy needle was operated according to the manufacturer's recommendations in the following way:- With the specimen notch covered (needle in the "closed" position) the entire needle was thrust into the kidney by the operator to a depth of 20 to 25 mm. The obturator was held steady by an assistant and the cannula retracted by the operator to expose the specimen notch. With the obturator still held steady, the cannula was quickly advanced over the obturator and the needle removed in the closed position (Figure 2.4).

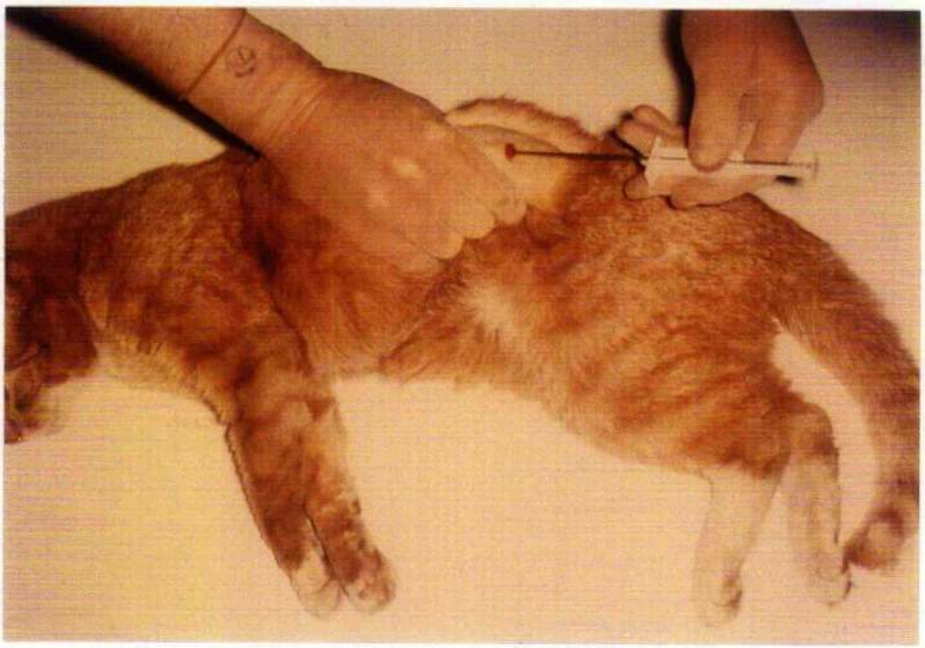


FIGURE 2.2. Cat anaesthetised with ketamine hydrochloride undergoing direct percutaneous renal biopsy of the left kidney.

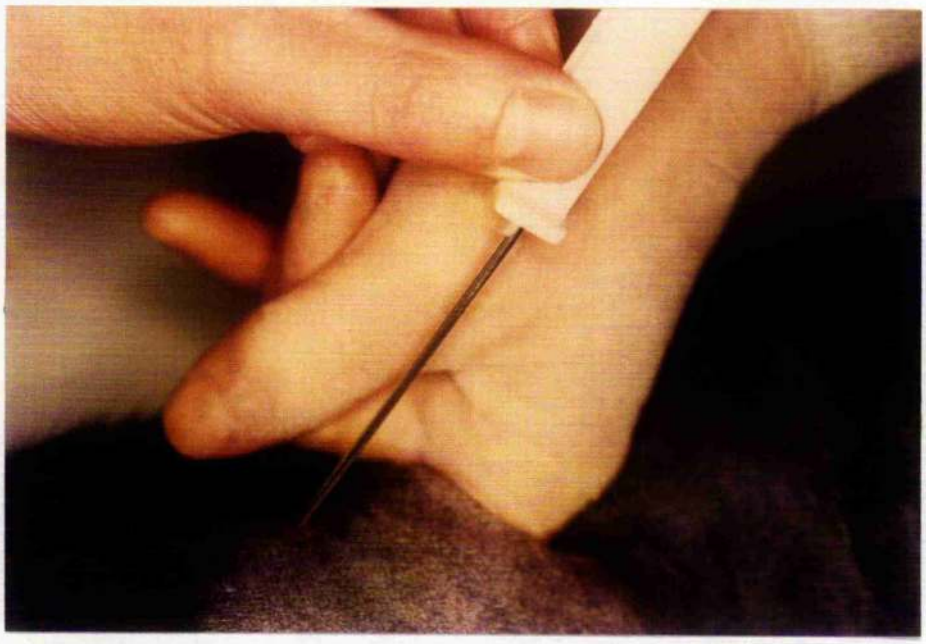


FIGURE 2.3. Dog heavily sedated with "Immobilon" undergoing "keyhole" renal biopsy of the left kidney. The incision for the biopsy needle was further than usual from the opening for the finger because the kidney in this dog was particularly small and cranially situated.
Sterile drapes were removed for photography.

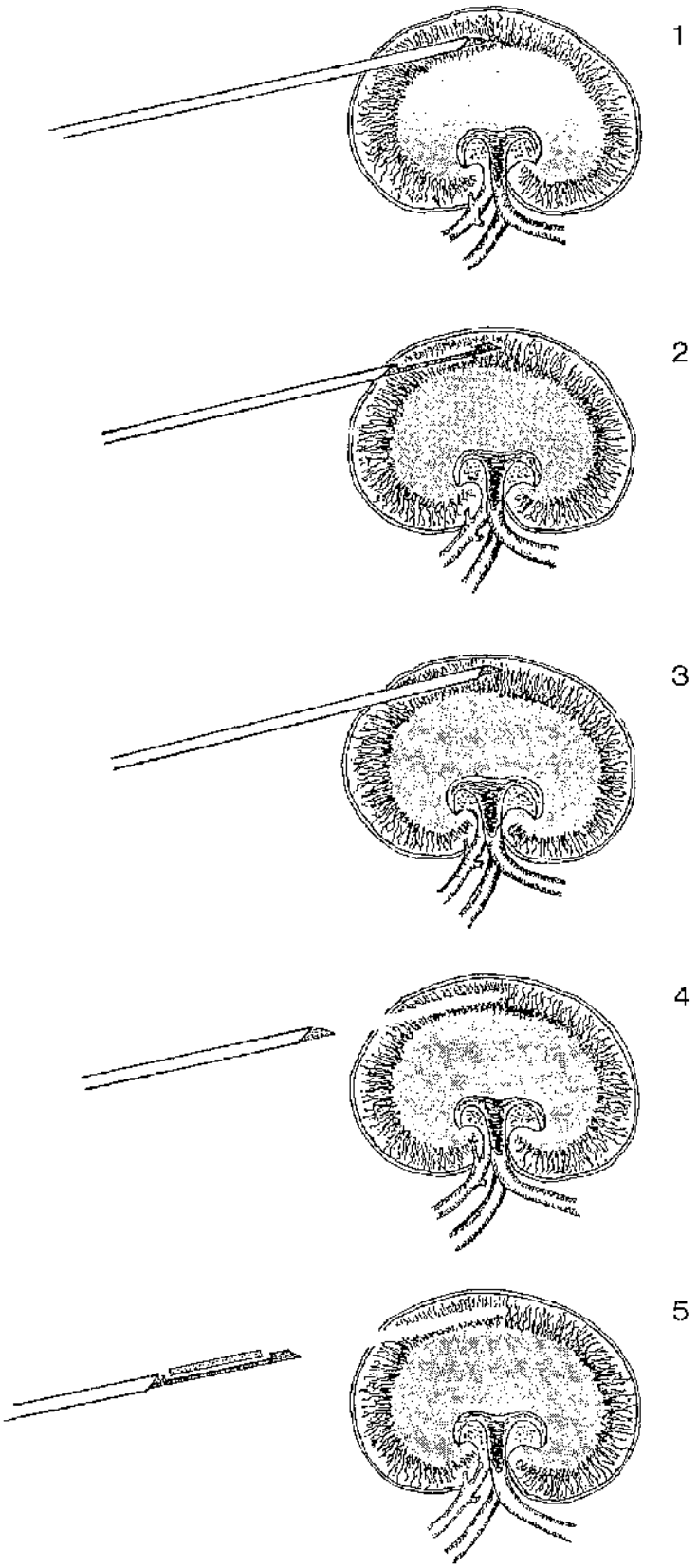


FIGURE 2.4. Method of operation of the "Tru-Cut" disposable biopsy needle as recommended by the manufacturer and employed in this study.

The specimen was measured and examined for its content prior to removal from the specimen notch for fixing. If it was considered to be inadequate in length or content, further biopsy attempts were made until a satisfactory sample was obtained (Figure 2.5).

A pro forma Renal Biopsy form (Figure 2.6) was completed in duplicate on each biopsy occasion and one copy retained by the operator while the other accompanied the biopsy specimen to the laboratory, for use by the pathologist.

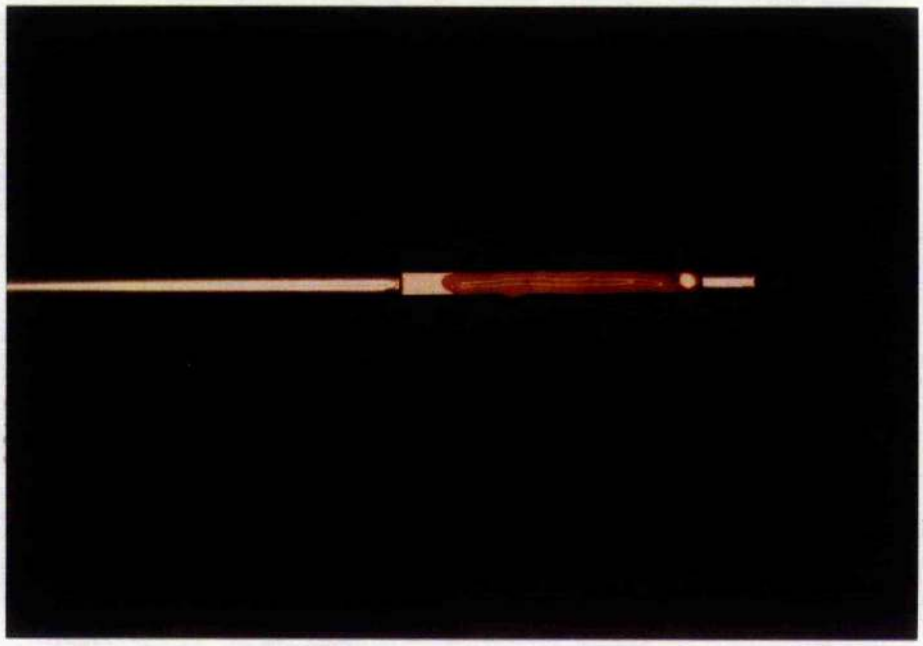


FIGURE 2.5. "Tru-Cut" biopsy needle with a 15 mm. renal biopsy specimen in the specimen notch. (x 2).

RENAL BIOPSY

CASE NO. | CLINICAL | DATE

OWNER | EXPERIMENTAL

CANINE | BREED | OPERATOR

FELINE | AGE | PATHOLOGIST

SEX

ANAESTHESIA IMMOBILON ACP THIOPENTONE HALOTHANE

LOCAL KETAMINE

APPROACH LEFT SIDE RIGHT SIDE

PERCUTANEOUS KEYHOLE LAPAROTOMY

KIDNEY POLE CAUDAL CRANIAL MIDDLE

SAMPLE ASSESSMENT LENGTH 5mm 10mm 15mm 20mm

NUMBER OF CUTS 1 2 3 4

HAEMORRHAGE YES NO

RECOVERY NORMAL LONG VERY LONG DIED/DESTROYED

POST OPERATIVE HAEMATURIA YES NO

COMPLICIATIONS/COMMENTS

PATHOLOGY ASSESSMENT

HISTOLOGY

FLUORESCENCE

ELECTRON MICROSCOPE

NUMBER OF GLOMERULI

COMMENTS

DIAGNOSIS

FIGURE 2.6 Pro forma Renal Biopsy form

7. Post-biopsy management.

Immediately after withdrawal of the biopsy needle, digital pressure was applied to the biopsy site for about one minute before the kidney was released.

Keyhole incisions were closed with a single layer of continuous 0 catgut in the peritoneum and muscles, and interrupted mattress sutures of monofilament nylon in the skin. Stab incisions for needle entry were closed with a single mattress suture of monofilament nylon if required.

Whenever possible, patients were observed for several hours post-biopsy for evidence of post-operative shock and haemorrhage. In many cases, urine samples were taken at 5 minutes post-biopsy and again after 24 hours. Care was taken to avoid disturbing blood clots in the biopsy sites. Post-biopsy examinations were recorded daily as part of the routine patient recording until the discharge or death of the animal.

8. Processing of biopsy specimens.

Where possible, samples were divided into 3 parts and treated as follows:-

(a) Histologic studies.

One portion was fixed in 10 per cent neutral buffered formalin for 7 days and postfixed for at least 2 days in mercuric chloride formol. Paraffin sections, 3 µm. thick, were stained routinely with Mayer's haemalum and eosin (H & E) and with Martius scarlet blue (MSB), Masson's trichrome, fluorescent periodic acid-Schiff (PAS) and silver methenamine methods.

(b) Immunofluorescence studies.

The second portion was frozen, and sections 3 µm. thick were washed in phosphate-buffered saline, pH 7.4, for 30 minutes, fixed in acetone for 10 minutes, and stained with fluorescein-conjugated rabbit antidog or anticat IgG and C3. After washing in phosphate-buffered saline for 10 minutes, stained sections were then examined with a Leitz Orthoplan fluorescence microscope equipped for incident light fluorescence. Suitable control sections were employed with all of the immunofluorescence procedures.

(c) Ultrastructural examinations.

The third portion of the biopsy sample was diced into pieces less than 0.5 mm. thick and fixed in paraformaldehyde glutaraldehyde and postfixed in one per cent osmic acid. Sections, one µm. thick were cut in an LKB pyramitome and stained with toluidine blue. Once glomeruli had been identified, ultrathin sections were cut in an LKB mark III ultramicrotome and stained with uranyl acetate and lead citrate. They were then examined with a Hitachi HS8 electron microscope.

9. Follow-up studies.

Animals which died or were euthanased subsequent to biopsy were followed to necropsy whenever possible. When this was not possible, an attempt was made to obtain information from the owner as to the date and reason for euthanasia. Surviving animals were followed up wherever possible and repeat examinations, including further biopsies in some cases, were carried out at intervals. Repeated biopsies were performed in some animals on up to 6 occasions.

RESULTS

(a) Dogs.

Relevant data from each dog are presented in Appendix A and details have been summarised in Tables 2.1 to 2.6 inclusive.

1. Patients.

During the period of study, biopsy specimens were obtained from 53 dogs. Forty dogs were purebred, 5 were recognisably crossbred and 8 were mongrels. Their ages at biopsy ranged from 4 months to 14 years with an average age of 5.0 years. Thirty two dogs were male and 21 were female (Table 2.1).

Forty seven dogs were biopsied once; 3 were biopsied twice; one on 3 occasions and 2 on 4 occasions.

On 30 biopsy occasions (46.9 per cent) the dogs were uraemic.

2. Anaesthesia.

The majority of dogs were heavily sedated with an intravenous injection of "Immobilon" and sedation and relaxation were adequate for the biopsy to be performed. However, in 2 cases (case nos. 61702 and 74755) the abdominal muscles remained tense and sodium thiopentone was used. One of these dogs (case no. 61702) became apnoeic and after resuscitation was intubated and maintained on a halothane and oxygen mixture. Dogs anaesthetised with sodium thiopentone and maintained on a mixture of halothane and oxygen or with sodium thiopentone following sedation with acetylpromazine or sodium thiopentone alone were sufficiently relaxed in every case for biopsy to be performed. On the 2 occasions when acetylpromazine and local infiltration with lignocaine hydrochloride was used (case nos. 52750 and 68409), extra attendants had to be present to help with restraint but satisfactory results were obtained.

Apart from the dog which became apnoeic, induction and maintenance of anaesthesia was without complications. One dog (case no. 67539) failed to recover from anaesthesia after the fourth biopsy occasion. Death was associated with severe anaemia which had not been thoroughly investigated prior to biopsy. Seven other dogs had prolonged recovery

TABLE 2.1

RENAL BIOPSY IN 53 DOGS AND 50 CATS: SUMMARY OF SUBJECTS

BREED	DOG	CAT
Pure bred	40	6
Cross bred	5	
Mongrel	8	
Domestic		44
AGE		
Range	4 mth-14 yr	8 mth-15 yr
Average (years)	5.0	4.4
SEX		
Male	32	40
Female	21	10

TABLE 2.2

RENAL BIOPSY IN DOGS AND CATS: ANAESTHESIA AND RECOVERY

ANAESTHETIC AGENTS USED	DOG	CAT
Ketamine hydrochloride		59
Immobilon	29	
Immobilon/sod. thiopentone	1	
Immobilon/sod. thiopentone/halothane	1	
Sodium thiopentone	4	2
Acetylpromazine/sodium thiopentone	12	
Acetylpromazine/sod. thiopentone/halothane	15	
Sodium thiopentone/halothane		2
Acetylpromazine/lignocaine hydrochloride	2	
Lignocaine hydrochloride		4
Total number of biopsy occasions	64	67
RECOVERY		
Normal	47	55
Prolonged	7	2
Death before recovery	1	0
Immediate post-biopsy euthanasia	9	10
Total number of biopsy occasions	64	67

times and one of these (case no. 70446) required a second dose of "Revivon" and remained ataxic until euthanasia 5 days later. On the other 47 occasions recovery times were normal. Euthanasia with sodium pentobarbitone was carried out on 9 dogs immediately after biopsy (Table 2.2)

3. Approach.

The direct percutaneous route was used whenever possible. When the left kidney could not be palpated or adequately fixed, the "keyhole" approach was used on the same side so as to avoid having to prepare the other side. On 5 occasions a decision to use the right side by "keyhole" approach was made in advance and on 7 other occasions dogs were biopsied while undergoing exploratory laparotomy. (Table 2.3).

TABLE 2.3

RENAL BIOPSY IN DOGS AND CATS: SUMMARY OF APPROACH

	DOG		CAT	
	left	right	left	right
Direct percutaneous	37	2	66	1
Keyhole	13	5		
Laparotomy	6	1		
Total	56	8	66	1
Total number of biopsy occasions	64		67	

4. Biopsy results.

The number of biopsy attempts before satisfactory specimens were obtained on each occasion was recorded on 58 occasions and ranged from one to 4 attempts, with an average of 2.1 attempts. The lengths of samples obtained were recorded on 56 occasions and ranged from 0 to 20 mm. The longest sample obtained on each occasion was recorded on 56 occasions and lengths ranged from 5 to 20 mm. with an average

longest sample length of 14.7 mm. In addition, the average numbers of biopsy attempts and sample lengths for each method of approach were recorded. (Table 2.4).

5. Post-biopsy complications.

Self-limiting post-biopsy haematuria occurred on 33 occasions (53.2 per cent) out of 62 occasions recorded. Post-biopsy haemorrhage was commonly observed in dogs in which the "keyhole" approach was used but in all cases satisfactory haemostasis was obtained following local digital pressure.

One dog (case no. 76704) developed a left flank abscess 5 days post-biopsy and this responded satisfactorily to drainage and broad spectrum antibiotic therapy.

6. Examination of biopsy specimens.

Renal tissue was present in all 64 biopsy specimens although one of these contained only haemorrhagic fragments (case no. 71268). Glomeruli were present in 53 out of 63 recorded specimens (84.1 per cent) with up to 47 glomeruli per sample and an overall average glomerular content of 10.7. The average glomerular content per sample for each method of approach was also recorded (Table 2.4).

A definite diagnosis was made following examination of 54 biopsy specimens out of 64 (84.4 per cent) and 10 samples were recorded as inconclusive. In two of the inconclusive cases there were no glomeruli present in the first samples and the dogs were re-biopsied (case nos. 74755 and 93604) and a diagnosis then made. In one other case (no. 71268) the material was inadequate for examination and in another 7 cases the kidney tissue examined was reported to be normal. If the repeated biopsy attempts are ignored and inconclusive results excluded, then a diagnosis was possible at the first biopsy attempt in 43 out of 53 dogs (81.1 per cent) (Table 2.5).

7. Follow-up studies

Of the 53 dogs biopsied, 4 are alive; 8 others may be alive but no recent reports about them have been obtained; 41 are dead and of these 36 were followed through to necropsy. In one necropsied case (no. 60348) the kidney blocks were lost during processing.

In 32 cases the biopsy and necropsy diagnosis were the same (91.4 per cent). Of the other 3 cases (Table 2.6), one was an inadequate biopsy sample (case no. 71268)(Figure 2.7), and in another the necropsy examination was not possible until 72 hours after the

TABLE 2.4

RENAL BIOPSY IN DOGS AND CATS: SUMMARY OF BIOPSY RESULTS

AVERAGE NUMBER OF BIOPSY ATTEMPTS/OCCASION	DOG	CAT
Direct percutaneous	2.0	2.1
Keyhole	2.3	
Laparotomy	2.1	
Overall average	2.1	2.1
AVERAGE LENGTH OF LONGEST SAMPLE/OCCASION		
Direct percutaneous	15.1	14.0
Keyhole	14.3	
Laparotomy	13.6	
Overall average	14.7	14.0
AVERAGE GLOMERULAR CONTENT/BIOPSY OCCASION		
Direct percutaneous	9.8	7.0
Keyhole	12.5	
Laparotomy	10.7	
Overall average	10.7	7.0

TABLE 2.5

RENAL BIOPSY IN DOGS AND CATS: SUMMARY OF BIOPSY DIAGNOSES

DIAGNOSIS	DOG	CAT
Acute interstitial nephritis	4	
Amyloidosis	3 (1)*	
Chronic nephropathy	20 (1)	7 (1)
Glomerulonephritis (unclassified)	3 (2)	2
Membranous nephropathy	8	27
Nephrocalcinosis	(1)	2
Nephrosis	2 (2)	
Pyelonephritis	1	1 (1)
Lymphosarcoma	2	4
Other neoplasia	2	
Inconclusive: Kidney apparently normal	7	7
Inadequate sample	1	
TOTAL	53	50

*Figures in parentheses indicate subsidiary diagnoses.

TABLE 2.6

SUMMARY OF CASES IN WHICH BIOPSY AND NECROPSY DIAGNOSIS DIFFERED

CASE NUMBER	BIOPSY DIAGNOSIS	NECROPSY DIAGNOSIS
DOGS		
71268	Inconclusive	Transitional cell carcinoma
76112	Amyloidosis	Inconclusive
67327	Chronic nephritis	Chronic pyelonephritis
CATS		
78546	Lymphosarcoma	Feline infectious peritonitis
74269	Chronic nephritis	Unclassified glomerulonephritis

FIGURE 2.7. Sagittal section through the left kidney of Case no. 71268. Large, loculated cystic areas prevented adequate harvesting of tissue at biopsy. Transitional cell carcinoma diagnosed at necropsy.

the dog died and a full histological and ultrastructural examination of the kidneys was not possible (case no. 76112). In the third case (no. 67327) the discrepancy between biopsy and necropsy diagnosis lay in the specific diagnosis. In both cases it was regarded as an end-stage kidney (Figure 2.8).

In one case (no. 53287), although there was confirmation of the biopsy diagnosis of pyelonephritis, amyloidosis was also diagnosed at necropsy.

Three dogs whose biopsy specimens contained apparently normal kidney, including glomeruli, were also followed through to necropsy (case nos. 67795, 75824 and 76199). In each case the kidneys were found to be normal, although in one there was a mild, focal pyelonephritis associated with the biopsy track (case no. 67795). These cases were included among the 32 dogs having a positive correlation between biopsy and necropsy diagnosis.

Of the dogs subjected to repeated biopsies, only one (case no. 50535) showed evidence of progression of the disease process. At the first biopsy amyloidosis was diagnosed, while at the second, taken immediately before euthanasia and necropsy, 16 months after the first, there was evidence of marked glomerular loss as well as interstitial fibrosis. In the other cases (nos. 56315, 67539 and 77448) the time intervals between the first and last biopsies were shorter (up to 9 months) and progressive lesions were not demonstrated.

At necropsy performed up to 3 days post-biopsy, 4 dogs showed evidence of perirenal, subcapsular and intrarenal haemorrhage (case nos. 53287, 67539, 70417 and 70446). In these cases, the biopsy track (Figure 2.9) and renal pelvis (Figure 2.10) were filled with blood but there was no evidence of infarction. Where the biopsy to necropsy interval was longer, examination of the biopsied kidneys revealed resolving haemorrhage, capsular adhesions, cortical depressions and or linear scars in some cases, while in others, no lesion could be found.

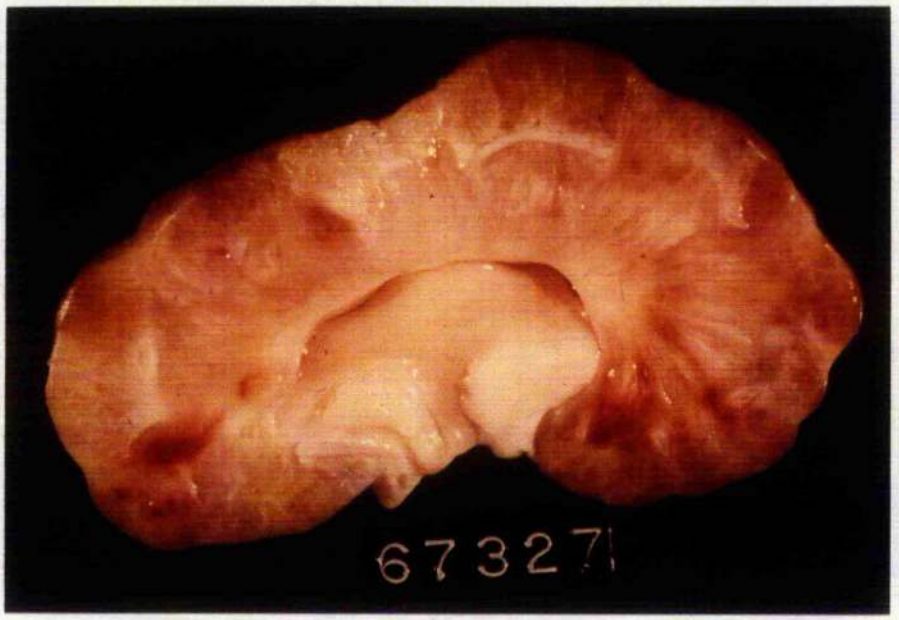


FIGURE 2.8. Sagittal section through the left kidney of Case no. 67327. Biopsy diagnosis of chronic nephritis and necropsy diagnosis of chronic pyelonephritis.

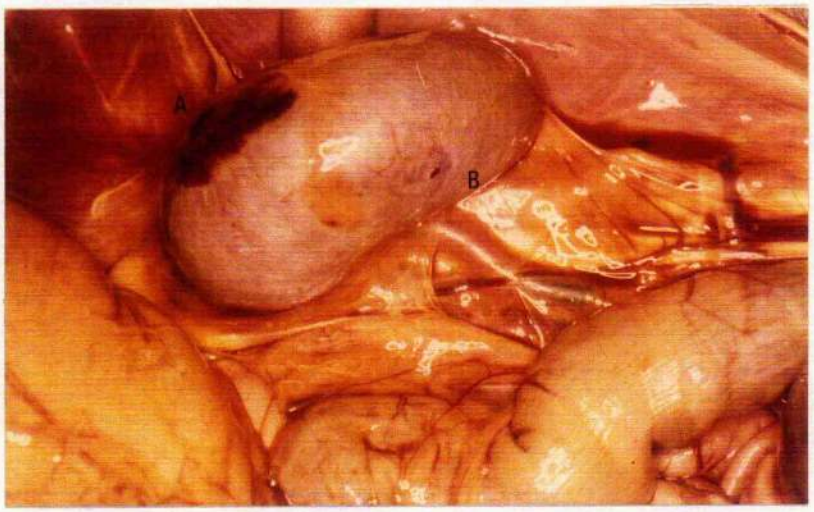


FIGURE 2.9a. Left kidney of Case no. 70417 in situ one hour post-biopsy. Subcapsular haemorrhage at point of needle entry (A) and point of haemorrhage at point of re-emergence (B).

FIGURE 2.9b. Sagittal section of left kidney of Case no. 70417. Small cortical haemorrhage underlies subcapsular haemorrhage at (A) in Figure 2.9a.

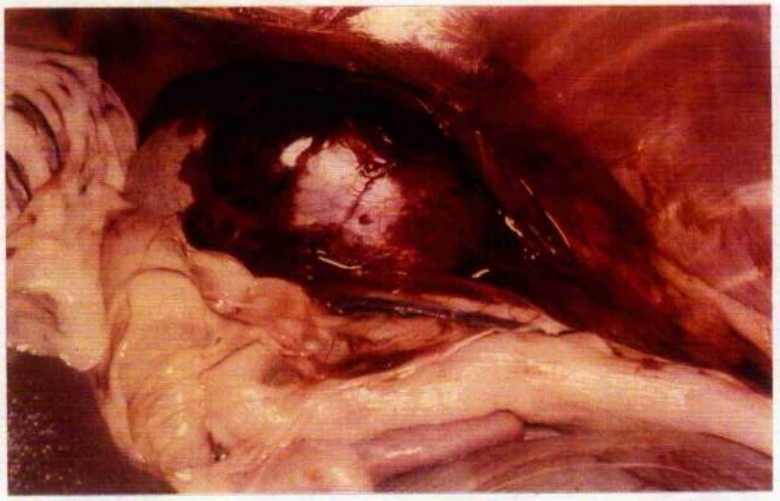


FIGURE 2.10a. Left kidney of Case no. 70446 *in situ* 3 days post-biopsy. Marked subcapsular, perirenal and peritoneal haemorrhage present.

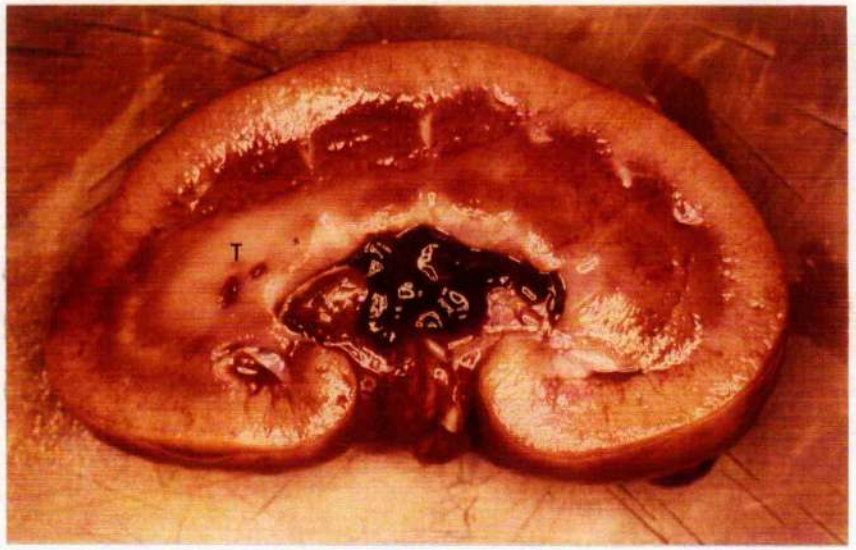


FIGURE 2.10b. Sagittal section of left kidney of Case no. 70446. Part of biopsy track (T) and blood clots in renal pelvis.

B. Cats.

Relevant data from each cat is presented in Appendix B and details have been summarised in Tables 2.1 to 2.6 inclusive.

1. Patients.

During the period of study 67 renal biopsy biopsy specimens were obtained from 50 cats, of which 42 were domestic short-haired, 2 were domestic long-haired and 6 were purebred. Their ages at biopsy ranged from 8 months to 15 years with an average age of 4.4 years. Forty cats were male and 10 were female (Table 2.1).

Ten animals were biopsied on more than one occasion; 7 were biopsied twice, one 3 times, one 4 times and one 6 times.

On 34 occasions (50.1 per cent) the cats were uraemic.

2. Anaesthesia.

On 59 occasions cats were given ketamine hydrochloride and good relaxation occurred in the majority of cases. Occasionally a further injection containing half the initial dose of ketamine was administered prior to biopsy if there was inadequate relaxation. Four cats were given sodium thiopentone, 2 of which subsequently received halothane, and all were well relaxed. Relaxation was poor in 4 cats given local anaesthesia and although anaesthesia was apparently effective, there was a tendency for these cats to struggle unexpectedly, which prolonged the biopsy procedure and necessitated the presence of extra attendants to provide restraint (Table 2.2).

Recovery times were normal and without incident on 55 occasions. On 2 occasions recovery was prolonged and in one case (no. 74369) the animal vomited 20 minutes post-biopsy and became apnoeic but responded well following resuscitation and oxygen therapy. Ten cats were euthanased with sodium pentobarbitone immediately after biopsy (Table 2.2).

3. Approach.

The direct percutaneous approach was used in every case and there were no difficulties experienced in palpating or holding the kidney for biopsy, even in obese cats or nephrotic animals that were ascitic at the time. On 66 occasions the left kidney was biopsied and in one case (no. 73501) the right was biopsied as the left was found to be cystic (Table 2.3).

4. Biopsy results.

The number of biopsy attempts per adequate specimen was recorded on 64 occasions and ranged from one to 5 attempts with an average of 2.1. The lengths of samples ranged from 0 to 20 mm. and the longest sample obtained per biopsy occasion was recorded on 66 occasions, with a range of 2.5 mm. to 20 mm. and an average longest sample length of 14.0 mm. (Table 2.4).

5. Post-biopsy complications.

Moderate bleeding through the stab incision in the abdominal wall occurred on a number of occasions. However, since the biopsies were performed blind, it was impossible to assess the volume of haemorrhage within the abdomen.

Post-biopsy haematuria was recorded on 43 occasions out of 64 recorded (68.3 per cent).

Wound healing was consistently good and post-biopsy renal or abdominal pain was only rarely demonstrated on the following day.

6. Examination of biopsy specimens.

Renal tissue was present in all 67 specimens. Glomeruli were present in 59 out of 64 recorded specimens (89.4 per cent) with up to 24 glomeruli per sample and an average glomerular content of 7.0.

A definite diagnosis was made after examination of 57 biopsy specimens out of 67 (85.1 per cent) and 10 samples were recorded as inconclusive. On 3 occasions a positive diagnosis would probably have been made if immunofluorescence and ultrastructural studies had been carried out (case nos. 62195 and 62718, B1 and B2) and on one other (case no. 85273, B1) had glomeruli been present. On 6 other occasions, the samples contained apparently normal kidney. A definite diagnosis was made following the first biopsy attempt in 41 out of 50 cats biopsied (82.0 per cent). (Table 2.5).

7. Follow-up Studies.

Of the 50 cats biopsied, 4 are alive, 3 others may be alive but no recent reports about them have been obtained and 43 are dead, of which 36 were followed through to necropsy.

In 34 cases the biopsy and necropsy diagnosis was the same (94.4 per cent). Of the 2 cases in which there were different diagnoses, one case (no. 78546) was diagnosed at biopsy as having possible lymphosarcoma infiltration but at necropsy was found to be suffering from feline infectious peritonitis. However, in neither instance was a primary renal disease diagnosed. The other cat (case no. 74369) was said to have chronic nephritis at biopsy and found to be an unclassified glomerulonephritis at necropsy. However, on both occasions it was regarded as an end-stage kidney condition (Table 2.6).

Three of the cats in which the biopsy result was recorded as inconclusive because the renal tissue present was apparently normal were followed through to necropsy and found then to have normal kidneys (case nos. 61998, 73718 and 76758). These animals were included among the 34 cats in which there was a positive correlation between biopsy and necropsy diagnosis.

Of the 10 cats subjected to repeated biopsies, 4 showed evidence of a progression in the disease progress (case nos. 62718, 71792, 73644 and 77152) and were all eventually followed through to necropsy in chronic (case no. 73644) or terminal renal failure (case nos. 62718, 71792 and 77152). In another case, (no. 80204) there was no evidence of change in the severity of lesions in the 5 months between the first and second biopsies but clinically the cat had recovered after a further 13 months. A third biopsy attempt was requested but has not been permitted by the owner.

In 7 of the cases (nos. 71792, 74368, 77152, 78535, 79837, 81534 and 85496) which were followed to necropsy at varying intervals following one or more biopsies, examination of the biopsied kidney revealed quite alarming post-biopsy lesions, including extensive scarring in a longstanding case (no. 71792) and large wedge-shaped infarcts and extensive haemorrhage in more recent cases. Infarction was particularly evident in case no. 85496, (Figure 2.11), in which there was a progression from what appeared clinically to be moderate chronic renal failure to terminal renal failure in 7 days. In most other cases, the extent of renal damage in the biopsied kidney was minimal, with a small depressed scar at the point of needle entry and a scarred cortical biopsy track, while in a few animals there was no evidence of a post-biopsy lesion (Figure 2.12).

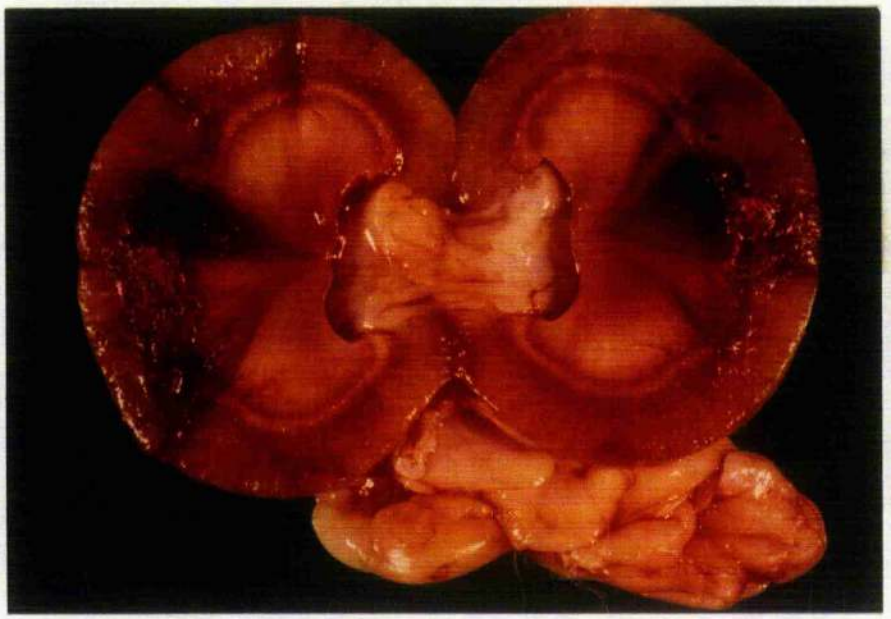


FIGURE 2.11. Sagittal section of left kidney of Case no. 85496, 7 days post-biopsy. Severe wedge-shaped infarcts extended deep into the medulla.

FIGURE 2.12. Left kidney of Case no. 91890, 6 months post-biopsy. Fine linear scar in outer cortex resultant from superficial biopsy track. Minimal renal parenchymal damage but 2 subcapsular veins (v) affected.

DISCUSSION

This study of 131 renal biopsies in 53 dogs and 50 cats with suspected renal disease is the first investigation of its kind in Britain. It also embodies the largest series of cat renal biopsies hitherto reported and thus has provided an opportunity for the most comprehensive appraisal to date of the application of the technique in this species and an evaluation of its potential as an aid to diagnosis. In addition, the approximately equal numbers of dogs and cats in this series have permitted for the first time a comparative study of the results in each species. This work has been performed throughout with the "Tru-Cut" disposable biopsy needle and represents the largest series of clincial renal biopsy cases to date in which it has alone been used, thus giving an opportunity for a critical assessment of its effectiveness and also a comparison with earlier reports of studies in which the Franklin-Silverman needle has been used (Osborne et al, 1967; Osborne, 1971b). Follow through to necropsy of 36 dogs and 36 cats in the present series also represents the largest proportion of both dogs (68 per cent) and cats (72 per cent) in which this has been possible and has therefore permitted a more critical comparison to be made between initial biopsy and eventual necropsy diagnosis.

The major differences between this study and those of Osborne et al (1967), Osborne (1971b), Jeraj et al (1982) and Grauer et al (1983) are in respect of:

(a) the use of a neuroleptanalgesic sedative ("Immobilon") in a majority of the dogs;
(b) the use of ketamine hydrochloride in most of the cats;
(c) the route of approach and use of the left kidney in a majority of the dogs; and
(d) the sole use and method of operation of the $4\frac{1}{2}$ inch "Tru-Cut" needle.

Anaesthesia for any procedure must be both effective and safe. For successful renal biopsy the anaesthetic must give adequate muscle relaxation as well as analgesia. Two dogs in this series were insufficiently relaxed with a neuroleptanalgesic drug ("Immobilon") and required additional anaesthesia. The problems of inadequate analgesia in dogs sedated with morphine followed by local infiltration of lignocaine have been highlighted by Jeraj et al (1982) and these authors came to prefer general anaesthesia with barbiturates (Osborne, 1971b)

or inhalation agents (Osborne, 1975). Although there is substance in the assertion that inhalation anaesthetics are preferable to parenteral agents because problems of drug metabolism and renal clearance are eliminated (Osborne, 1975), there is no evidence in previous reports to show that the parenteral agents, when used for renal biopsy procedures, have been any less safe. There are no reports of deaths due to anaesthesia in renal biopsy cases, even though many patients have been uraemic at the time. In the present series the one dog which died had been sedated with acetylpromazine and anaesthetised with sodium thiopentone. This animal was moderately uraemic, but more important, she was severely anaemic prior to biopsy, and it was concluded that the latter was the reason for her death. Apart from inadequate relaxation in 2 dogs and prolonged recovery and ataxia in another dog, which was severely uraemic,"Immobilon" proved both safe and adequate in 93.5 per cent of the occasions on which it was used. On the 2 occasions when it proved inadequate, the immediate addition of sodium thiopentone in both cases and halothane in one of them was quite straightforward. The positive benefits of "Immobilon" are that it is quick acting, safe in uraemic animals, requires no maintenance and is reversible. On the other hand, local anaesthesia, as used in 2 dogs and 4 cats in this series was adequate only as an analgesic and the animals required considerable restraint by additional assistants, which not only made the procedure more labour intensive but decreased the working area available to the operator and his assistant and is therefore not regarded as a useful procedure.

Anaesthesia for renal biopsy using ketamine hydrochloride has not been reported previously as there has, until recently, been concern about its safety in uraemic cats, because of its alleged unchanged renal excretion (Osborne et al 1974; Gaskell, Denny, Jackson and Weaver, 1978). On the 59 occasions when ketamine was used in cats in this series, some of which were profoundly uraemic, it was found to be completely safe, effective and adequate, and on only 3 of the 52 occasions when recovery was permitted was recovery prolonged. These findings have recently gained support from a study of the pharmacokinetics and metabolism of ketamine in the cat by Waterman (1983), who reported that the drug is metabolised in this species and that urinary excretion of ketamine and its primary metabolite, norketamine, only accounted for 0.8 per cent of the injected dose after 90 minutes, by

which time the cats were clinically recovered. She suggested that if prolonged anaesthesia occurs in uraemic cats following administration of ketamine it is likely to be due to an altered biodisposition of the drug caused by an accompanying metabolic acidosis and concluded that its use in uraemic cats is not potentially hazardous.

From the earliest report of clinical renal biopsy in the dog (Osborne et al, 1967), the right kidney has been consistently preferred because of its firmer attachment and proximity to the caudate lobe of the liver (Osborne, 1971b; Jeraj et al, 1982; Grauer et al, 1983). However, Osborne et al (1967) reported successful biopsy of the left kidney in 4 dogs by the blind percutaneous approach and in 6 dogs by the "keyhole" approach. If the blind percutaneous approach is used then the left becomes the kidney of choice, partly because of its more caudal position compared with the right, and also because its greater mobility permits more freedom to the operator in manipulating it. The left kidney was successfully located and positioned for biopsy on 37 out of 50 biopsy occasions (74 per cent) in this study and on the other 13 occasions when it was either not palpable or palpable but unable to be adequately positioned, there was no difficulty in adopting the "keyhole" approach on the same side, thus avoiding movement of the dog and preparation for biopsy on the opposite side. The results obtained from the use of the left kidney and the direct percutaneous route were very similar to those from the right and left kidneys using the "keyhole" approach. There would appear to be a distinct advantage in setting out to use a method which is both quicker to perform and less traumatic to the patient, a high proportion of which are likely to be uraemic. The fact that this approach was successful in approximately three quarters of the dogs on which it was attempted may in part be due to more adequate analgesia than that found unsatisfactory by Osborne (1971b) and Jeraj et al (1982) and may have influenced their eventual decision to use the "keyhole" approach and the right kidney. In addition, the present author is left-handed and may have been unconsciously influenced in the decision to use the left kidney wherever possible as the left kidney was held in the right hand and the needle in the left, the ideal arrangement for someone left-handed.

This study is the first to report sole use of the "Tru-Cut" disposable needle in all 3 routes of approach described by Osborne (1971b). The results obtained compare favourably with those of Osborne (1971b) in respect of success in obtaining adequate specimens, diagnostic correlation and relative lack of post-biopsy complications. The same comparison can also be made with the results reported by Jeraj et al (1982) but there was no separation of their results for comparison of the 3 needle types they used. The results of this study also compare favourably with those of Grauer et al (1983), using the same needle but a more laborious technique of approach.

It is interesting that both Osborne (1975) and Grauer et al (1983) described the same method for use of the "Tru-Cut" needle but that this was not the method currently recommended by the manufacturer. The possible advantage of the method adopted by these authors is that the depth to which the obturator was advanced into the kidney could be controlled to some extent more readily than with the method recommended by the manufacturer. This might be of benefit in animals with small kidneys, just as the Metcoff needle was similarly beneficial (Osborne, 1975; Jeraj et al, 1982). At present, favourable results have been obtained with both the recommended method as used in this study and that described by Osborne (1975), and reported by Jeraj et al (1982), but further investigation would be required for a meaningful comparison to be made.

Accuracy of diagnosis is most important if renal biopsy is to be shown to be a worthwhile procedure and it is encouraging that the diagnostic results and correlations between biopsy and necropsy findings in this study compare favourably with those of previous reports.

It is interesting to note the apparent change in incidence of certain diseases, particularly glomerulonephropathies, by comparison of the biopsy diagnoses given by Osborne (1971b) with those reported by Jeraj et al (1982) and diagnoses in the present study (Table 2.7). The increase in the frequency of diagnosis of glomerular diseases is not necessarily due to an overall increase in their occurrence and may be a reflection of 2 other factors. The first is that Osborne (1971b) only performed histological examinations. In the intervening

TABLE 2.7

COMPARISON OF BIOPSY DIAGNOSES

BIOPSY DIAGNOSIS	NOS. OF CASES (DOG AND CAT COMBINED) OSBORNE (1971b)	JERAJ ET AL (1982)	PRESENT STUDY
Chronic nephritis	39	49	27
Amyloidosis	11	15	3
Glomerulonephropathies	6	56	40
Diabetic glomerulosclerosis	3	3	-
Nephrosis	7	8	2
Pyelonephritis	3	16	2
Infarction	1	-	-
Polycystic kidney	1	-	-
Acute interstitial nephritis	1	-	4
Lymphosarcoma	1	2	6
Other neoplasia	3	3	2
Nephrocalcinosis	-	9	2
Normal kidney	13	29	14
No diagnosis - poor sample	3	3	1
Totals	92	193	103

years, the introduction of immunofluorescence techniques and increasing use of electron microscopy have permitted much greater accuracy in the diagnosis of glomerulonephropathies. The second is that the experience gained from the earlier study (Osborne, 1971b), which had been initiated as a feasibility study of the value of renal biopsy in the dog and cat (Osborne et al, 1967), probably led the authors of the later study (Jeraj et al, 1982) to be more selective in the type of cases biopsied. While cases of end-stage renal disease were useful subjects for studying the technique, and more likely to be available for necropsy because of the terminal state of many of them, the majority can be adequately diagnosed by clinical, laboratory and radiographic examination without the need for back-up by a biopsy (Osborne, Low and Finco, 1969). Immunofluorescence and structural studies have been used throughout the present study in

addition to routine histological techniques and the list of diagnoses compares favourably with that of Jeraj et al (1982). For example, chronic nephritis in the present study represented 26.2 per cent of cases and 25.4 per cent in that of Jeraj et al. Glomerular disease was present in 38.8 per cent of the cases in this series and in 29.0 per cent in that of Jeraj et al. The author is aware that in the present series, most of the chronic nephritis cases were biopsied during the first half of the study and that with the passage of time, fewer cases have been biopsied because they could be adequately diagnosed by other means, whereas glomerulonephropathies can only be specifically diagnosed on examination of renal tissue.

In the present series it is notable that membranous nephropathy was diagnosed in 27 cats (54 per cent). This is the largest number of cats with clinically apparent membranous nephropathy hitherto reported in one series and it was deemed worthy of a more detailed study, particularly as follow-up by subsequent re-biopsy or necropsy was carried out in 20 cases. The results of this investigation will be presented in Chapter 3.

While post-biopsy complications were relatively rare and those which did occur were similar in frequency and type to those previously reported, the presence of severe lesions in the biopsied kidneys of 7 of the cats indicated an alarming degree of vascular damage and may have contributed to the rate of onset of terminal renal failure in some cases. These lesions were seen in cats more frequently than in dogs and underlined the fact that whereas the effects of biopsy on the dog kidney have been thoroughly investigated (Osborne and Low, 1971a and b; Osborne et al, 1972; Sweet et al, 1969), similar studies have never been conducted in the cat. It is important to discover whether this feature is associated primarily with the peculiar structure of the cat kidney and its response to needle biopsy, or with the relatively large biopsy needle and its method of use. This will be the subject of further study, the results of which will be presented in Chapter 4.

CHAPTER THREE

SECTION ONE

THE ROLE OF RENAL BIOPSY IN THE DIAGNOSIS AND FOLLOW UP OF MEMBRANOUS NEPHROPATHY IN THE CAT

INTRODUCTION AND REVIEW OF THE LITERATURE

Membranous nephropathy is a form of immune-complex mediated glomerulonephritis. Its occurrence in man is well documented and the clinical and pathological features of the disease in a large number of patients have been thoroughly investigated and long-term follow-up studies reported (Ehrenreich and Churg, 1968; Gluck, Gallo, Lowenstein and Baldwin, 1973; Beregi and Varga, 1974; Row et al, 1975; Kashgarian, Hayslett and Spargo, 1977).

In recent years there has been a growing number of reports of the disease in the dog (Hermann, 1970, one case; Murray, Pirie, Thompson, Jarrett and Wiseman, 1971, one case; Osborne et al, 1973, one case; Murray and Wright, 1974, 5 cases; Rouse and Lewis, 1975, 3 cases; Casey and Splitter, 1975, 5 cases; Lewis, 1976, 23 cases; Osborne et al, 1976a, one case; Muller-Peddinghaus and Trautwein, 1977, 26 cases; Dibartola et al, 1980, 7 cases; Sabri and Hayward, 1981, 6 cases).

In the cat, most reports of membranous nephropathy have been confined to individual cases or small groups and have not included long-term follow-up studies (Farrow, Huxtable and McGovern, 1969; Ward, Sodikoff and Schalm, 1969; Anderson and Jarrett, 1971; Bown, 1971; Farrow and Huxtable, 1971, Slauson et al, 1971; Scott et al, 1975; Crowell and Leininger, 1976; Thornburg et al, 1979; Evans 1981; Sabri and Hayward, 1981; Johnson, Dibartola and Gelberg, 1983; Crowell and Barsanti, 1983). A brief report of 22 cases with long-term follow-up of 12 cases has also been published (Lucke, 1982).

Larger groups of cats with glomerular lesions associated with feline leukaemia virus (FeLV) infection were reported by Glick, Horn and Holscher, (1978), and Jakowski, Essex, Hardy, Stephenson and Cotter (1981), but without any evidence of clinical renal disease. Moreover, in the latter study membranous nephropathy was diagnosed solely on the basis of histological examination.

Similar reports exist linking the virus of feline infectious peritonitis (F.I.P.) with the development of immune-complex glomerular lesions in both experimental (Jacobse-Geels, Daha and Horzinek, 1980), and naturally occurring cases (Hayashi, Ishida and Fujiwara, 1982), but no indication was given in either report that the cats had been examined for evidence of clinical renal disease.

A summary of published reports of feline membranous nephropathy is presented in Table 3.1. While all 17 reports contain details of the histological features, only 10 include ultrastructural studies and in only 6 had immunofluorescence techniques been applied. Only 5 reports indicated that renal biopsies had been taken and in one of these (Lucke, 1982) renal biopsy examination was not reported but inferred from the results. Sixteen reports included results of necropsy examinations.

The initial clinical picture of the disease in man is usually that of the nephrotic syndrome and many cases progress to chronic renal failure (Kashgarian et al, 1974). Some cases of membranous nephropathy have been discovered in man when renal biopsies have been carried out on patients with persistent proteinuria (Beregi and Varga, 1974). In the dog, most cases have been presented with the nephrotic syndrome, but some non-nephrotic renal failure cases have been seen (Hermann, 1970, Murray and Wright, 1974; Casey and Splitter, 1975; Lewis, 1976; and Muller-Peddinghaus and Trautwein,1977). In cats, the majority (87 per cent) of individually reported cases of membranous nephropathy have been presented with the nephrotic syndrome (Table 3.1), but the case reported by Slauson et al (1971), was not nephrotic and in another report, 2 cats were in chronic renal failure (Crowell and Barsanti, 1983).

From reports in which details of breed, sex and age have been given it would appear that most affected cats are domestic short-haired and only a few are pure bred (Lucke, 1982). There has been a greater incidence of the condition in neutered males but it has also been reported in neutered females and entire cats of both sexes (Lucke, 1982). Most affected cats are young adults with an overall age range from 7 months up to 9 years with an average of between 3 and 4 years. The 2 cats reported by Crowell and Barsanti (1983) were male siblings but none of the other reported cases have occurred in related animals.

In man and dog the disease has been reported in a number of diverse situations including autoimmune diseases, infections, drug toxicoses and neoplasia. These reports are summarised in Table 3.2.

TABLE 3.1

SUMMARY OF PUBLISHED CASE REPORTS OF FELINE MEMBRANOUS NEPHROPATHY

AUTHOR	DATE	TOTAL CASES	DETAILS RECORDED		DIAGNOSTIC BASIS						
			Clinical Features	Blood & Urine Analysis	Hist.	FA	EM	RELATED DISEASE	RENAL BIOPSY	FOLLOW UP	NECROPSY
FARROW et al	1969	1*	+ (NS)	+	+	-	-	-	-	1 mth	+
WARD et al	1969	1	(+)	-	+	-	-	FeLV	-	-	+
ANDERSON & JARRETT	1971	3	-	-	+	-	-	FeLV	-	-	+
BOWN	1971	1	+ (NS)	+	+	-	-	-	-	2½ mth	+
FARROW & HUXTABLE	1971	4	+ (4NS)	+	+	-	+	-	-	4 mth	+
SLAUSON et al	1971	1	+ (RF)	+	+	+	+	SLE	+	1½ yr	-
SCOTT et al	1975	1	+ (NS)	+	+	-	+	-	+	5½ mth	+
CROWELL & LEININGER	1976	3	+ (2NS/1RF)	+	+	-	+	-	-	-	+
GLICK et al	1978	15	-	-	+	+	+	FeLV	-	-	+
THORNBURG et al	1979	1	+ (NS)	+	+	-	+	FeLV	+	-	+
JAKOWSKI et al	1981	29	-	-	+	-	-	FeLV	-	-	+
EVANS	1981	1	+ (NS)	+	+	+	+	-	+	3 mth	+

TABLE 3.1 (Cont'd)

AUTHOR	DATE	TOTAL CASES	DETAILS RECORDED		DIAGNOSTIC BASIS						
			Clinical Features	Blood & Urine Analysis	Hist.	FA	EM	RELATED DISEASE	RENAL BIOPSY	FOLLOW UP	NECROPSY
SABRI & HAYWARD	1981	13	-	-	+	+	+	-	-	-	+
LUCKE	1982	16	+ (16NS)	+	+	+	+	-	+	up to 5 yr	+
HAYASHI et al	1982	22	-	-	+	+	+	FIP	-	-	+
CROWELL & BARSANTI	1983	2	+ (2RF)	+	+	-	-	-	-	2 mth	+
JOHNSON et al	1983	1	+ (NS)	+	+	-	-	Cholangio-hepatitis	-	-	+
TOTAL CASES		114	27 (NS) 4 (RF)								
TOTAL REPORTS				11	17	6	10		5		16

*This case was reported again by Farrow and Huxtable (1971) and has not been included in the totals.

(+) Clinical details confined to description of anaemia/myeloproliferative disease.

Key to abbreviations: Hist. - histological examination; FA - immunofluorescence microscopy; EM - electron microscopy; NS - nephrotic syndrome; RF - renal failure; FeLV - feline leukaemia virus; SLE - systemic lupus erythematosus; FIP - feline infectious peritonitis

TABLE 3.2

ANTIGENS AND CIRCUMSTANCES REPORTED TO BE ASSOCIATED WITH MEMBRANOUS NEPHROPATHY IN MAN AND DOG

Intrinsic antigens	Extrinsic antigens	Debatable associations
(a) MAN *		
DNA	Hepatitis B	Renal venous thrombosis
Renal tubular epithelial	Tuberculosis pallidum	Diabetes
Carcinoembryonic	Filarial	Rheumatoid arthritis
Other tumour	Mercury and mercurials	Sjögren's syndrome
Thyroglobulin	Gold	Sarcoidosis
	Penicillamine	Tuberculosis
	Tridione	
(b) DOG +		
Lupus erythematosus	Dirofilariasis	
Tumours		

* After Cameron (1979).

\+ After Osborne et al (1977).

The causal factors involved in the initiation of membranous nephropathy in the cat are unknown, although one case was associated with systemic lupus erythematosus (LE) (Slauson et al, 1971) and the lesion has also been found in cats with FeLV infection and leukaemia virus associated disease (Ward et al, 1969; Anderson and Jarrett, 1971; Thornburg et al, 1978; Jakowski et al, 1981) and F.I.P. infection (Jacobse-Geels et al, 1980, Hayashi et al, 1982).

Renal pathologists have found difficulty in making a definite diagnosis of membranous nephropathy on the histological appearance of the glomeruli alone, except in well established cases (Ehrenreich and Churg, 1968) and rely on immunofluorescence and ultrastructural studies for confirmation. In human cases of membranous nephropathy, Ehrenreich and Churg (1968) described 4 sequential ultrastructural stages (I to IV) corresponding to the development and subsequent alteration of the electron dense deposits in the glomerular basement membrane. This classification has been applied by other workers (Gluck et al, 1973; Cameron, Ogg, Turner and Weller, 1973). The latter workers pointed out that while this classification provided a basis for suggesting that there is a progression of the disease through the 4 stages, nevertheless it is possible to have all 4 stages present at the same time in the same glomerulus.

In an analysis of 260 cases of human membranous nephropathy (Beregi and Varga, 1974) 3 stages were described, based on histological, immunofluorescence and ultrastructural studies and these corresponded to stage I, stages II and III combined and stage IV of the previous classification (Ehrenreich and Churg, 1968). Beregi and Varga (1974) defined stage I as having virtually no visible histological changes, but immune deposits present on the basement membrane when examined by immuno-histology and electron microscopy. In Stage II there was thickening of the basement membrane and spike-like protrusions towards the epithelial side with visible immune deposits. Stage III was characterised by thickening of the basement membrane and partial hyalinisation of the glomeruli with variably distributed immune deposits.

In the cat, Lucke (1982) reported varying degrees of severity of membranous nephropathy in the nephrotic cases but gave no details of classification. It is generally agreed that idiopathic membranous nephropathy in the cat is a progressive protein losing nephropathy which can lead to the development of the nephrotic syndrome and may progress to chronic renal failure, although in some cases chronic renal failure is the only clinical manifestation of the disease (Slauson and Lewis, 1979).

In most cases of feline membranous nephropathy the prognosis is poor. Some cases in which the nephrotic syndrome develops without renal failure may, however, continue, following diuretic therapy, for up to 5 years, though there may be periodic exacerbations requiring further diuretic therapy. Other cases deteriorate despite treatment and survive only for a few months. Renal failure cases are either in the terminal phase when presented or reach it soon after and there is little or no response to palliative treatment (Lucke, 1982).

MATERIALS AND METHODS

Case Material

The following 27 cases of feline membranous nephropathy were included in the series of cats reported earlier (Chapter 2) as they had all undergone at least one renal biopsy. Eighteen cases were followed through to necropsy and 2 others which were re-biopsied are still alive. Five other cases were followed up clinically until death but were not available for necrospy examination and 2 other cats are still alive but have not been re-biopsied.

Renal biopsy, Laboratory and Necropsy procedures

These were all performed in accordance with the techniques and methods previously described (Chapter 2).

RESULTS

Detailed case summaries for each cat are presented in Appendix C.

History and Presenting signs

A summary of the initial clinical features of each case is presented in Table 3.3 All the cats except one domestic long haired were domestic short haired. The age at the time of referral ranged from 12 months to 8 years, with an average of 3.5 years. (Figure 3.1). Seventeen cats were neutered males, 5 were entire males and 5 were neutered females. Eleven cats were unvaccinated, in 7 others the vaccination history was unknown, and of the other 9, 8 had been vaccinated against feline infectious enteritis and one had been given a combined vaccination against feline infectious enteritis, feline calicivirus and feline herpesvirus.

Twenty five cases were from separate households and were unrelated, and in multicat households other cats showed no signs of membranous nephropathy throughout the period of study. Two cats (case nos. 80204 and 81982) were siblings and lived in the same household. Two cats (case nos. 62718 and 66669) had been boarded in the same cattery during the same 2 months prior to the development of the nephrotic syndrome. Both had suffered from infectious diarrhoea whilst in the cattery. Four cats (case nos. 86792, 78897, 80589 and 92587) had survived road traffic accidents early in life and in all cases had suffered hind end injuries from which they had recovered. A further cat (case no. 89236), had recovered slowly from a dog bite abscess at 6 months of age. Three other cats (case nos. 71570, 80204 and 81982) had suffered from severe upper respiratory infections when less than 6 months of age from which they had recovered. There was no history of serious previous or concurrent illness in any of the other cats prior to the onset of the presenting signs.

Twenty five cats developed the nephrotic syndrome at some point in the course of their illness, the other 2 cats (case nos. 74368 and 83976) were presented in renal failure and were never nephrotic (Table 3.3).

TABLE 3.3

SUMMARY OF 27 CATS WITH MEMBRANOUS NEPHROPATHY

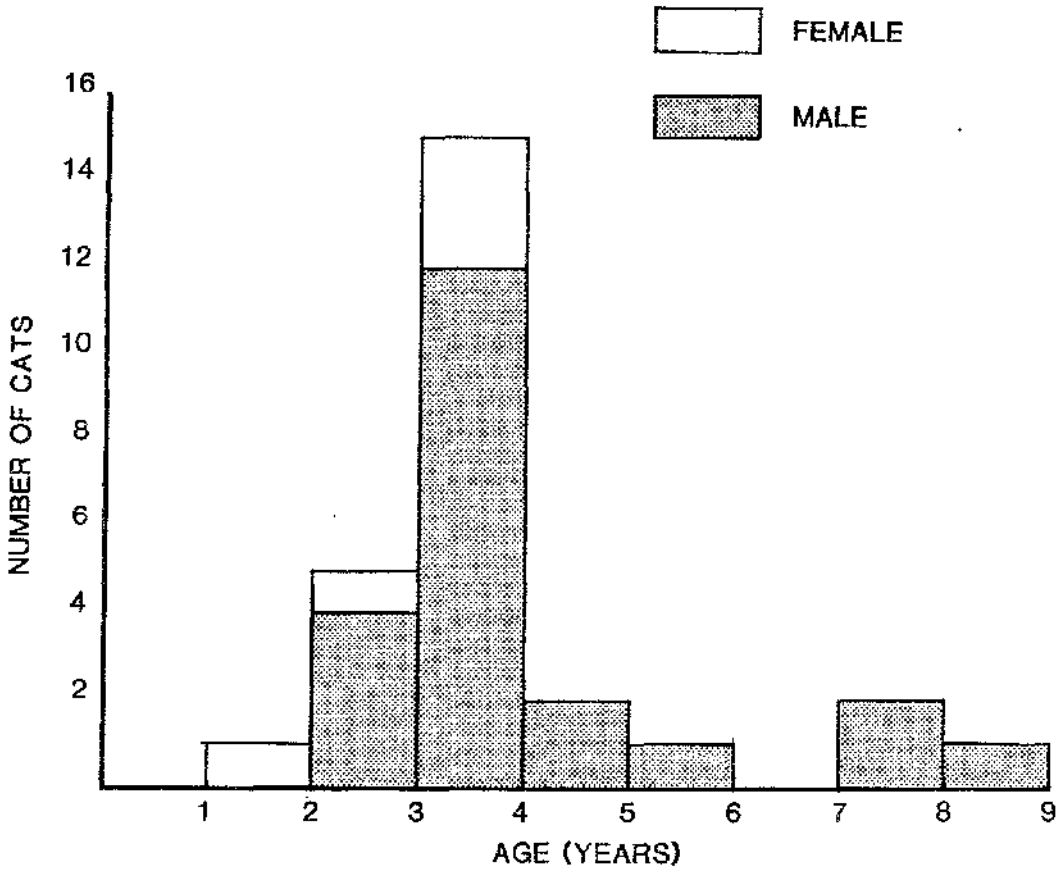
CASE NO.	SEX	AGE AT FIRST REFERRAL (yr)	PRESENTING SIGNS		FOLLOW UP	OUTCOME	TIME FROM REFERRAL TO OUTCOME
			Nephrotic Syndrome	Renal Failure			
70151	M	3	+		-	Euth	6 mth
71377	MC	7	+		-	Euth	6 wk
71570	MC	2½	+		-	Died	4 days
85273	FS	3½	+		-	Alive	2½ yr
86792	MC	3	+		-	Euth	6 wk
81982	MC	3¾	+		-	Alive	1 yr
91585	MC	8	+		-	Died	2 mth
62718	MC	3	+		B+N	Euth	3 yr
66669	MC	3	+		N	Died	2½ mth
70865	MC	4	+		N	Euth	2½ yr
71792	MC	3½	+		B+N	Euth	4 mth
73644	MC	7	+		B+N	Euth	3 mth
74368	MC	3		+	N	Euth	1 mth
78535	FS	3	+		N	Euth	2 days
78897	MC	2½	+		N	Died	3 wk
79837	MC	3	+		N	Euth	4 wk
80204	FS	1	+		B	Alive	3½ yr
80589	FS	3	+		B+N	Euth	1 yr
82525	M	3	+		B	Alive	3 yr
82987	M	2	+		N	Died	4 wk
83187	M	5	+		B+N	Euth	11 mth
83976	MC	3		+	N	Euth	1 day
89236	M	3	+		N	Euth	6 wk
90812	MC	2½	+		N	Euth	2 mth
91631	MC	4	+		N	Euth	6 wk
91890	FS	3	+		N	Euth	6 mth
92587	MC	3	+		N	Euth	4 mth

With the exception of case no. 82525 which was domestic long haired all the cats were domestic short haired.

M - male MC - castrated male FS - spayed female B - biopsy N - necropsy Euth. - euthanasia

FIGURE 3.1.

AGE DISTRIBUTION OF 27 CATS WITH MEMBRANOUS NEPHROPATHY AT FIRST REFERRAL



Nephrotic syndrome cases

The most striking feature was the presence of oedema (Table 3.4). This was manifested initially in the lower hindlimbs (24 cats) and as ascites (23 cats) (Figures 3.2, 3.3 and 3.4). Pitting oedema in the hindlimbs was present up to the level of the tarsal joints in most cases but in a few it extended as far as the stifle area. Later, the ventral body wall became oedematous in 20 cases and this varied from a small increase in the thickness of the skin in the inguinal region to a massive swelling of the entire ventral body wall from the thoracic inlet to the lower perineum. The lower forelimbs became swollen in 12 cats and in 3 cases oedema extended up to the level of the elbow joints. In 5 cats the head and neck were also oedematous. Varying degrees of ascites were detected in 14 cats. Hydrothorax was detected in 4 cats in which there was hyperpnoea or tachypnoea. The presence of free pleural fluid was confirmed in lateral thoracic radiographs.

Twenty one cats were thin or were in poor body condition on initial examination even though in some cases fluid retention had caused an overall weight increase. In other cases weight loss became obvious following diuretic therapy and regression of the oedema fluid. Dullness and reduced mobility were noted in 19 cases. Ocular and oral mucous membranes were slightly pale in 14 cases and markedly pale in one other (case no. 78535). Appetite was reduced in 11 cats but total anorexia was uncommon. Twelve cats were noticed to be thirsty; polyuria and polydipsia was often first observed when the animal developed a preference for water and drank from unusual sources. Ten cats suffered from diarrhoea and in some cases this was recurrent. Vomiting was uncommon and was reported in only 4 cases prior to referral (case nos. 71570, 85273, 86792, and 90812). Two other cats (case nos. 66669 and 78897) vomited while hospitalised. Three cats (case nos. 66669, 71570 and 90812) developed intussusceptions. Only 2 cats (case nos. 78535 and 89236) showed evidence of uraemic halitosis on initial examination.

TABLE 3.4

INITIAL CLINICAL FINDINGS IN 27 CATS WITH MEMBRANOUS NEPHROPATHY

Case Number	Loss of condition	Dull/ Inactive	Temp. (°F)	Heart rate/min	Respiratory rate/min	FLUID RETENTION						KIDNEYS		
						Hind limb	Fore limb	Body wall	Ascites	Head	Hydro-thorax	Enlarged	Normal	Small
70151	+	-	N	160	36	+	-	+	+	-	-	+	-	-
71377	+	+	N	180	28	+	+	+	+	-	-	+	-	-
71570	+	+	100.2	200	28	+	-	+	+	-	-	-	+	-
82573	+	+	N	240	100	+	+	+	+	+	+	+	-	-
86792	-	-	N	180	30	+	-	+	+	-	-	+	-	-
81982	+	+	N	200	28	+	-	+	-	-	-	-	+	-
91585	+	+	N	200	60	+	-	+	+	-	-	+	-	-
62718	-	-	N	186	38	+	-	+	+	-	+	+	-	-
66669	+	+	N	200	42	+	-	-	+	-	-	-	+	-
70865	+	-	N	170	45	+	+	-	-	-	-	+	-	-
71792	+	+	N	200	36	+	+	+	+	+	-	-	+ *	-
73644	+	+	N	190	36	+	-	+	+	-	-	+	-	-
74368	+	+	N	180	40	-	-	-	-	-	-	-	-	+
78535	+	+	N	150	30	-	-	-	+	-	-	-	+	-
78897	+	-	103.5	180	24	+	-	+	+	-	-	-	+	-
79837	+	-	N	230	28	+	-	-	+	-	-	+	-	-
80204	-	+	N	220	48	+	+	+	+	-	-	-	+	-

TABLE 3.4 Cont'd

Case Number	Loss of condition	Dull/ Inactive	Temp. (°F)	Heart rate/min	Respiratory rate/min	FLUID RETENTION						KIDNEYS		
						Hind limb	Fore limb	Body wall	Ascites	Head	Hydro-thorax	Enlarged	Normal	Small
80589	-	+	N	200	32	+	+	+	+	+	-	-	+	-
82525	+	-	N	160	36	+	+	+	+	-	-	-	+	-
82987	+	-	N	180	42	+	+	+	+	+	-	+	-	-
83187	+	+	N	180	36	+	+	+	+	+	+	-	+	-
83976	+	+	100.6	200	30	-	-	-	-	-	-	+	-	-
89236	+	+	N	160	40	+	+	+	+	-	-	-	+	-
90812	-	+	N	200	46	+	+	+	+	-	+	+	-	-
91631	+	+	N	200	36	+	+	+	+	-	-	+	-	-
91890	-	+	N	180	40	+	-	+	+	-	-	+	-	-
92587	+	+	N	210	30	+	-	-	+	-	-	-	+	-
Totals	21	19	24N 1F 2SN			24	12	20	23	5	4	14	12	1

N - normal (101.5°F)

F - Febrile

SN - sub-normal

' Oedema described by owner

* Kidneys were not palpable until ascites reduced

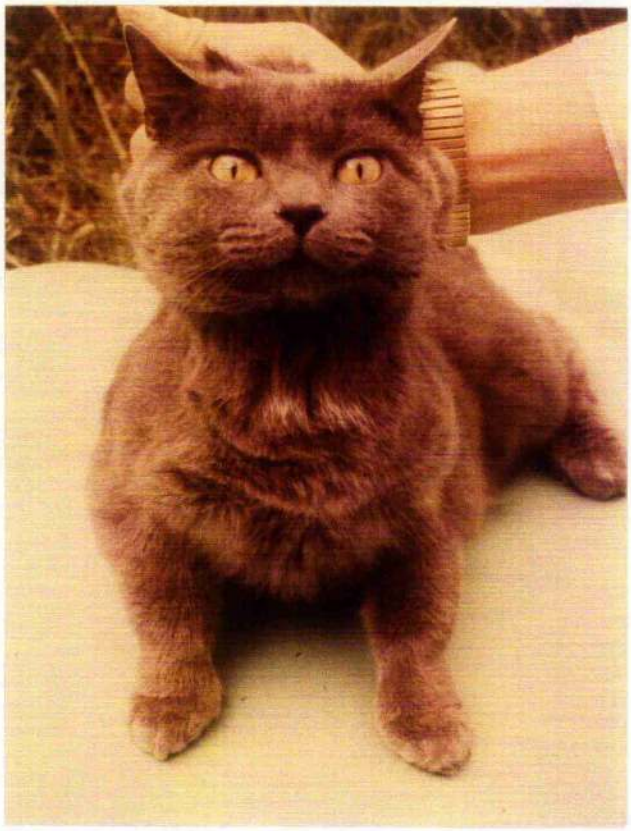


FIGURE 3.2. Nephrotic syndrome (Cat no. 83187). Oedema of the head and both forelimbs, especially the left, in which there is obvious waisting at the carpus.

FIGURE 3.3. Nephrotic syndrome (Cat no. 83187). Hind limb oedema especially the right in the tarsal region.

FIGURE 3.4. Nephrotic syndrome (Cat no. 91890). Severe abdominal swelling due to ascites and moderate oedema of the upper hind limbs. (Neck and shoulders appear foreshortened due to restraint for photography).

Non-nephrotic cases

In both cats (case nos. 74368 and 83976) polydipsia, polyuria and weight loss were evident for up to 2 months prior to referral. A progressive dullness and reduction in appetite followed. Later still, both cats began to vomit. Case no. 83976 was in a collapsed state when referred and had uraemic halitosis with associated lingual and buccal ulceration (Figure 3.5).

Initial laboratory findings

A summary of the initial haematological and biochemical findings for each case is given in Table 3.5.

Initial haematocrit levels ranged from 0.37 l/l down to 0.18 l/l with an average of 0.30 l/l. With 0.30 l/l taken as the lower limit of normality, 11 cats were anaemic. Of these, 10 cats were mildly anaemic (haematocrit range from 0.25 to 0.29 l/l) and only one (case no. 78535) was severely anaemic.

Total white blood cell counts on admission varied widely in a range from 1.6 x 10^9/l up to 46.0 x 10^9/l, with an average of 20.7 x 10^9/l. With the normal range taken as 6.0 to 20.0 x 10^9/l, one cat (case no. 62718) was severely leukopaenic, while 11 cats had a leukocytosis.

Initial plasma urea levels ranged from 7.1 to 110.0 mmol/l with an average of 24.6 mmol/l. Fasting plasma urea levels in the normal cat are less than 9.0 mmol/l. Only 4 cats had normal urea levels at initial examination (Table 3.5).

Plasma albumin levels were all reduced, in a range from 25 g/l to as low as 3 g/l, with an average of 13.5 g/l. The albumin level in normal cats is in the range 35 to 45 g/l. Seventeen cats were hyperglobulinaemic and ranged overall from 25 g/l up to 60 g/l, with an average of 40.5 g/l. The globulin level in normal cats is in the range 30 to 35 g/l.

Plasma cholesterol levels were measured in 21 cases while the cats were nephrotic and these ranged from 1.9 mmol/l to 12.4 mmol/l with an average of 5.7 mmol/l. In 18 cases cholesterol levels were higher than the normal upper limit in the cat of 4.1 mmol/l. One non-nephrotic cat (case no. 83976) was also hyercholesterolaemic.

TABLE 3.5

INITIAL LABORATORY FINDINGS IN 27 CATS WITH MEMBRANOUS NEPHROPATHY

	HAEMATOLOGY		PLASMA BIOCHEMISTRY						URINE ANALYSIS	
Case Number	Haematocrit (l/l)	Total White cells ($\times 10^9$/l)	Urea (mmol/l)	Albumin (g/l)	Globulin (g/l)	Creatinine (µmol/l)	Cholesterol (mmol/l)	Phosphate (mmol/l)	Protein (mg%)	Specific gravity
70151	.33	10.4	25.5	7	54	239	5.8	2.5	2300	1 031
71377	.27	7.1	38.3	10	39	ND *	5.9	5.8	1100	1.032
71570	.34	18 7	37 6	11	33	179	3.2	3.4	460	1 044
82573	.31	17.6	12.5	10	31	150	1.9	1.5	1800	1.050
86792	.30	18.2	22.3	14	36	212	6.3	1.1	250	1.015
81982	.34	13.2	12.9	15	34	106	4.9	2.2	340	1 026
91585	.30	22.5	14.7	20	42	124	7.2	2.3	662	1 024
62718	.35	1.6	11.1	6	56	71	ND	2.1	1870	1 039
66669	.29	27.5	12.9	5	60	231	ND	1.2	5600	1 050
70865	.35	17.8	16.8	9	44	150	7.4	1.7	3500	1 046
71792	.25	12.5	7.1	3	51	ND	ND	ND	875	1.046
73644	.26	6.1	15.0	6	44	133	4.5	1.7	1100	1 034
74368	.34	34 6	31.2	8	54	231	ND	2.9	159	1 020
78535	.18	34.8	52.9	18	29	265	4.7	6.5	1120	1 027
78897	.30	25.7	31.4	22	27	177	5.1	1.9	2100	1 049
79837	.28	6.7	43.2	19	31	302	6.5	ND	1300	1 027
80204	.29	20.3	12.8	10	29	124	4.3	1.9	2640	1 046

TABLE 3.5 Cont'd)

Case Number	HAEMATOLOGY		PLASMA BIOCHEMISTRY						URINE ANALYSIS	
	Haematocrit (l/l)	Total White cells ($\times 10^9$ /l)	Urea (mmol/l)	Albumin (g/l)	Globulin (g/l)	Creatinine (µmol/l)	Cholesterol (mmol/l)	Phosphate (mmol/l)	Protein (mg%)	Specific gravity
80589	.37	37.6	7.1	17	39	133	4.5	1.8	730	1.021
82525	.29	41.9	7.7	24	25	88	4.4	1.2	920	1 025
82987	.30	40.7	22.3	13	42	159	5.1	2.1	4000	1 055
83187	.32	46.0	22.3	12	58	124	5.6	2.4	1580	1 040
83976	.28	15.5	110.0	25	48	610	8.2	5.9	324	1 025
89236	.27	10.3	32.5	16	35	141	12.4	1.9	505	1.050
90812	.32	14.3	11.9	23	38	115	5.5	1.4	1125	1 030
91631	.28	14.2	33.1	17	35	185	6.1	2.7	1325	1 039
91890	.32	15.3	8.8	13	42	106	5.7	1.7	1000	1 050
92587	.30	28.8	11.1	11	38	141	2.7	2.6	1000	1.036
AVERAGE	.30	20.7	24.6	13.5	40.5	179.8	5.6	2.5	1470	1 036
NORMAL	>.30	<20 0	<9.0	~ 40	~ 35	<150	1.8-4.1	<3.0	0-30	>1 025

* ND - not done

FIGURE 3.5. Terminal renal failure (Cat no. 83976). Extensive lingual and gingival ulceration.

Urine protein levels were consistently high with a range from 159 mg. per cent up to 5600 mg. per cent. Twenty two cats had urine protein levels of 500 mg. per cent or more and of the other 5, 2 were non-nephrotic and another (case no. 86792), was already on diuretic treatment and had dilute urine. The 2 non-nephrotic cats and cat no. 81982 subsequently had levels of proteinuria of over 1000 mg. per cent. The average level of urine protein at initial examination was 1470 mg. per cent.

Urine specific gravity ranged from 1.015 (case no. 86792) up to 1.055, with an average of 1.036.

Blood from all 27 cats was examined for the presence of FeLV infections and was negative in all cases. Serum from 13 cats was examined for the presence of viral neutralising antibodies to FeLV. In 4 cases (cat nos. 62718, 70865, 90812 and 91631) low levels of antibody were present and the other 9 were negative. Serum from the same 13 cats was examined for the presence of antibodies to F.I.P. virus. Three cats (cat nos. 70865, 80589 and 82987) had insignificant titres and the other 10 were negative.

Blood from 8 cats (case nos. 62718, 73644, 74368, 79837, 80204, 81982, 82525 and 82987) was examined for LE cells. No LE cells were demonstrated.

Mouth swabs from 10 cats (case nos. 70865, 71792, 73644, 80204, 81982, 82525, 83187, 91631, 91890 and 92587) were examined for the presence of upper respiratory tract viruses. In one case (no. 73644) feline calicivirus was isolated while all the other cases were negative.

Management and Follow-up studies

All 27 cats were hospitalised on the day of initial examination. Twenty four were oedematous on admission, one other (case no. 71377) had been oedematous previously but had recovered after diuretic therapy, and 2 were never oedematous (case nos. 74368 and 83975). Oedematous cats were treated with frusemide ("Lasix", Hoechst, U.K. Limited, Hounslow, England) at the recommended dose rate of 5.0 mg. per kg., by intramuscular injection soon after admission and thereafter once daily. Frusemide tablets ("Lasix" 40 mg.) were given orally at a dose rate of approximately 7 mg. per kg. (half a tablet per 3 kg). once daily in cases where cats tolerated oral therapy.

In addition to the 3 cats which were not nephrotic on admission to the hospital (case nos. 71377, 74368 and 83976) one nephrotic cat (case no. 78535) also did not receive diuretic therapy as she had only very mild ascites and was in terminal renal failure. Another cat (case no. 71570) only received diuretic therapy for 2 days and was dead within 4 days of admission. Of the 22 cats which received diuretic treatment over longer periods, initial therapy resulted in complete resolution of oedema in 20 cases in 3 to 14 days, with an average of 7 days. In the other 2 cases (case nos. 91631 and 91890) diuretic treatment was less effective, especially in the latter, which required manual drainage of the ascitic fluid on several occasions.

Seven cats (case nos. 70151, 71377, 78897, 79837, 80204, 82525 and 82987) did not receive further diuretic therapy, but of these, 3 cats were dead within 3 weeks of being discharged (case nos. 71377, 78897 and 79837) and in one case (no. 78897) oedema was present at necropsy examination. The remaining 13 cats all had at least one further episode of oedema commencing at intervals ranging from 1 week up to 6 months after the initial course of diuretic treatment. Four cats (case nos. 85273, 71792, 83187 and 92587) had more than one recurrence and in 1 case (no. 71792) the cat remained on continuous diuretic therapy after the second relapse until euthanasia. Another cat (case no. 86792) remained on a reduced dose of diuretic therapy for 4 weeks after being discharged and was then euthanased 1 week after treatment was stopped.

Prednisolone ("Delta-Cortril", Pfizer, Sandwich, England), was given orally to case nos. 66669 and 91585 at the rate of 5 mg. daily for 8 days and then, in the latter case, reduced to 2.5 mg. daily for 14 days. Prednisolone was given orally to case no. 80204 at the rate of 5 mg. daily for 5 days and then 2.5 mg for 5 weeks, after which the dose was halved for a further 2 weeks. Betamethasone ("Betsolan", Glaxovet, Greenford, England), was given orally for 3 weeks and 5 weeks respectively. There was no indication that these preparations either helped to control oedema or affected the course of the disease.

A course of antibiotic treatment using either ampicillin ("Penbritin" injection and capsules, Beecham Animal Health, Brentford, England) or trimethoprim and sulphadiazine ("Tribrissen 20" tablets, The Wellcome Foundation Limited, Crewe, England) was given to cats with elevated white blood cell counts for periods ranging from 3 to 7 days.

On regression of oedema, most of the cats became brighter and had an improved appetite. Case nos. 71792, 91631 and 91890, which had more persistent oedema, remained rather dull throughout the course of their illness, although the latter cat became brighter for short periods following the occasions on which abdominal parentesis was carried out.

Cats were followed-up at varying intervals throughout the remaining period of their lives. In 2 cases (nos. 70151 and 86792) the cats were not examined again following their discharge from hospital but verbal reports were received from their owners regarding events leading up to euthanasia.

Two cats (case nos. 66669 and 82987) had persistent diarrhoea until their death and another 6 cats (case nos. 70865, 82573, 89236, 90812, 91585 and 92587) had episodes of diarrhoea later in the course of the disease.

The outcome of each case is summarised in Table 3.3. Two cats were euthanased for domestic reasons (case nos. 70151 and 73644). Fifteen cats were euthanased or died either in terminal renal failure or with evidence of chronic renal failure; one other (case no. 71792) had intractable oedema. One cat died following surgical correction of an intussusception (case no. 71570); another cat (case no. 90812) was euthanased in extremis and at necropsy was found to have an intussusception; one cat (case no. 78897) died from the effects of a pulmonary arterial thrombosis; and one other (case no. 66669) died from the effects of both an intussusception and pulmonary arterial thrombosis.

Four cats are still alive, of which 3 have a protein losing nephropathy (case nos. 81982, 82525 and 85273), while one cat (case no. 80204) has been in complete clinical remission for more than 2 years.

Biopsy results

In all cases, renal biopsy was performed on the left kidney using the direct percutaneous approach and the cat anaesthetised with ketamine hydrochloride. The biopsy findings have been recorded previously in Chapter 2 but are further presented in conjunction with the renal findings at necropsy (where carried out) in Table 3.6. Subsequent biopsies were performed on 7 cats (case nos. 62718, 71792, 73644, 80204, 80589, 82525 and 83187).

Glomeruli were present in all samples except the first from case no. 85273. This cat was re-biopsied 2 weeks later and glomeruli were present in this specimen; only the second biopsy findings have been recorded for this animal in Table 3.6. In the fourth biopsy specimens from case nos. 62718 and 82525, glomeruli were not present in the histological sections and only one squashed glomerulus was present in the histological section of the biopsy from case no. 91585. On these occasions no assessment of glomerular features could be made but a diagnosis was possible because glomeruli were present in sections examined for immunofluorescence and by electron microscopy. Numbers of glomeruli present per histological sample ranged from 1 (on 2 occasions from case no. 62718) to 24 (case no. 71792) with an average of 8.3. In each case, with the exception of case no. 91585, the diagnosis of membranous nephropathy was based on a combination of histological, immunofluorescence and electron microscopical findings.

Necropsy findings

Of the 23 cats which were euthanased or died, 5 were not made available for post-mortem examination (case nos. 70151, 71377, 71570, 86792 and 91585). However, the intra-abdominal organs of case no. 71570 were observed during laparotomy when an intussusception was resected, and apart from this feature, there was moderate ascites present and oedema of the abdominal and intestinal walls.

Full necropsy examinations were carried out on 17 cats and in one other (case no. 71792) the examination was limited to the abdomen.

The extra-renal lesions found at necropsy examination in 14 cats are summarised in Table 3.7. Reports of necropsy examinations are detailed in Appendix C.

TABLE 3.6

FELINE MEMBRANOUS NEPHROPATHY: SUMMARY OF GLOMERULAR PATHOLOGY IN 27 CASES

CASE No.	BIOPSY (B) NECROPSY (N)	GLOMERULAR SCARRING				OTHER GLOMERULAR LESIONS			IMMUNOFLUORESCENCE		ELECTRON DENSE DEPOSITS	GRADE	Interval Between First Biopsy And Necropsy
		NORMAL	<50%	>50%	100%	LOOP THICKENING	FIBRIN	ADHESIONS	IgG	C3			
70151	B	1(11)	7(11)	2(11)	1(11)	1+ 3(11)	-	1+ 3(11)	+	ND	+	M/S	Biopsy only
71377	B	3(13)	3(13)	7(13)	1(13)	2+ 12(13)	1+ 2(13)	3+ 7(13)	+	+	+	Adv	Biopsy only
71570	B	5(9)	4(9)	0(9)	0(9)	-	-	-	+	ND	+	Mild	Biopsy only
85273	B	2(16)	2(16)	3(16)	9(16)	1+ 7(16)	1+ 1(16)	2+ 4(16)	+	+	+	Adv	Biopsy only
86792	B	5(13)	7(13)	1(13)	0(13)	1+ 13(13)	2+ 3(13)	1+ 2(13)	+	+	+	M/S	Biopsy only
81982	B	6(9)	2(9)	0(9)	1(9)	1+ 8(9)	-	-	+	+	+	M/S	Biopsy only Alive
91585	B	-	-	-	-	-	-	-	+	+	+	M/S*	Biopsy only
62718	B1	1(1)	0(1)	0(1)	0(1)	2+ 1(1)	-	-	+	+	ND	M/S	3 Years
	B2	0(1)	1(1)	0(1)	0(1)	2+ 1(1)	-	-	ND	ND	ND	M/S	
	B3	0(6)	5(6)	0(6)	1(6)	2+ 5(6)	-	-	ND	ND	+	M/S	
	B4	0(0)	0(0)	0(0)	0(0)	NA	NA	NA	+	+	+	M/S	
	B5	4(11)	3(11)	2(11)	2(11)	2+ 9(11)	-	1+ 1(11)	+	ND	+	M/S	
	B6	0(8)	6(8)	1(8)	1(8)	2+ 7(8)	-	1+ 1(8)	+	+	ND	M/S	
	N	21	47	14	18	3+	1+	2+	+	+	+	Adv.	
66669	B	0(2)	2(2)	0(2)	0(2)	2+ 2(2)	-	1+ 1(2)	+	+	+	M/S	2 months
	N	7	60	29	4	2+	1+	2+	+	+	+	M/S	
70865	B	7(10)	3(10)	0(10)	0(10)	1+ 10(10)	-	-	+	+	+	Mild	2½ years
	N	?	21	55	22	3+	2+	3+	+	+	+	Adv.	

* One only squashed glomerulus on histology. Assessment made on appearance of one glomerulus examined by immunofluorescence

NA = Not assessed ND = Not done. M/S = Moderately severe Adv. = Advanced.

TABLE 3.6 (Cont'd)

CASE No.	BIOPSY (B) / NECROPSY (N)	GLOMERULAR SCARRING				OTHER GLOMERULAR LESIONS			IMMUNOFLUORESCENCE		ELECTRON DENSE DEPOSITS	GRADE	Interval Between First Biopsy And Necropsy
		NORMAL	<50%	>50%	100%	LOOP THICKENING	FIBRIN	ADHESIONS	IgG	C3			
71792	B1	4(24)	16(24)	3(24)	1(24)	1+ 23(24)	-	-	+	+	+	Mild	4 months
	B2	1(12)	10(12)	0(12)	1(12)	2+ 11(12)	1+ 1(12)	3+ 7(12)	+	+	+	M/S	
	N	17	40	35	8	2+	1+	1+	+	+	+	M/S	
73644	B1	2(4)	2(4)	0(4)	0(4)	1+ 4(4)	-	-	+	+	+	M/S	
	B2	1(10)	9(10)	0(10)	0(10)	2+ 10/10)	-	1+ 4(10)	+	+	+	M/S	
	N	38	30	22	10	2+	-	1+	+	+	+	M/S	
74368	B	2(10)	2(10)	5(10)	1(10)	2+ 10(10)	1+ 4(10)	2+ 6(10)	+	+	+	Adv.	15 days
	N	2	27	55	16	2+	1+	3+	+	+	+	Adv.	
78535	B	0(2)	1(2)	1(2)	0(2)	3+ 2(2)	-	1+ 2(2)	+	+	+	M/S	2 days
	N	5	20	22	3	3+	1+	2+	+	+	+	M/S	
78897	B	11(19)	7(19)	1(19)	0(19)	2+ 19(19)	1+ 2(19)	1+ 1(19)	+	+	+	M/S	18 days
	N	89	11	0	0	2+	1+	1+	+	+	+	M/S	
79837	B	0(11)	1(11)	6(11)	4(11)	3+ 7(11)	-	3+ 7(11)	+	+	+	Adv.	2 5 days
	N	0	12	50	38	3+	1+	3+	+	+	+	Adv.	
80204	B1	3(19)	14(19)	2(19)	0(19)	1+ 19(19)	-	1+ 4(19)	+	+	+	Adv.	
	B2	7(18)	6(18)	3(18)	2(18)	1+ 18(18)	1+ 2(18)	1+ 6(18)	+	+	+	Mild	
80589	B1	3(5)	2(5)	0(5)	0(5)	2+ 5(5)	-	1+ 1(5)	+	+	+	M/S	1 yr 1 mth
	B2	1(4)	3(4)	0(4)	0(4)	2+ 4(4)	-	1+ 1(4)	+	+	+	M/S	
	N	7	32	39	22	2+	2+	3+	+	+	+	Adv.	

TABLE 3.6 (Cont'd)

CASE No.	BIOPSY (B) NECROPSY (N)	GLOMERULAR SCARRING				OTHER GLOMERULAR LESIONS			IMMUNOFLUORESCENCE		ELECTRON DENSE DEPOSITS	GRADE	Interval Between First Biopsy And Necropsy
		NORMAL	<50%	>50%	100%	LOOP THICKENING	FIBRIN	ADHESIONS	IgG	C3			
82525	B1	2(4)	2(4)	0(4)	0(4)	2+ 4(4)	-	-	+	+	+	Mild	B1-B2 1 yr 2 mths.
	B2	2(3)	1(3)	0(3)	0(3)	2+ 3(3)	1+ 1(3)	-	+	+	+	Mild	
	B3	2(15)	5(15)	2(15)	6(15)	2+ 9(15)	-	3+ 10(15)	+	+	+	M/S	
	B4	0(0)	0(0)	0(0)	0(0)	NA	NA	NA	+	+	+	M/S	
82987	B	1(3)	0(3)	2(3)	0(3)	1+ 3(3)	1+ 2(3)	1+ 2(3)	+	+	+	Adv.	14 days
	N	9	46	39	6	2+	2+	3+	+	+	+	Adv.	
83187	B1	2(10)	8(10)	0(10)	0(10)	2+ 10(10)	-	2+ 4(10)	+	+	+	M/S	11 months
	B2	1(5)	1(5)	2(5)	1(5)	2+ 4(5)	-	2+ 3(5)	+	+	+	M/S	
	B3	0(14)	3(14)	4(14)	7(14)	2+ 7(14)	1+ 2(14)	2+ 7(14)	+	+	+	Adv.	
	N	-	20	43	37	1+	2+	3+	+	+	+	Adv.	
83976	B	0(3)	0(3)	3(3)	0(3)	1+ 3(3)	2+ 3(3)	2+ 3(3)	+	+	+	Adv.	1 day
	N	3	21	39	27	2+	3+	3+	+	+	+	Adv.	
89236	B	3(8)	5(8)	0(8)	0(8)	1+ 1(8)	1+ 1(8)	2+ 2(8)	+	+	+	M/S	6 weeks
	N	2	65	26	7	1+	3+	3+	+	+	+	M/S	
90812	B	4(5)	1(5)	0(5)	0(5)	2+ 5(5)	-	1+ 2(5)	+	+	+	M/S	
	N	37	51	8	4	2+	1+	2+	+	+	+	M/S	
91631	B	3(10)	6(10)	1(10)	0(10)	1+ 10/10)	-	1+ 2(10)	+	+	+	M/S	6 weeks
	N	8	51	35	6	2+	1+	2+	+	+	+	Adv.	

TABLE 3.6 (Cont'd)

CASE No.	BIOPSY (B) NECROPSY (N)	GLOMERULAR SCARRING				OTHER GLOMERULAR LESIONS			IMMUNOFLUORESCENCE		ELECTRON DENSE DEPOSITS	GRADE	Interval Between First Biopsy And Necropsy
		NORMAL	<50%	>50%	100%	LOOP THICKENING	FIBRIN	ADHESIONS	IgG	C3			
91890	B	3(3)	0(3)	0(3)	0(3)	-	1+ 1(3)	-	+	+	+	Mild	6 months
	N	13	66	13	8	3+	2+	3+	+	+	+	M/S	
92587	B	0(9)	5(9)	4(9)	0(9)	2+ 8(9)	-	2+ 7(9)	+	+	+	M/S	4 months
	N	3	25	47	25	3+	2+	3+	+	+	+	Adv.	

TABLE 3.7

EXTRA-RENAL LESIONS FOUND AT NECROPSY EXAMINATION IN 14 CATS WITH MEMBRANOUS NEPHROPATHY

Case Number	Extra-renal lesions
62718	Emaciation; oral ulceration
66669	Peripheral oedema; pulmonary arterial thrombosis; intussusception
70865	Emaciation
71792	Peripheral oedema; ascites
78897	Peripheral oedema; ascites; pulmonary arterial thrombosis
79837	Calcification of aorta and pulmonary artery
80589	Emaciation; oral ulceration
83187	Oral and lingual ulceration
83976	Pneumonia and pulmonary calcification
89236	Oral and lingual ulceration; haemorrhagic gastritis; parathyroid hyperplasia
90812	Emaciation; intussusception
91631	Ascites
91890	Emaciation; intercostal myositis; calcification of the aorta
92587	Severe chronic cystitis; cholangitis

Histopathological findings

All 27 cases were initially assessed according to the biopsy findings which were later compared with subsequent biopsy findings (57 cats) and necropsy findings (18 cats). Of prime concern were the changes in the glomeruli observed by light, electron and fluorescence microscopy.

The criteria used for the histologic diagnosis of membranous nephropathy were:

1. Diffuse (all glomeruli involved) thickening of the glomerular basement membranes without major proliferative (mesangial) changes;

2. Presence of deposits scattered along the glomerular basement membrane as visualised with trichrome stains;

3. Spiky nature of the glomerular basement membrane when stained with silver methenamine;

4. Presence of sub-epithelial and intramembranous electron dense deposits scattered along the glomerular basement membrane;

5. Granular immunofluorescence pattern of IgG and C3 again scattered along the capillary walls.

All 27 cases showed these features to a varying extent and, depending on the overall degree of involvement, each first biopsy was graded as "mild," "moderately severe", or "advanced". These assessments were made independently of the available clinical and biochemical data. Subsequent biopsies and the final necropsy features were likewise graded in an attempt to ascertain whether or not the glomerular lesions had stablised or deteriorated. As the immunofluorescence patterns did not seem to vary greatly among the cases, except in so far as the deposits of IgG and C3 tended to be heavier in the moderately severe and advanced cases, grading of severity was based mainly on a semi-quantitative assessment of the glomerular alterations in both biopsy and necropsy material. Thus in each biopsy specimen, the number of glomeruli was counted and the range of parameters such as the degree of loop thickening and overall glomerular scarring was assessed. In the latter respect, the term "scarring" was used to denote segmental (part of a glomerulus) or global (all of the glomerulus) obliteration of glomerular capillaries due to

collapse and extensive thickening of the glomerular basement membrane with adjacent, often expanded mesangial matrix thus becoming contiguous. Where scarring was global, the term "glomerular obsolescence" was used. The incidence of fibrin deposition and capsular adhesions was also recorded.

At necropsy, one hundred glomeruli were assessed from the non-biopsied kidney. As some cases were biopsied repeatedly and thereby some degree of renal damage was artificially induced, it was judged that a true assessment of the glomerular alterations between biopsy and necropsy could only be made on the non-biopsied kidney. These glomerular alterations and assessments are presented in summary in Table 3.6.

Ultrastructural findings, however, were also of prime importance in assessing not only the degree of deposition of immune complexes but also the other glomerular alterations, particularly the nature and extent of expansion of the mesangial matrix.

No assessment as to the morphologic progression of the disease could be made in the 7 cats biopsied only once and either still alive or dead but not examined at necropsy. In 3 other cats (case nos. 78535, 83976 and 71792 (second biopsy), necropsy was performed within 2 days of biopsy and no meaningful information was available about progression of the disease. However, in these cases, necropsy served to show that, in the main the biopsy specimen, provided a sufficient number of glomeruli were present, gave a true reflection of the histological diagnosis and the extent of overall glomerular involvement at that particular time.

Mild group (7 cases: Nos. 71570, 70865, 71792, 73644, 80204, 82525 and 91890)

In this group, thickening of capillary loops was minimal or judged equivocal. On examination with sections stained with haemotoxylin and eosin alone a feature common to all 7 cases was mild expansion of the mesangial matrix (Figure 3.6). Staining with silver methenamine proved inconclusive and no obvious spiky alterations of the glomerular basement membrane could be determined. Immunofluorescence examination, however, showed fine granular deposition of IgG and C3 along the capillary walls (Figure 3.7).

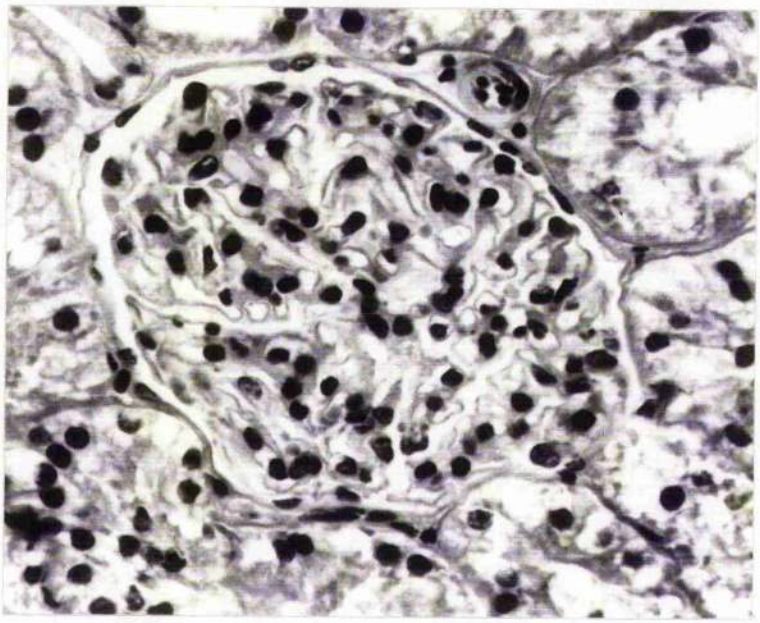


FIGURE 3.6. "Mild" membranous nephropathy. Biopsy specimen from Cat no. 70865. Thickening of the capillary loops is minimal and there is no scarring. There is an apparent increase in the mesangial matrix. H & E; x 285.

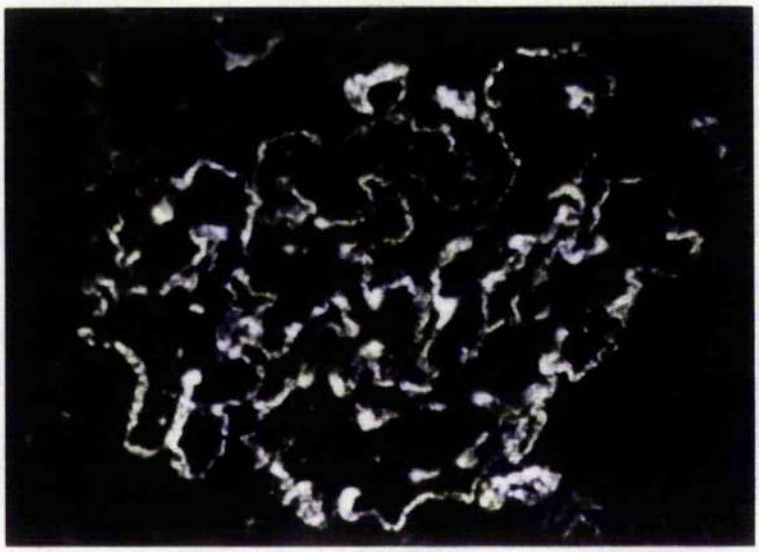


FIGURE 3.7. "Mild" membranous nephropathy.
Biopsy specimen from Cat no. 70865
showing granular deposition of IgG along
the capillary walls.
Immunofluorescence; x 350

On electron microscopy, sparse electron dense deposits were found in subepithelial locations in all cases. Obliteration of the foot processes of the podocytes was also prominent, and many loops showed only this latter finding (Figure 3.8). It was of interest to note that the degree of deposition of IgG and C3 was always much greater than might otherwise be expected in relatively histologically normal glomeruli with a few electron dense deposits.

Only 4 cats in this group have been followed through to necropsy as case no. 71570 was not available for necropsy and case nos. 80204 and 82525 are still alive. Case no. 80204 was re-biopsied after an interval of 5 months and was again placed in the mild group. However, subsequent clinical examinations have shown that this cat has apparently made a complete recovery. Case no. 82525 was re-biopsied on 3 occasions, after intervals of 6 months, 1 year and 2 years, respectively. On the first occasion the cat was retained in the mild group but subsequently was placed in the moderately severe group because loop thickening was more established. Nevertheless, the cat has remained well after more than 3 years, although he is still heavily proteinuric.

Case no. 71792, after a comparatively short interval of 4 months, was placed in the moderately severe group because, at the second biopsy taken immediately prior to necropsy, loop thickening was now well established. Case no. 91890 followed a similar pattern and was transferred to the moderately severe group at necropsy after 6 months. Case no. 73644, when first evaluated, was placed in the mild group. Of particular interest in this case was the fact that the electron dense deposits were, in the main, mesangial and subendothelial. Only a few subepithelial deposits were found. (Figure 3.10). Two months later, a second biopsy showed, in addition to thickening of the capillary loops, electron dense deposits located in a definite subepithelial as well as intramembranous position; a few mesangial deposits were found, but no subendothelial deposits were evident. This case was subsequently placed in the moderately severe group and this was confirmed at necropsy 2 weeks later. Case no. 70865 was necropsied after an interval of more than 2 years and had during that time progressed to an advanced stage.

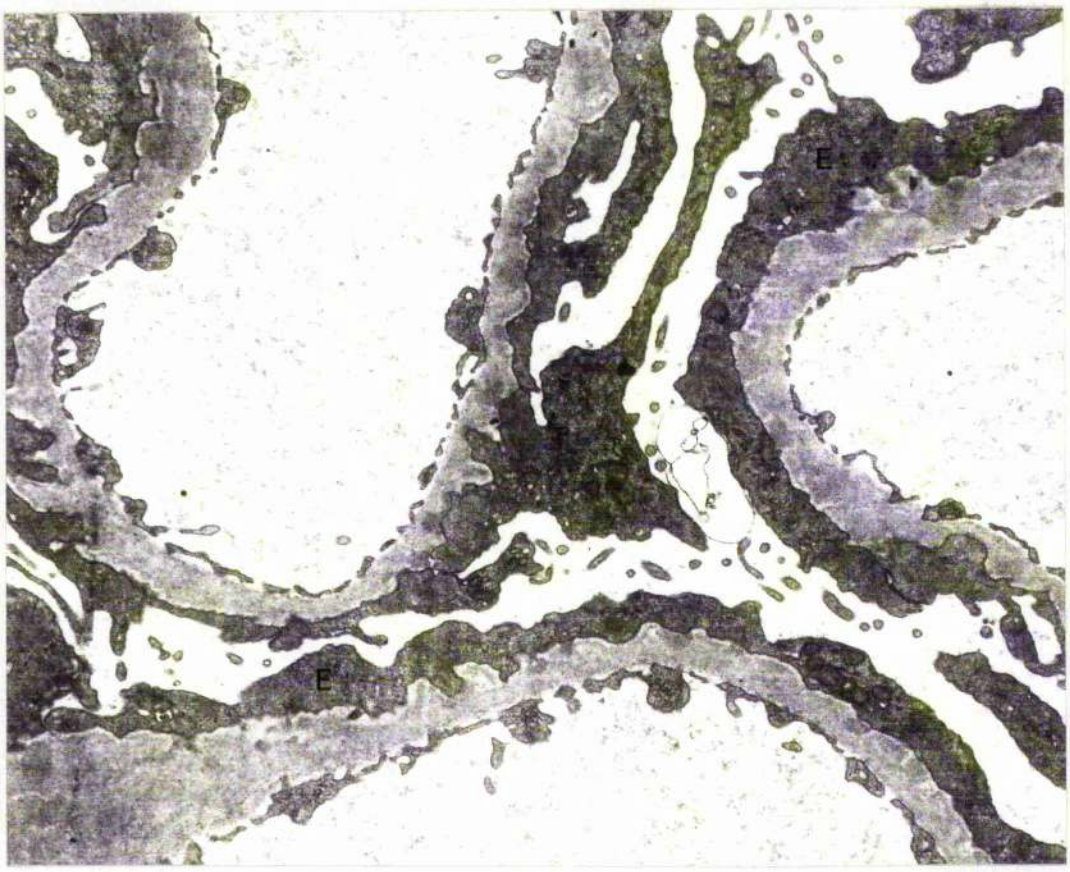


FIGURE 3.8. "Mild" membranous nephropathy. Biopsy specimen from Cat no. 70865. Three capillary loops showing distinct fusion of the foot processes of the epithelial cells (E). Small electron dense deposits are visible in subepithelial and intramembranous locations. Electron microscopy; x 10500.

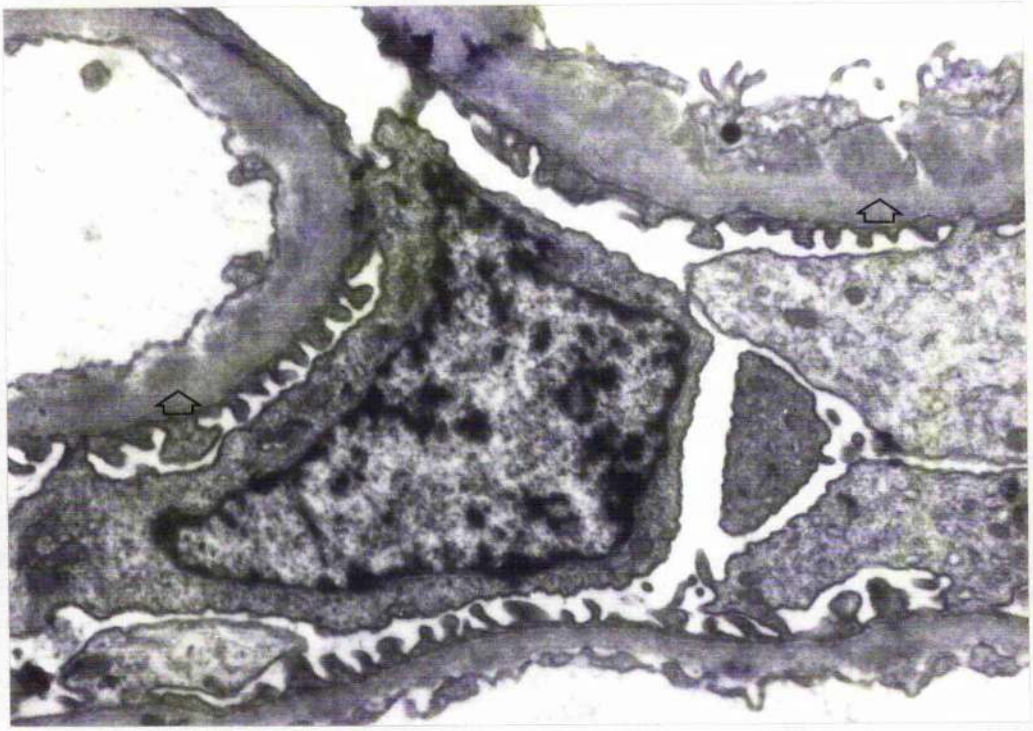


FIGURE 3.9. First biopsy, Cat no. 73644.
Epithelial cell foot processes are quite distinct and electron dense deposits are in subendothelial locations (arrows).
Electron microscopy; X 10500.

Moderately severe group (14 cases: Nos. 70151, 62718, 66669, 78535, 78897, 80589, 81982, 83187, 86792, 89236, 90812, 91585, 91631 and 92587).

At first biopsy this group was characterised by well established loop thickening (Figure 3.10), and immunofluorescence deposits of IgG and C3 were heavy (Figure 3.11). Subepithelial and intramembranous deposits were extensive, but what characterised this group from the mild cases was the degree of loop thickening which was by far the most expressive of the glomerular lesions (Figure 3.12). The Masson trichrome stain showed particularly clearly the extent of the deposits scattered along the glomerular basement membrane. Moreover, the silver methenamine stain showed the characteristic spiky appearance of the glomerular basement membrane (Figure 3.13).

In general, the degree of focal glomerular scarring and incidence of fibrin deposition and adhesions between the glomerular tuft and Bowman's capsule distinguished this group from the mild cases (Figure 3.11). The overall range of glomerular lesions in this group appeared to be wide; thus, whereas some cases were characterised by loop thickening with few other glomerular alterations, others showed a greater range of glomerular changes.

Case no. 81982 is still alive and has not been re-biopsied. Case nos. 70151, 86792 and 91585 were only biopsied once and were not necropsied, and case no. 78535 was necropsied only 2 days after biopsy. No meaningful conclusions were drawn from the latter case, except that the necropsy findings confirmed the biopsy conclusions.

Case nos. 66669, 78897 and 90812 all died within a relatively short time after biopsy. In the first 2 cases, pulmonary arterial thrombosis was the cause of death and intussusceptions were found in case nos. 66669 and 90812. In none of these cases was there any apparent progression of the disease and they remained in the moderately severe group.

Two cats (case nos. 89236 and 91631) developed terminal renal failure 6 weeks after biopsy. At necropsy the former showed no apparent change in the severity of the glomerular changes but in the latter there had been a progression and it was transferred to the advanced group.

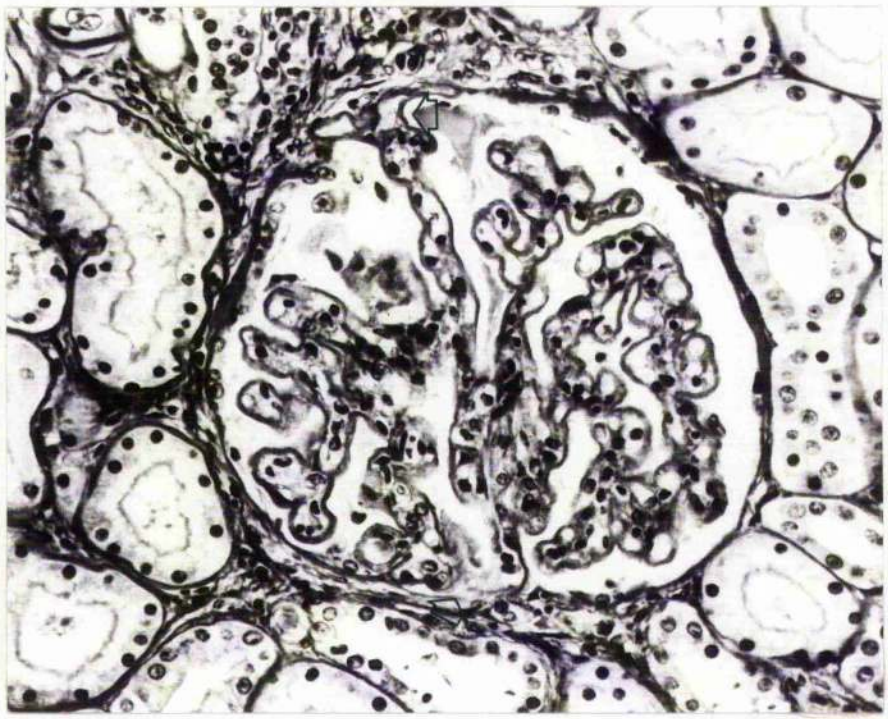


FIGURE 3.10. "Moderately severe" membranous nephropathy.
Biopsy specimen from Cat no. 90812.
There is obvious moderate capillary loop thickening and early adhesions between the glomerular tuft and Bowman's capsule (arrows).
PAS; x 300.

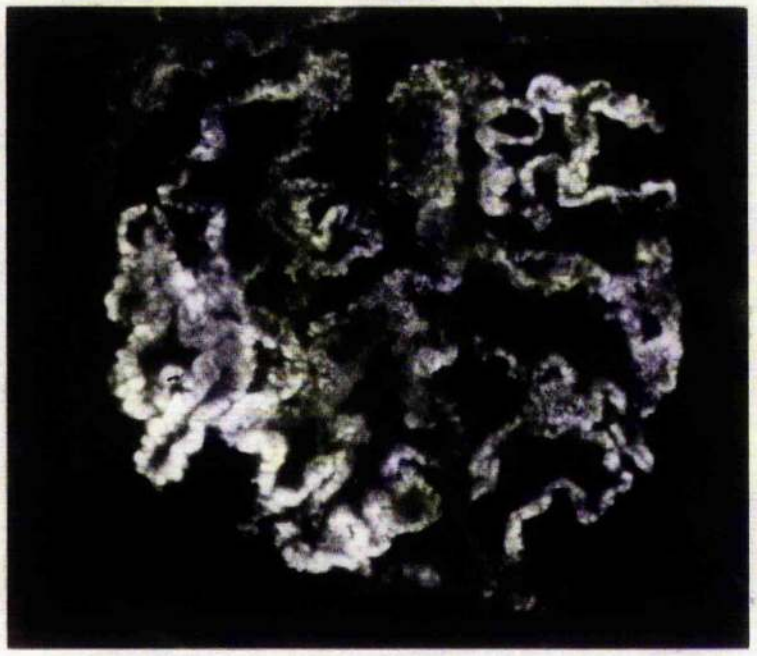


FIGURE 3.11. "Moderately severe" membranous nephropathy. Biopsy specimen from Cat no. 71792 showing heavy deposition of C3 scattered along the capillary walls.
Immunofluorescence; X 350.

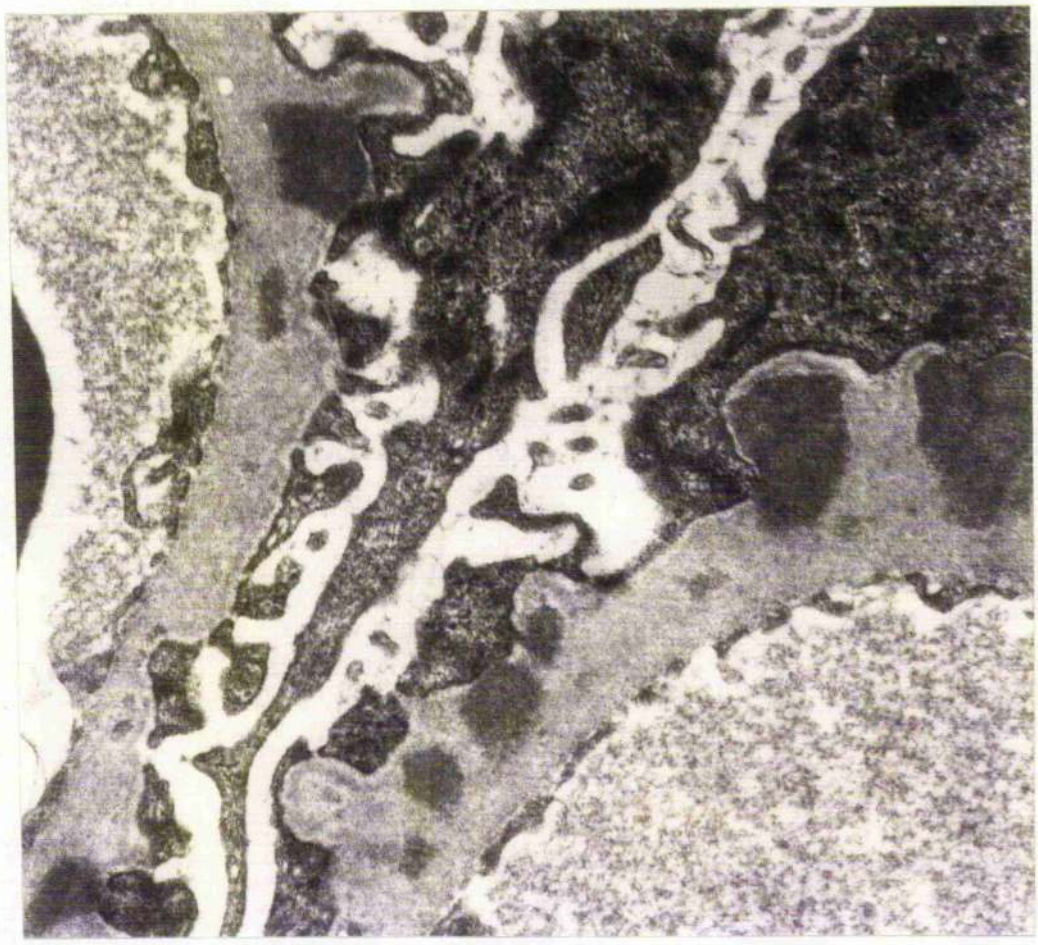


FIGURE 3.12. "Moderately severe" membranous nephropathy. Third biopsy from Cat no. 82525. The glomerular basement membrane is markedly thickened and contains electron dense deposits in subepithelial and intramembranous locations, with spikes extending between the deposits.

Electron microscopy; x 10500.

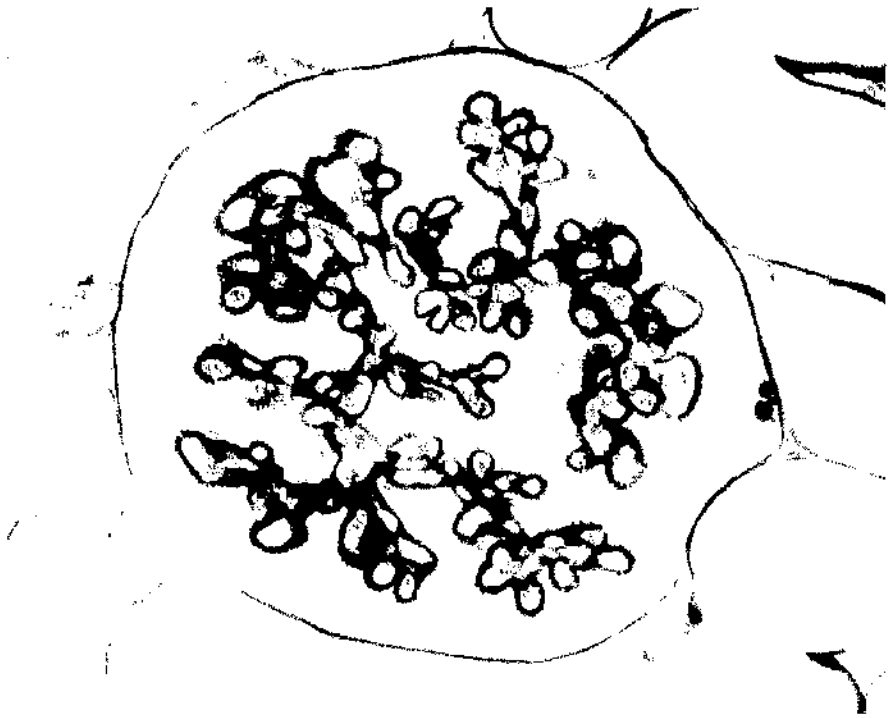


FIGURE 3.13. "Moderately severe" membranous nephropathy. Biopsy specimen from Cat no. 66669 showing moderate thickening of capillary loops and spiky appearance of the glomerular basement membrane. Silver methanamine. X 285

Cat no. 92587 deteriorated slowly but did not develop severe chronic renal failure. Euthanasia was requested after 4 months. At necropsy, the carcase was thin and the kidneys were slightly enlarged and firm. In addition, this cat had a severe chronic cystitis and a non-suppurative cholangitis.

Case nos. 62718, 80589 and 83187 were followed up for periods of 3 years, 13 months and 11 months respectively, and in all 3 cases, subsequent biopsies showed an apparent deterioration in glomerular morphology and, at necropsy, the general overall picture indicated an advanced form of the disease.

Advanced group (6 cases: Nos. 71377, 85273, 74368, 79837, 82987 and 83976)

At biopsy, these cases showed marked thickening of capillary loops together with a high incidence of glomerular scarring (Figure 3.14). In all cases, electron microscopy confirmed massive deposition of complexes in subepithelial, intramembranous, and, to a lesser extent, mesangial sites, to such a degree that some of the capillary loops were completely obliterated. Many deposits were disintegrating, giving the glomerular basement membrane a "moth-eaten" appearance (Figure 3.15).

Case no. 71377, although not available for necropsy apparently developed signs of terminal renal failure within 6 weeks of the biopsy. Another cat (case no. 83976) was necropsied 2 days after biopsy. Necropsy examination of the kidneys confirmed the biopsy classification. Both non-nephrotic cats (case nos. 74368, and 83976) were in the advanced group and 4 cats (case nos. 74368, 79837, 82987) and 83976) were dead within 2½ weeks of biopsy. In all these cases the necropsy findings confirmed the biopsy classification. Surprisingly, cat no. 85273 is still alive and clinically stable after over 2 years, although still heavily proteinuric.

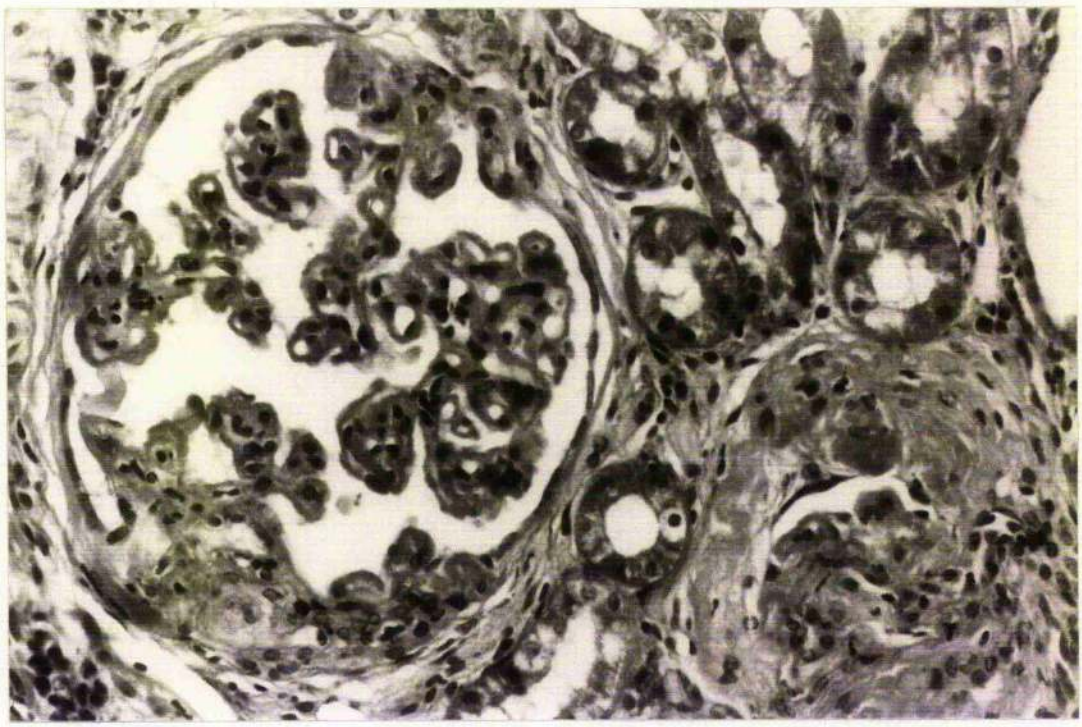


FIGURE 3.14. "Advanced" membranous nephropathy.
Biopsy specimen from Cat no. 71377.
Two glomeruli are present; one is obsolescent while the other has patent capillary loops with grossly thickened walls and adhesions between the tuft and Bowman's capsule.
H & E; x 285

FIGURE 3.15. "Advanced" membranous nephropathy.
Necropsy specimen from Cat no. 79837.
The expanded mesangial matrix (M) contains electron dense deposits, some of which are disintegrating.
Electron microscopy; X 9500

DISCUSSION

In the present study, idiopathic membranous nephropathy was diagnosed in 27 cats, comprising the most extensive investigation into the feline disease hitherto reported. Moreover, for the first time in this species, an attempt was made to follow the progression of the disease by means of clinical examinations, biochemical monitoring of blood and urine, sequential renal biopsies and necropsy examinations wherever possible.

Previous reports of the idiopathic disease in the cat have either been of single or very small groups of cases (Table 3.1) or larger, but too abbreviated (Lucke, 1982), for meaningful comparisons to be made. In other cases, diagnosis has been based on necropsy examinations, sometimes only by histopathology, in the absence of clinical details (Table 3.1).

In this series, 25 cats (92 per cent) developed the nephrotic syndrome at some stage in the course of the illness. This corresponds to a collation of the earlier reports that included clincal details, in which 26 of 29 idiopathic cases (90 per cent) were nephrotic (Table 3.1). However, these figures may not represent a true reflection of the disease patterns for 2 reasons. First, an oedematous cat is more likely to be presented to the veterinary surgeon than a cat in mild renal failure because of the more obvious clinical signs. Moreover, a nephrotic cat is more likely to be referred to a veterinary school for further investigation. On the other hand, when a non-nephrotic cat in more advanced renal failure is presented, the veterinary surgeon is more likely to recognise the condition and initiate treatment or advise euthanasia without referring it for further investigation. Second, a nephrotic cat referred to a veterinary school is more likely to undergo a renal biopsy than a cat in renal failure because it is unlikely to be so severely ill. During the course of the present study, the author examined 6 other non-nephrotic cats which were diagnosed at necropsy as having membranous nephropathy but were not biopsied. In the same period, only one nephrotic cat diagnosed at necropsy as having membranous nephropathy was not made available for biopsy. Only a prospective study of proteinuric cats using renal biopsy procedures would give a true picture of the overall disease incidence.

The factors which determine the development of the nephrotic syndrome are complex and not fully understood (Levy and Seely, 1981). However, from the present study it was clear that levels of plasma albumin, although below normal values in every case at initial examination, were very varied and there did not appear to be a critical level below which fluid retention was initiated. Indeed, one of the non-nephrotic cats (case no. 74368) had an initial albumin level of 8.0 g/l, while other severely nephrotic animals had much higher albumin levels, for example, 24.0 g/l in case no. 82525. Plasma globulin levels were also variable and hyperglobulinaemia (plasma globulin level in excess of 35 g/l) was only found at first examination in 17 cats (62.0 per cent) and in 4 cases there was hypoglobulinaemia. Cholesterol levels are usually elevated in the nephrotic syndrome in man (Cameron, Turner, Ogg, Sharpstone and Brown, 1974) and dog (Osborne et al 1976a), but in the latter this is not always the case (Larkin, Lucke and Kidder, 1972). In the present study, cholesterol levels were raised in 19 of 22 nephrotic cats (86.3 per cent). However, it is interesting to note that the second highest recorded level was in one of the non-nephrotic cats (case no. 74368). Cholesterol levels were only reported in 5 cats in earlier studies and in every case they were raised (Farrow et al, 1969; Farrow and Huxtable, 1971; Johnson et al, 1983).

The progressive nature of the disease has been demonstrated in 14 cats by means of repeated biopsy and or necropsy examinations performed 6 weeks or more after the initial biopsy. In the majority of cases the initial grading of severity and subsequent progression has been reflected in the biochemical findings.

The division of membranous nephropathy in man into 4 sequential stages depending on the development and subsequent alteration of the electron-dense deposits in the glomerular basement membrane as described by Ehrenreich and Churg (1968) was not attempted in this series. It was discovered that ultrastructural changes corresponding to those described by these workers could be found in the same glomerulus (Cameron et al, 1973) and for this reason it was on the overall general histologic and ultra-structural features that the present series of cases was divided into mild, moderately severe and advanced groups. It must be accepted, however, that these groupings are somewhat artificial and are only morphologic indices of the expression of the disease at a particular point in time; not

all future cases of feline membranous nephropathy or indeed even those in the present series will necessarily fit neatly into one or other of the groups. It could be argued, for example, that case no. 89236, which was nephrotic and also showed a high and rising blood urea level, was in reality an advanced case. Likewise, case no. 80204, although now apparently fully recovered, showed some indications in the second biopsy of developing into a moderately severe case. However, until more cases have been studied over a longer period, it may be helpful to retain the use of a simple morphologic classification similar to the one employed in the present study, if only to establish a broad estimation of the extent to which the disease has progressed at the time when the animal is first presented for clinical examination.

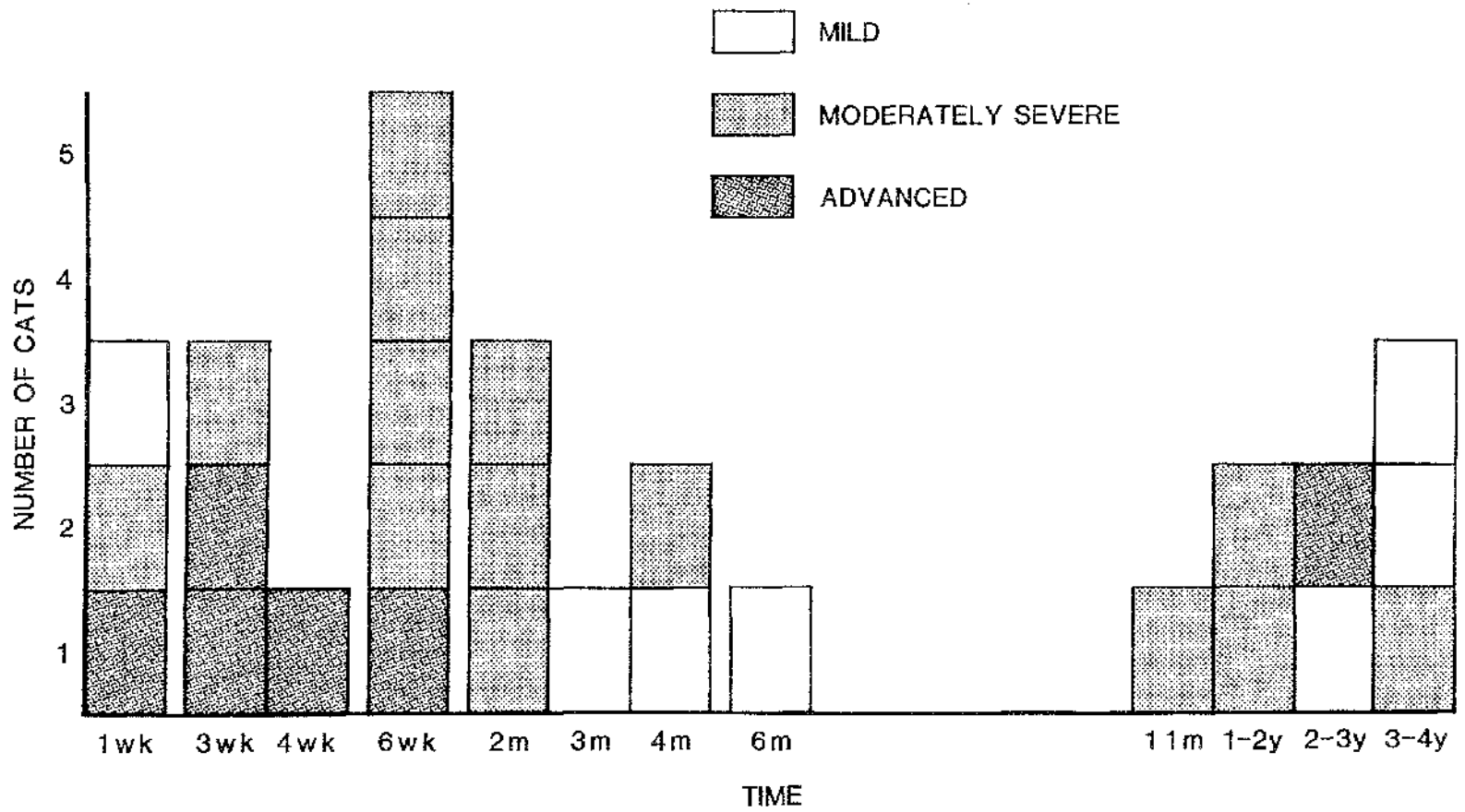
Cases which were euthanased shortly after biopsy showed a good correlation between biopsy and necropsy findings and served to emphasise the value of renal biopsy in the diagnosis of membranous nephropathy in the cat. Similar correlations were also established in 8 dogs with membranous nephropathy (Chapter 2).

The moderately severe and advanced groups were characterised by a relatively high percentage of partially or completely scarred glomeruli. This change appeared to accompany elevation of plasma urea and creatinine levels and, in some glomeruli, tended to mask the membranous transformation of the capillary walls. The basic underlying membranous change, however, was always still identifiable in these cases, and there were always some glomeruli, even in the advanced group which showed only membranous change with little or no scarring. There did, moreover, appear to be a good correlation between these groups and the type and severity of the presenting clinical signs. Cases first presented with the nephrotic syndrome alone were usually placed in the histologically mild or moderately severe groups, although case nos. 71377, 79837 and 82987, which were histologically advanced cases with uraemia, were also nephrotic. The two non-nephrotic cases were also both advanced cases.

As the period of follow-up of a number of cases has extended, a relationship between the initial histological grade and survival time has become apparent (Figure 3.16). Only one cat (case no. 85273) which was placed in the advanced group has survived for more than 6 weeks. The reason for this particular cat remaining well

FIGURE 3.16.

DURATION OF ILLNESS IN 27 CATS WITH MEMBRANOUS NEPHROPATHY COMPARED WITH THE SEVERITY OF LESIONS AT FIRST BIOPSY.



for over 2 years in spite of the apparent severity of the glomerular lesions cannot be explained and only a further biopsy would indicate the present state of the disease. However, during the course of this study it has been common to find a wide range of glomerular damage within the same specimen. Although in membranous nephropathy all the glomeruli are affected, even in the most severely affected cases there are always some glomeruli with relatively minor changes. The histological interpretation of a single biopsy sample, as in the case of cat no. 85273, must therefore be treated with some caution, especially where only a relatively few glomeruli are being evaluated. In addition, the possibility of cutting through an earlier biopsy track when performing a subsequent biopsy cannot be overlooked (Osborne et al, 1974). If this occurred and went unrecognised, the artifact could lead to an over-estimation of the severity of the condition. The case in point (no. 85273), underwent a second biopsy 2 weeks after the first because the initial sample contained no glomeruli.

Nevertheless, in other cases, morphological changes which occurred, even in a short period of time, were demonstrated, indicating the progressive nature of the disease. This was well illustrated in case no. 73644, which appeared to differ somewhat from the general pattern. The first biopsy specimen from this nephrotic cat showed mainly mesangial and subepithelial deposits; yet one month later, a second biopsy showed the deposits to be subepithelial and this pattern persisted to necropsy. It is possible that this change in localisation of deposits reflected a change in the size and/or solubility of the circulating immune complexes, which, early in the disease, were large and therefore deposited in the mesangium, whereas later they had become smaller or more soluble and were deposited in subepithelial sites. Although the general pattern of deposits was subepithelial and intramembranous, the advanced cases, especially nos. 74368 and 79837, also showed deposition in the mesangial matrix. This latter finding is uncommon in the human disease (Ehrenreich and Churg, 1968).

The treatment of membranous nephropathy in man is somewhat controversial. Corticosteroid drugs have been prescribed in large numbers of cases and there are reports of remission of clinical signs following their use (Gluck et al, 1973). However, spontaneous remissions also occur, even though the glomerular lesions persist and even deteriorate, and the view held by many workers is that the use of corticosteroids does not alter the course of membranous

nephropathy in man (Row et al, 1975; Pierides et al, 1977).

In the dog, reports of the treatment of membranous nephropathy are sparse but claims for the apparent success of corticosteroid therapy in maintaining the remission of clinical signs have been made (de Schepper et al, 1974). However, Osborne et al (1976a), when describing the spontaneous regression of membranous nephropathy in a dog, rightly pointed out the dangers of uncontrolled use of corticosteroids in the treatment of glomerulonephritis in general.

In the cat, there are even fewer well documented reports of the treatment of membranous nephropathy. Farrow and Huxtable (1971) described a temporary reduction in proteinuria and disappearance of oedema in 2 cats treated with prednisolone but on cessation of therapy the nephrotic syndrome recurred. Scott et al (1975) treated a cat with a reducing dose of prednisolone continuously for 5 months but the animal progressively deteriorated. Evans (1981) also treated a cat with a prolonged course of an unspecified corticosteroid and reported remission of clinical signs and a reduction in proteinuria to one twelfth of the original loss after 3 months. On the other hand, Slauson et al (1971) gave no treatment to a cat which, although never nephrotic, continued to be severely proteinuric during the subsequent $1\frac{1}{2}$ years but was still bright and active when the report was written.

In the present series only 5 cases (cat nos. 62718, 66669, 73644, 80204 and 91585) were treated with corticosteroids and in no instance did it appear to be helpful. Indeed, case no. 73644 showed deterioration in glomerular morphology despite corticosteroid therapy and case no. 80204, after an even longer course, showed no signs of improvement at the second biopsy, but subsequent to this, and long after the cessation of treatment, is apparently cured.

Diuretic therapy in nephrotic cats has proved beneficial in promoting the regression of oedema in most cases and where there have been recurrences, these may have been a result of therapy being stopped too soon. In a few cases, (cat nos. 71792 and 91890 in particular) the response to diuretic given at even higher than recommended dose rates over prolonged periods has been poor. These findings support those in earlier reports (Lucke, 1982).

In man, and to a lesser extent, the dog, some of the causal factors involved in the development of membranous nephropathy have been established (Table 3.2). However, in the cat, the aetiology remains obscure. Although earlier reports have demonstrated an association between membranous nephropathy and FeLV infection (Anderson and Jarrett, 1971; Glick et al, 1978; Thornburg et al, 1979; Jakowski et al, 1981) or myeloproliferative disease (Ward et al, 1969), of the 49 cats reported, only one (Thornburg et al, 1979) showed evidence of clinical renal disease. However, in another report, unspecified glomerulonephritis was described in 5 cats, 3 of which were nephrotic, and in all 5 cases, FeLV was demonstrated (Cotter, Hardy and Essex, 1975). More recently, Hardy (1981), reported the presence of FeLV immune complexes in the glomeruli of cats persistently viraemic with FeLV. Thus, although in the majority of reported cases of feline membranous nephropathy with clinical evidence of renal disease in which FeLV tests have been carried out, FeLV has been consistently absent (Scott et al, 1975; Lucke, 1982; Crowell and Barsanti, 1983; Johnson et al, 1983), a finding supported by the present study, the possibility that FeLV might have been involved in these cases cannot be ruled out. Plasma tests to detect the presence of FeLV antigen or virus may have been inadequate if a transient infection resulted in the production of circulating immune complexes which initiated the reaction in the kidney. Further serological and immunofluorescence investigations are required.

More recently, F.I.P. virus has been implicated (Jacobse-Geels, et al, 1980; Hayashi et al, 1982) in the development of immune-mediated glomerulonephropathies, including membranous nephropathy. However, reports of glomerular changes consistent with a diagnosis of membranous nephropathy have yet to be substantiated by clinical evidence of a protein-losing nephropathy and in the present study, sera from 13 cats examined for the presence of F.I.P. antibodies gave negative or insignificant results.

One cat with membranous nephropathy was diagnosed as having systemic lupus erythematosus (Slauson et al, 1971) but this finding has never been reported since. Moreover, blood samples from 8 cats in this series examined for the presence of LE cells were all negative.

CHAPTER THREE

SECTION TWO

MEMBRANOUS NEPHROPATHY IN SIBLING CATS WITH COMPLETE CLINICAL REMISSION IN ONE CAT

INTRODUCTION

During the course of this study 2 of the cats which developed membranous nephropathy and became nephrotic were siblings (case nos. 80204 and 81982). Subsequently one of these animals (case no. 80204) has apparently made a complete recovery and has since remained only minimally proteinuric. Although membranous nephropathy in 2 other sibling cats was reported recently (Crowell and Barsanti, 1983) neither of these became nephrotic, both were dead within 2 months of first being examined and the diagnosis was made at necropsy solely on histological examination. In view of the significance of the findings in the present study and the opportunity to follow the progress of these 2 cats for more than 3 years, and 2 years respectively, it was deemed appropriate to include a more detailed case description.

HISTORY AND CLINICAL FINDINGS

Two short haired domestic kittens, a female (case no. 80204) and a male (case no. 81982) from the same litter and aged six weeks, were purchased from a Glasgow pet shop in March 1979). Both were suffering from a severe upper respiratory tract infection which lasted 2 weeks; thereafter both animals made an uneventful recovery.

In February 1980, over a 4 week period, the female cat developed polydipsia, intermittent diarrhoea, ascites and progressive oedema of the lower hindlimbs, ventral body wall and head. During the fourth week she became dull, inactive and inappetent and was referred to Glasgow University Veterinary School on 27 March. Clinical examination revealed no further significant features and a provisional diagnosis of the nephrotic syndrome was made based on biochemical analyses of blood and urine (Table 3.8). Tests for FeLV antigen, F.I.P. antibody, feline respiratory viruses, antinuclear antibody (ANA) and LE cells were negative.

FIGURE 3.17. Sibling cats with membranous nephropathy. The female (case no. 80204), in the foreground, was still proteinuric at the time and the male yet to become affected (9 September 1980).

TABLE 3 8

MEMBRANOUS NEPHROPATHY IN 2 RELATED CATS: SUMMARY OF LABORATORY FINDINGS.

Date	PLASMA						URINE	
	Urea (mmol/l)		Albumin (g/l)		Globulin (g/l)		Protein (mg/100ml)	
	Cat no. 80204	Cat no. 81982	Cat no. 80204	Cat no. 81982	Cat no. 80204	Cat no. 81982	Cat no. 80204	Cat no. 81982
27.3.80*	12.8	-	10	-	29	-	2640	-
12.5.80	12.9	-	19	-	23	-	2900	-
12.8.80	8.7	-	25	-	39	-	530	-
9.9.80	6.5	10.0	25	31	32	34	905	0
27.11.81	12.8	-	34	-	44	-	25	-
22.12.82+	10.3	12.9	33	15	32	34	35	340
30.12.82	7.2	9.8	32	20	28	32	18	850
10.1.83	8.0	9.1	33	25	29	32	5	275
9.3.83	11.2	11.1	34	27	35	35	55	875
28.6.83	-	9.9	-	15	-	32	4	525
3.2.84	11.3	13.3	36	25	24	27	7	1050
NORMAL	9.0		~40		~35		0 - 30	

* Case no. 80204 nephrotic

\+ Case no. 81982 nephrotic

A renal biopsy sample was obtained on 28 March 1980 and following a comprehensive examination by light, fluorescence and electron microscopy, a diagnosis of membranous nephropathy was made.

Diuretic therapy ("Lasix", Hoechst Limited, Middlesex, England) was instituted at a dose rate of 5mg per kg per day and maintained for 7 days, during which time the oedema and ascites regressed, bodyweight was reduced by one kg., and the cat began to eat normally. She was then discharged and at the same time placed on prednisolone therapy ("Delta-Cortril", Pfizer, Kent, England) at a dose of 5.0 mg daily for 5 days and 2.5 mg daily for 5 weeks, thereafter reduced to 2.5 mg every second day for 2 weeks. During the following 14 weeks, the cat remained stable with no recurrence of the nephrotic syndrome, although she was still persistently severely proteinuric.

A second biopsy sample obtained on 9 September 1980 - i.e. 5 months after the first biopsy - indicated that the glomerular lesions were unchanged. At this stage the cat was well but still heavily proteinuric. It was on this occasion that the opportunity was given to examine the male sibling and blood and urine samples taken. There was no evidence of renal dysfunction and the urine was free of protein (Table 3.8).

When next examined, more than one year after the second biopsy (and 18 months after the nephrotic episode) the female was still in good health and urinalysis indicated that the proteinuria was now minimal. This improvement has been maintained during the subsequent 26 months and there is every indication that the cat has made a complete clinical recovery. The owner has not permitted a third renal biopsy to estimate the nature and extent of any residual glomerular lesions.

On 22 December 1982 (33 months after the female cat developed the disease) the male cat was presented having developed oedema of the lower hindlimbs and ventral body wall within a space of a few days; he had also become thirsty, less active and inappetent. Clinical examination revealed no further significant findings other than oedema and a provisional diagnosis of the nephrotic syndrome was made. Laboratory examination of blood and urine samples confirmed the presence of the nephrotic syndrome but did not reveal any evidence of renal failure (Table 3.8). Tests for FeLV, F.I.P. antibody, ANA and LE were all negative.

A renal biopsy sample obtained on 30 December 1982 and examined under light, fluorescence and electron microscopy established a diagnosis of membranous nephropathy. There was a striking similarity between the appearance of the glomerular lesions in this cat when compared with the biopsy specimens from his sister

Diuretic therapy ("Lasix") at a dose rate of 5 mg per kg per day was subsequently given for 5 days, by which time the oedema disappeared completely and the cat had lost 0.8 kg. in bodyweight. Within a further few days he was bright, eating normally and was discharged 2 weeks later.

On 9 March 1983 both cats were re-examined. They were bright, eating normally and not drinking excessive amounts of water. The condition of the female was unchanged and she was still only minimally proteinuric. The male had improved in body condition and had gained 0.9 kg. He had had no recurrence of oedema but was still heavily proteinuric (Table 3.8).

On 28 June 1983 both cats were again examined and re-sampled. Case no. 80204 remained healthy and was not proteinuric but case no. 81982 had shown a recent increase in thirst and in the previous few days had had a recurrence of mild lower hindlimb oedema and ascites. Diuretic therapy was instituted ("Lasix") and the fluid regressed quickly over the following 4 days. The latter cat was still heavily proteinuric and on this occasion albumin levels were considerably lower than on the previous occasion.

The two cats were not re-examined or sampled again until 3 February 1984 but in the intervening 7 months they had remained healthy and case no. 81982 had regained some of his body weight, although he remained thinner than prior to the onset of the illness. Laboratory results indicated that case no. 80204 was still in complete remission and case no. 81982 remained heavily proteinuric. In both cases (and on several previous occasions, Table 3.8) plasma urea levels were slightly raised. This was probably due to the fact that the cats were in a post-prandial state when sampled.

DISCUSSION

In this Section, 2 important and hitherto unrecorded features of the natural history of feline membranous nephropathy have been described, first, the remission of clinical features including the reduction of proteinuria to minimal levels in one cat, and second, the subsequent development of the disease in a sibling. Both cats were presented with the nephrotic syndrome.

In the previous Section and other reports of membranous nephropathy in cats (Scott et al, 1975; Evans, 1981; Lucke, 1982), follow-up studies have demonstrated that while the nephrotic syndrome may be transient, the underlying diease is either progressive towards renal failure or apparently stationary and not remissive (Lucke, 1982).

The same is true of membranous nephropathy in dogs (Osborne et al, 1976). In man, however, complete remission is not uncommon and in a summary of published data on human membranous nephropathy it was shown that 16 per cent of adults and 49 per cent of children affected with membranous nephropathy underwent complete remission (Row et al, 1975).

In this study, the female cat (case no. 80204), although clinically normal, was heavily proteinuric for at least 6 months, before going into remission during the period between September 1980 and November 1981, by which time urine protein levels had dropped to normal This occurrence could not have been predicted at the time of the second biopsy (5 months after the onset of the disease) as the immune complex glomerular lesions were unchanged, and if anything had progressed, from those seen in the first biopsy specimen. Moreover, proteinuria was still marked. The fact that urine protein loss has been minimal since November 1981 is reinforced by continuing normal levels of plasma albumin at and since that date. While clear proof of the regression of the underlying glomerular lesion could only be demonstrated with a further renal biopsy, the owner's attitude that further interference would not benefit the cat must be respected.

The fact that this apparently recovered cat received prednisolone therapy for 2 months following the nephrotic episode does not necessarily support the suggestion that corticosteroids are of value in the treatment of feline membranous nephropathy (Farrow and Huxtable, 1971). Indeed it might lend weight to the opposite view, for, nearly 3 months after treatment ceased a second renal biopsy revealed no change in the underlying glomerular lesions, while the cat remained heavily proteinuric. A further 13 months on, the cat appeared to be in complete remission as urine protein levels had fallen to within the normal range.

With the exception of the sibling cats reported by Crowell and Barsanti (1983), all other cases of feline membranous nephropathy have occurred sporadically. In the present study, cat nos. 62718 and 66669, unrelated and from different homes, were boarded at the same cattery at the same time, during which period both suffered from infectious diarrhoea and subsequently became nephrotic within 2 months. In man, idiopathic membranous nephropathy appears to be sporadic and no reports of related patients have been found in the literature.

It is of interest that although the 2 cats in this study were the same age and experienced the same environmental conditions, they became nephrotic 33 months apart, the male having been clinically normal during the period that the female was nephrotic and thereafter severely proteinuric. The 2 sibling cats reported by Crowell and Barsanti (1983) also developed the illness separately, with an interval of about 3 years, although there is no evidence that the second cat was examined prior to the onset of renal failure 3 years after the first cat. The fact that 2 pairs of sibling cats have developed idiopathic membranous nephropathy many months apart raises the possibility that genetic factors may be involved in the pathogenesis of this disease.

CHAPTER FOUR

SECTION ONE

RENAL BIOPSY IN THE NORMAL CAT: AN EXAMINATION OF THE EFFECTS OF A SINGLE NEEDLE BIOPSY

INTRODUCTION

The first brief reports of renal biopsy techniques in cats were published by Osborne et al (1967), Gudat (1968) and Osborne (1971b). Franklin-Silverman needles were used in these studies. More recently, Jeraj et al (1982) reported a 10 year review of renal biopsy methods employed clinically in 34 cats, in which Franklin-Silverman, Metcoff and "Tru-Cut" needles had all been used. The latter is now widely used in both human and veterinary medicine (Kark and Smith, 1974; Osborne, 1975) but it has not received the same critical study as the Franklin-Silverman needle. Furthermore, although renal biopsy is apparently a relatively straightforward and safe procedure in the cat (Jeraj et al, 1982), there are no reports of the structural or functional effects of the technique on the cat kidney. This is surprising, as the unique topographical anatomy of the feline kidney with its subcapsular veins might indicate that this species is particularly vulnerable to subcapsular and perirenal haemorrhage, 2 of the more common post-biopsy complications in man (Slotkin and Madsen, 1962) and dog (Osborne, 1971b). Moreover, in the present study, it has been recorded (Chapter 2) that 7 of the cats which underwent biopsy and were subsequently examined at necropsy showed evidence of severe renal vascular damage, with widespread intrarenal haemorrhages and large wedge-shaped infacts extending deep into the medulla. For this reason it was decided to investigate the effect of a single renal biopsy puncture on the normal cat kidney by means of clinical and morphological assessments, followed by radiographic and histological examinations of the biopsied kidneys carried out at intervals, ranging from 2 hours to 2 months, following biopsy.

MATERIALS AND METHODS

Thirteen young adult cats were obtained from commercial sources. Eleven cats were biopsied. Prior to biopsy each cat was examined, weighed and samples of blood, via jugular puncture, and urine, via manual expression of the bladder, were obtained. Full haematological and biochemical examinations were performed to assess normal functional parameters. The results of these examinations are summarised in Appendix D (Cat nos. 1 to 13).

Cats were injected intramuscularly with ketamine hydrochloride and the left flank prepared for biopsy. A single, direct percutaneous biopsy of the left kidney was performed in each cat using a 4½ inch "Tru-Cut" biopsy needle. The biopsy specimen was measured whilst in the specimen notch, then removed and placed in 10 per cent neutral buffered formalin prior to histological examination. The cats were monitored clinically daily for up to one week post biopsy and subsequently at weekly intervals. Three cats were destroyed 2 hours post biopsy and thereafter 2 cats were euthanased at 2 days, one week, 2 weeks and 2 months, respectively. Euthanasia was performed by intracardiac injection of pentobarbitone sodium ("Euthatal", May and Baker Limited, Dagenham, England) following ketamine hydrochloride anaesthesia. A further 2 cats were prepared, anaesthetised and monitored for 7 days in exactly the same way as the biopsied cats but were not subjected to renal biopsy.

At necropsy, the abdominal wall, peritoneal cavity and kidneys of all the cats were inspected particularly for evidence of haemorrhage, infarcts, adhesions or other abnormalities.

Both kidneys were removed and the renal arteries cannulated with a 4 FG nylon tube (Portex Ltd. Hythe, England). After flushing out the renal vasculature with warm, normal physiological saline, a contrast gel consisting of a mixture of Micropaque (Nicholas Laboratories, Ltd., Slough, England) and gelatine crystals warmed in a waterbath, was infused until it flowed from the renal vein. The renal artery and vein were then clamped and the kidneys chilled until the contrast gel had set. Where paired or branched renal arteries were present, each trunk was cannulated separately and contrast gel infused through each cannula simultaneously.

Both kidneys were radiographed whole, laterally and cranio-caudally using fast non-screen film at 90cm, 12 Ma.s and 50 K.v. A magnified image was produced by raising the kidneys on a thin plastic sheet, 25 cm. above the film. The kidneys were then sectioned transversely at 4 mm. intervals and the resulting slices arranged serially and radiographed. The slices were photographed and fixed prior to histological examination. Four μm thick sections of the biopsy specimens and serial sections of kidney slices were prepared and stained with H & E and Masson's trichrome stains prior to histological examination.

RESULTS

(a) Clinical findings

All 11 cats tolerated ketamine hydrochloride anaesthesia at the dose used. In every case relaxation was sufficient to allow easy location, fixation and biopsy of the kidneys. There were no complications during recovery of the 8 cats surviving beyond 2 hours post biopsy, during which time the cats were ataxic but able to walk within 4 hours. Return to normal appetite and movement was observed by 24 hours post biopsy.

None of the cats showed evidence of localised renal or generalised abdominal pain and a small reduction in body weight in 3 cats during the first 48 hours post biopsy was quickly regained. Rectal temperatures remained normal throughout the experiment.

Haematuria, determined by a commercial dip-stick ("Lab-Stix"), Ames Laboratories, Slough, England) was not found in any of the cats prior to biopsy but was present in 7 of the 11 cats sampled at 5 minutes post-biopsy and in 8 animals at 2 hours post-biopsy (Table 4.1). In 3 cats there was no evidence of haematuria throughout the experiment. Haematuria persisted in 4 of the 6 cats surviving after 48 hours but was occult at that stage. One control cat had developed macroscopic haematuria when sampled at 5 minutes and both controls had evidence of haematuria at 2 hours.

(b) Haematological and biochemical findings

Four cats showed a slight fall in haematocrit levels 2 hours post biopsy. Thereafter there were minor fluctuations in haematocrit levels which were not thought to be attributable to renal biopsy, as they also occurred in the control cats. White blood cell counts rose appreciably in only 2 of the 8 cats surviving for 48 hours or longer, but at necropsy, no evidence of infection associated with the biopsy procedure was found.

There was no evidence of major renal dysfunction reflected by plasma urea and creatinine levels in any cat during the post biopsy period (Appendix D).

TABLE 4.1

SINGLE RENAL BIOPSY IN NORMAL CATS: POST BIOPSY HAEMATURIA

CAT NO.	PRE-BIOPSY	TIME POST-BIOPSY 5 min.	2 hr.	24 hr.	48 hr.	1 wk.	2 wk.	2 mth.
1	-	-	- ‖					
2	-	M	M ‖					
3	-	M	M ‖					
4	-	-	-	-	- ‖			
5	-	M	O	O	M ‖			
6	-	M	M	O	O	- ‖		
7	-	O	O	M	O	O ‖		
8	-	-	-	-	-	-	- ‖	
9	-	O	O	-	-	-	O ‖	
10	-	M	M	M	O	O	O	- ‖
11	-	-	M	M	M	O	O	O ‖
12 +	-	-	O	-	-	- ‖		
13 +	-	M	M	-	O	- ‖		

M = Macroscopic haematuria

O = Occult haematuria

- = No haematuria

‖ = End of experiment

\+ = Control cats

(c) Biopsy findings

The major findings are summarised in Table 4.2. Biopsy samples from 2 cats contained only medulla. Otherwise, samples all contained cortex with an average of over 13 glomeruli per sample. Major arterial vessels (interlobar or arcuate) and medullary tissue were present in 7 of the 11 biopsy samples (Figure 4.1).

(d) Necropsy findings

The following descriptions refer to the left, biopsied kidneys unless otherwise stated.

Cats killed 2 hours post biopsy (Cat nos. 1, 2 and 3)

The point of entry of the biopsy needle in each kidney was clearly visible as a small haemorrhagic tear in the renal capsule at the caudal pole.

All 3 cats had an area of focal subcapsular haemorrhage and this was particularly severe in cat no. 3. In this animal there was also considerable blood staining of the perirenal tissues and a small volume of free blood was present in the abdominal cavity. Mild perirenal haemorrhage had occurred in cat no. 2.

In all 3 animals transverse sections of kidney revealed an area of haemorrhage surrounding the biopsy track. This was particularly marked in cat no. 3 where the biopsy track could be traced through the cortex and medulla into the renal pelvis.

On radiographic examination of transverse sections the biopsy track was clearly visible at different levels. In cat no. 2, the track had only just penetrated the cortex and part of the capsule was missing (Figures 4.2 and 4.3). In cat no. 3 the track was seen in the lower cortex and extending into the medulla.

Kidneys from cat nos. 1 and 2 were not available for histological examination. In cat no. 3, there was a large area of haemorrhage and thrombosis in the region of a damaged interlobar artery. Contrast gel had also leaked from the damaged vessels into the surrounding interstitium. There was no evidence of infarction.

TABLE 4 2

SINGLE RENAL BIOPSY IN NORMAL CATS:

SUMMARY OF BIOPSY DATA AND CORRELATION OF BIOPSY,

RADIOGRAPHIC AND NECROPSY FINDINGS

Cat No.	Length (mm) before fixation	BIOPSY SPECIMEN			LEFT KIDNEY	
		No. of glomeruli	% Medulla present	Major artery present	RADIOGRAPHY Large area unfilled by contrast gel	NECROPSY Thrombosis or infarct present
1	15	7	0	-	-	-
2	10	33	0	-	-	-
3	15	19	66	+	-	+
4	15	10	0	-	-	+
5	10	5	66	+	+	+
6	15	0	100	+	+	+
7	10	0	100	+	+	+
8	6	31	0	-	-	-
9	12	20	33	+	-	+
10	20	14	75	+	+	+
11	15	13	25	+	+	+
Average	13 mm.	13.8				

FIGURE 4.1. Part of the biopsy specimen from Cat no. 10. Nine glomeruli are clearly visible and 2 large arteries are present at the corticomedullary junction.
H & E; x 60

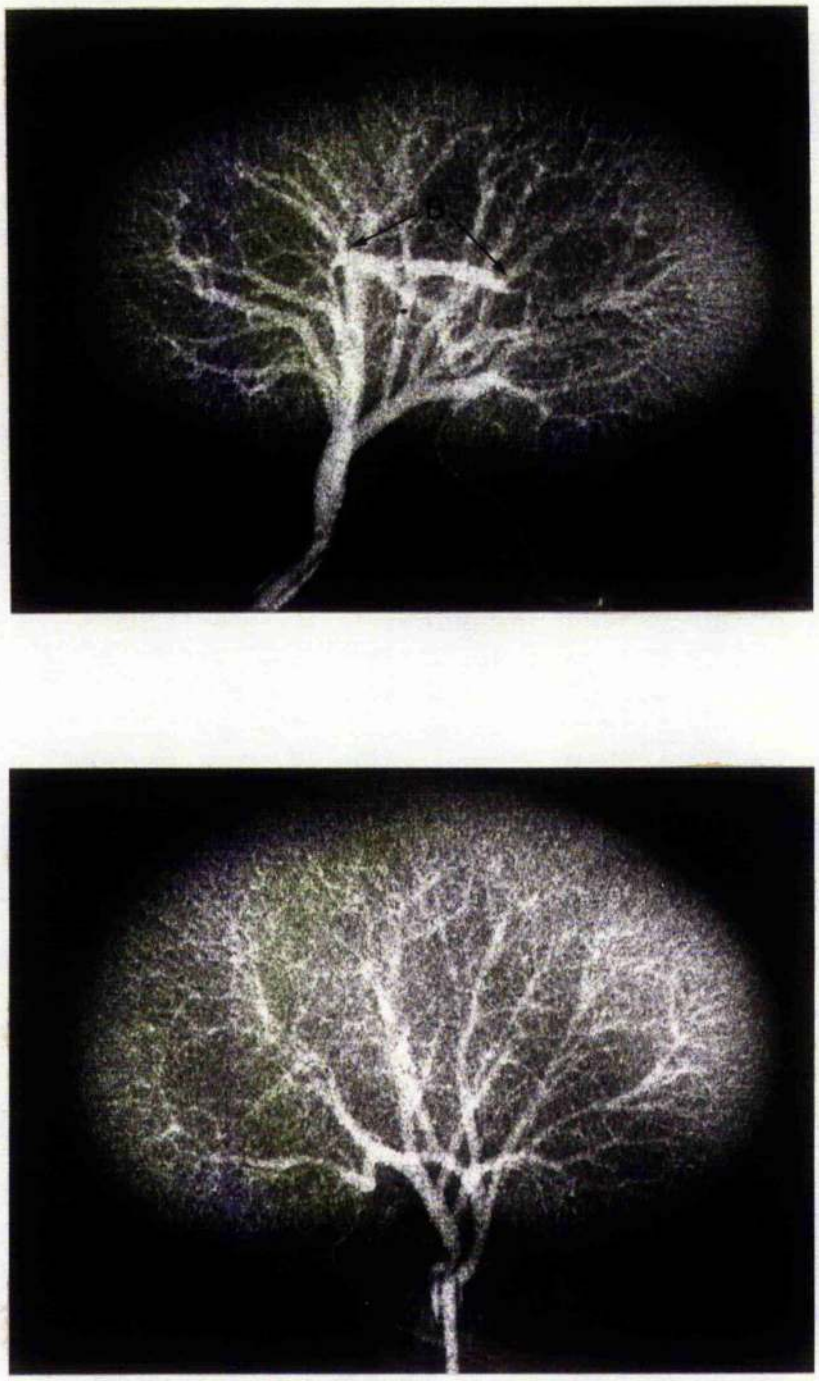


FIGURE 4.2. Radiographic lateral views of the left (above) and right (below) kidneys of Cat no. 2 (killed 2 hours post biopsy) after filling with contrast gel to show the biopsy track (B) in the left kidney.

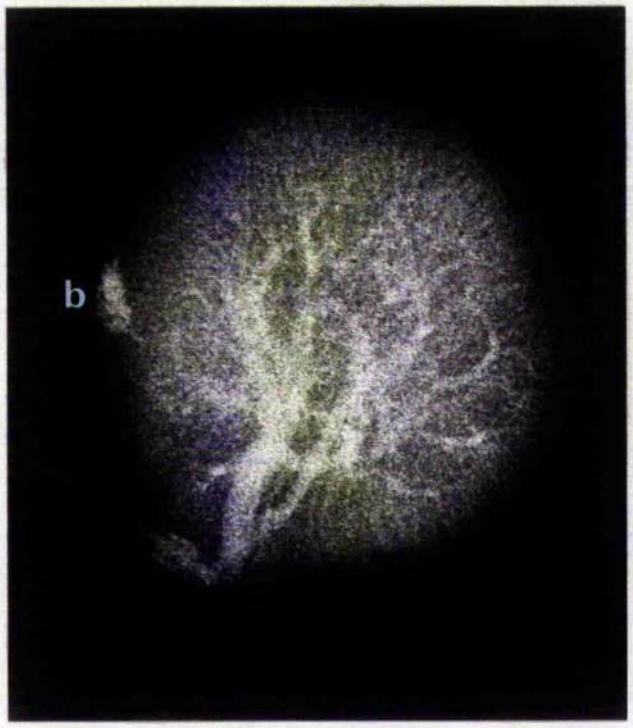


FIGURE 4.3. Radiographic craniocaudal view of the left kidney of Cat no. 2 after filling with contrast gel to show the biopsy track (b) in the outer cortex. The biopsy specimen contained only cortex and no major blood vessel was present.

Cats killed 2 days post biopsy (Cat nos. 4 and 5)

Both cats had a small subcapsular haemorrhage with blood staining of the adjacent perirenal fat and peritoneum. The needle puncture through the renal capsule into the caudal pole was obvious and there was a blood clot plugging the biopsy track. In both cases, the track extended into the medulla but more deeply so in cat no. 5. In transverse sections of cat no. 4, extensive haemorrhage was obvious in and around the track and also in the renal pelvis. Contrast gel had not filled the cortex above the track. In cat no. 5, there was less extensive haemorrhage but there was poor filling by contrast gel of the caudal pole of the kidney. A cortical infarct was visible in the vicinity of the biopsy track.

Radiographically, the biopsy track was not visible in either cat. The major finding in both biopsied kidneys was lack of contrast gel filling the lateral, i.e. biopsied, half and this was more evident in cat no. 5.

In both cats, histological examination showed damage to an arcuate artery with thrombosis, perivascular haemorrhage and fibrin deposition in association with the biopsy track. Overlying this was a wedge-shaped infarct, which was more extensive in cat no. 5.

Cats killed one week post biopsy (Cat nos. 6 and 7)

Both cats had a focal resolving haemorrhage in the perirenal fat around the caudal pole and in cat no. 7, there was a focal subcapsular haemorrhagic plug at the point of entry of the biopsy needle. Transverse sections from both cats revealed a haemorrhagic track extending through the cortex and into the medulla. This was much more obvious in cat no. 7 in which there was also poor filling with contrast gel.

On radiographic examination, there was good contrast filling of the left kidney of cat no. 6 but the biopsy track was not visible and there was no obvious vascular impairment. In cat no. 7, a lateral view showed reduced contrast gel filling in the caudal pole and this was also evident in caudal transverse slices, suggestive of a severely impaired blood supply. (Figure 4.4). The biopsy track was not visible.

In both cats, histological examination provided evidence of damage to an arcuate artery in the region of the biopsy track, with thrombosis, perivascular haemorrhage and fibrin deposition.

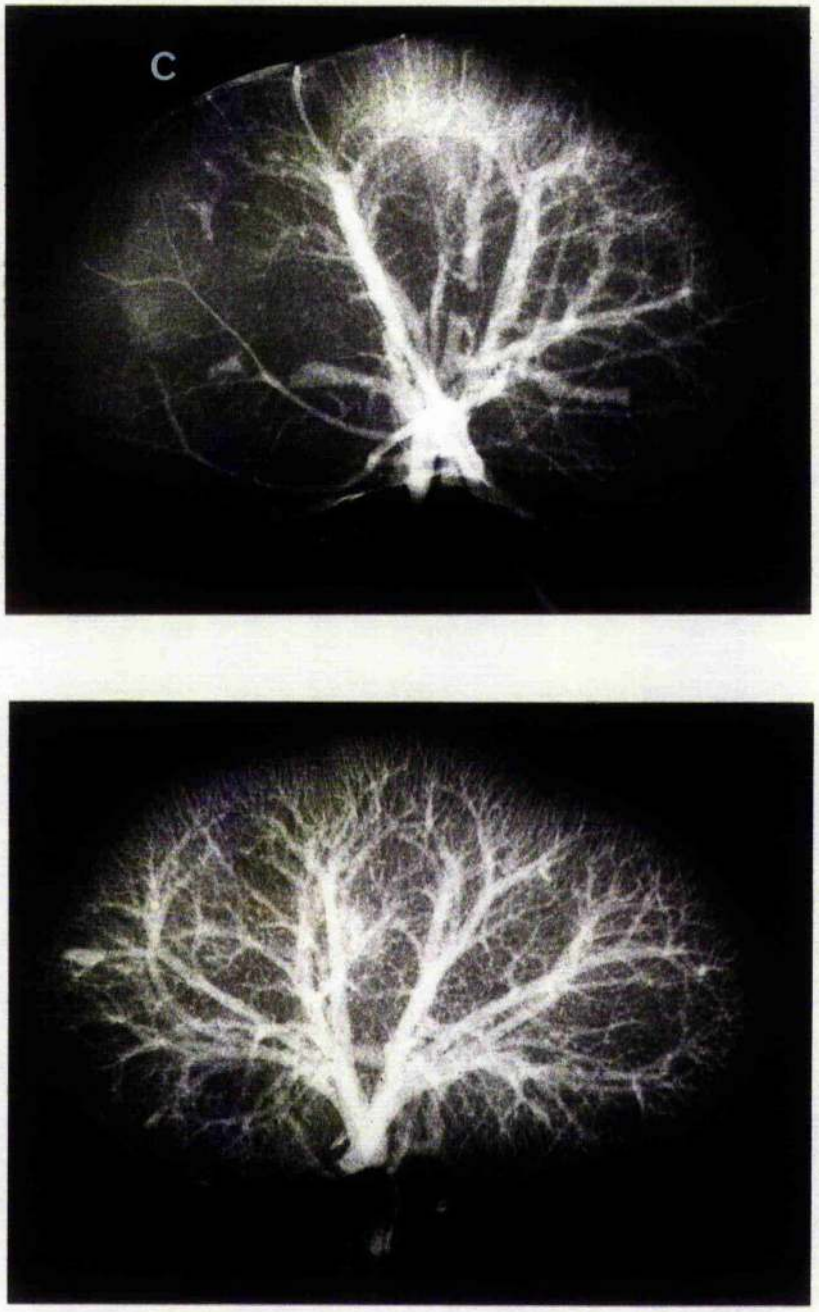


FIGURE 4.4. Radiographic lateral views of left (above) and right (below) kidneys of Cat no. 7 (killed one week post biopsy) after filling with contrast gel. The caudal pole (C) of the left kidney, into which the biopsy needle had been inserted, did not fill with contrast gel. The biopsy specimen contained only medulla and a large artery.

There was developing fibrosis in the vicinity of the damaged vessel. In both cases, there was an overlying infarct which in cat no. 7 was extensive. In the infarcted zones, the cortex was collapsed, with compressed necrotic tubules containing hyaline casts and calcified tubular debris.

Cats killed 2 weeks post biopsy (Cat nos. 8 and 9)

Cat no. 9 had a small amount of altered blood in the subcapsular space at the point of entry of the biopsy needle and in cat no. 8 the biopsy site was marked by a depressed scar at the caudal pole. In transverse sections, there appeared to be poor gel filling in the regions of the biopsy track in cat no. 8 but in neither case was there evidence of haemorrhage or infarction.

On radiographic examination, the biopsy track was not highlighted in either cat. In cat no. 8, there was some reduction in contrast gel filling laterally, immediately surrounding the biopsy site (Figure 4.5).

In both cats, in the region of the biopsy track, histological examination showed scarring, tubular necrosis and cellular infiltration composed mainly of plasma cells and a few lymphocytes. In cat no. 9, at the core of the biopsy there was thrombosis, perivascular haemorrhage and fibrin desposition associated with one damaged arcuate artery. In the area of the biopsy track and extending into the medulla there were focal accumulations of neutrophils, suggestive of acute pyelonephritis and early fibrosis.

Cats killed 2 months post biopsy (Cat nos. 10 and 11)

In both cats, there was a depressed scar in the caudal pole, marking the site of biopsy. There was no evidence of haemorrhage in either cat.

In transverse sections in cat no. 10, there was evidence of poor contrast gel filling and infarction on the lateral, biopsied side of the kidney. In cat no. 11, however, filling appeared to be complete.

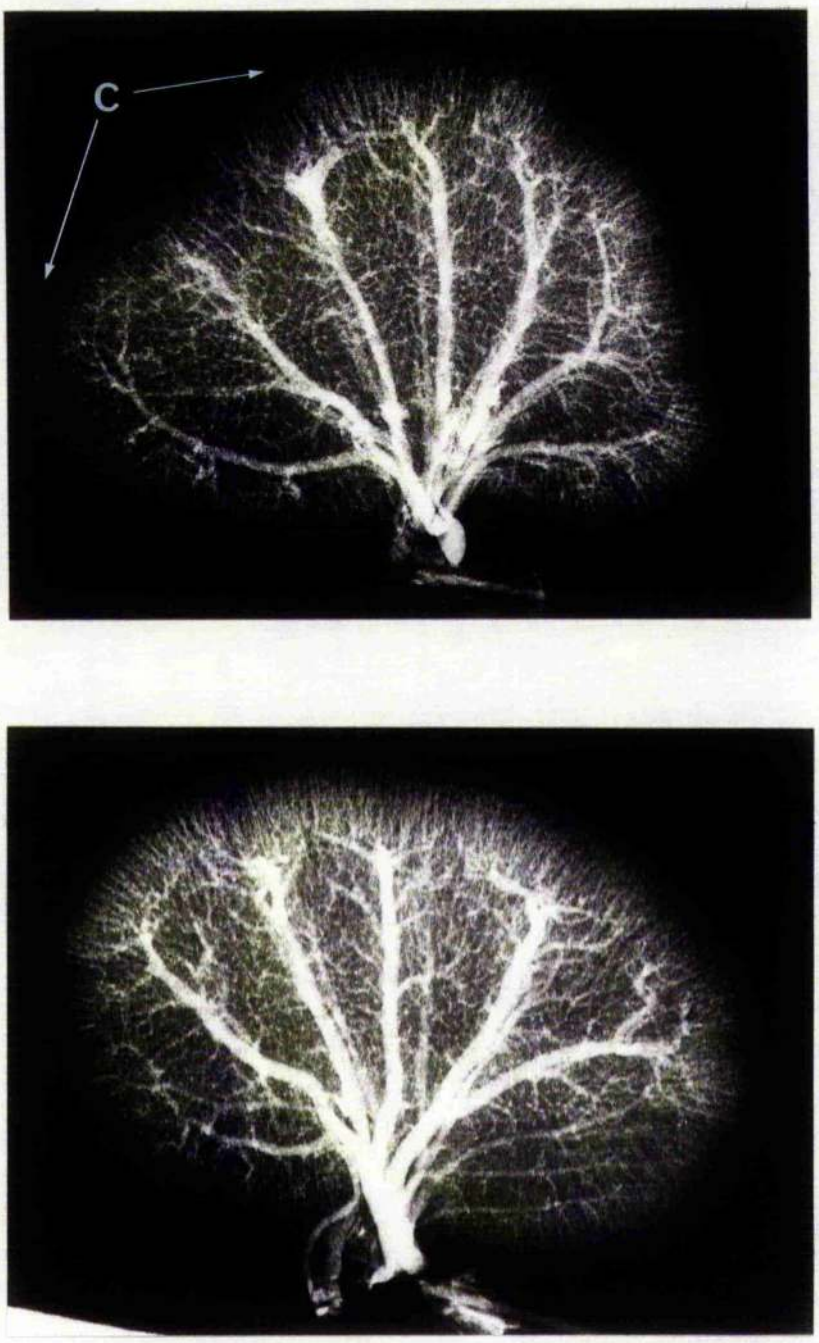


FIGURE 4.5. Radiographic lateral view of left (above) and right (below) kidneys of Cat no. 8 (killed 2 weeks post biopsy) after filling with contrast gel. The small unfilled area of the caudal pole (C) in the left kidney surrounded the point of entry of the biopsy needle. The biopsy specimen contained only cortex and no major blood vessel was present.

On radiographic examination, there was poor gel filling in the lateral half of the kidney of cat no. 10 (Figures 4.6 and 4.7). In cat no. 11, filling was good except for an unfilled cortical wedge in the region of the biopsy scar. No biopsy tracks were visualised.

In both cats, histological examination showed wedge-shaped infarcts, consisting of a depressed cortical scar extending from the capsule to the outer medulla. In these areas there was scarring of glomeruli, tubular degeneration, calcification, hyaline cast formation, interstitial fibrosis and a mild cellular infiltrate of plasma cells and lymphocytes.

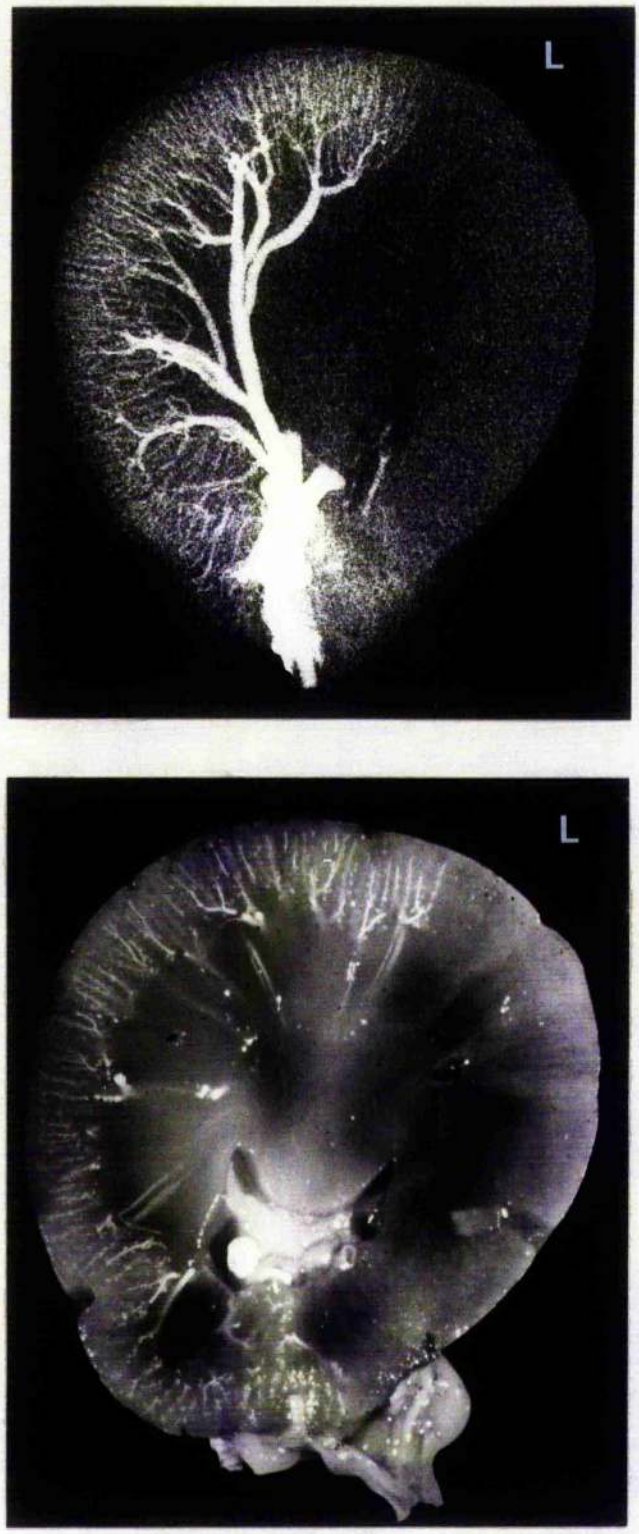


FIGURE 4.6. Radiographic (above) and photographic (below) views of central transverse slice of the left kidney of Cat no. 10 (killed 2 months after biopsy) after filling with contrast gel. The lateral half (L), into which the biopsy needle had been inserted, did not fill with contrast gel. The biopsy specimen contained mainly medulla and a major artery.

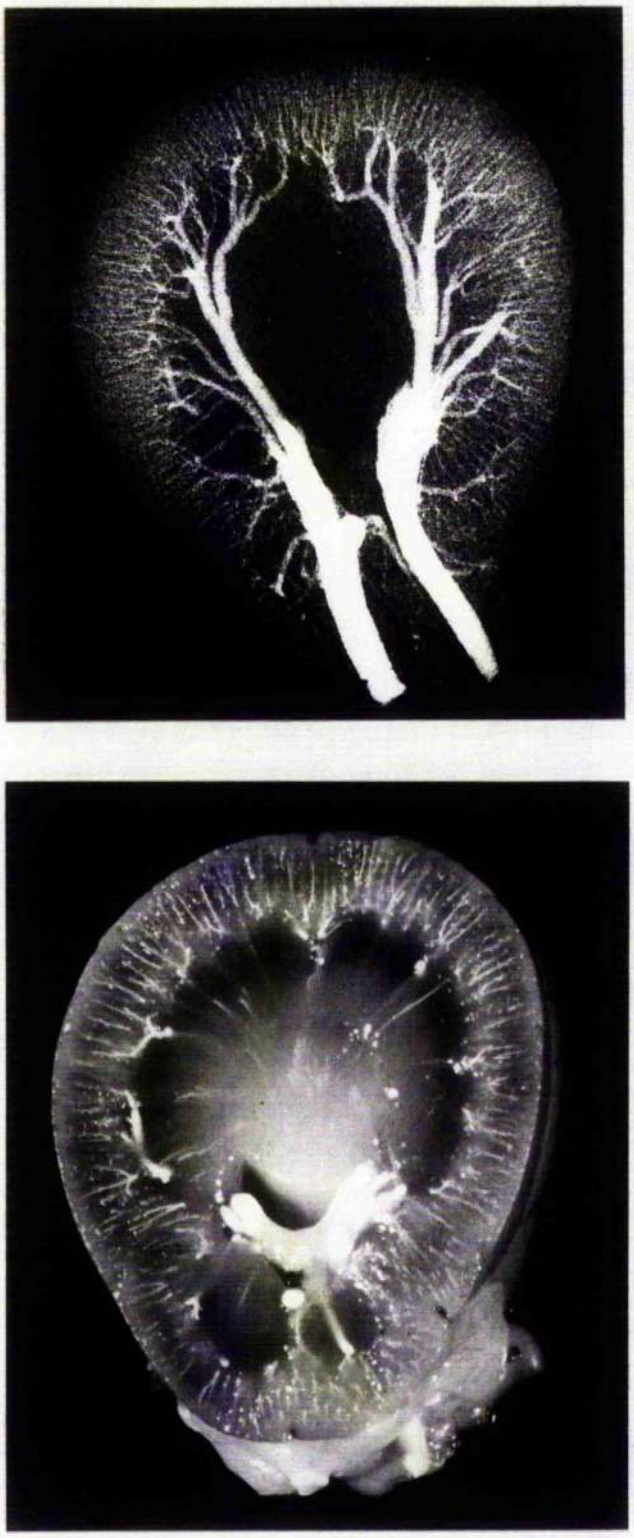


FIGURE 4.7. Radiographic (above) and photographic (below) views of corresponding transverse slice from the right (non-biopsied) kidney of Cat no. 10 to show uniform filling with contrast gel.

DISCUSSION

Previous studies on the effects of renal biopsy on the normal kidney have only been carried out in dogs, (Sweet et al, 1969; Osborne et al, 1972). These workers made multiple punctures in each biopsied kidney and then examined the resultant effects over varying periods, up to 105 days. In the present investigation one biopsy sample was taken from one kidney in each cat in an attempt to simulate the clinical ideal of obtaining adequate renal tissue for diagnostic purposes at one biopsy attempt. The results show that, even though the cats maintained for up to 2 months post biopsy remained apparently healthy, in 7 out of 11 there was evidence of quite severe haemorrhage, thrombosis, infarction and renal fibrosis in the biopsied kidneys. The radiographic studies were useful in revealing the full extent of the renal lesions. Reduced contrast gel filling was so extensive in the left kidneys of 5 of the cats that if the non biopsied kidneys had not been available for comparison, it might have been regarded as an artifact (Figures 4.6 and 4.7).

Although macroscopic haematuria is regarded as a potentially serious post biopsy complication in man (Kark, 1968) it was not a consistent finding in cats with severe post biopsy renal lesions. Moreover, the fact that macroscopic haematuria occurred in one of the non-biopsied control cats indicated that the haematuria may have arisen as a result of manual expression of the urinary bladder and not necessarily solely as a result of the biopsy procedure.

There was, however, a direct relationship between the presence of major renal vessels in the biopsy specimens and the presence, at necropsy, of severe renal damage (Table 4.2). These biopsy samples also all contained renal medulla indicating a deeper than necessary penetration by the biopsy needle and confirming the observation by Sweet et al (1969) in dogs, that biopsy tracks which pass through the cortico-medullary junction result in more severe lesions than those confined to the cortex. This supports the view that, in order to minimise renal damage, it is important that the needle should be directed at such an angle so as to penetrate only the cortex, even at the expense of a smaller sample (Figure 4.8).

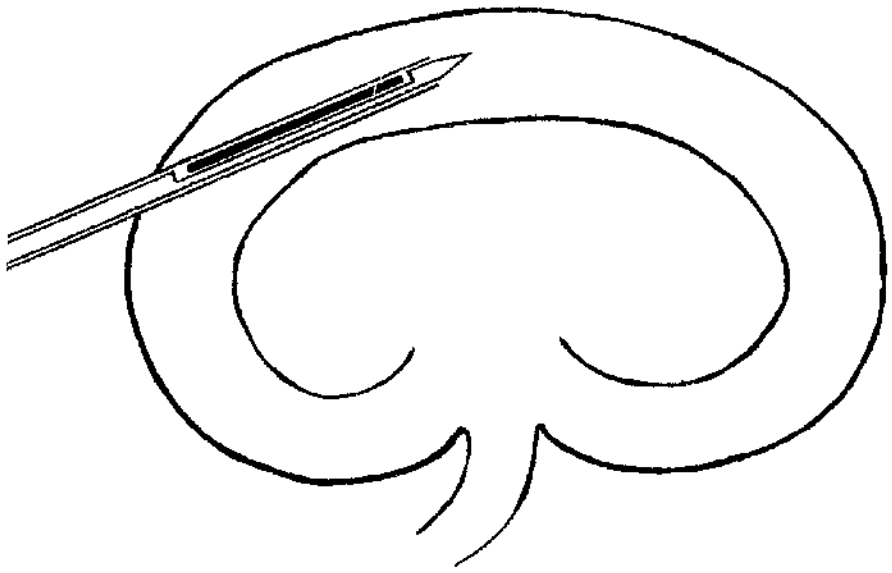


FIGURE 4.8. Diagrammatic representation of biopsy needle in kidney showing the desired needle angle avoiding the corticomedullary junction.

The post biopsy lesions were not sufficiently severe to have any demonstrable effect on renal function. However, it is possible that an equivalent amount of damage inflicted on a cat with pre-existing renal disease could trigger or exacerbate renal failure. Furthermore, the lesions described in this study were produced by a single biopsy puncture whereas, in the clinical situation, it is not uncommon for two or more biopsy attempts to be made before adequate material is obtained and subsequent biopsies are often taken to monitor the progress of the disease or response to treatment. Therefore, it is likely that the lesions described following a single biopsy would be much more severe if several biopsy attempts are made on the same kidney.

In previous experimental biopsy studies, Franklin-Silverman needles were used and found to be effective (Osborne et al, 1967; Gudat, 1968; Sweet et al, 1969). However, Osborne (1971b) observed that 67 per cent of biopsy samples from cats contained transitional epithelium, indicating deep penetration by the needle and the danger of damage to major renal vessels. He suggested that the use of a relatively large needle suitable for use in man may not be appropriate in the small cat kidney, and later (Osborne, 1975) recommended use of the Metcoff paediatric modification of the Franklin-Silverman needle although he appreciated that its very high cost might prohibit its use.

Although disposable biopsy needles have been available for a considerable time (Kark, 1968), there are no reports of their use in experimental biopsy studies in cats. In the present study, disposable needles were used and results were favourable in comparison with reports of biopsies in normal dogs, using Franklin-Silverman needles. Renal tissue was obtained at the first attempt in each cat and the fact that 2 samples did not contain renal cortex was the fault of the operator rather than the needle. The average sample length (13 mm.) was the same as that obtained with Franklin-Silverman needles from canine kidneys (Osborne and Low, 1971a). Although the average number of glomeruli per sample (13) was considerably less than that (25) recorded by Osborne and Low (1971a), it must be remembered that the feline kidney contains less than half the number of glomeruli found in canine kidneys (Smith, 1951). Moreover, a range of 5 to 33 glomeruli per sample as obtained in the present study would be considered adequate for the diagnosis of diffuse glomerular disease, such as amyloidosis, or glomerulonephritis (Kark et al, 1958).

Although the biopsy samples were satisfactory, the presence of severe renal lesions resulting from damage to blood vessels must raise doubts about the safety of the needle in its present form. On insertion into the kidney, the solid needle tip extends 6mm. beyond the specimen notch and could well damage a major vessel, while the biopsy specimen might not give any indication that this had occurred (Figure 4.9). Indeed, this occurred in cat no. 4 where there was evidence of extensive renal haemorrhage at necropsy but no large vessel in the biopsy specimen. In this respect, the Franklin-Silverman needle is similar, as the filled portions at the tip of the cutting prongs also necessarily penetrate renal tissue not included in the sample.

Further studies are necessary to investigate the effects of multiple and repeated biopsies on the same kidney in the cat and these are reported in the following Section. Furthermore, in view of the post biopsy lesions produced in the kidneys examined in this study, modifications to existing disposable biopsy needles to minimise vascular damage must be considered. This investigation is reported in Chapter 4 Section 3.

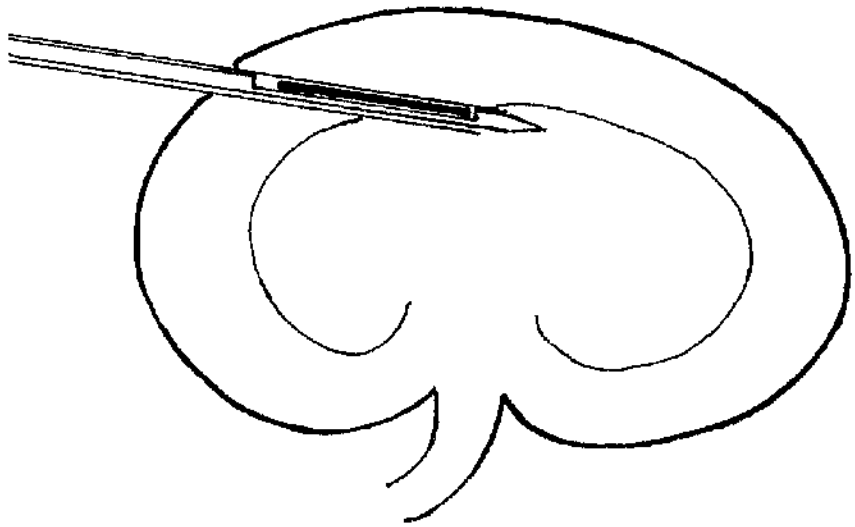


FIGURE 4.9 Diagrammatic representation of biopsy needle in kidney showing incorrect angle of direction likely to penetrate the corticomedullary junction and damage major blood vessels even though they may not be harvested in the specimen.

SECTION TWO

RENAL BIOPSY IN THE NORMAL CAT: AN EXAMINATION OF THE EFFECTS OF REPEATED NEEDLE BIOPSY

INTRODUCTION

In the previous Section the results of a study of the clinical and morphological effects of a single renal biopsy attempt using a disposable biopsy needle in 11 adult cats were reported. Although biopsy sampling was straightforward and successful, 7 of the cats showed evidence of severe renal lesions in the biopsied kidneys when killed at intervals up to 2 months post biopsy. There was a direct relationship between the kidneys with severe lesions and the presence of major renal arteries in the biopsy specimens. Concern was expressed at the nature and extent of the lesions caused by a single biopsy in a normal kidney in view of the fact that renal biopsies are normally performed on patients with pre-existing renal disease and also that it is not uncommon for more than one biopsy attempt to be made in order to obtain an adequate sample. In Chapter 2 it was recorded that the average number of biopsy attempts per adequate specimen in dogs and cats was 2.1. Up to 3 specimens per biopsy were obtained from 163 dogs and 34 cats (Jeraj et al, 1982). Although rarely reported, renal biopsy in human patients also may require more than one biopsy attempt. Leiter, Gribetz & Cohen (1972), however, reported having made 3 consecutive biopsy punctures on a 3 year old boy and even though these were performed under fluoroscopy, a life threatening arteriovenous fistula was created. In a report of 97 successful biopsies in a series of 100 consecutive young patients ranging in age from 4 months to 22 years, Colodny and Reckler (1975) implied that 3 biopsy specimens were removed from each patient per biopsy. White (1962) stated that it was his practice to take a second biopsy whenever possible and did so in 68 out of a series of 80 children aged from less than one year to 15 years.

Moreover, repeated renal biopsies in man and animals allow monitoring of renal disease processes and response to therapy (Kark, 1958; Osborne et al, 1976a) and the benefits of follow up studies have already been highlighted in the study of feline membranous nephropathy in Chapter 3. However, the possibility that cumulative iatrogenic renal damage may occur in already diseased kidneys has not been investigated.

Investigations into the effects of multiple biopsy sampling in normal dogs were reported by Sweet et al (1969) and Osborne and Low (1971a). The effects of sequential biopsies taken at intervals has also been studied in normal dogs (Osborne and Low, 1971b). There are no reports of similar investigations in the cat.

The present study was designed to examine the effects of repeated biopsy attempts in normal cats, in view of the serious sequelae resulting from single biopsy in some cases, as recorded in the previous Section, and also because of the peculiar anatomy of the cat kidney in respect of subcapsular veins.

MATERIALS AND METHODS

Six young adult cats were obtained from commercial sources. Pre-biopsy preparation, blood and urine sampling and anaesthesia were performed as described in the previous Section.

In 3 cats, a single, percutaneous biopsy of the left kidney was performed on 3 occasions, at monthly intervals. In the other 3 cats, 3 consecutive percutaneous biopsy attempts were made in the left kidney. In each case, biopsy was performed using a $4\frac{1}{2}$ inch "Tru-Cut" needle.

Each biopsy specimen was first measured and then removed from the specimen notch in the needle and placed in 10 per cent neutral buffered formalin before histological examination. The cats were monitored clinically daily for up to one week after biopsy and subsequently at weekly intervals.

All 6 cats were killed one month after the last biopsy with an intracardiac injection of pentobarbitone sodium following ketamine hydrochloride anaesthesia. Immediately prior to euthanasia each cat was given 12000 IU of heparin by intravenous injection. Necropsy procedures were performed as described in Section One.

The results of clinical and laboratory examinations are summarised in Appendix D (Cat nos. 14 to 19).

RESULTS

(a) Clinical findings

The biopsy procedure was straightforward in every case and on every occasion. The only anaesthetic complication was that cat no. 14 had a convulsive episode while anaesthetised prior to the second biopsy. Recovery was normal and anaesthesia for the third biopsy was uneventful. Full recovery to normal appetite and movement following biopsy procedures took up to 48 hours on a number of occasions. None of the cats showed evidence of localised renal or generalised abdominal pain.

Weight loss was recorded after all biopsies except in cat no. 18. Bodyweight was never fully regained in cat nos. 14 and 19. In the other 3 cats original weight was regained within 3 days of the first biopsy. In cat nos. 14, 15 and 16, there was a gradual reduction of bodyweight throughout the course of the study following each successive biopsy. Cat no. 15 became especially light after the third biopsy.

Cat no. 17 made a good recovery from the 3 consecutive biopsies but suddenly became ill at the end of the second week and was destroyed. Necropsy findings indicated that this cat had an acute enteritis. As the experiment had continued for more than half its course it was decided not to exclude this animal from the study.

Occult haematuria was demonstrated in the urine of cat no. 17 prior to biopsy and in cat no. 16 prior to the second and third biopsies. Blood was detected in the urine of all of the cats on 8 occasions post-biopsy and in 2 cases, (cat no. 14 (first biopsy) and cat no. 18) it was macroscopic. No blood was present in any urine sample at 48 hours post-biopsy. Thereafter, with the exception of cat no. 14, which developed macroscopic haematuria while suffering from mild cystitis, only occult haematuria was demonstrated on 19 occasions in 48 urine samples taken from one to 4 weeks post-biopsy. Details with regard to haematuria are presented in Table 4.3.

(b) Haematological and Biochemical findings

In 5 cases there was a slight fall in haematocrit reading 24 hours post-biopsy. Thereafter there were minor fluctuations in haematocrit which was not thought to be attributable to renal biopsy. White blood cell counts ranged from 5.1 to 35.1 x 10^9/l (normal range

TABLE 4.3

REPEATED RENAL BIOPSY IN NORMAL CATS: POST BIOPSY HAEMATURIA.

Cat No.	Biopsy No.	Pre-Biopsy	5 min	24 hr	48 hr	1 wk	2 wk	3 wk	4 wk
14	1	-	M	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-
	3	-	0	-	-	-	-	-	- ‖
15	1	-	0	-	-	0	-	-	-
	2	-	-	-	-	0	-	0	-
	3	-	0	-	-	-	-	0	- ‖
16	1	-	-	0	-	0	-	0	0
	2	0	0	0	-	-	0	0	0
	3	0	0	-	-	0	0	0	0 ‖
17	1	0	0	-	-	-	0 ‖		
18	1	-	M	0	-	-	0	0	- ‖
19	1	-	-	0	-	0	0	-	0 ‖

M Macroscopic haematuria

0 Occult haematuria

- No haematuria detected

‖ Experiment terminated

6.0 to 20.0 x 10^9/l) and fluctuated considerably but were not considered to be attributable to the effect of renal biopsy. At necropsy, none of the cats showed evidence of infection attributable to the biopsy procedure.

(c) Biopsy findings

The major findings are summarised in Table 4.4. Six (33.3 per cent) of the biopsy specimens contained only muscle or muscle and fat, but no renal tissue. Five other samples contained renal tissue, but in addition, varying amounts of muscle or fat. The other 7 samples contained kidney tissue with varying amounts of cortex and medulla. Glomeruli were present in all 12 specimens containing renal tissue, with an average of 9.7 per sample. Major arterial vessels (interlobar or arcuate) were present in only 2 samples (cat nos. 18 and 19).

(d) Necropsy findings

With the exception of cat no. 17, killed at 2 weeks post biopsy, the cats were killed 4 weeks after the last biopsy. Immediate post mortem inspection of the peritoneal cavity revealed no major abnormalities. The right kidney showed no evidence of trauma or adhesions. There was a small volume of fresh, subcapsular haemorrhage in the right kidney of cat no. 17. On removal and cannulation, the right kidney of cat no. 16 was found to have a divided renal artery but dual cannulation was unnecessary.

The details of findings related to the left (biopsied) kidney of the 6 cats are summarised in Table 4.5.

Capsular adhesions and small depressed scars were present on the left kidneys of all cats except no. 15. However, only one case (cat no. 18), showed evidence of any additional lesion, a moderately large, subcapsular haematoma (Figure 4.10). In cat nos. 14 and 17 there were quite extensive elliptical tears in the renal capsule over the lateral border but it is possible that these became enlarged during removal of the kidneys and disturbance of adherent omental fat.

TABLE 4.4

REPEATED RENAL BIOPSY IN NORMAL CATS:

SUMMARY OF BIOPSY DATA AND CORRELATION OF BIOPSY RADIOGRAPHIC AND NECROPSY FINDINGS

Cat No.	Biopsy No.	Length before fixation (mm)	No. of glomeruli	Biopsy content	Major vessel present	Radiographic filling defect	Visible histological lesion
14	B1	5	0	muscle	-		
	B2	10	0	muscle	-	-	-
	B3	5	14	1/3 musc 2/3 cort	-		
15	B1	5	20	cortex	-		
	B2	10	2	9/10 musc 1/10 cort	-	-	-
	B3	15	5	2/5 cort 3/5 med	-		
16	B1	5	10	3/5 cort 2/5 med	-		
	B2	15	19	4/5 cort 1/5 med	-	-	-
	B3	5	0	muscle	-		
17	B1	5	0	muscle	-		
	B2	10	0	fat/musc	-	-	-
	B3	15	13	1/2 musc 1/2 cort	-		
18	B1	15	1	1/20 cort 19/20 med	-		
	B2	20	20	1/5 musc/fat 3/10 cort 3/10 med	+	+	+
	B3	10	3	1/5 cort 4/5 med	-		
19	B1	10	0	Fat/musc	-		
	B2	15	1	4/5 fat 1/5 cort	-	-	+
	B3	20	19	2/5 cort 3/5 med	+		
Average		10.8	9.7				

Musc. - muscle; cort. - cortex; med. - medulla

TABLE 4.5

REPEATED RENAL BIOPSY IN NORMAL CATS: SUMMARY OF NECROPSY FINDINGS

Cat No.	VISUAL INSPECTION	RADIOGRAPHIC	HISTOLOGIC
14	Elliptical area of damage to renal capsule at caudal pole with adhesion of omental fat	Small lateral depression with adjacent filling defect in slice 3	Two small wedge-shaped lesions extending from cortex into medulla. Smaller one has a depressed scar and band of cellular infiltrate with early fibrosis. Larger area more organised and fibrosed.
15	No adhesions or obvious capsular scars	Small outer cortical depression with small filling defect extending into medulla in slices 2,3 & 4.	Single wedge-shaped lesion from cortex deep into medulla. Cellular infiltrate and small amount of early fibrosis
16	Small scarred portion of capsule at caudal pole with adhesion of perirenal fat.	Small outer cortical dpression in slices 3 & 4 without obvious filling defect.	Very narrow track from cortex into medulla with mild cellular infiltrate and early fibrosis.
17	Large tear in renal capsule over greater curvature with adhesion of omental fat.	Lateral whole kidney shows two tiny filling defects either side of centre of greater curvature. Small dorsal swelling and slight vascular disruption in slices 2 & 4.	Depression of capsule with 2 small wedge-shaped lesions in dorsal cortex. Small amount of early fibrosis
18	Subcapsular haematoma in midline in centre of greater curvature with adhesion of perirenal fat	Lateral and end-on whole kidney show swelling on greater curvature and some disruption of underlying cortex. Midline swelling of capsule and underlying large wedge-shaped filling defect in slices 3 & 4.	Large organised blood clot in outer cortex. Cellular reaction and fibrosis mark biopsy track deep into medulla.
19	Depressed capsular scars at caudal and cranial poles with adhesions of perirenal fat	Outer cortical depression in slices 3 and 4. Evidence of capsular adhesion in slice 2. Possible filling defect in deep cortex.	Small depression of capsule and short wedge-shaped track in cortex. Large wedge-shaped lesion deep into medulla with early fibrosis.

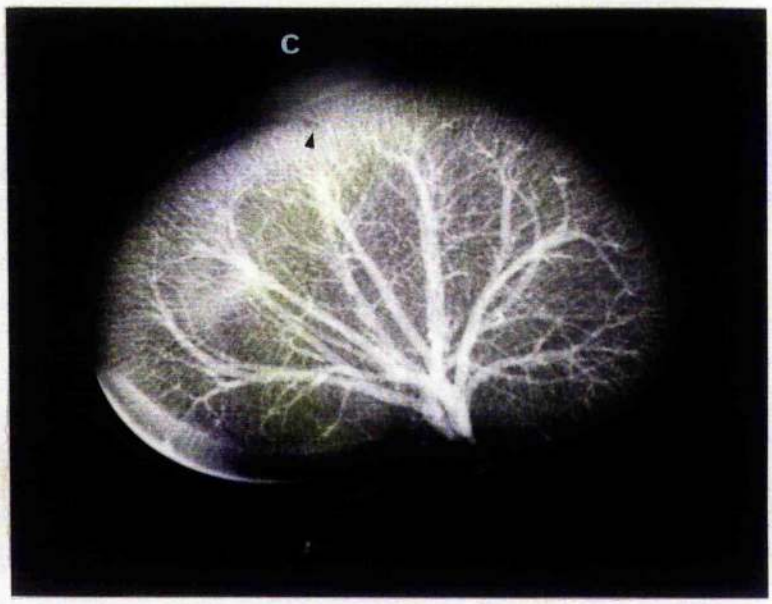


FIGURE 4.10. Radiographic lateral view of the left kidney of Cat no. 18. Contrast gel has filled a swelling (C) on the greater curvature which depresses the outer cortex (arrow). The swelling represents a large subcapsular, organised blood clot overlying one of the biopsy tracks.

There was radiographic evidence of extensive filling defects in the 2 middle slices of kidneys from cat nos. 15 and 18, and in the latter case, there was poor contrast filling in the area of the haematoma (Figures 4.11 and 4.12). In the other 4 cats there were only small unfilled areas related to the needle tracks (Figure 4.13).

Histological examination of the kidney sections showed changes ranging from very small capsular depressions and early scars (cat nos. 16 and 17) through larger wedge-shaped areas of disrupted renal tissue bounded by moderate lymphocyte and plasma cell infiltrates and early fibrosis (cat no. 14), to more extensive wedge-shaped scars with more established fibrosis (cat nos. 15, 18 and 19), and the large, organised blood clot in cat no. 18.

A correlated summary of the biopsy and necropsy findings is presented in Table 4.4.

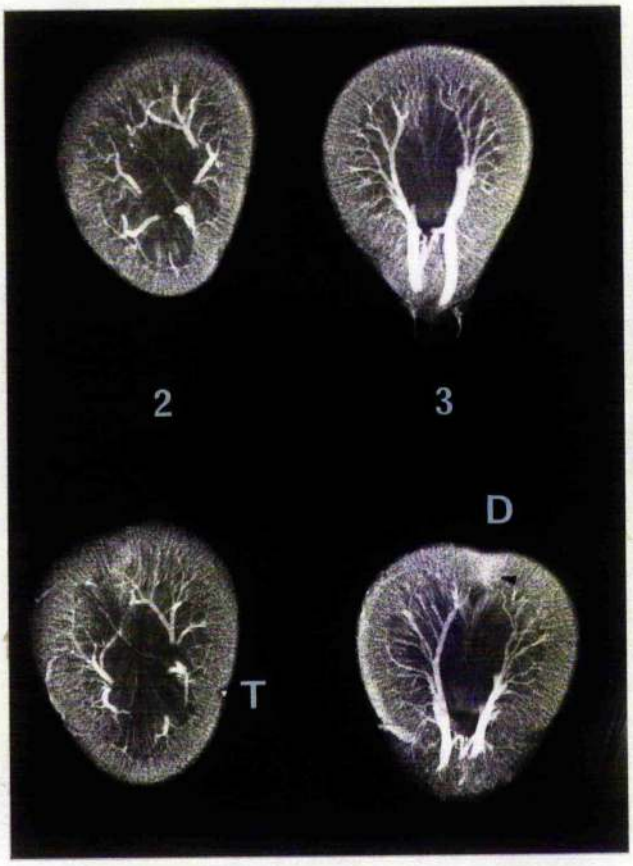


FIGURE 4.11. Radiographic transverse sections (numbers 2 and 3) of the right (above) and left (below) kidneys of Cat no. 15. There is cortical depression (D) and a wedge-shaped filling defect extending into the medulla (arrowed) in section 3. In addition there is evidence of a very small filling defect associated with a superficial biopsy track (T) in section 2. One of the biopsy specimens (B3) contained medulla but no major blood vessel.

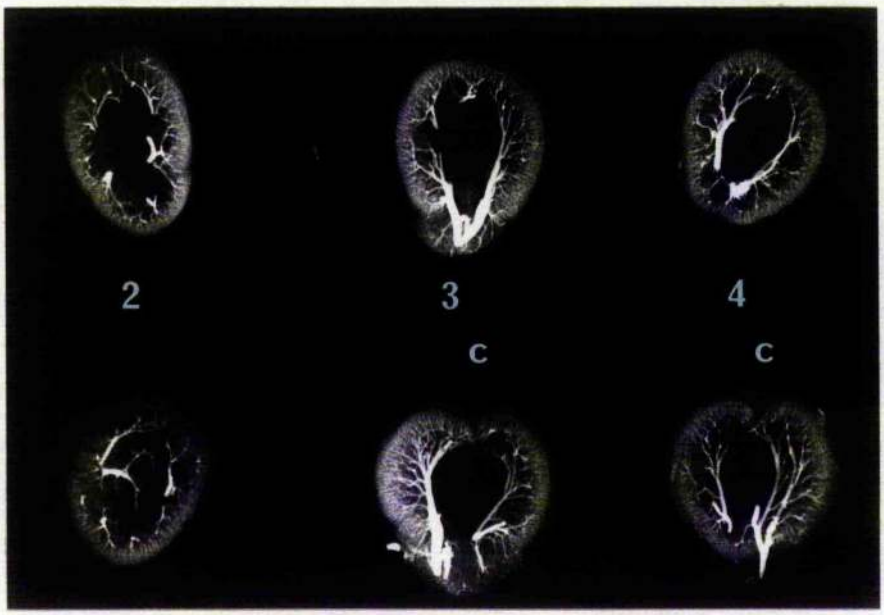


FIGURE 4.12. Radiographic transverse sections (numbers 2, 3 and 4) of the right (above) and left (below) kidneys of Cat. no. 18. Filling with contrast gel is uniform in all 3 sections of the right kidney and in section 2 of the left. In sections 3 and 4 the overlying blood clot (C) is clearly visible. In addition the wedge-shaped unfilled area of cortex is particularly obvious in section 3. One of the biopsy specimens (B2) contained a large artery.

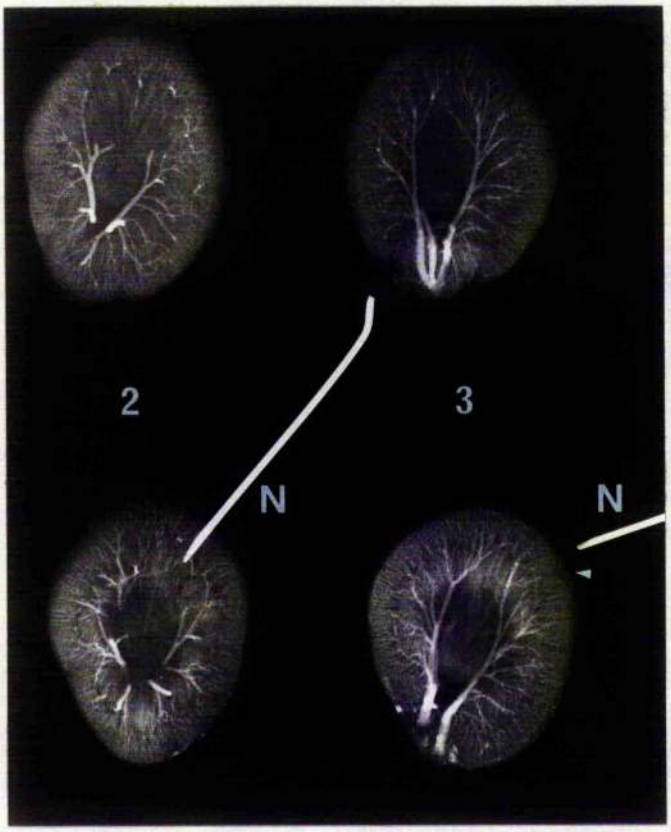


FIGURE 4.13. Radiographic transverse sections (nos. 2 and 3) from right (above) and left (below) kidneys of Cat no. 14. The position and direction of the biopsy track is marked by hypodermic needles (N) The only filling defect is in the outer cortex of section no. 3 (arrowed). The biopsy specimens from this cat consisted only of muscle (B1 and B2) and muscle and cortex (B3).

DISCUSSION

The present investigation has demonstrated that repeated biopsy attempts made on the cat kidney, on the same or different occasions, do not appear to increase the amount of damage inflicted upon the kidney when compared with that caused by a single biopsy attempt (Section One). Indeed, caution exercised in the angle and depth of insertion of the needle at 3 attempts may have resulted in less severe damage than in some cases following a single biopsy attempt. However, this caution is reflected in the relatively poor results in terms of adequate kidney samples. Six biopsy specimens (33.3 per cent) consisted entirely of non-renal tissue and 5 others (27.7 per cent) contained muscle and/or fat in addition to varying amounts of renal tissue. In many cases, the nature of the tissue obtained was identified visually at the time, but in view of the design of the study, only the required number of biopsy attempts were made on each occasion; for example, cat no. 14. In the clinical situation, further biopsy attempts would be made immediately it was realised that the sample obtained was unsuitable, either on grounds of inadequate length or absence of visually identifiable renal tissue (Osborne, 1971b). This is mirrored in cat nos. 17 and 18, where the first samples in each case did not contain renal tissue. At the second attempt in cat no. 18, renal tissue plus fat and muscle was obtained but the second biopsy from cat no. 16 was again unsuitable. The third sample in both cases was entirely of renal origin.

The exercise of caution may have resulted in a poorer sample yield but it is encouraging that glomeruli were present in all the 12 samples containing renal tissue. However, 7 (58.3 per cent)of these samples contained medulla as well as cortex, ranging from 20 to 95 per cent of the sample content, and 2 of these included major arterial blood vessels. At necropsy, the kidneys from these 2 cats (nos. 18 and 19) showed radiographic and histologic evidence of severe renal damage, thus confirming the findings of the study in the previous Section. Nevertheless, the number of kidneys with extensive renal damage, 2 out of 6, in this study, compared very favourably with 7 out of 11 in the single biopsy experiment (Section One). Care in insertion of the needle may reduce the number of useful biopsy samples but it does reduce the likelihood of severe renal damage.

It is not possible to suggest any real difference between the cats biopsied 3 times on separate occasions and those biopsied 3 times on one occasion, for although the 2 cats showing signs of extensive renal damage were in the latter category, they were also the cats in which the biopsy specimens contained major blood vessels. However, by comparison with the changes observed in the previous study following only one biopsy attempt, it would appear that 3 biopsy attempts either at the same time or repeated at intervals do not increase the risk of extensive renal damage.

The only obvious external post-biopsy lesion other than capsular scars and localised adhesions was the presence of a moderately large subcapsular haematoma in the left kidney of one cat (no. 18). This is not unexpected in view of the fact that this is the commonest post-biopsy complication in man (Slotkin and Madsen, 1962) and a frequent one in the dog (Osborne and Low, 1971b).

The fact that cautious sampling led to a large proportion of non-renal specimens and that 7 of 18 renal specimens contained medullary tissue adds further support to the conclusion drawn in Section One that the disposable needle used is too long in relation to the size of the cat kidney. Moreover, in 2 cats from which renal tissue was only obtained at the third biopsy attempt (nos. 14 and 17), on histological examination there were 2 separate small wedge-shaped scars in the renal cortex. This suggests that the kidney had been penetrated on at least 2 occasions in each case even though renal tissue was only obtained once. Therefore the necessity for the tip of the obturator to be as long as 6 mm. must again be questioned. The 20 mm. specimen notch is also unnecessarily long and fully extended into a cat kidney is likely to penetrate to dangerous levels. It is of interest that the 2 specimens which contained blood vessels (cat nos. 18 and 19), were the only 2 which were fully 20 mm. long. Although these specimens also contained 20 and 19 glomeruli each, respectively, other, shorter samples contained similar numbers of glomeruli (Table 4.4).

The efficacy of a modified "Tru-Cut" needle having a shorter obturator tip and effective length of specimen notch will be examined in the following Section.

SECTION THREE

RENAL BIOPSY IN THE NORMAL CAT: AN EXAMINATION OF THE EFFECTIVENESS OF A MODIFIED DISPOSABLE BIOPSY NEEDLE

INTRODUCTION

In the previous 2 Sections, attention was drawn to the fact that the disposable biopsy needle used in that work could have been responsible for unnecessary trauma to the kidney because of the 6 mm. long solid needle tip and that the 20 mm. long specimen notch was probably too long for reasonable use in cats and small dogs. The relatively small size of the kidney in these animals makes it quite possible for the fully extended obturator, a total of 26 mm., properly positioned, to enter the kidney at one pole and emerge from the other pole (Figure 4.14).

Paediatric Franklin-Silverman needles already exist; the White (White, 1962) and Metcoff (Osborne et al, 1974), modifications were introduced in order to accommodate the relatively small size of a child's kidney but their high cost has made their use in animals prohibitive (Osborne, 1975).

This section of the work was designed to examine the possibility of modifying the existing "Tru-Cut" disposable biopsy needle in order to minimise the problems outlined above by: (a) shortening the length of the obturator tip, and (b) permitting only the leading half of the specimen notch to enter the kidney. By incorporating these potentially beneficial features it would have to be established that the modified needle was capable, not only of harvesting renal tissue, but also of ensuring that the volume of sample was diagnostically acceptable.

MATERIALS AND METHODS

(a) Biopsy needles

Eight $4\frac{1}{2}$ inch "Tru-Cut" biopsy needles were modified as shown in Figure 4.15 and 4.16. The solid obturator tip was reduced by means of rotary disc sander and sharpened on an oil stone. In 4 of the needles the original direction of the point was retained (Figure 4.15, Type B), while in the remainder, the direction of the point was reversed to correspond with the angle of the over-riding tip of the cannula (Figure 4.16, Type A).

A hole was drilled through both sides of the T-shaped plastic handle at a position where only half of the specimen notch was exposed when the obturator was extended. A blunted, 16 gauge hypodermic needle was then inserted between the 2 holes to act as a barrier to

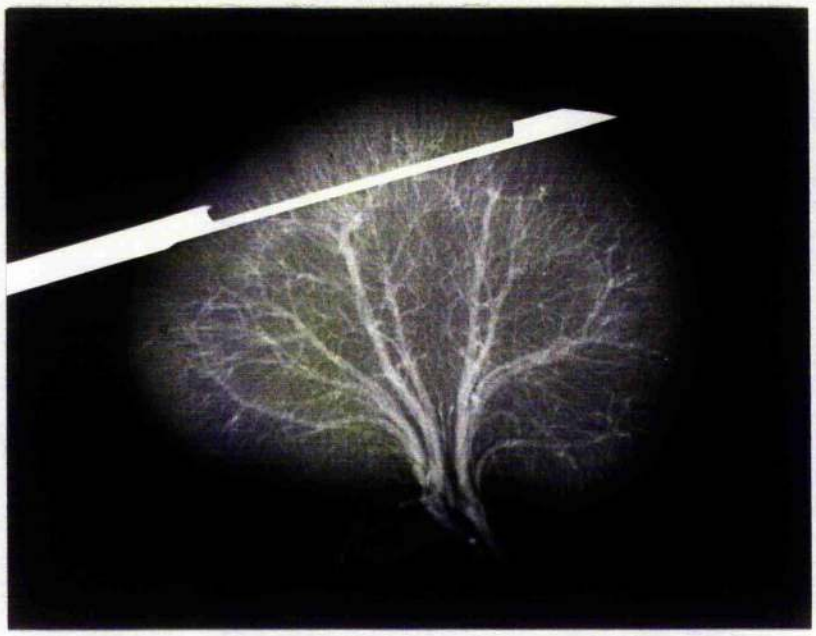


FIGURE 4.14. Radiographic lateral view of an adult cat kidney after infusion with contrast gel. A standard length "Tru-Cut" disposable biopsy needle has been introduced in the "open" position at the caudal pole. Although narrowly missing the corticomedullary junction, the obturator tip has re-emerged at the cranial pole.

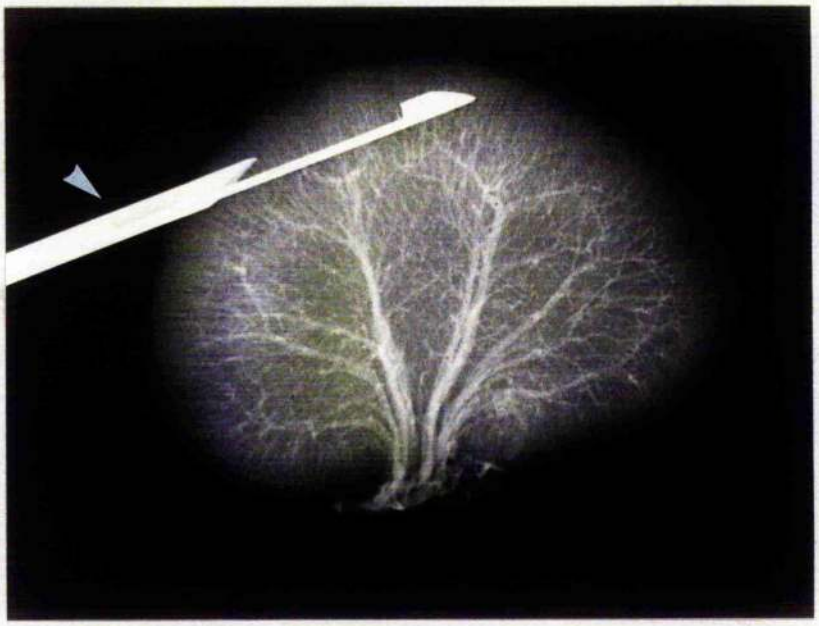


FIGURE 4.15. Radiographic lateral view of adult cat kidney with modified "Tru-Cut" biopsy needle (Type B) introduced in the "open" position to show the reduced length of the obturator tip and reduced capacity of the specimen notch. The unexposed portion of the specimen notch is visible (arrowed at proximal end). The suitability of the reduced length of needle is clearly illustrated.

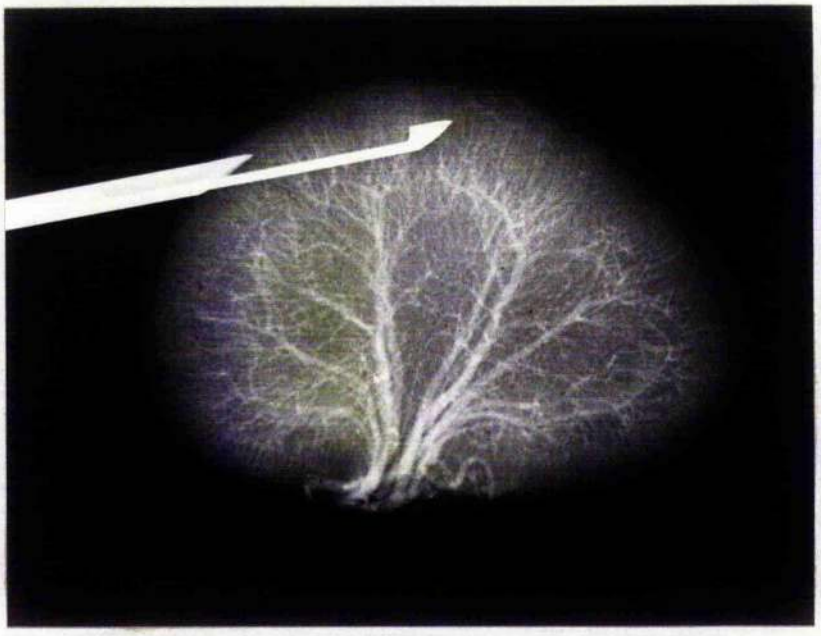


FIGURE 4.16. Radiographic lateral view of adult cat kidney filled with contrast gel with modified "Tru-Cut" biopsy needle (Type A) introduced in the "open" position. The length of the obturator tip is greatly reduced, thus minimising unnecessary trauma.

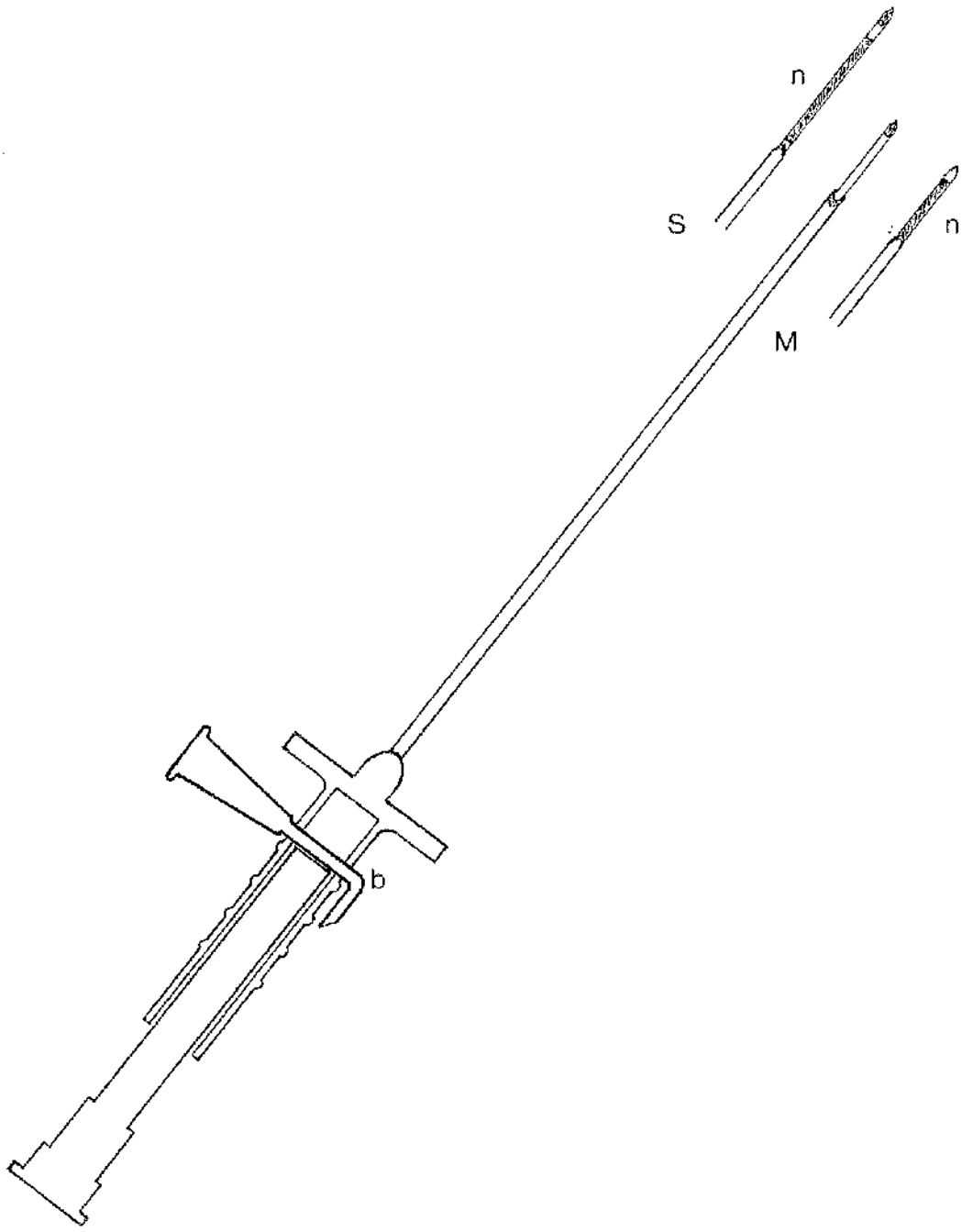


FIGURE 4.17. Diagrammatic representation of modified "Tru-Cut" biopsy needle to show the reduced length of the obturator tip and the barrier introduced into the handle in order to reduce obturator travel and thus the capacity of the specimen notch.

S = standard needle; M = modified needle;
b = barrier; n = specimen notch.

to further travel of the plastic covered end of the obturator (Figure 4.17).

The needles were thoroughly cleaned and stored in absolute alcohol prior to use.

(b) Animals

Four healthy young cats (nos. 20 - 23 inclusive) were obtained from commercial sources and were deeply anaesthetised with ketamine hydrochloride. Both flanks were prepared for percutaneous renal biopsy.

(c) Technique

In each cat, consecutive biopsy attempts were made on the caudal pole of the left kidney, using type A needles. A further 4 biopsy attempts were made on the cranial pole of the right kidney, using type B needles. In each kidney, the first 2 biopsy attempts were made using the approach whereby the obturator was advanced "open" into the kidney and then the cannula forced over it (biopsy method 1). The second 2 biopsy attempts in each kidney were made by advancing the needle "closed" into the kidney, the cannula was then retracted to expose the specimen notch and forced closed again (biopsy method 2).

After each biopsy attempt, specimens were assessed and measured prior to removal from the specimen notch, then they were removed and placed separately in 10 per cent buffered neutral formalin. Following the last biopsy attempt on each cat, the animal was destroyed by an intracardiac injection of pentobarbitone sodium. The kidneys were removed and stored in buffered neutral formalin.

Biopsy specimens were processed and 3 μm sections cut and stained with H & E. Each specimen was examined microscopically to determine the nature and content of the specimen, including the number of glomeruli present and the presence or absence of blood vessels.

RESULTS

The biopsy procedure was straightforward in all 4 cats. Slight difficulty was encountered in penetrating the kidneys of cat nos. 20 (left), 21 (right) and 22 (both). This was considered to be due possibly to bluntness of the modified obturator tips, caused by inconsistent hand sharpening. In addition, the needle used on the right kidney of cat no. 22 was found to have a small gap between the leading edge of the cannula and the top of the obturator tip. This acted as a further impediment to smooth entry of the needle into the substance of the kidney.

Results of the 32 biopsy attempts are recorded in Table 4.6. Visual examination of the samples within the specimen notch indicated that a core of tissue was obtained from 27 out of the 32 attempts. On 3 occasions only fragments of solid tissue and blood were present in the specimen notch but these could not be definitely identified as kidney. However, they were fixed and processed with the other 27 samples. On 2 other occasions, blood only was present and this was discarded.

Samples measured in the specimen notch, prior to removal ranged in length from 2.5 to 10.0 mm. Fragmented samples were given a notional measurement of 1.0 mm. The average length of the 27 samples was 5.9 mm.

Sample lengths obtained from the 2 needle types were averaged separately, as were the average lengths of samples obtained by the 2 biopsy methods. These figures are summarised in Table 4.7. From these results, it is apparent that needle type B, using biopsy method 2, gave slightly better results than the other combinations.

Histological examination of the 30 specimens, fixed and processed, revealed that 28 contained renal tissue only; one contained renal tissue and muscle and the other one contained only muscle. Twenty samples of renal tissue (68.9 per cent) contained one or more glomeruli (range 1 to 40) with an average of 6.4 per sample. Two of the fragmented specimens contained renal cortex and glomeruli and one of these had as many as 11 glomeruli.

TABLE 4.6

RENAL BIOPSY IN NORMAL CATS:

RESULTS OF 32 BIOPSY ATTEMPTS USING A MODIFIED BIOPSY NEEDLE

CAT NO.	KIDNEY/ NEEDLE TYPE	CUT NO.	BIOPSY METHOD	EXAMINATION OF SPECIMEN VISUAL		MICROSCOPIC					
				CONTENT	LENGTH (mm)	KIDNEY	CORT	MED	BV	NO. OF GLOM.	SCORE
20	Left	1	1	Kidney	10.0	+	70	30	-	15	7
	A	2	1	Kidney	5.0	+	90	10	-	5	7
		3	2	Fragments	1.0	+	100	-	-	1	5
		4	2	Kidney	7.0	+	100	-	-	14	7
	Right	1	1	Blood	0	-	-	-	-	14	7
	B	2	1	Kidney	7.0	+	20	80	+	17	7
		3	2	Kidney	7.0	+	10	90	-	1	5
		4	2	Kidney	6.0	+	100	-	-	10	7
21	Left	1	1	Kidney	5.0	+	90	10	-	5	7
	A	2	1	Kidney	2.5	+	-	100	-	0	2
		3	2	Kidney	5.0	+	100	-	-	12	7
		4	2	Kidney	7.5	+	100	-	-	23	7
	Right	1	1	Kidney	7.5	+	-	100	-	0	2
	B	2	1	Kidney	6.5	+	60	40	+	18	7
		3	2	Kidney	6.0	+	-	100	+	0	2
		4	2	Kidney	7.5	+	20	80	+	6	7
22	Left	1	1	Kidney	2.5	+	30	70	-	4	5
	A	2	1	Fragments	1.0	-*	0	0	-	0	0
		3	2	Fragments	1.0	+	50+	-	-	11	7
		4	2	Kidney	7.5	+	-	100	-	0	2
	Right	1	1	Kidney	7.0	+	5	85'	+	1	5
	B	2	1	Blood	0	-	-	-	-	0	0
		3	2	Kidney	5.0	+	30	70	-	3	5
		4	2	Kidney	2.5	+	-	100	-	0	2

TABLE 4.6 Cont'd

CAT NO.	KIDNEY/ BIOPSY TYPE	CUT NO.	BIOPSY METHOD	EXAMINATION OF SPECIMEN VISUAL		MICROSCOPIC					
				CONTENT	LENGTH (mm)	KIDNEY	CORT	MED	BV	No. of GLOM.	SCORE
23	Left	1	1	Kidney	4.0	+	-	100	-	0	2
	A	2	1	Kidney	9.0	+	100	-	-	40	7
		3	2	Kidney/Bl	5.0	+	-	100	-	0	2
		4	2	Kidney/Bl	2.5	+	-	100	-	0	2
	Right	1	1	Kidney	6.0	+	-	100	+	0	2
	B	2	1	Kidney	5.0	+	5	95	+	2	5
		3	2	Kidney	5.0	+	10	90	-	4	5
		4	2	Kidney	10.0.	+	10	90	-	4	5

* - 100 per cent muscle

\+ - 50 per cent muscle

' - 10 per cent muscle

Cort - Cortex

Med - Medulla

BV - Blood Vessel

Glom - glomeruli

Bl - blood

TABLE 4.7

SUMMARY OF AVERAGE SAMPLE LENGTHS

BIOPSY METHOD	NEEDLE TYPE	AVERAGE SAMPLE LENGTHS				OVERALL AVERAGE
		CAT 20	CAT 21	CAT 22	CAT 23	
1	A	7.5	3.8	1.8	6.5	4.9
	B	3.5	7.0	3.5	5.5	4.9
	A + B	5.5	5.4	2.7	6.0	4.9
2	A	4.0	6.3	4.3	3.8	4.6
	B	6.5	6.8	3.8	7.5	6.2
	A + B	5.3	6.5	4.1	5.7	5.4
1 + 2	A					4.8
1 + 2	B					5.6

A further comparative assessment of the 2 needle types and 2 biopsy techniques used was made following histological examination of the specimens obtained. Failure to collect renal tissue occurred on 2 occasions with needle type B (blood only), and once with needle type A (muscle only). All 3 failed attempts occurred using biopsy technique 1.

Biopsy specimens were given scores, as follows:

renal tissue with 5 or more glomeruli	7
renal tissue with less than 5 glomeruli	5
renal tissue without glomeruli	2
no renal tissue present	0

Out of a total potential of 224 points for the 32 biopsy attempts, the total score was 142 (63.4 per cent). Sample scores for the 2 needle types were averaged separately, as were average scores obtained for the 2 biopsy methods. These figures are summarised in Table 4.8. From these results it is apparent that biopsy method 2 gave better results than biopsy method 1 and that needle A gave better results than needle B. However, the overall average score for biopsy method 2 using needle type B was only 0.1 point less than that using needle Type A.

TABLE 4.8

SUMMARY OF AVERAGE SAMPLE SCORES

BIOPSY METHOD	NEEDLE TYPE	AVERAGE SAMPLE SCORE				OVERALL AVERAGE
		CAT 20	CAT 21	CAT 22	CAT 23	
1	A	7.0	4.5	2.5	2.5	4.6
	B	3.5	4.5	2.5	3.5	3.5
	A + B	5.3	4.5	2.5	4.0	4.1
2	A	6.0	7.0	4.5	2.0	4.9
	B	6.0	4.5	3.5	5.0	4.8
	A + B	6.0	5.8	4.0	3.5	4.0
1 + 2	A					4.8
1 + 2	B					4.2

DISCUSSION

Useful specimens of renal tissue were obtained from normal cats using a modified disposable biopsy needle with half the specimen capacity of the commercially available needles. Taking into account this reduction, the average sample length of 5.9 mm. and average glomerular content of 6.4 per renal sample compare favourably with the corresponding results of 13 mm. and 13.8 glomeruli in Section 1, and 10.8 mm. and 10.7 glomeruli in Section 2, using the standard needle. Indeed, the present figures represent an improvement in the ratio of glomerular content to sample length (1.08 : 1) when compared with that in Section 1 (1.06 : 1) and Section 2 (0.99 : 1). Moreover, in the present experiment, specimens were obtained with instruments which were only hand sharpened, so it is possible that improved results could be obtained with machine sharpened needles.

There is no evidence to suggest that the shortened obturator tip reduced the efficiency of the needle in obtaining specimens. Indeed, the presence of major blood vessels in 7 out of 28 renal samples (25 per cent) in this experiment compares favourably with 7 out of 11 samples (63.6 per cent) in Section 1, and 2 out of 12 renal samples (16.6 per cent) in Section 2. Furthermore, 3 of the specimens containing blood vessels were obtained using the same needle (needle B in cat 21) which was noted at the time of use to be particularly blunt. Greater pressure on this needle was required to penetrate the kidney, which led to a corresponding reduction in control over the depth of penetration and, to some extent, the angle of entry. However, survival and subsequent necropsy studies as in Sections 1 and 2 would be necessary to confirm any positive advantage of the shorter obturator tip in reducing the risk of permanent severe renal damage.

In another study, (Author's unpublished observations), satisfactory specimens of up to 20 mm. in length were obtained from normal dog kidneys using needles with shortened obturator tips but allowing full exposure of the 20 mm. standard specimen notch. The modified obturator tip could therefore be applied to all disposable biopsy needles, irrespective of modifications which might be made to the specimen notch.

The results of this study have not shown that there is any particular advantage in altering the shape of the shortened obturator tip. Needle B retains the same shape as the standard needle tip and although it is slightly longer than the tip of needle A, it probably is an advantage to have the point at the lower side of the needle as this will tend to bend the obturator upwards on entry into the kidney, while if the point is at the upper side as in needle A, the tendency is to bend the obturator downwards. This could result in the cannula cutting a larger bite than the specimen notch can accommodate, leading to crushing of the specimen.

The better results obtained by using biopsy method 2 have confirmed the manufacturer's recommendation that this is the preferred method for renal biopsy.

FINAL SUMMARY AND CONCLUSIONS

The results of this study have achieved 4 major objectives:

1. An extension of the existing knowledge of renal biopsy techniques applied to clinical cases of renal disease in the dog and cat (Chapter 2).

Reports by Osborne (1971b) and Jeraj et al (1982) of renal biopsy in the dog indicated that the technique should preferably be performed under inhalation general anaesthesia via the "keyhole" small laparotomy approach to the right kidney. In this study, by comparison, adequate results were obtained using parenteral neuroleptanalgesia via the direct ("blind") percutaneous approach to the left kidney. This method has several advantages:

(a) it is less invasive and quicker to perform, thus reducing the risk to the patient;

(b) the neuroleptanalgesic agent is reversible, thus decreasing the recovery time: and

(c) the method is less labour intensive, therefore more economical.

The disadvantages, arising from poor abdominal relaxation in a few cases, restricting or preventing adequate access to the left kidney, were quickly overcome by anaesthetising the already heavily sedated animal with barbiturate and or halothane, and using the direct approach if the kidney was then accessible, or the "keyhole" approach on the same side if the left kidney could not be palpated.

The possibility that better relaxation for renal biopsy might be obtained using the sedative xylazine ("Rompun", Bayer U.K. Limited, Bury St Edmunds) has yet to be explored.

In this study, good results were obtained in cats using the direct percutaneous approach, thus confirming the recommendation of earlier workers (Osborne 1971b; Jeraj et al, 1982). However, unlike previous studies in which cats were sedated and locally anaesthetised (Osborne, 1971b; Jeraj et al, 1982), cats in this series were anaesthetised with ketamine hydrochloride. The excellent results obtained defy the warnings of Osborne et al, (1974) and Osborne (1975) against its use in uraemic cats, and confirm the reassurance by Waterman (1983) of its relative safety in these animals.

Although the overall first biopsy diagnosis rate (84.7 per cent) in this study compared favourably with that of Osborne (1971b); Jeraj et al (1982) and Grauer et al (1983), it would have been higher had glomeruli been present in a greater number of specimens. Kark and Muehrcke (1954) recommended examination of biopsy specimens under a hand lens immediately after removal and this or some similar procedure will be adopted in future studies in an attempt to improve the quality of results.

2. An in depth study of membranous nephropathy in the cat; a disease reliant upon renal biopsy for initial diagnosis and effective follow up (Chapter 3).

Renal biopsy yielded adequate specimens for the diagnosis of this disease. It was confirmed that immunofluorescence and ultrastructural examinations are essential, as histopathology alone would have been insufficient in the majority of cases.

The value of follow up biopsies in indicating the progressive nature of the disease was not so fully explored as might have been hoped, as further biopsies in 2 cats of particular interest, one of which has made an apparently full recovery and the other which has survived for more than 2 years in spite of being classified as an "advanced" case, have not been allowed.

The grading of severity as observed at the first biopsy was successful in providing a retrospective index confirming, in the majority of cases, the clinical and biochemical expressions of the disease at the time. This procedure will be continued as the number of subsequent cases grows, although the need for flexibility in such a system will continue to be recognised.

An ongoing search for possible aetiologic agents will be made, especially in view of the close similarities with the disease in man. Studies beneficial to both species could accrue if such agents were identified and a disease model system developed.

3. An investigation into the effects on the normal cat kidney of single and repeated biopsy puncture (Chapter 4, Sections 1 and 2).

For the first time, experimental investigations into the effects of renal biopsy on the cat kidney were carried out. The use of a radioopaque contrast gel infused into kidneys immediately after death provided a useful means of examination and comparison of the vasculature in the biopsied and non-biopsied kidneys. The method did not substantially interfere with later processing for routine histopathological examination.

These studies confirmed the finding in some clinical cases seen at necropsy, that over-penetration of the biopsy needle could cause extensive renal damage and that care must be exercised over the angle and depth of insertion. Unfortunately, the converse, excessive caution, led to a reduction in the quality of samples obtained.

Further studies must be undertaken to investigate a method of determining the depth of the kidney below the abdominal wall, in order to improve the safety and efficiency of sampling.

Multiple and repeated biopsies did not appear to increase the severity of renal damage. This is encouraging, in view of the number of multiple punctures required for adequate sampling in the clinical situation in both animals and man. However, care in insertion of the needle is still of vital importance.

4. An evaluation of the effectiveness of the "Tru-Cut" disposable biopsy needle (Chapters 2 and 4).

Results obtained with this needle compared favourably with those reported by Osborne (1971b), using the Franklin-Silverman needle. However, the severe post-biopsy lesions seen at necropsy in 20 per cent of the cats in the present series of clinical cases raised the question of the safety of the "Tru-Cut" needle in this species.

Experimental studies indicated that this needle in its present form is too long for satisfactory use in the cat and is, therefore, probably also too long for use in small dogs and possibly young children.

The success of a prototype modification to shorten the existing needle has been encouraging and further studies will be undertaken to confirm its safety and effectiveness both experimentally and in the clinical situation.

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APPENDICES

APPENDIX A

RENAL BIOPSY IN THE DOG:

SUMMARIES OF 53

CLINICAL CASES

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
50535	Labrador Retriever	5	FS	Episodes of polydipsia and polyuria for 2 - 3 years. Weight and appetite unchanged. 14 months later, weight loss, dullness and occasional vomiting. Gradual deterioration over next 2 months ending in terminal renal failure.	Protein - losing nephropathy	B1: persistent proteinuria. B2: prior to euthanasia.	Terminal renal failure; renal amyloidosis; chronic interstitial nephritis
52750	Cocker Spaniel X	7	M	Confirmed Leptospirosis canicola when 2 years old. Recovered but remained thin and intermittently polydipsic. Lost when 9 years old. Presumed dead.	Mild chronic interstitial nephritis	Examined for evidence of progression of original illness	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
50535 a	16 months	13.4	149	1.5	ND	28	34	0.38	17.0	288	-	1.024
b		96.0	1105	9.6	6.8	22	47	0.24	9.2	300	+++	1.020
52750 a	6 years	16.0	277	3.2	ND	29	36	0.39	28.7	32	-	1.021
b		10.1	123	2.0	ND	50	52	0.53	15.1	32	-	1.035
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
50535 B1	Acetylpromazine/ thiopentone/ halothane	-		+		+		+			3	1 x 0 1 x 5 1 x10	-	Normal
B2	"Immobilon"	+	+	+		+			+		3	NR	+	Immediate euthanasia
52750	Acetylpromazine/ lignocaine	-	+			+			+		2	1 x 0 1 x15	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
50535 B1	+	21	Moderate glomerular deposition of amyloid. Some interstitial fibrosis and foci of mononuclear cells. FA negative.	Amyloidosis; mild chronic interstitial nephritis	+	+
B2	+	5	Marked glomerular deposition of amyloid. Advanced interstitial fibrosis.	Amyloidosis; Severe chronic interstitial nephritis	+	+
52750	+	42	40% glomeruli sclerotic. Scattered strands of interstitial fibrosis.	Chronic interstitial nephritis	+	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
53287	Mongrel	14	M	Polydipsia for 6 weeks. Muscle wasting, dullness. Abdominal distention, liver and prostate enlarged. Euthanasia after 1 week.	Protein - losing nephropathy; possible amyloidosis	Persistent proteinuria	Amyloidosis; chronic pyelonephritis
56769	Mongrel	12	FS	Dullness and anorexia for 2 weeks. Maintained on low protein diet but gradually deteriorated. Terminal renal failure after 11 months.	Protein - losing nephropathy	Persistent proteinuria	Chronic interstitial nephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
53287 a	1 week	6.6	79	1.6	ND	19	42	0.48	8.6	548	-	1.022
b		9.1	ND	ND	ND	ND	ND	ND	ND	620	-	1.024
56769 a	11 months	13.6	150	1.7	10.3	15	48	0.48	9.1	648	-	1.024
b		124.0	1052	7.3	14.9	14	51	0.29	9.9	178	-	1.011
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
53287	Acetylpromazine/ thiopentone/ halothane	-	+			+		+			2	1 x 0 1 x20	+	Normal
56769	Acetylpromazine/ thiopentone	-	+			+			+		1	20	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
53287	+	17	Mild glomerular sclerosis and evidence of amyloid deposition. Foci of polymorphs in medulla. Mild interstitial fibrosis. A few hyaline casts. FA negative.	Chronic pyelonephritis; amyloidosis	+	+
56769	+	6	Three glomeruli scarred. Interstitial fibrosis and foci of mononuclear cell infiltrates. FA negative.	Chronic interstitial nephritis	-	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
56315	Old English Sheepdog	2	M	Gradual onset abdominal swelling for 2 months. Latterly weight loss, reduced appetite, polydipsia and polyuria, and intermittent diarrhoea. Ascites and hind limb oedema. Good early response to diuretic therapy but relapsed several times and diarrhoea became chronic. Euthanasia after 11 months.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
56315 a	11 months	6.0	50	1.5	ND	9	27	0.32	11.5	2230	-	1.039
b		7.0	90	2.5	ND	12	23	0.26	5.1	257	-	1.010
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	-35	-30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
56315 B1	"Immobilon"	-	+			+		+			NR	NR	NR	Normal
B2	"Immobilon"	-	+			+		+			NR	NR	-	Normal
B3	"Immobilon"	-	+			+		+			NR	NR	-	Normal
B4	"Immobilon"	-	+			+		+			NR	NR	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
56315 B1	+	7	All 4 specimens appeared very similar. Some partial glomerular scarring. All glomeruli showed diffuse thickening of the capillary loops but no increase in cellularity. IF positive for IgG and C3. EM showed extensive subepithelial and intramembranous electron dense deposits.	Membranous nephropathy	+	+
B2	+	4		"	+	+
B3	+	2		"	+	+
B4	+	9		"	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
59163	Labrador Retriever	5	FS	Polydipsia, reduced appetite and weight loss for 3 weeks. Vomiting in the third week. Quite bright. both kidneys grossly enlarged. Euthanasia after 8 days.	Lymphosarcoma	Renal failure	Alimentary and renal lympho-sarcoma.
60348	Irish Setter	11	M	Loss of condition and aggressive behaviour for 3 months. Large anterior abdominal mass. Laparotomy confirmed hepatic neoplasia. Immediate euthanasia.	Hepatic neoplasia; protein - losing nephropathy	Persistent proteinuria	Hepatic carcinoma. Renal blocks lost in processing.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
59163 a	1 week	30.7.	ND	1.8	5.5	27	48	0.41	12.1	917	-	1.022
b		36.7	645	2.1	ND	22	32	0.24	6.5	166	-	1.021
60348 a	10 days	6.8	ND	1.3	ND	29	35	0.50	12.4	1131	-	1.046
b		6.5	ND	1.5	ND	16	37	0.39	4.5	552	-	1.029
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
59163	"Immobilon"	+	+				+	+			1	20	-	Normal
60348	Acetylpromazine/ thiopentone/ halothane	-			+	+			+		2	1 x 0 1 x10	-	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
59163	+	3	Massive accumulation of malignant lymphocytes leaving only a few islands of renal tissue.	Lymphosarcoma	+	+
60348	+	4	One glomerulus severely scarred. The other 3 showed mild diffuse mesangial expansion, focal capsular adhesions and periglomerular fibrosis FA negative but section contained no glomeruli. EM section contained no glomeruli.	Possibly glomerulo-nephritis	+	No correlation of renal disease possible

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
60738	Labrador Retriever	10	F	Grossly obese. Moderate polydipsia and proteinuria. Discharged unchanged and died 1½ years later. No necropsy examination.	Mild chronic nephritis	Persistent proteinuria	No necropsy examination
61702	Mongrel	4	M	Confirmed Leptospirosis canicola when 1 year old. Apparently good recovery. Followed up for 5 years then owner moved away. No further report received.	Mild chronic interstitial nephritis	Examined for evidence of progression of original illness.	No necropsy examination.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
60738 a	6 weeks	6.0	238	1.2	4.5	27	28	0.53	12.9	360	–	1.031
b		6.8	97	1.6	ND	24	32	0.51	19.4	660	+	1.041
61702 a	3 years	12.3	ND	1.8	ND	24	44	0.40	12.8	69	–	1.023
b		6.0	114	ND	2.1	28	29	0.53	12.1	33	–	1.035
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
60738	"Immobilon"	-		+		+		+			2	1 x 0 1 x15	+	Normal
61702	"Immobilon"/ thiopentone/ halothane	-		+		+		+	+		4	2 x 0 1 x15 1 x20	-	Prolonged. Insufficient relaxation with "Immobilon"

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
60738	+	12	One glomerulus scarred. Mild interstitial fibrosis. FA showed C3 staining in tubular basement membranes.	Mild chronic interstitial nephritis	+	No necropsy
61702	+	40	Most glomeruli normal. One focal scar. Very mild interstitial fibrosis and a few small foci of mononuclear cells. FA negative	Mild chronic interstitial nephritis	+	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
62574	Dalmatian	5	M	Dullness, anorexia and vomiting for 2 days. Congested mucous membranes Laparotomy for suspected intestinal foreign body but none found. Kidneys moderately enlarged. Uneventful recovery and discharged.	Acute gastro-enteritis	Enlarged kidneys	No necropsy examination
63772	Afghan	1	M	Weight loss, dullness, reduced appetite, ascites and hind limb oedema for 6 weeks. Sudden onset dyspnoea 4 weeks later. Euthanasia.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy. Pulmonary arterial thrombosis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
62574 a	2 days	18.4	ND	2.1	ND	25	47	0.66	26.8	200	++	1.029
b		ND	ND	ND	ND	ND	ND	ND	ND	0	+	1.032
63772 a	4 weeks	6.7	80	1.9	ND	11	36	0.45	13.6	3560	-	1.049
b		11.2	79	2.4	6.7	8	35	0.28	13.7	628	-	1.030
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	-35	-30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
62574	Acetylpromizine/ thiopentone/ halothane	-			+	+		+			2	1 x 0 1 x15	+	Normal
63772	Acetylpromazine/ thiopentone	-		+			+	+			1	20	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
62574	+	13	All glomeruli normal. No significant abnormalities found. FA negative.	Inconclusive	+	No necropsy
63772	+	23	Eighteen normal glomeruli. Five slightly scarred. Thickened capillary loops in all glomeruli. FA was positive for IgG and C3. Extensive subepithelial and intramembranous electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
65361	Poodle	1	F	Polydipsia and polyuria for 6 months. Otherwise the dog appeared normal. Discharged unchanged and followed up for 6 months. Euthanasia at 2½ years and body not available for necropsy examination.	Renal tubular defect	Persistent polyuria	No necropsy examination
65401	Samoyed	2	F	Episodes of dullness and anorexia for 6 months followed by weight loss, polydipsia and vomiting. Uraemic halitosis and small kidneys. Maintained on low protein diet for one year but then rapidly deteriorated and died. Unavailable for necropsy.	Chronic nephritis, possibly familial.	Chronic renal failure	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
65361 a	6 months	7.1	88	1.3	5.2	28	33	0.56	7.8	0	-	1.023
b		6.0	71	1.2	ND	26	34	0.45	8.0	0	+	1.016
65401 a	5 months	44.8	469	3.9	5.7	25	57	0.28	3.1	380	-	1.021
b		51.0	474	3.5	ND	24	33	0.33	11.4	853	-	1.022
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	-35	-30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
65361	Thiopentone	-		+		+		+			2	1 x 0 1 x15	-	Normal
65401	Acetylpromazine/ thiopentone/ halothane	+		+			+	+			NR	NR	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
65361	+	18	All glomeruli normal. No significant abnormalities found	Inconclusive	-	No necropsy
65401	+	7	Three glomeruli obsolescent and 2 others partially scarred. Marked interstitial fibrosis.	Chronic nephritis	+	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
66087	Mongrel	4	M	Dullness, anorexia, weight loss and vomiting for one week. Inelastic pulse; uraemic halitosis and oral ulceration. Small kidneys. Gradual deterioration. Euthanasia after 2 weeks.	Chronic interstitial nephritis	Renal failure	Chronic interstitial nephritis
66186	Labrador Retriever	8	M	Polydipsia and polyphagia for 2 months. Dullness and reluctance to exercise. Good response to specific therapy for Cushing's syndrome. Contact lost after 6 months.	Cushing's syndrome	Persistent moderate proteinuria	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a—b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $\times 10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
66087 a	2 weeks	94.0	1273	6.0	5.3	22	34	0.21	6.8	156	-	1.016
b		198.0	1609	10.1	ND	19	57	0.20	12.2	420	+	1.021
66186 a	4 months	4.3	97	1.8	6.6	19	35	0.52	5.7	373	-	1.027
b		4.2	ND	1.9	ND	19	19	0.50	9.2	149	-	1.006
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	-35	-30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
66087	Acetylpromazine/ thiopentone	+		+			+	+			2	1 x 5 1 x10	-	Normal
66186	Acetylpromazine/ thiopentone/ halothane	-		+			+	+			NR	NR	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
66087	+	0	Heavy interstitial fibrosis and a small mononuclear cell infiltrate.	Chronic interstitial nephritis	+	+
66186	+	22	All glomeruli were normal. No hyaline casts were seen suggesting that the protein leak was not of renal origin. FA negative	Inconclusive	-	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
66236	West Highland terrier	3	F	Smallest in her litter and polydipsic since weaned. For 3 weeks prior to referral she was dull, ate less, drank even more and became incontinent. Improved in hospital. Discharged on a low protein diet. Thereafter contact was lost.	Chronic nephritis; possibly congenital nephropathy	Mild renal failure	No necropsy examination
67327	Boxer	3	F	Recurrent bouts of anorexia, weight loss, dullness and vomiting for 2 months. Pale mucosae, uraemic halitosis and oral ulceration. Progressive deterioration and euthanasia after 10 days.	Chronic interstitial nephritis	Renal failure	Chronic pyelonephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
66236 a	3 weeks	15.9	ND	1.5	ND	23	36	0.46	9.0	279	–	1.015
b		13.2	ND	1.3	ND	23	38	0.44	19.0	123	+	1.015
67327 a	10 days	46.3	636	3.9	ND	24	36	0.22	3.8	35	–	1.014
b		84.0	727	4.5	ND	19	57	0.21	10.2	140	–	1.015
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
66236	Acetylpromazine/ thiopentone	-		+			+	+			1	10	+	Proglonged but no complications
67327	Acetylpromazine/ thiopentine	+		+		+		+		+	4	3 x 0 1 x10	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
66236	+	7	Five glomeruli were sclerotic. There was mild interstitial fibrosis and a small infiltrate of mononuclear cells.	Chronic nephritis	+	No necropsy
67327	+	6	Two glomeruli were sclerotic. There was marked interstitial fibrosis and a small infiltrate of mononuclear cells.	Chronic interstitial nephritis	+	-

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
67389	Springer Spaniel	3	M	Recurrent episodes of fever, dullness, anorexia and coughing for 2 years. Deterioration at 3 years with enlarged superficial lymph nodes and chronic skin lesions. Improved with prednisolone therapy and discharged. Died suddenly 4 months later.	Lupus erythematosus	Renal failure and persistent moderate proteinuria	Probably lupus erythematosus. Glomerulonephritis confirmed.
67393	Border Collie	3	M	Reluctant to work, dull, reduced appetite and weight loss for 2 months. Improved and gained weight over 2½ months in hospital. Discharged and maintained improvement.	Mild renal failure/ hookworm infection	Renal failure	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $\times 10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
67389 a	6 months	55.0	530	2.7	ND	28	40	0.28	13.3	120	-	1.019
a		11.0	150	1.5	ND	22	42	0.30	14.6	237	-	1.019
67393 a	2½ months	20.4	151	1.4	ND	20	49	0.46	12.2	33	-	1.025
b		11.5	124	1.9	ND	26	38	0.45	8.8	4	-	1.022
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
67389	Acetylpromazine/ thiopentone	+		+		+		+			3	2 x 0 1 x 5	+	Normal
67393	Acetylpromazine/ thiopentone	+	+			+		+			2	1 x 0 1 x20	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
67389	+	22	Segmental glomerular hypercellularity with mesangial expansion and basement membrane thickening. Tubular calcium precipitates. FA negative	Proliferative glomerulonephritis; nephrosis	+	+
67393	+	0	Interstitial fibrosis, especially at the corticomedullary junction.	Mild chronic nephritis	+	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
67795	Poodle	4	M	Polydipsia, polyuria and slight weight loss for 3 months. otherwise apparently normal. No improvement in 4 weeks. Owner requested euthanasia.	Psychogenic polydipsia	Elimination of possible renal disease	Inconclusive. Focal acute pyelonephritis at biopsy site. Kidneys otherwise normal.
67539	Cocker Spaniel	1	F	Polydipsia for 5 months. Thin, bright, variable appetite, occasional vomiting. Hypertensive femoral pulse. Anaemia latterly. Gradual deterioration in 4 months. Died after fourth biopsy attempt.	Familial nephropathy	Chronic renal failure and persistent proteinuria	Severe anaemia. Confirmed chronic nephritis.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
67795 a	4 weeks	8.6	53	1.0	ND	39	37	0.45	11.7	0	–	1.013
b		3.9	96	1.3	ND	26	46	0.38	7.4	0	–	1.005
67539 a	4 months	35.9	292	9.6	ND	17	39	0.34	11.2	335	++	1.016
b		41.1	362	9.9	ND	17	27	0.10	5.0	362	+++	1.016
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
67795	Acetylpromazine/ thiopentone/ halothane	-		+		+		+			1	10	+	Normal
67539 B1	Acetylpromazine/ thiopentone	+	+			+		+			3	3 x 5	+	Normal
B2	"	+	+			+		+			1	20	NR	Normal
B3	"	+	+			+		+			2	1 x 0 1 x20	+	Normal
B4	"	+	+			+		+			3	2 x 5 1 x10	+	Died without recovering from anaesthesia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
67795	+	3	Glomeruli and tubules appeared normal.	Inconclusive	+	+
67539 B1	+	1	All 4 specimens were very similar.	Chronic nephritis	+	+
B2	+	7	Three glomeruli were sclerotic. There was marked interstitial fibrosis in the cortex and medulla with small foci of mononuclear cells. FA negative.	"	+	+
B3	+	0		"	+	+
B4	+	0		"	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
68409	West Highland Terrier	1½	F	Dullness, weight loss, variable appetite and vomiting for 3 months. Polydipsia latterly. Discharged after 3 weeks and died 4 weeks later. Unavailable for necropsy examination.	Protein - losing nephropathy	Persistent proteinuria	No necropsy examination
68501	Cairn Terrier	9	FS	Dullness, anorexia and vomiting for one week. Obese, tachypnoeic and congested mucosae. Uraemic halitosis and oral ulceration. Euthanasia on the day of admission.	Terminal nephritis	Renal failure	Chronic nephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
68409 a	3 weeks	10.3	ND	1.3	ND	8	43	0.38	26.8	675	-	1.020
b		17.4	115	3.0	12.1	7	35	0.26	8.4	745	-	1.020
68501	-	129.0	1157	14.8	6.7	30	49	0.38	14.2	300	++	1.020
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
68409	Acetylpromazine/ lignocaine	-	+			+		+			2	1 x 0 1 x20	-	Normal
68501	Thiopentone	+	+			+		+			3	1 x 0 2 x10	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
68409	+	28	Extensive amyloid deposits in all glomeruli. Mild interstitial fibrosis. A few hyaline casts. FA showed diffuse, faint masses of IgG, IgM, C3 and fibrin.	Amyloidosis	+	No necropsy
68501	+	12	4 scarred glomeruli. Diffuse interstitial fibrosis. Many hyaline casts. FA positive for C3 and fibrinogen in tubules. EM showed possible fibrin in urinary spaces.	Chronic interstitial nephritis	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
70417	Mongrel	1	M	Dullness, anorexia, weight loss, polydipsia and polyuria for 7 days. Congested mucosae, hyperpnoea and watery nasal discharge. Jaundice developed later. Left kidney enlarged. Anterior thoracic mass on x-ray. Progressive deterioration and euthanasia after 4 days.	Thymic lympho-sarcoma with renal and hepatic involvement	Renal failure	Thymic lympho-sarcoma with infiltration of liver and kidneys; nephrosis and renal calcification
70446	Mongrel	8	M	Weight loss for 2 months. Vomiting and polydipsia for 1 week. Dull, congested mucosae, inelastic pulse; uraemic halitosis. Progressive deterioration and euthanasia after 8 days.	Terminal chronic nephritis	Renal failure	Chronic interstitial nephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
70417 a	4 days	21.1	212	1.6	ND	28	29	0.49	16.3	40	+	1.023
b		37.8	194	2.5	3.9	18	31	0.49	18.4	96	+	1.019
70446 a	8 days	58.9	778	2.6	ND	31	33	0.46	11.4	126	–	1.016
b		86.0	ND	8.1	ND	28	36	0.42	10.7	94	+++	1.019
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	-35	-30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	UREAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
70417	"Immobilon"	+	+			+			+		2	1 x 6 1 x20	–	Immediate euthanasia
70446	"Immobilon"	+	+			+		+			3	2 x 6 1 x10	+	Prolonged. A second dose of "Revivon" was given 4 hours after the first. The dog remained ataxic until euthanasia.

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
70417	+	30	Glomeruli normal. There was calcification of tubular basement membranes and crystals were present in the tubules. Small foci of malignant lymphocytes were present.	Renal calcification; nephrosis; lymphosarcoma	+	+
70446	+	47	Many glomeruli were moderately sclerosed There was marked interstitial fibrosis with foci of mononuclear cells. Tubules were compressed and atrophied.	Chronic interstitial nephritis	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
70617	Irish Setter	8½	F	Dullness, anorexia, weight loss, vomiting and melaena for 7 days. Very weak and severly dehydrated. Melaena investigated by laparotomy. Progressive deterioration and euthanasia 4 days after laparotomy.	Protein - losing nephropathy	Renal failure and persistent proteinuria	Membranous nephropathy. Renal vein thrombosis Haemorrhagic gastro-enteritis
71268	Labrador Retriever	11	M	Dullness, vomiting and haematuria for 5 weeks. Reduced appetite and weight loss latterly. Pale mucosae and large anterior abdominal mass, probably left kidney. Confirmed on IVP. Progressive deterioration and euthanasia after 7 days.	Renal tumour	Enlarged left kidney	Transitional cell carcinoma with metastases to spleen and lungs.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
70617 a	10 days	48.6	239	1.7	ND	15	32	0.34	17.5	2275	-	1.045
b		18.5	230	2.5	ND	10	29	0.28	7.5	2080	+	1.045
71268 a	7 days	13.2	ND	1.1	ND	24	37	0.37	13.7	140	+++	1.021
b		5.4	ND	2.1	ND	18	37	0.25	15.0	140	+++	1.036
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
70617	Acetylpromazine/ thiopentone/ halothane	+			+	+		+	+		4	3 x 0 1 x15	+	Normal
71268	Acetylpromazine/ thiopentone/ halothane	-	+			+		+			1	20	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
70617	+	21	Diffuse thickening of capillary loops with areas of scarring and fibrin deposition. Hyaline casts present in some tubules. FA positive for IgG and C3 EM showed subepithelial and intramembranous electron dense deposits.	Membranous nephropathy	+	+
71268	+	0	Specimen contained only necrotic haemorrhagic debris. No recognisable renal structure or cell types were seen.	Inconclusive	-	-

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
71337	Shetland Sheepdog	2	M	Dullness, reduced appetite, polydipsia and occasional vomiting for 2 weeks. Thin. Uraemic halitosis and oral ulceration. Small kidneys. Progressive deterioration to death 5 weeks later.	Chronic nephritis	Renal failure	Chronic nephritis
71791	Labrador Retriever	5	M	Vomiting and reduced appetite for 10 days. Weight loss dullness, congested mucosae, uraemic halitosis and brown tongue. Laparotomy to investigate possible intestinal obstruction. Progressive deterioration and euthanasia 24 hours later.	Acute renal failure	Kidneys enlarged at laparotomy	Chemical nephrosis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
71337 a	5 weeks	51.0	ND	2.0	ND	17	42	0.30	8.1	140	-	1.015
b		62.8	301	4.1	ND	16	39	0.21	7.8	158	+++	1.021
71791 a	2 days	91.0	ND	18.6	ND	27	28	0.42	16.0	14	-	1.022
b		107.0	ND	ND	ND	28	35	0.38	9.9	0	-	1.016
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
71337	Acetylpromazine/ thiopentone	+	+			+		+			1	20	+	Normal
71791	Acetylpromazine/ thiopentone/ halothane	+			+	+			+		2	1 x 0 2 x20	-	Prolonged but no complications

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
71337	+	5	All glomeruli scarred. Extensive interstitial fibrosis and small foci of mononuclear cells. FA faintly positive for IgG and C3 in glomeruli.	Chronic interstitial nephritis	+	+
71791	+	12	Glomeruli normal. Tubular degeneration and necrosis in some convoluted tubules. Birefringent crystals present in tubules.	Toxic nephrosis	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
72295	Rough Collie	6	M	Polydipsia, reduced appetite and intermittent vomiting for several weeks. Basal cell tumour excised from cheek at time of biopsy. Improved and discharged. Still alive after more than 3 years.	Mild chronic nephritis	Mild renal failure	No necropsy examination
74050	Lurcher	1	F	Osteomyelitis and discharging sinus following attempted repair of fractured right femur. Trimethoprim/sulphadiazine treatment for several months. Vomiting for 5 days prior to biopsy. Improved and discharged. Still alive after more than 3 years.	Protein-losing nephropathy, possibly drug-induced	Renal failure and persistent proteinuria	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
72295 a	10 days	18.7	124	1.1	ND	26	43	0.45	8.7	66	-	1.029
b		6.1	115	1.1	ND	25	36	0.43	15.7	316	-	1.036
74050 a	3 weeks	60.1	136	2.9	ND	20	23	0.25	5.2	930	-	1.026
b		6.5	97	ND	ND	ND	ND	0.41	5.5	280	-	1.020
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	-35	-30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
72295	Acetylpromazine/ thiopentone/ halothane	–		+		+			+		2	1 x 0 1 x20	–	Normal
74050	Acetylpromazine/ thiopentone/ halothane	+		+		+		+			2	1 x 5 1 x15	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
72295	+	7	One glomerulus sclerotic. A little interstitial fibrosis. FA negative	Mild chronic nephritis	+	No necropsy
74050	+	9	Three glomeruli showed mesangial expansion with fibrin deposition in one. FA faintly positive IgG and C3 EM showed patchy fusion of epithelial foot processes but no electron dense deposits.	Unclassified glomerulonephritis	+	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
74070	Wheaten Terrier	6 mth	F	Smallest in litter. Litter mate died in renal failure at 5 weeks of age. Persistent vomiting after food until surgical correction of pyloric stenosis at 5 months. Polydipsia and uraemia then which continued in spite of improvement for 3 months on low protein diet. Gradual deterioration during following 3 months and euthanasia.	Familial nephropathy	Renal failure	Chronic nephritis
74476	Labrador Retriever	4	M	Unvaccinated. Vomiting, dullness and anorexia for 4 days. Congested mucosae, uraemic halitosis and oral ulceration, tense abdomen and swollen kidneys. Died after 5 days.	Acute interstitial nephritis	Acute renal failure	Acute Leptospiral nephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
74070 a	7 months	33.5	265	2.8	ND	16	39	0.22	19.1	0	+	1.010
b		59.3	778	5.7	ND	30	36	0.25	11.6	50	–	1.014
74476 a	4 days	79.5	2740	5.9	ND	18	49	0.26	12.2	74	++	1.016
b		136	3023	11.8	3.0	ND	ND	ND	ND	300	–	1.020
			L. canicola agglutination titre 1: 10,000							Leptospiruria		
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
74070	"Immobilon"	+	+			+		+			2	1 x 5 1 x15	+	Normal
74476	"Immobilon	+		+		+		+			2	1 x 5 1 x20	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
74070	+	3	Two glomeruli scarred. Extensive interstitial fibrosis FA negative	Chronic nephritis	+	+
74476	+	6	Glomeruli appeared normal. Marked interstitial infiltrate of plasma cells and lymphocytes. FA positive for Leptospira canicola antigen.	Acute Leptospiral nephritis.	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
74564	Springer Spaniel	4	F	Variable appetite with preference for soft food for over 2 years. Thin, uraemic halitosis and maxillary osteodystrophia fibrosa. Improved for 10 weeks on low protein diet. Deteriorated and euthanasia after 12 weeks.	Chronic renal failure	Renal failure	Chronic nephritis
74755	Old English Sheepdog	4	M	Weight loss for 3 months. Gradual swelling of abdomen. Occasional vomiting. Thin, marked ascites, scrotal and peripheral oedema. Progressive deterioration and euthanasia after 10 days.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
74564 a	3 months	42.5	539	3.3	ND	34	39	0.43	6.5	72	-	1.016
b		54.4	884	5.6	9.9	29	41	0.41	18.4	540	-	1.015
74755 a	10 days	4.2	115	1.4	8.8	9	25	0.34	19.0	1190	-	1.030
b		9.7	123	ND	8.9	11	43	0.27	22.6	600	+	1.024
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
74564	"Immobilon"	+	+			+		+			1	10	-	Normal
74755 B1	"Immobilon"	-	+				+	+			1	15	+	Normal
B2	"Immobilon"/ thiopentone	-	+			+		+			1	15	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
74564	+	1	Glomerulus scarred. Marked interstitial fibrosis. Many hyaline casts in tubules.	Chronic nephritis	+	+
74755 B1	+	0	No glomeruli present in any of the preparations.	Inconclusive	-	-
B2	+	24	Diffuse thickening of glomerular capillary loops. FA positive IgG and C3 EM showed intramembranous and subepithelial electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY

DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
74934	Collie X	2	M	Unvaccinated. Vomiting for 6 days. Dullness, anorexia, tarry faeces. Uraemic halitosis and lingual necrosis. Abdominal pain and swollen kidneys. Progressive deterioration and euthanasia after 24 hours.	Acute interstitial nephritis	Acute renal failure	Acute interstitial nephritis
75154	Alsatian	8	M	Vaccinated as a pup but never re-vaccinated. Dullness, anorexia, weight loss, polydipsia and vomiting, for 10 days. Congested mucosae. Severe anterior abdominal pain and swollen kidneys. Progressive deterioration and death after 2 days.	Acute interstitial nephritis	Acute renal failure	Acute interstitial nephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
74934	–	103.5	2360	10.3	6.9	21	70	0.34	46.7	145	++	1.020
			L. canicola agglutination titre 1: 30000									
75154	–	96.3	1803	10.2	ND	17	57	0.33	20.0	0	–	1.021
			L. canicola agglutination titre 1: 30000									
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
74934	"Immobilon"	+	+			+		+			4	2 x 0 1 x 5 1 x20	+	Immediate euthanasia
75154	"Immobilon"	+	+			+		+			1	10	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy / Necropsy
74934	+	0	Severe interstitial infiltrate of plasma cells and lymphocytes. FA section contained 4 glomeruli. All were positive for Leptospira canicola antigen.	Acute interstitial nephritis	+	+
75154	+	4	Glomeruli appeared normal. Interstitial infiltrate of plasma cells and lymphocytes with a mild degree of fibrosis. FA negative for Leptospira canicola antigen.	Acute interstitial nephritis.	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
75513	Mongrel	1	M	Unvaccinated. Polydipsia and polyuria and weight loss for 2 weeks. Leptospiruria observed on dark ground microscopy. Improved following antibiotic therapy and discharged. Remained well for at least 2 years.	Mild acute interstitial nephritis	Leptospiruria	No necropsy examination
75695	Mongrel	8	M	Weight loss, polydipsia and polyuria for 4 months. Thin, systolic murmur, small kidneys and enlarged prostate. Discharged unchanged after 3 weeks. No further contact.	Chronic nephritis	Mild renal failure and persistent proteinuria	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
75513 a	6 weeks	4.2	ND	1.4	ND	25	53	0.37	16.9	0	-	1.010
b		4.9	ND	1.9	ND	27	30	0.39	16.3	0	-	1.016
		L. canicola agglutination titre: 1: 10000										
75695 a	3 weeks	19.9	221	1.9	5.2	29	30	0.33	11.7	300	++	1.018
b		14.7	ND	1.4	ND	30	32	0.35	18.2	362	+	1.010
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
75513	"Immobilon"	-	+			+		+			1	15	-	Normal
75695	"Immobilon"	+	+			+		+			2	NR	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
75513	+	0	A few foci of mononuclear cells in the medulla and some fibrosis. FA negative for Leptospira canicola antigen.	Possible acute interstitial nephritis	+	No necropsy
75695	+	32	Five glomeruli scarred. Moderate interstitial fibrosis.	Chronic nephritis	+	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
75824	Collie X	3	M	Chronic pustular demodectic mange with continued antibiotic therapy for several months. General condition gradually deteriorated and euthanasia after 3 months.	Possible drug-induced nephropathy	Persistent moderate proteinuria	No evidence of renal disease.
76112	Border Collie	1	M	Farm dog, reluctant to work for 2 weeks. Reduced appetite and gross ascites. Bright and thin. Improved with treatment and discharged after 2 months. Worked with sheep for a further 16 months, then suddenly declined and died 4 days later.	Chronic active hepatitis (liver biopsy)	Persistent moderate proteinuria	Hepatic cirrhosis. Kidneys only available for histology but appeared normal

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
75824 a	3 months	3.0	ND	1.3	ND	37	55	0.39	10.9	254	+++	1.025
b		5.5	88	1.4	ND	35	58	0.39	14.8	100	-	1.037
76112 a	2 months	2.9	ND	1.6	ND	18	34	0.36	13.0	110	+	1.048
b		5.4	ND	1.4	3.4	34	37	0.33	14.2	70	-	1.040
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
75824	"Immobilon"	-	+			+		+			2	1 x10 1 x15	+	Normal
76112	Acetylpromazine/ thiopentone/ halothane	-			+	+		+			2	1 x 5 1 x10	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
75824	+	9	Glomeruli appeared normal. No other abnormalities detected.	Inconclusive; kidney normal	-	+
76112	+	10	Glomeruli appeared normal. Congo red preparation negative. FA: IgG and C3 faintly positive in capillary loops. EM showed subendothelial electron dense deposits suggestive of amyloid.	Possible amyloidosis	-	-

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY. CLINICAL FINDINGS. FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
76226	German short-haired Pointer	8	F	Weight loss, dullness and reduced appetite for 3 weeks. Congested mucosae, uraemic halitosis and oral ulceration. Deterioration and euthanasia after 36 hours.	Chronic nephritis	Renal failure	Nephrosis; pulmonary calcification; endocardosis.
76199	Shetland Sheepdog	2	F	Weight loss, dullness and reduced appetite for 4 weeks followed by development of ascites and hydrothorax. Gradual deterioration. Euthanasia after 3 weeks.	Chronic hepatic failure	Examination for evidence of glomerulosclerosis	Hepatic cirrhosis. Kidneys normal.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
76226 a	1 day	110.0	849	3.0	ND	36	40	0.58	18.8	110	+	1.048
b		135.0	1034	3.3	4.4	ND	ND	ND	ND	70	–	1.040
76199 a	3 weeks	4.9	88	1.2	1.8	14	28	0.62	18.3	0	–	1.010
b		6.4	ND	1.2	ND	11	15	0.27	35.0	ND	ND	ND
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
76226	Thiopentone	+	+			+		+			3	2 x10 1 x15	-	Immediate euthanasia
76199	Acetylpromazine/ thiopentone/ halothane				+	+			+		2	1 x 0 1 x15	+	Prolonged but no complications

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy /Clinical	Biopsy/Necropsy
76226	+	9	Slight increase in mesangial matrix and severe fatty degeneration of renal cortical tubules.	Nephrosis	-	+
76199	-	7	Glomeruli appeared normal. FA negative	Inconclusive: kidney normal	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY. CLINICAL FINDINGS. FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
76704	Cocker Spaniel X Poodle	10	M	Dull, restless, weight loss and polydipsia for 10 days. Difficulty in rising. Constant tachycardia; bilateral uveitis and conjunctivitis; grossly thickened forelimbs. Gradual deterioration and euthanasia after 6 weeks.	Thyroid carcinoma with renal metastases; hypertrophic osteo-arthropathy.	Persistant proteinuria	Thyroid carcinoma with widespread metastases, including kidneys. Unclassified glomerulonephritis. Hypertrophic pulmonary osteo-arthropathy.
77556	West Highland Terrier	11	F	Dullness, anorexia, polydipsia, vomiting and diarrhoea for 3 weeks. Haematuria later. Pale mucosae; right kidney easily palpable. Exploratory laparotomy and euthanasia after 2 days.	Right renal tumour	Mild renal failure right kidney enlarged.	Renal carcinoma.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
76704 a	6 weeks	4.5	122	1.7	6.6	24	48	0.47	17.7	1850	–	1.034
b		31.0	220	2.5	4.6	16	46	0.30	45.6	280	–	1.022
77556	–	22.4	ND	2.6	ND	32	33	0.12	10.1		++	1.016
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
76704	"Immobilon"	–		+		+				+	2	1 x 5 1 x15	+	Prolonged. Flank abscess at site. Good healing in 10 days.
77556	Acetylpromazine/ thiopentone/ halothane	+			+		+	+			1	10	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
76704	+	16	Some glomeruli partially scarred; others sclerotic. Evidence of mesengial expansion. Foci of neoplastic cells. FA negative. EM showed mesangial expansion and thickening of the GBM.	Unclassified glomerulonephritis and metastatic tumour deposits.	+	+
77556	+	8	All glomeruli partially scarred. Foci of neoplastic cells. FA negative.	Possible renal carcinoma.	+	+

CLINICAL SUMMARY

DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
77448	Labrador Retriever	6	M	Weight loss, polydipsia and polyuria for 2 months. Ascites, hind limb and body wall oedema developed after 4 weeks. Kidneys slightly enlarged. Poor response to treatment and euthanasia after 3 months.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
77448 a	3 months	6.8	61	1.8	7.7	11	37	0.46	11.0	375	–	1.010
b		6.9	71	1.2	5.9	19	39	0.44	12.0	210	–	1.015
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	-35	-30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
77448 B1	"Immobilon"	-	+			+		+	+		2	2 x15	-	Normal
B2	"Immobilon"	-	+			+		+			2	1 x 5 1 x15	+	Normal
B3	"Immobilon"	-	+			+		+			3	1 x 0 2 x15	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
77448 B1	+	4	Three glomeruli normal; one partially scarred. Hyaline casts in tubules. FA positive for IgG and C3 but poor sections. EM specimen lost in processing.	Unclassified glomerulonephritis	+	+
B2	+	6	Five glomeruli normal; one partially scarred. FA positive for IgG and C3 EM showed thickening of the GBM and subepithelial electron dense deposits	Membranous nephropathy	+	+
B3	+	11	Ten glomeruli normal; one scarred. FA and EM as at B2. No apparent progression of the condition.	Membranous nephropathy	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
77613	Shetland Sheepdog	10	FS	Dullness, weight loss, reduced appetite, polydipsia and vomiting for 2 weeks. Hypertensive pulse; uraemic halitosis and oral ulceration. Euthanasia after 24 hours.	Chronic nephritis	Renal failure	Chronic interstitial nephritis
78175	Cocker Spaniel	8	FS	Episodes of anorexia and extreme nervousness. Spontaneous recovery. Discharged after 8 days and no further contact.	Hysteria; possible protein losing nephropathy	Persistent proteinuria	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
77613	–	127	3094	7.5	ND	28	40	0.39	8.1	360	++	1.025
78175 a	8 days	3.4	ND	1.3	21.1	27	44	0.44	29.4	1750	-	1.042
b		5.4	ND	ND	6.1	28	32	0.34	20.6	740	++	1.036
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
77613	Thiopentone	+	+			+				+	2	1 x 5 1 x15	-	Immediate euthanasia
78175	"Immobilon"	-	+			+		+	+		3	2 x 5 1 x10	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
77613	+	14	All glomeruli scarred. Marked interstitial fibrosis. FA negative.	Chronic interstitial nephritis	+	+
78175	+	12	Glomeruli normal. No significant findings. FA negative EM showed no significant changes.	Inconclusive	-	No necropsy

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
82167	Samoyed	4 mth	M	Dullness, anorexia and vomiting for 4 weeks. Poor body condition, pale mucosae, tense abdomen. Uraemic halitosis, osteodystrophia fibrosa. Small kidneys. Progressive deterioration, with development of uraemic neuropathy, Euthanasia after 3 weeks.	Congential nephropathy	Renal failure and moderate proteinura	Severe chronic nephritis
85605	Alsatian	7	M	Dullness, anorexia, weight loss, polydipsia and polyuria for 2 weeks. Hind limb, ventral body wall and facial oedema and ascites. Poor response to treatment and died after 3 weeks.	Nephrotic syndrome	Persistent proteinuria and renal failure	Membranous nephropathy with evidence of terminal uraemia

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
82167 a	3 weeks	61.2	442	8.8	6.3	27	34	0.29	7.9	350	+	1.010
b		51.0	440	5.0	9.4	25	24	0.22	11.5	240	+++	1.010
85605 a	3 weeks	25.2	521	3.0	7.1	12	33	0.33	28.9	265	++	1.015
b		62.8	618	4.4	ND	15	32	0.42	14.6	1250	+	1.030
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
82167	"Immobilon"	+	+			+		+			2	1 x 0 1 x15	+	Prolonged
85605	"Immobilon"	+	+			+		+			2	1 x 0 1 x 5	-	Normal Kidney difficult to maintain against body wall

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
82167	+	0	Severe interstitial fibrosis FA stained positive for IgG, C3, IgM and fibrinogen in focal segmental patterns.	Chronic nephritis	+	+
85605	+	NR	Histology sections lost in processing. FA section contained 2 glomeruli which were strongly positive for IgG and C3. EM showed marked thickening of the GBM; fusion of podocytes and large subepithelial and intramembranous electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
91049	Rottweiler	2½	FS	Ovariohysterectomy following pyometra 4 weeks earlier. Continuing dullness, anorexia, polydipsia and vomiting Anaemia latterly. Improved with antibiotic and fluid therapy. Discharged after 2 weeks. Still alive.	Chronic nephritis	Renal failure and moderate proteinuria	No necropsy examination
91335	Springer Spaniel	2	M	Weight loss, dullness, polydipsia and polyuria for 3 weeks, with gradual development of ascites and peripheral oedema. Pale mucosae. Kidneys slightly enlarged. Poor response to treatment and euthanasia after 8 weeks	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
91049 a	2 weeks	70.0	716	8.1	8.1	22	39	0.33	21.9	200	-	1.016
b		23.1	309	3.3	ND	20	24	0.18	13.5	210	++	1.015
91335 a	8 weeks	9.5	133	1.6	8.1	15	27	0.41	8.3	962	++	1.021
b		18.0	106	2.3	11.9	11	27	0.28	7.8	62	+	1.024
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laperotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
91049	"Immobilon"	+		+		+		+			2	1 x 5 1 x20	–	Normal
91335	"Immobilon"	–	+			+		+			2	1 x 5 1 x10	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
91049	+	1	Glomerulus was sclerotic. Moderate interstitial fibrosis. FA negative.	Chronic nephritis	+	No necropsy
91335	+	7	One glomerulus scarred. Moderate thickening of capillary loops. FA positive for IgG and C3 EM showed fusion of podocytes and thickening of the GBM with intramembranous and subepithelial electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — DOG

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
93604	Golden Retriever	2	M	Weight loss, reduced appetite and gradual abdominal swelling for 4 weeks. Thin and bright. Ascites and tarsal oedema. Poor response to diuretic therapy but condition stable and still alive after 6 months.	Nephrotic syndrome	Persistent proteinuria	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
93604 a	5 months	5.1	88	1.1	11.4	18	21	0.38	9.3	2250	-	1.050
b		11.6	115	1.5	9.2	17	22	0.34	9.6	2000	++	1.042
NORMAL VALUE		<7.5	44-155	1.3-3.0	2-7	~35	~30	>38	6-17	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
93604 B1	"Immobilon"	–	+			+		+			2	1 x 0 1 x15	–	Normal
B2	"Immobilon"	–	+			+		+			2	1 x 5 1 x20	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
93604 B1	+	0	Histology: all medulla, which appeared normal. FA and EM: no glomeruli present	Inconclusive	–	No necropsy
B2	+	17	All glomeruli normal on histological examination. FA positive for IgG and C3. EM showed fusion of podocytes and thickening of GBM with intramembranous and subepithelial electron dense deposits.	Membranous nephropathy	+	No necropsy

APPENDIX B

RENAL BIOPSY IN THE CAT:

SUMMARIES OF 50

CLINICAL CASES

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
42443	DSH	15	FS	Weight loss, dullness, anorexia and polydipsia for 7 days. Kidneys grossly enlarged, especially the right. Progressive deterioration and euthanasia after 7 days.	Lymphosarcoma (FeLV -ve)	Renal failure	Histioblastic renal and alimentary lymphosarcoma
61998	Siamese	3	FS	Intermittent periods of anorexia and altered temperament for 8 months with gradual weight loss. Very dull for 4 days. Dehydrated, pale mucosae and irregular mid abdominal mass palpated. Deteriorated. Euthanasia on the following day.	Alimentary lymphosarcoma (FeLV +ve)	Renal functions apparently normal Examination for evidence of changes due to FeLV infection	Alimentary lymphosarcoma and FeLV related anaemia. Kidneys normal.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
42443 a	1 week	39.7	597	2.9	ND	19	59	0.32	13.3	322	+	1.025
b		49.1	ND	4.4	ND	ND	ND	0.29	9.8	ND	ND	ND
61998 a	8 months	12.0	ND	ND	ND	30	33	0.32	7.9	24	-	1.025
b		10.2	ND	1.5	ND	ND	ND	0.09	4.4	ND	ND	ND
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
42443	Ketamine	+	+			+			+		1	20	+	Normal
61998	Thiopentone	-	+			+		+			2	2 x15	-	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
42443	+	0	Mostly necrotic tissue. Viable cells were anaplastic, with large nuclei and prominent nucleoli and were most likely malignant lymphoid cells.	Lymphosarcoma	+	+
61998	+	6	Glomeruli appeared normal. FA negative. EM not done	Inconclusive - kidney normal	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
62195	DSH	1½	M	Weight loss and reduced appetite for 7 days. Ascites and tarsal oedema. Responded to diuretic therapy and discharged after 10 days. Recurrence of oedema after 2 months and euthanasia but body not available for necropsy.	Nephrotic syndrome	Persistent proteinuria	No necropsy examination
67485	DSH	6	F	Polydipsia for several months. Thin. Small kidneys. Improved for 2 months and then deteriorated. Euthanasia after 3 months.	Chronic nephritis	Renal failure	Chronic nephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
62195 a	10 days	8.9	ND	1.5	ND	5	44	0.30	11.0	884	–	1.038
b		ND	ND	ND	ND	15	43	ND	ND	896	–	1.030
67485 a	3 months	19.1	ND	1.9	4.6	20	66	0.40	22.6	41	–	1.042
b		47.3	ND	2.6	ND	23	49	0.30	18.0	ND	ND	ND
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
62195	Ketamine	-	+			+		+			1	15	-	Normal
67485 B1	Ketamine	-	+			+		+			3	2 x 0 1 x10	-	Normal
B2	Ketamine	+	+			+				+	1	15	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
62195	+	5	Glomeruli appeared normal. FA and EM specimens contained no glomeruli	Inconclusive	-	No necropsy
67485 B1	+	22	Diffuse glomerular sclerosis. Extensive interstitial fibrosis and mononuclear cell infiltrate.	Chronic nephritis	+	+
B2	+	2	Both glomeruli sclerosed. Interstitial fibrosis and mononuclear cell infiltrate.	Chronic nephritis	+	+

CLINICAL SUMMARY

CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
62718	DSH	2½	MC	Dullness, anorexia, ascites and peripheral oedema for 10 days. Prominent kidneys. Remained in the Hospital for 3½ years. Good response to diuretic therapy with one relapse. Lived normally for 3 years and then deteriorated gradually. Euthanasia when in terminal renal failure after 3½ years.	Nephrotic syndrome	Persistent proteinuria	Terminal renal failure; membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
62718 a	3½ years	11.1	71	2.1	ND	6	56	0.35	1.6	1870	-	1.039
b		185.0	ND	10.2	9.1	16	70	0.20	16.7	280	-	1.022
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
62718 B1	Ketamine	-	+			+		+			1	5	+	Normal
B2	Ketamine	-	+			+		+			NR	NR	NR	Normal
B3	Ketamine	-	+			+		+			NR	NR	NR	Normal
B4	Ketamine	-	+			+				+	NR	NR	NR	Normal
B5	Ketamine	-	+			+			+		2	1 x10 1 x20	+	Normal
B6	Ketamine	+	+			+		+			2	1 x 5 1 x20	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
62718 B1	+	1	Poor sample. Mainly muscle. Glomerulus appeared normal. FA and EM examinations not performed.	Inconclusive	-	-
B2	+	1	Poor sample. Glomerulus had thickened capillary loops. No glomeruli in FA and EM specimens.	Inconclusive	-	-
B3	+	6	Thickened glomerular capillary walls; hyaline casts in tubules; mild interstitial fibrosis.	Membranous nepropathy	+	+
B4	+	0	FA positive for IgG	"	+	+
B5	+	11	EM showed fusion of podocytes; thickened GBM, with intramembranous and subepithelial electron dense deposits.	"	+	+
B6	+	8	One glomerulus sclerotic. All others were scarred and had thickened capillary walls. Moderate interstitial fibrosis. FA and EM as B3 - B5.	"	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
66669	DSH	3	MC	Polydipsia and polyuria for 6 weeks followed by dullness, reduced appetite, diarrhoea and development of peripheral oedema and ascites. Slow response to diuretic therapy with recurrence of oedema after 3 weeks and 7 weeks. Diarrhoea became uncontrollable and cat started vomiting after 7 weeks. Mid abdominal tubular mass. Euthanasia after 8 weeks.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy; oedema; intussusception
68019	DSH	1	M	Dullness and reduced appetite for 7 days. Pale mucosae; tachycardia; bilateral hypopyon. Kidneys swollen and irregular. Progressive deterioration and euthanasia after 12 days.	Multicentric lymphosarcoma (FeLV -ve)	Renal failure	Multicentric lymphosarcoma with infiltration into eyes, kidneys spleen, myocardium muscles and bladder

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
66669 a	2 months	12.9	231	1.2	ND	5	60	0.29	27.5	5600	-	1.050
b		20.4	170	2.2	ND	6	41	0.30	12.3	526	+	1.029
68019 a	12 days	28.6	ND	2.6	ND	24	39	0.35	6.2	ND	ND	ND
b		70.2	504	6.1	ND	32	47	ND	ND	71	++	1.023
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
66669	Ketamine	–	+			+		+			1	10	+	Normal
68019	Ketamine	+	+			+		+			1	10	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
66669	+	2	Both glomeruli were slightly scarred and the capillary loops were thickened FA positive for IgG EM showed fusion of podocytes; thickened GBM and intramembranous and subepithelial electron dense deposits.	Membranous nephropathy	+	+
68019	+	0	Sample was mostly medulla. A diffuse infiltrate of lymphocytes and lymphoblasts was present in the medulla.	Lymphosarcoma	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
68167	DSH	4	M	Dullness, reduced appetite and weight loss for 3 months. Kidneys prominent and very firm. Discharged unchanged. Contact with owner lost after 3 months.	Mild renal failure	Moderately raised plasma urea	No necropsy examination
70151	DSH	3	M	Peripheral oedema 6 months previously Recurred 5 months later, together with weight loss. Kidneys firm and prominent Good response to diuretic therapy but euthanasia performed after 6½ months for domestic reasons.	Nephrotic syndrome; renal failure	Persistent proteinuria	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
68167 a	10 days	14.2	ND	5.0	ND	21	66	0.41	16.4	40	–	1.050
b		16.1	186	3.0	ND	ND	ND	0.42	24.0	225	+++	1.050
70151 a	5 months	25.5	239	2.5	5.8	7	54	0.33	10.4	2300	trace	1.031
b		32.7	520	3.8	8.6	14	63	0.30	8.4	210	–	1.022
NORMAL VALUE		<9	50-146	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
68167	Ketamine	-	+			+		+			1	10	+	Normal
70151	Ketamine	+	+			+		+			3	1 x 0 2 x20	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
68167	+	6	Glomeruli appeared to be normal. An arcuate artery was present. Medulla appeared to be normal. FA negative.	Inconclusive - kidney normal	-	No necropsy
70151	+	11	10 glomeruli scarred and slight thickening of capillary loops. Foci of mononuclear cells and polymorphs. FA positive for IgG EM showed fusion of podocytes, thickening of GBM and subepithelial electron dense deposits.	Membranous nephropathy; mild chronic pyelonephritis	+	No necropsy

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
71337	DSH	7	MC	Weight loss for 6 months followed 3 months later by peripheral oedema which responded to diuretic therapy. Progressive dullness, inappetence, polydipsia and polyuria. Poor condition, pale mucosae, halitosis, prominent firm kidneys. Discharged unchanged after 7 days. Euthanasia 2 weeks later when in terminal renal failure. Body not available for necropsy.	Protein-losing nephropathy; renal failure	Persistent proteinuria	No necropsy examination
71570	DSH	2½	MC	Polydipsia, anorexia, dullness, weight loss and vomiting for 10 days. Dehydrated, moderate hindlimb oedema and ascites. Cylindrical mass palpable in mid-abdomen. Resection of intussusception but cat deteriorated. Euthanasia after 5 days.	Nephrotic syndrome; intussusception	Proteinuria	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD UREA mmol/l	BLOOD CREATININE µmol/l	BLOOD PHOSPHATE mmol/l	BLOOD CHOLESTEROL mmol/l	BLOOD ALBUMIN g/l	BLOOD GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	URINE PROTEIN mg/100ml	URINE BLOOD	URINE SPECIFIC GRAVITY
71337 a	7 days	38.3	ND	5.8	5.9	10	39	0.27	7.3	1100	trace	1.032
b		37.8	ND	ND	ND	9	34	0.20	5.0	400	-	1.029
71570	-	37.6	179	3.4	3.2	11	33	0.34	18.7	460	++	1.044
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
71337	Ketamine	+	+			+		+			1	20	+	Normal
71570	Ketamine	+	+			+		+			4	2 x 0 2 x20	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
71337	+	13	10 glomeruli scarred and capillary loops thickened. FA positive for IgG and C3. EM showed fusion of podocytes and thickening of GBM, with intramembranous electron dense deposits.	Membranous nephropathy	+	No necropsy
71570	+	9	6 glomeruli were scarred. A few hyaline casts present in tubules. FA positive for IgG EM showed thickening of GBM and intramembranous electron dense deposits.	Membranous nephropathy	+	No necropsy

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
70865	DSH	4	MC	Limb oedema for 2 months. Coat in poor condition. Kidneys prominent. Good response to diuretic therapy with one relapse after 6 weeks. Diarrhoea developed after 1½ years and from then on the cat gradually declined. Terminal renal failure after 2¼ years and euthanasia performed.	Nephrotic syndrome	Persistent proteinuria	Terminal renal failure; membranous nephropathy
71792	DSH	3½	MC	Weight loss, dullness, reduced appetite and polydipsia for 3 weeks with later development of hind limb oedema and ascites. Pale mucosae and severe peripheral oedema. Poor response to diuretic therapy, gradual deterioration and euthanasia after 4 months.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
70865 a	2 yr 4 mth	26.8	150	1.7	7.4	9	44	0.35	17.8	3500	+	1.046
b		115.0	770	7.4	7.6	25	40	0.29 *	7.8 *	350 *	- *	1.025 *
71792 a	4 months	7.1	ND	ND	ND	3	5	0.25	12.5	675	-	1.046
b		36.1	239	5.0	5.3	51	56	0.21	3.7	750	-	1.022
								(* after 1½ years)				
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
70865	Ketamine	-	+			+		+		+	2	1 x 5 1 x15	+	Normal
71792 B1	Ketamine	-	+			+		+			3	3 x10	+	Normal
B2	Ketamine	+	+			+		+			1	15	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
70865	+	10	3 glomeruli scarred. A few strands of interstitial fibrosis and small foci of mononuclear cells present. FA positive for IgG and C3. EM showed fusion of podocytes, thickened GBM and intramembranous electron dense deposits.	Membranous nephropathy	+	+
71792 B1	+	24	22 glomeruli scarred. Mild mesangial expansion. Large arcuate artery present. FA positive for IgG and C3. EM showed fusion of podocytes and thickened GBM containing electron dense deposits.	Membranous nephropathy	+	+
B2	+	12	All glomeruli scarred with some capsular adhesons. Some interstitial fibrosis. FA and EM as for B1.	Membranous nephropathy	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
73501	DSH	9	MC	Polydipsia and altered drinking habits for 1 year. Reduced appetite and some vomiting for 2 months. Dull, weak, pale mucosae. Left kidney swollen and cystic; right kidney small, hard and irregular. Gradual deterioration and euthanasia after 4 weeks.	Chronic nephritis with hydronephrosis of left kidney	Renal failure	Chronic nephritis; hydronephrosis of left kidney
73718	DSH	3	MC	Vomiting and diarrhoea for 10 days with weight loss, dullness and anorexia. Superficial lymphadenopathy and jaundice latterly. Progressive deterioration and euthanasia after 2 days.	Multicentric lymphosarcoma (FeLV +ve)	Renal failure	Kidney normal Colitis; possible pauleukopaenia; erythrophago-cytosis.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
73501 a	4 weeks	33.2	592	3.3	ND	39	35	0.15	6.1	0	–	1.012
b		71.3	849	7.2	ND	34	39	0.15	8.9	0	–	1.010
73718 a	2 days	58.2	ND	3.0	ND	20	51	0.36	0.6	36	+	1.030
b		ND	ND	ND	ND	ND	ND	0.28	0.8	30	+	1.030
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
73501	Ketamine	+	+				+	+			2	1 x 5 1 x15	-	Normal. Fine needle aspiration of cystic fluid from left kidney.
73718	Ketamine	+	+			+		+			2	1 x 0 1 x10	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
73501	+	7	3 glomeruli scarred. Marked interstitial fibrosis. FA showed linear staining of C3 in the tubular basement membrane.	Chronic nephritis	+	+
73718	+	5	Glomeruli normal. No renal lesion apparent. FA negative.	Inconclusive - kidney normal	-	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
73644	DSH	7	MC	Dullness, weight loss, reduced appetite for 3 weeks. Limb oedema and ascites for 2 weeks. Pale mucosae, kidneys prominent. Slow response to diuretic therapy over 3 weeks with relapse 2 weeks later. Thereafter bright but remained thin. Euthanasia at owners request after 3 months.	Nephrotic Syndrome	Persistent proteinuria	Membranous nephropathy
74368	DSH	3	MC	Weight loss for 2 months with gradual reduction in appetite and occasional vomiting. Poor condition; pale mucosae. Gradual deterioration over 4 weeks and euthanasia.	Protein - losing nephropathy	Renal failure and persistent proteinuria	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
73644 a	3 months	15.0	133	1.7	4.5	6	44	0.26	6.1	1100	+	1.034
b		10.0	89	1.5	6.3	8	44	0.27	5.8	620	-	1.027
74368 a	4 weeks	31.2	231	2.9	ND	8	54	0.34	34.6	159	+++	1.020
b		42.9	300	5.8	6.3	8	55	0.19	19.4	1230	+	1.029
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
73644 B1	Ketamine	-	+			+		+			2	1 x 5 1 x10	+	Normal
B2	Ketamine	-	+			+		+		+	4	2 x 0 1 x10 1 x20	+	Normal
74368	Ketamine	+	+			+		+		+	3	2 x 0 1 x 5	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
73644 B1	+	4	Increased mesangial matrix. FA specimen contained no glomeruli. EM showed electron dense depostis in mesangial and subendothelial locations.	Membranous nephropathy	+	+
B2	+	10	All glomeruli partially scarred with thickened capillary loops and capsular adhesions. FA positive for IgG and C3. EM showed fusion of podocytes, thickening of GBM and electron dense deposits in intra-membranous and subepithelial locations.	Membranous nephropathy	+	+
74368	+	10	Most glomeruli scarred. Thickened glomerular capillary loops with fibrin deposition and capsular adhesions. FA positive for IgG and C3. EM showed thickened GBM and electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
74369	DSH	7	MC	Reduced appetite and weight loss for 2 weeks. Dullness and some vomiting. Poor condition, pale mucosae. Uraemic halitosis and oral ulceration. No improvement; euthanasia after 11 days.	Protein - losing nephropathy chronic renal failure	Renal failure	Unclassified glomerulo-nephritis
76758	DSH	6	M	Weight loss and dullness for several weeks. Enlarged superficial and mesenteric lymph nodes and spleen. Euthanasia after 13 days.	Multicentric lymphosarcoma (FeLV -ve)	Examination for possible glomerular changes due to lymphosarcoma	Multicentric lymphosarcoma. Kidneys normal

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD UREA mmol/l	BLOOD CREATININE µmol/l	BLOOD PHOSPHATE mmol/l	BLOOD CHOLESTEROL mmol/l	BLOOD ALBUMIN g/l	BLOOD GLOBULIN g/l	BLOOD HAEMATOCRIT l/l	BLOOD WBC $x10^9$/l	URINE PROTEIN mg/100ml	URINE BLOOD	URINE SPECIFIC GRAVITY
74369 a	11 days	70.6	ND	5.1	ND	19	62	0.21	12.9	1000	trace	1.025
b		58.4	886	3.7	4.6	19	59	0.18	27.1	590	++	1.025
76758	-	9.2	ND	1.6	ND	34	51	0.29	9.6	20	-	1.048
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
74369	Ketamine	+	+			+		+			1	20	+	Prolonged. Vomited 20 minutes post-biopsy followed by cardiorespiratory failure. Uneventful recovery after resuscitation.
76758	Ketamine	–	+			+		+			1	10	–	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy / Necropsy
74369	+	5	1 scarred glomerulus. Interstitial fibrosis. FA negative.	Probably chronic nephritis	+	–
76758	+	3	Glomeruli appeared normal. No significant abnormalities observed. FA negative.	Inconclusive - kidney normal	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
77102	DSH	12	MC	Dullness, anorexia and polydipsia for 2 weeks. Very poor condition and severe weakness. Dehydrated; pale mucosae; uraemic halitosis; kidneys small and very firm. Euthanasia after 1 day.	Chronic nephritis	Renal failure	Chronic nephritis
77152	DSH	3½	M	Weight loss, reduced appetite and polydipsia for 2 months with gradual development of limb and body wall oedema and ascites. Kidneys prominent. Good early response to diuretic therapy but relapsed after 3 weeks. Gradual deterioration and euthanasia after 6 weeks.	Nephrotic syndrome	Persistent proteinuria and renal failure	Chronic glomerulo-nephritis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
77102	–	113.0	ND	9.8	ND	28	35	0.21	22.0	35	+	1.022
77152 a	6 weeks	33.2	212	3.4	6.3	9	34	0.41	20.7	1660	–	1.036
b		72.0	724	3.4	7.9	11	49	0.37	21.7	875	–	1.028
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laperotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
77102	Thiopentone	+	+			+		+			1	5	-	Immediate euthanasia
77152 B1	Ketamine	+	+			+		+			3	1 x2.5 1 x10 1 x15	+	Normal
B2	Ketamine	+	+			+		+			4	2 x 0 1 x 5 1 x15	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
77102	+	0	Marked interstitial fibrosis and calcification. FA showed C3 staining of the tubular basement membranes.	Chronic nephritis	+	+
77152 B1	+	5	All glomeruli partially scarred. Moderate interstitial fibrosis. FA Negative. EM showed a few subepithelial and intramembranous electron dense deposits.	Chronic glomerulo-nephritis	+	+
B2	+	8	2 glomeruli sclerotic and 6 partially scarred. FA positive for IgG and C3. EM as for B1	Chronic glomerulo-nephritis	+	+

CLINICAL SUMMARY

CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
77309	Siamese	4	MC	Granulomatous skin lesions on left forelimb for 6 weeks Dullness and reduced appetite for 2 weeks. Pale mucosae; bilateral renal enlargement and palpable intra-abdominal masses. Gradual deterioration and euthanasia after 1 week.	Multicentric lymphosarcoma with renal infiltration (FeLV +ve)	Renal failure	Multicentric lymphosarcoma. Both kidneys heavily infiltrated.
78535	DSH	3	FS	Weight loss, reduced appetite and polydipsia for 1 week. Very dull, weak, pale mucosae; uraemic halitosis and facial twitches. Moderate ascites. Progressive deterioration and euthanasia after 2 days.	Nephrotic syndrome and renal failure	Renal failure and heavy proteinuria	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
77309 a	7 days	31.7	ND	2.9	ND	21	30	0.27	19.0	240	–	1.033
b		45.7	362	ND	ND	24	45	0.22	26.0	95	+	1.026
78535 a	2 days	52.9	265	6.5	4.7	18	21	0.18	34.8	1120	–	1.027
b		63.0	407	8.8	3.7	29	21	0.15	14.0	224	++	1.020
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
77309	Ketamine	+	+			+		+			1	15	-	Immediate euthanasia
78535	Lignocaine	+	+			+		+			3	1 x 0 2 x15	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
77309	+	0	Heavy infiltration of malignant lymphocytes and lymphoblasts. Very little renal tissue observed. FA negative.	Lymphosarcoma	+	+
78535	+	2	Both glomeruli scarred, with thickened capillary loops and capsular adhesions. FA positive for IgG and C3 EM showed fusion of podocytes and thickened GBM, with subepithelial and intramembranous electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
78546	Abyssinian	6	MC	Dullness, weight loss, anorexia and polydipsia for 4 weeks. Very weak and dehydrated. Pale mucosae, uraemic halitosis and grossly enlarged kidneys. progressive deterioration and euthanasia after 4 days.	Renal lymphosarcoma (FeLV -ve)	Renal failure	Feline infectious peritonitis ("Dry form")
78897	DSH	2½	MC	Peripheral oedema for 2 weeks with reduced appetite and weight loss. Good response to diuretic therapy but appetite remained reduced. Discharged after 11 days. 11 days later developed dyspnoea and died within 2 hours.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy; pulmonary arterial thrombosis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
78546	–	100.0	1114	6.8	4.8	35	46	0.21	11.2	176	++	1.020
78897 a		31.4	177	1.9	5.1	22	27	0.30	25.7	2100	++	1.049
b	8 days	17.9	141	1.3	6.3	23	37	0.30	5.8	2420	++	1.044
NORMAL VALUE		<9	50 - 145	1.3 - 3.0	1.8 - 4.1	-40	-35	>30	5 - 20	0 - 30	–ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
78546	Lignocaine	+	+			+		+			2	2 x15	+	Normal
78897	Ketamine	+	+			+		+		+	3	1 x 0 1 x10 1 x15	+ (pre-biopsy)	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
78546	+	2	Both glomeruli appeared normal. A large mononuclear cell infiltration was present. FA negative.	Probably lymphosarcoma	+	-
78897	+	19	All glomeruli were scarred, with diffuse capillary loop thickening, fibrin deposits and capsular adhesions. FA positive for IgG and C3 EM showed fusion of podocytes, thickening of the GBM with intra-membranous and subepithelial electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
79563	DSH	3	F	No earlier history available. Cat was very dull, weak and dehydrated, with pale mucosae and moderate ascites. Ascitic fluid brownish colour and oily. Euthanasia after 3 days.	Feline infectious peritonitis and protein - losing nephropathy	Proteinuria	Feline infecticus peritonitis. Unclassified glomerulo-nephritis
79837	DSH	3	MC	Recurrent ascites for 4 months and peripheral oedema for 2 months. Loss of condition and polydipsia Slightly pale mucosae; kidneys prominent. Good response to diuretic therapy and discharged after 7 days. Progressive deterioration and euthanasia 3 weeks later.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy. Calcification of kidneys, aorta and pulmonary arteries.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
79563	-	25.2	176	1.9	2.0	32	66	0.19	41.8	850	++	1.047
79837 a	4 weeks	43.2	302	ND	6.5	19	21	0.28	6.7	1300	-	1.027
b		68.3	796	6.1	8.8	31	53	0.26	13.9	560	-	1.026
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
79563	Ketamine	+	+			+		+		+	3	1 x10 2 x20	+	Immediate euthanasia
79837	Ketamine	+	+			+		+	+		3	1 x10 2 x15	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
79563	+	18	All the glomeruli appeared normal. FA was negative for IgG but there was fine granular staining of C3. EM showed moderate thickening of the GBM with a few small subepithelial electron dense deposits.	Unclassified glomerulonephritis	+	+
79837	+	11	All glomeruli scarred, with marked thickening of capillary loops and capsular adhesions. FA positive for IgG and C3 EM showed large intramembranous electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
80204	DSH	1	FS	Dullness, reduced appetite, polydipsia and intermittent diarrhoea for 6 weeks with gradual development of severe peripheral oedema and ascites. Good response to diuretic therapy and thereafter maintained good health. Within 20 months and ever since, proteinuria has been minimal.	Nephrotic syndrome	Persistent proteinuria	Still alive having made an appaiently spontaneous recovery
80589	DSH	3	FS	Dullness, reduced appetite, peripheral oedema and ascites developed over a 3 week period. Good early response to diuretic therapy but oedema recurred after 3 months. After 12 months there was progressive deterioration and euthanasia was performed after 13 months	Nephrotic syndrome	Persistent proteinuria	Uraemic renal failure; membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
80204 a	4 years	12.8	124	1.9	4.3	10	29	0.29	20.3	2640	+	1.046
b		11.3	115	1.5	4.4	36	24	0.46	10.0	7.5	-	1.023
80589 a	13 months	7.1	133	1.8	4.5	17	35	0.37	37.6	730	++	1.021
b		107.5	688	6.8	7.4	25	57	0.15	58.6	625	+	1.015
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
80204 B1	Ketamine	-	+			+		+			3	2 x 5 1 x10	+	Normal
B2	Lignocaine	-	+			+		+			1	15	+	Normal
80589 B1	Ketamine	-	+			+		+		+	5	2 x 5 2 x10 1 x15	+	Normal
B2	Ketamine	-	+			+		+			3	1 x 5 2 x10	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
80204 B1	+	19	16 glomeruli partially scarred with loop thickening and capsular adhesions. FA positive for IgG and C3. EM showed fusion of podocytes and subepithelial and intramembranous electron dense deposits in the thickened GBM.	Membranous nephropathy	+	No necropsy
B2	+	18	13 glomeruli partially scarred. FA and EM as for B1.	"	+	No necropsy
80589 B1	+	5	2 glomeruli partially scarred; diffuse capillary loop thickening. FA positive for IgG and C3. EM showed GBM thickening with subepithelial electron dense deposits.	Membranous nephropathy	+	+
B2	+	4	3 glomeruli partially scarred; diffuse loop thickening. FA and EM as for B1.	"	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
80722	Persian	7	MC	Polydipsia and polyuria for 2 months. Anorexia, weight loss and some vomiting for 7 days. Very weak; pale mucosae; uraemic halitosis and oral ulceration. Kidneys grossly enlarged and irregular. Euthanasia after 24 hours.	Renal lymphosarcoma (FeLV -ve)	Renal failure	Polycystic kidneys; severe chronic nephritis
81534	DSH	8	MC	Weight loss and dullness for 2 months with gradually increasing thirst and swollen abdomen. Poor condition. Systolic murmur; swollen carpi; hydrothorax latterly. Deteriorated and died after 8 weeks.	Possible endocarditis with joint and renal involvement	Mild renal failure	Extensive atheromatous arteritis, pyelonephritis; chylothorax

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
80722	–	122	1281	8.1	ND	36	56	0.21	10.4	90	+	1.018
81534 a	8 weeks	14.9	150	ND	26.4	26	44	0.37	17.8	175	-	1.038
b		21.9	168	ND	7.1	25	41	0.30	20.0	96	+	1.024
NORMAL VALUE		<9	50 - 145	1.3 - 3.0	1.8 - 4.1	~40	~35	>30	5 - 20	0 - 30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
80722	Ketamine	+	+			+		+			4	1 x 0 3 x 5	+	Prolonged. Euthanasia before fully recovered
81534	Thiopentone/ halothane	+	+			+		+			3	2 x 0 1 x15	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
80722	+	3	All 3 glomeruli scarred. Marked interstitial fibrosis. FA negative.	Chronic nephritis	-	+
81534	+	7	Glomeruli appeared normal. Interstitial cellular infiltrate consisiting mainly of polymorphs. FA negative	Pyelonephritis	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
56956	Chinchilla	10	MC	Recurrent febrile episodes and shifting lameness for 8 months. Gradual increase in thirst. Mucosae slightly pale; kidneys small. Improved with corticosteroid therapy. Contact lost after 2 months.	Idiopathic polyarthritis; chronic nephritis.	Mild renal failure.	No necropsy
81972	DSH	6	MC	Weight loss and polydipsia following 2 weeks in a cattery. Then became dull, inappetent and developed a head tilt, ataxia and incoordination. Uraemic halitosis; kidneys small. Gradual deterioration and died after 2 weeks. Body not made available for necropsy.	Chronic nephritis; otitis media.	Renal failure	No necropsy examination

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
56956 a	2 months	15.2	239	1.8	3.9	27	47	0.27	35.4	150	-	1.020
b		23.5	186	2.9	3.2	27	30	0.31	12.3	80	-	1.025
81972 a	7 days	33.4	ND	3.0	ND	43	54	0.34	12.3	60	-	1.014
b		60.4	344	3.9	5.3	39	40	ND	ND	200	+++	1.010
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
56956	Thiopentone/ halothane	-	+			+		+			4	2 x 0 1 x 5 1 x15	-	Normal
81972	Ketamine	+	+			+		+			2	1 x 5 1 x15	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
56956	+	NR	Histologically normal kidney. Specimens were subsequently lost. FA negative.	Inconclusive	-	No necropsy
81972	+	2	Both glomeruli scarred. Extensive interstitial fibrosis. FA was positive for C3 in the tubular basement membranes.	Chronic nephritis	+	No necropsy

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
82525	DLH	3	M	Severe peripheral oedema and ascites for 2 weeks. Poor condition; thin; slightly pale mucosae. Good response to diuretic therapy and cat has remained well for 3½ years although still proteinuric.	Nephrotic syndrome	Persistent proteinuria	Still alive and well

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
82525 a	3 years	7.7	88	1.2	4.4	24	25	0.29	41.9	920	+	1.020
b		9.6	124	1.7	3.7	31	42	0.49	16.2	125	-	1.039
NORMAL VALUE		<9	50 - 145	1.3 - 3.0	1.8 - 4.1	-40	-35	>30	5 - 20	0 - 30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
82525 B1	Ketamine	-	+			+		+			2	2 x 5	NR	Normal
B2	Ketamine	-	+			+		+			1	15	-	Normal
B3	Ketamine	-	+			+		+			2	1 x C 1 x12	+	Normal
B4	Ketamine	-	+			+		+			2	1 x O 1 x15	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
82525 B1	+	4	2 glomeruli partially scarred. Thickened capillary loops. FA specimen contained no glomeruli. EM showed fusion of podocytes and electron dense deposits in the thickened GBM.	Membranous nephropathy	+	No necropsy
B2	+	3	FA positive for IgG and C3. Histology and EM as for B1	"	+	"
B3	+	15	6 glomeruli sclerotic and 7 partially scarred. Diffuse loop thickening and capsular adhesions. FA and EM as above.	"	+	"
B4	+	0	3 glomeruli present in FA specimen, positive for IgG and C3. EM as for B1	"	+	"

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
82987	DSH	2	M	Polydipsia and loss of condition followed by development of peripheral oedema, ascites and diarrhoea over a 2 week period. Thin, oral halitosis and gingivitis; kidneys prominent. Diuretic therapy reduced oedema but cat remained diarrhoeic. Sudden deterioration and death after 18 days.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy
83187	DSH	5	M	Weight loss for several weeks, followed by peripheral oedema and dyspnoea. Dull, thin, gross ascites and hydrothorax. Responded to diuretic therapy with 2 further oedematous episodes. Remained thin, developed terminal renal failure and was euthanased after 11 months.	Nephrotic Syndrome	Persistent proteinuria	Terminal uraemia; membranous nephropathy.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC x10⁹/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
82987 a	18 days	22.3	159	2.1	5.1	13	42	0.30	40.7	4000	+	1.055
b		59.2	150	3.7	4.8	14	41	ND	ND	420	–	1.030
83187 a	11 months	22.3	124	2.4	5.6	12	58	0.32	46.0	1580	+	1.040
b		149.0	990	15.6	10.3	26	67	0.34	12.5	500	–	1.020
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
82987	Ketamine	+	+			+		+			2	1 x10 1 x15	-	Normal
83187 B1	Ketamine	-	+			+		+			2	2 x15	+	Normal
B2	Ketamine	-	+			+		+			2	1 x 0 1 x20	+	Normal
B3	Ketamine	+	+			+		+			2	NR	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
82987	+	3	2 glomeruli scarred and diffuse capillary loop thickening. FA positive for IgG and C3.	Membranous nephropathy	+	+
83187 B1	+	10	8 glomeruli partially scarred. Loop thickening and some capsular adhesions. FA positive for IgG and C3. EM showed thickened GBM with electron dense deposits.	Membranous nephropathy	+	+
B2	+	5	As for B1.	"	+	+
B3	+	14	7 glomeruli sclerotic. Otherwise as for B1	"	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
83976	DSH	3	MC	Weight loss, polydipsia, dullness and inappetence developed over several weeks, with some vomiting latterly. Thin, weak and dehydrated. Uraemic halitosis and oral ulceration. Kidneys enlarged. Progressive deterioration and euthanasia after 36 hours.	Terminal renal failure, possibly protein - losing nephropathy	Proteinuria	Membranous nephropathy; Calcification of pulmonary tree
84228	DSH	8½ mth	MC	Poor growth compared with 2 litter mates. Dullness, weight loss and reduced appetite for 4 weeks. Very weak on hind limbs; osteodystrophia fibrosa; uraemic halitosis. Coughing; harsh inspiratory crackles. Subcutaneous cervical calcification. Progressive deterioration and euthanasia after 3 weeks.	Calcium nephropathy	Renal failure	Calcium nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
83976	–	110	610	5.9	8.2	18	43	0.28	15.5	745	–	1.025
84228 a	3 weeks	48.5	195	2.6	4.6	40	47	0.53	14.6	0	++	1.015
b		70.0	486	4.0	6.4	38	43	0.27	11.6	0	+	1.020
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
83976	Ketamine	+	+			+		+			3	1 x 5 2 x15	+	Immediate euthanasia
84228	Lignocaine	+	+			+		+			1	15	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
83976	+	3	All 3 glomeruli partially scarred, with diffuse capillary loop thickening, fibrin deposition and capsular adhesions. FA positive for IgG and C3 EM showed fusion of podocytes and thickened GBM, containing intra-membranous and subepithelial electron dense deposits.	Membranous nephropathy	+	+
84228	+	0	Marked interstitial fibrosis. Some tubular epithelial necrosis and extensive calcification. FA specimen contained 2 glomeruli. Linear staining of C3 in tubular basement membranes.	Nephrocalcinosis	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
85194	DSH	3	FS	Dullness, anorexia and weight loss, with intermittent pyrexia for 3 weeks. Uraemic halitosis. Kidneys felt small. Good response to antibiotic therapy and discharged after 2 weeks. Improvement maintained for 3 months and then contact lost.	Renal failure, possibly pyelonphritis	Renal failure	No necropsy examination
85496	DLH	3	MC	Weight loss, dullness, reduced appetite, polydipsia and polyuria for 3 months. Osteodystrophia fibrosa; uraemic halitosis. Kidneys small, firm and irregular. Deterioration and euthanasia after 8 days.	Chronic nephritis	Renal failure	Chronic nephritis Left kidney had large biopsy - induced infarcts

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	B L O O D								U R I N E		
		UREA mmol/l	CREATININE μmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
85194 a	2 weeks	33.0	177	ND	ND	27	61	0.39	48.2	0	–	1.020
b		27.9	221	2.8	4.7	ND	ND	0.30	17.0	0	+	1.020
85496 a	8 days	47.6	539	3.9	6.6	27	49	0.36	22.0	6.5	–	1.015
b		148.0	1698	8.9	ND	38	65	0.40	17.4	23	+	1.017
NORMAL VALUE		<9	50 - 145	1.3 - 3.0	1.8 - 4.1	~40	~35	>30	6 - 20	0 - 30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
85194	Ketamine	+	+			+		+			1	20	+	Normal
85496	Ketamine	+	+			+		+			2	1 x 5 1 x10	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
85194	+	1	Glomerulus appeared normal. Very mild interstitial fibrosis but no cellular infiltration. FA negative.	Inconclusive	-	No necropsy
85496	+	4	2 glomeruli totally scarred. Marked interstitial fibrosis and moderate tubular calcification. FA showed linear staining of C3 in tubular basement membranes.	Chronic nephritis	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
85273	DSH	3½	FS	Polydipsia for 2 months and occasional vomiting. Extensive oedema and ascites developed after 4 weeks. Thin; hyperpnoea due to hydrothorax; kidneys prominent Slow response to diuretic therapy and 2 further episodes of oedema. Gradual improvement which has been maintained for over 2½ years although still proteinuric.	Nephrotic syndrome	Persistent proteinuria	Still alive
86792	DSH	3	MC	Oedematous episode 4 months earlier, followed by polydipsia, occasional vomiting and diarrhoea. Peripheral oedema recurred and ascites developed. Slightly pale mucosae; kidneys prominent. Good response to diuretic therapy and discharged after one week. Owner moved away but reported cat euthanased 6 weeks later. Body unavailable for necropsy.	Nephrotic syndrome	Peristent proteinuria	No necropsy examination.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
85273 a	2½ years	12.5	150	1.5	1.9	10	31	0.31	17.6	1800	-	1.050
b		9.6	124	1.7	7.2	34	31	0.43	3.6	200	trace	1.020
86792 a	1 week	22.3	212	1.1	6.3	14	36	0.30	18.2	300	-	1.015
b		25.0	212	ND	8.3	20	42	0.25	13.3	500	-	1.020
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	-40	-35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
85273 B1	Ketamine	-	+			+		+			2	1 x10 1 x20	+	Normal
B2	Ketamine	-	+			+		+			4	2 x 0 1 x10 1 x15	+	Normal
86792	Ketamine	+	+			+		+			2	1 x 0 1 x15	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
85273 B1	+	0	No glomeruli present in any of the specimens. Medullary tissue appeared normal.	Inconclusive	-	No necropsy
B2	+	16	Extensive glomerular scarring, capillary loop thickening and some capsular adhesions. FA positive for IgG and C3. EM showed fusion of podocytes and intramembranous electron dense deposits in the thickened GBM.	Membranous nephropathy	+	"
86792	+	13	8 glomeruli partially scarred. Loop thickening and capsular adhesions. FA positive for IgG and C3. EM showed thickening of the GBM with intramembranous electron dense deposits	Membranous nephropathy	+	No necropsy

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
89236	DSH	3	M	Weight loss for 6 weeks together with development of peripheral oedema and ascites; latterly dullness and anorexia. Thin; pale mucosae; uraemic halitosis. Good response to diuretic therapy but cat remained uraemic. Discharged after 9 days but soon relapsed. Terminal renal failure and euthanasia after 6 weeks.	Nephrotic syndrome; renal failure	Proteinuria and renal failure	Membranous nephropathy Oral and lingual ulceration
88803	Birman	2	M	Weight loss, dullness, reduced appetite and polydipsia for 2 months. Thin, uraemic halitosis, kidneys small and firm. Deteriorated; euthanasia after 1 day	Chronic nephritis	Renal failure	Chronic nephritis/ nephrocalcinosis

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a–b	BLOOD UREA mmol/l	BLOOD CREATININE µmol/l	BLOOD PHOSPHATE mmol/l	BLOOD CHOLESTEROL mmol/l	BLOOD ALBUMIN g/l	BLOOD GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	URINE PROTEIN mg/100ml	URINE BLOOD	URINE SPECIFIC GRAVITY
89236 a	6 weeks	32.5	141	1.9	12.4	16	35	0.27	10.3	505	-	1.050
b		101.5	539	5.4	11.1	17	39	0.22	12.8	162	trace	1.022
88803	-	52.1	601	5.4	5.8	31	45	0.32	14.0	0	+	1.010
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
89236	Ketamine	+	+			+		+			2	1 x 5 1 x20	-	Normal
88803	Ketanine	+	+			+		+			1	1 x 0 1 x 5	+	Immediate euthanasia

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
89236	+	8	5 glomeruli partially scarred. Moderate loop thickening. FA positive for IgG and C3 EM showed thickening of the GBM and intramembranous and subepithelial deposits	Membranous nephropathy	+	+
88803	+	7	3 scarred glomeruli. Some tubular epithelial necrosis and calcification. Extensive interstitial fibrosis. FA negative.	Chronic nephritis/ nephrocalcinosis	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
81982	DSH	3¾	MC	Weight loss, polydipsia and peripheral oedema for 10 days. Good response to diuretic therapy and discharged. Oedema recurred months later. Thereafter has remained well although fairly thin and heavily proteinuric.	Nephrotic syndrome	Proteinuria	Still alive
90812	DSH	2½	MC	Polydipsia and some vomiting for 4 weeks with subsequent development of limb oedema and ascites. Thin, dull, kidneys enlarged. Slow response to diuretic therapy and diarrhoea developed, then further oedema. Gradual deterioration and euthanasia after 7 weeks.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy; intussusception

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
81982 a	13 months	12.9	106	2.2	4.9	15	34	0.34	13.2	340	–	1.026
b		13.3	133	1.5	6.3	25	27	0.37	11.0	1050	–	1.050
90812 a	7 weeks	11.9	115	1.4	5.5	23	38	0.32	14.3	1125	–	1.030
b		15.4	106	1.9	8.4	20	45	0.28	17.6	1250	–	1.031
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
81982	Ketamine	-	+			+		+			2	1 x 0 1 x15	-	Normal
90812	Ketamine	-	+			+		+			1	10	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
81982	+	9	3 scarred glomeruli. Moderate loop thickening. FA positive for IgG and C3 EM showed fusion of foot processes and moderate thickening of the GBM with intramembranous electron dense deposits.	Membranous nephropathy	+	No necropsy
90812	+	5	1 glomerulus partially scarred. Loop thickening. FA positive for IgG and C3. EM showed fusion of podocytes, thickening of the GBM and intramembranous electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY — CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
91585	DSH	8	MC	Weight loss for 2 months. One week prior to referral developed peripheral oedema and ascites. Dull, poor condition. Kidneys enlarged. Good early response to diuretic therapy but oedema recurred and diarrhoea developed. Cat discharged when slightly better but gradually deteriorated and died. Body was unavailable for necropsy.	Nephrotic syndrome	Persistent proteinuria	No necropsy examination
91631	DSH	4	MC	Ascites previously, followed by dullness and weight loss. Peripheral oedema and ascites, recurred. Some diarrhoea. Thin, kidneys slightly enlarged. Poor response to diuretic therapy. Gradual deterioration and euthanasia after 6 weeks.	Nephrotic syndrome; renal failure	Persistent proteinuria; renal failure	Membranous nephropathy

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $x10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
91585 a	4 weeks	14.7	124	2.3	7.2	20	42	0.30	22.5	660	-	1.024
b		15.3	124	2.2	5.7	21	38	0.20	14.3	590	-	1.026
91631 a	6 weeks	33.1	185	2.7	6.1	17	35	0.28	14.2	1325	-	1.039
b		94.0	654	7.1	4.7	13	33	0.14	6.7	500	+	1.016
NORMAL VALUE		<9	50-145	1.3-3.0	1.8-4.1	~40	~35	>30	5-20	0-30	-ve	>1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
91585	Ketamine	-	+			+		+			3	2 x 5 1 x10	-	Normal
91631	Ketamine	+	+			+		+			2	1 x 0 1 x15	-	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
91585	+	0	One squashed glomerulus was present in the histological section. FA section contained 2 glomeruli which were strongly positive for IgG and C3. EM showed fusion of podocytes, marked thickening of the GBM and intramembranous electron dense deposits.	Membranous nephropathy	+	No necropsy
91631	-	10	7 glomeruli partially scarred. Mild loop thickening. FA positive for IgG and C3. EM showed fusion of podocytes and thickening of the GBM with intramembranous electron dense deposits.	Membranous nephropathy	+	+

CLINICAL SUMMARY

CAT

CASE No.	BREED	AGE(yr)	SEX	HISTORY, CLINICAL FINDINGS, FOLLOW UP and OUTCOME	CLINICAL DIAGNOSIS	REASON FOR BIOPSY	NECROPSY DIAGNOSIS
91890	DSH	2	FS	Ascites and polydipsia for 4 weeks. Thin, mild peripheral oedema and gross ascites. Kidneys prominent. Poor response to diuretic therapy; ascites required manual drainage and recurred. Condition maintained for 5 months and then deteriorated. Euthanasia after 6 months.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy
92587	DSH	3	MC	Ascites for 2 weeks. Dull, mild hind limb oedema; slightly pale mucosae. Good early response to diuretic therapy but oedema recurred. Owner requested euthanasia after 4 months.	Nephrotic syndrome	Persistent proteinuria	Membranous nephropathy; chronic cystitis; cholangitis.

LABORATORY RESULTS (INITIAL & FINAL SAMPLES)

CASE No.	INTERVAL a – b	BLOOD								URINE		
		UREA mmol/l	CREATININE µmol/l	PHOSPHATE mmol/l	CHOLESTEROL mmol/l	ALBUMIN g/l	GLOBULIN g/l	HAEMATOCRIT l/l	WBC $\times 10^9$/l	PROTEIN mg/100ml	BLOOD	SPECIFIC GRAVITY
91890 a	6 months	8.8	106	1.7	5.7	13	42	0.32	15.3	1000	+	1.050
b		105.0	574	14.0	7.2	21	55	0.29	67.0	462	trace	1.015
92587 a	4 months	11.1	141	2.6	2.7	11	38	0.29	28.8	1000	+	1.036
b		18.4	257	3.8	7.4	16	56	ND	ND	970	++	1.015
NORMAL VALUE		<9	50 - 145	1.3 - 3.0	1.8 - 4.1	- 40	- 35	> 30	5 - 20	0 - 30	-ve	> 1.025

SUMMARY OF BIOPSY PROCEDURE

CASE No.	ANAESTHESIA	URAEMIA AT BIOPSY	APPROACH			KIDNEY		POLE			NUMBER OF CUTS	LENGTH OF SAMPLE(mm)	POST-BIOPSY HAEMATURIA	RECOVERY / COMPLICATIONS
			Percutaneous	Keyhole	Laparotomy	LEFT	RIGHT	CAUDAL	MIDDLE	CRANIAL				
91890	Ketamine	–	+			+		+			2	1 x 0 1 x15	+	Normal
92587	Ketamine	–	+			+		+			1	15	+	Normal

SUMMARY OF BIOPSY RESULTS

CASE No.	RENAL TISSUE PRESENT	NUMBER OF GLOMERULI (HISTOLOGY)	REPORT	BIOPSY DIAGNOSIS	CORRELATION	
					Biopsy / Clinical	Biopsy/Necropsy
91890	+	3	Glomeruli appeared normal. FA positive for IgG and C3. EM showed thickening of the GBM with intramembranous and subepithelial electron dense deposits.	Membranous nephropathy	+	+
92587	+	9	All glomeruli partially scarred; moderate loop thickening. FA positive for IgG and C3 EM showed fusion of podocytes; thickening of the GBM with intra-membranous electron dense deposits.	Membranous nephropathy	+	+

APPENDIX C

CASE SUMMARIES OF 27 CATS WITH MEMBRANOUS NEPHROPATHY

Case No. 70151 DSH 3 years Male

History and presenting signs: Unvaccinated. No previous illness. Fluid swellings of hind limbs and abdomen developed gradually 6 months earlier and were reduced with diuretic therapy. The cat remained thin but bright and eating well for 5 months before a more severe recurrence of fluid swellings of the hind limbs, ventral body wall and abdomen.

Initial clinical examination: Alert and active. Shook hind legs while walking. Temp. N. H.R. 160 per min. regular. R.R. 36 per min. with moderate hyperpnoea. Pitting oedema of lower hind limbs, ventral body wall and scrotum; mild ascites. Kidneys slightly enlarged, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome; mild renal failure.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: "Lasix" daily for 7 days. Oedema was reduced in 5 days. "Tribrissen 20" for 7 days.

Subsequent examinations: The cat was re-examined after 2 months and 5 months and during that period he remained bright and well and free of oedema.

Outcome: After 6 months the cat was euthanased by the referring veterinary surgeon due to domestic circumstances. The body was not made available for necropsy examination.

Case No. 70151 (Cont'd)

Laboratory test results:

		Initial	After 2 months	After 5 months
Haematology:	Hct (l/l)	0.33	0.26	0.30
	WBC ($x10^9$/l)	10.4	9.6	8.4
Biochemistry Plasma:	Urea (mmol/l)	25.5	32.6	32.7
	Creatinine (µmol/l)	239	539	520
	Phosphate (mmol/l)	2.5	3.2	3.8
	Cholesterol (mmol/l)	5.8	8.2	8.6
	Albumin /g/l)	7	13	14
	Globulin (g/l)	54	48	63
Urine:	Protein (mg%)	2300	880	210
	Blood	trace	-	-
	pH	6.5	6.0	7.0
	SG	1.031	1.025	1.022
Virology:	FeLV	-		
	URT viruses	ND		
	FIP	ND		
Immunology:	LE preparation	ND		

Case No. 71377 DSH 7 years Neutered male

History and presenting signs: Vaccination history unknown.

No previous illness. For 6 months the cat had lost weight and was dirty in the house. Fluid swellings of the abdomen and all 4 limbs developed after 3 months and these were reduced with diuretic therapy. Progressive inappetance, dullness and polydipsia with a preference for water, and intermittent diarrhoea.

Initial clinical examination: Moderately alert, very thin and coat in poor condition. T.N. H.R. 180 per min. R.R. 28 per min. Slightly pale ocular and oral mucosae. Periodontal disease and halitosis. Kidneys prominent, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; moderate renal failure.

Biopsy diagnosis: Membranous nephropathy (advanced).

Management: Hospitalised for 7 days. Appetite variable; thirsty. Rather dull. Treated orally with oxytetracycline (100mg b.i.d.) and ethylestrenol ("Nandoral" 0.5mg. daily). Discharged at owner's request.

Subsequent Report: Condition was unchanged for 2 weeks followed by extreme dullness, anorexia and gingival haemorrhage. Cried when handled. Terminal renal failure diagnosed by referring veterinary surgeon and euthanasia was carried out. The body was not made available for necropsy examination.

Case No. 71377 (Cont'd)

Laboratory test results:		Initial	After 1 week
Haematology:	Hct	0.27	0.20
	WBC	7.1	5.0
Biochemistry			
Plasma:	Urea	38.3	37.8
	Creatinine	ND	ND
	Phosphate	5.8	ND
	Cholesterol	5.9	ND
	Albumin	10	9
	Globulin	39	34
Urine:	Protein	1100	400
	Blood	Trace	-
	pH	6.0	6.0
	SG	1.032	1.029
Virology:	FeLV	-	
	URT viruses	ND	
	FIP	ND	
Immunology:	LE preparation	ND	

Case No. 71570 DSH 2½ years Neutered male

History and presenting signs: FIE vaccination. At 6 months of age developed a severe upper respiratory infection and pneumonia but made a good recovery. Ten days prior to referral he became polydipsic and inappetent, followed by fluid swelling of lower hind limbs, ventral body wall and abdomen. For 3 days he was very dull, vomited repeatedly and passed diarrhoeic faeces.

Initial clinical examination: Dull, weak and in poor condition. T. 100.2°F. H.R. 200 per min. R.R. 28 per min. Ocular and oral mucosae were pink and the mouth dry. Severe dehydration. Moderate pitting oedema of lower hind limbs and ventral abdominal wall and ascites. Kidneys felt normal. A 4 inch long curved, cylindrical mass was palpated in mid-abdomen and was painful when squeezed.

Provisional diagnosis: Intussusception; protein losing nephropathy; nephrotic syndrome; moderate renal failure.

Management: 150 ml N-saline intravenously; "Lasix" and procaine penicillin. Vomiting persisted. Owner requested surgery and intussusception was corrected by intestinal resection and anastomosis. The cat regained consciousness but continued to deteriorate. On the fifth day he was comatose and euthanased. Just before death a renal biopsy was performed. The owner refused permission for a necropsy examination.

Biopsy diagnosis: Membranous nephropathy (mild).

Case No. 71570 (Cont'd)

Laboratory test results		Initial
Haematology:	Hct	0.34
	WBC	18.7
Biochemistry		
Plasma:	Urea	37.6
	Creatinine	179
	Phosphate	3.4
	Cholesterol	3.2
	Albumin	11
	Globulin	33
Urine:	Protein	460
	Blood	Moderate
	pH	6.0
	SG	1.044
Virology:	FeLV	-
	URT viruses	ND
	FIP	ND
Immunology:	LE preparation	ND

Case No. 85273 DSH 3½ years Spayed female

History and presenting signs: Unvaccinated. No previous illness. Polydipsia for 2 months with a preference for water. Short episode of vomiting after 4 weeks was accompanied by fluid swelling of both hind limbs. This was followed later by oedema of the ventral body wall, forelimbs and head. Appetite remained normal but dullness and intermittent coughing were noted during the latter 2 weeks.

Initial clinical examination: Alert. Thin over neck and back. T.N. H.R. 240 per min. Heart sounds slightly muffled. R.R. 100 per min. Dyspnoeic when excited. Harsh respiratory sounds and bilaterally reduced thoracic resonance. Severe pitting oedema of all 4 limbs, ventral body wall and head; moderate ascites and hydrothorax. Kidneys prominent, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (advanced). (Second biopsy; no glomeruli in first biopsy).

Management: Hospitalised for 12 days. "Lasix" (30 mg daily). Oedema reduced slowly cleared after 10 days. The cat was discharged. Oedema occurred one week later in spite of continuing low dose of "Lasix" (10 mg daily) but regressed after the daily dose was increased to 40 mg. Intermittent diarrhoea and some defaecation in the house occurred for 4 weeks.

Subsequent examinations: After 4 weeks limb oedema and ascites recurred and cat was re-admitted. Further "Lasix" (30 mg daily) reduced oedema and the diarrhoea improved after tapeworm treatment ("Scolaban" 100 mg Wellcome Foundation Ltd). A second renal biopsy was performed and the cat was discharged after 3 weeks.

After one year the cat was bright and active. Appetite good, thirst reduced. No diarrhoea and clean in house. No further oedema. Further biopsy not permitted.

After 2½ years the cat was bright, active and had gained 3/4 kg. body weight since the previous examination. She was eating normally and was not thirsty.

Case No. 85273 (Cont'd)

Laboratory test results:		Initial	After 2 months	After 12 months	After 30 months
Haematology:	Hct	0.31	0.23	ND	0.43
	WBC	17.6	7.3	6.9	3.6*
Biochemistry					
Plasma:	Urea	12.5	12.7	13.7	9.6
	Creatinine	150	115	133	124
	Phosphate	1.5	2.3	1.7	1.7
	Cholesterol	1.9	4.9	7.8	7.2
	Albumin	10	17	17	34
	Globulin	31	40	32	31
Urine:	Protein	1800	1258	1250	200
	Blood	-	-	-	trace
	pH	6.0	6.5	6.0	7.0
	SG	1.050	1.048	1.049	1.021
Virology:	FeLV	-			
	URT viruses	ND			
	FIP	ND			
Immunology:	LE preparation	ND			

(* Reduced figure due to clumping of white cells)

Case No. 86792 DSH 3 years Neutered male

History and presenting signs: FIE vaccination. Road accident at one year old. Hind limbs paralysed for several days but uneventful recovery. Sudden onset swelling of limbs with spontaneous regression 4 months prior to referral. Polydipsia with preference for water, occasional vomiting and diarrhoea. Fluid swellings of limbs and abdomen suddenly reucrred 3 days prior to referral.

Initial clinical examination: Bright and active. T.N. H.R. 180 per min. R.R. 30 per min. Ocular and oral mucosae slightly pale. Hind limb and ventral body wall oedema. Kidneys prominent firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome; moderate renal failure.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: Hospitalised for 8 days. "Lasix" (20 mg. daily) for 6 days. Oedema reduced. Discharged with further "Lasix" for 2 weeks.

Outcome: The cat was not re-examined. The owner moved away but reported that after 4 weeks the cat became progressively duller and inappetent. Vomiting and muscle twitching developed and the cat was euthanased. The body was not made available for necropsy examination.

Case No. 86792 (Cont'd)

Laboratory test results:		Initial	After 1 week
Haematology:	Hct	0.30	0.23
	WBC	18.2	13.3
Biochemistry			
Plasma:	Urea	22.3	25.0
	Creatinine	212	212
	Phosphate	1.1	ND
	Cholesterol	6.3	8.3
	Albumin	14	20
	Globulin	36	42
Urine:	Protein	250*	465
	Blood	-	-
	pH	5.5	6.0
	SG	1.015*	1.020
Virology:	FeLV	-	
	URT viruses	ND	
	FIP	ND	
Immunology:	LE preparation	ND	

(* sample obtained after cat received initial high dose of "Lasix". A subsequent sample contained 925 mg% of protein and SG 1.034).

Case No. 81982 DSH $3^{3}/_{4}$ years Neutered male

History and presenting signs: Unvaccinated. No previous illness. First examined when healthy, 5 months after his litter sister (case no. 80204) developed the nephrotic syndrome. More than 2 years after the initial examination he developed fluid swellings of the lower hind limbs and ventral abdominal wall. At the same time he became thinner, thirsty, less active and had a reduced appetite.

Initial clinical examination: Quite bright and moved freely. T.N. H.R. 200 per min., regular. R.R. 28 per min., normal. Ocular and oral mucosae were smooth and pink. Moderate pitting oedema of the lower hind limbs and ventral body wall. Kidneys felt normal.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: On admission the cat was given "Lasix" daily for 5 days. Oedema was reduced rapidly and he became brighter and ate well. He was discharged after 3 weeks.

Subsequent examinations: After 3 months the cat had maintained progress and had increased in body weight by 0.9 kg. Three months later there was a recurrence of mild hind limb oedema and for the first time, mild ascites. Although still thirsty he was eating well and bright. Lasix was given for 7 days and the fluid regressed in 3 days. Thereafter the cat has remained well although still heavily proteinuric.

Case No. 81982 (Cont'd)

Laboratory test results:		Initial*	After 2 years 3 months	After 2 years 9 months	After 3 years 4 months
Haematology:	Hct	0.44	0.34	0.31	0.37
	WBC	16.0	13.2	12.9	11.0
Biochemistry					
Plasma:	Urea	10.0	12.9	9.9	13.3
	Creatinine	ND	106	115	133
	Phosphate	ND	2.18	1.55	1.47
	Cholesterol	ND	4.87	5.18	6.26
	Albumin	31	15	15	25
	Globulin	34	34	32	27
Urine:	Protein	0	340	525	1050
	Blood	-	-	trace	-
	pH.	6.5	7.0	6.0	6.5
	SG	1.041	1.026	1.030	1.050
Virology:	FeLV	-			
	URT viruses	-			
	FIP	-			
Immunology:	LE preparation	-			

* Cat was normal on this occasion; he did not become nephrotic until more than 2 years later.

Case No. 91585 DSH 8 years Neutered male

History and presenting signs: Vaccination history unknown. This cat was a stray adopted at approximately 1 year old. He had been castrated when 6 years old and subsequently developed a chronic skin condition.

For 2 months prior to referral the cat was reluctant to jump heights and gradually lost weight. One week prior to referral he developed fluid swellings of the lower hind limbs, ventral abdominal wall and abdomen. He was less active but ate and drank normally.

Initial clinical examination: Quite bright and thin. T.N. H.R. 200 per min., regular. R.R. 60 per min., shallow. Ocular and oral mucosae were smooth and pink. There was pitting oedema of the lower hind limbs and moderate ascites. The kidneys felt slightly enlarged, smooth and firm. The fur over the back and loins was sparse and in poor condition due to chronic flea dermatitis.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat was given "Lasix" daily for 5 days, during which time the oedema regressed. The cat was bright, ate well and was discharged after 12 days.

Subsequent examinations: Twelve days following discharge, the cat was re-admitted because oedema and ascites had recurred 2 days earlier. "Lasix" was given and the oedema reduced over 5 days. Diarrhoea developed during this time and the cat vomited on 2 occasions. Faeces were still soft when he was discharged after 2 weeks.

Outcome: The cat was not examined again. The owner reported that he seemed content but continued to lose weight and died 3 weeks after he was discharged. His body was not made available for necropsy examination.

Case No. 91585 (cont'd)

Laboratory test results:		Initial	After 1 week	After 4 weeks
Haematology:	Hct	0.30	0.26	0.20
	WBC	22.5	13.6	14.3
Biochemistry:				
Plasma:	Urea	14.7	16.1	15.3
	Creatinine	124	88	124
	Phosphate	2.3	2.1	2.2
	Cholesterol	7.2	ND	5.7
	Albumin	20	17	21
	Globulin	42	49	38
Urine:	Protein	660	1190	590
	Blood	-	-	-
	pH	6.0	7.0	6.5
	SG	1.024	1.025	1.026
Virology:	FeLV	-		
	URT viruses	ND		
	FIP	-		
Immunology:	LE preparation	ND		

Case No. 62718 DSH 3 years Neutered male

History and presenting signs: Vaccination status and previous history were unknown. The cat was healthy on arrival at a cattery where he had been boarded for 5 months prior to referral. After 4½ months, along with other cats, he became dull, febrile and had diarrhoea. He improved after symptomatic treatment but a few days later he developed fluid swellings of the hind limbs and abdomen.

Initial clinical examination: Bright and active. T.N. H.R. 186 per min. R.R. 38 per min; moderate hyperpnoea. Mild conjunctivitis. Pitting oedema of lower hind limbs and ventral body wall; moderate ascites and mild hydrothorax. Kidneys slightly enlarged, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: "Lasix" daily for 6 days. Oedema was reduced but recurred 10 days later. A further 6 day course of "Lasix" reduced the oedema which never recurred.

Subsequent examinations: The cat remained in the hospital until his death 3 years later. He was bright, ate well, maintained his body weight and was moderately thirsty until the last 6 months of his life. Thereafter he began to lose weight. During the last month he was increasingly dull and inappetent. Terminal renal failure developed and euthanasia was carried out.

Five further renal biopsies were performed over 3 years and of these the first 4 showed membranous changes very similar to those in the initial biopsy but the final one taken after 2¼ years revealed more extensive and severe changes.

Necropsy examination: The carcase was very thin and pale, kidneys were small and firm to cut. The renal cortex was irregularly narrowed. No significant extra-renal lesions were present.

Case No. 62718 (Cont'd)

Laboratory test results:		Initial	After 6 months	After 2 years	After 3 years	Final
Haematology:	Hct	0.33	0.30	0.35	0.30	0.20
	WBC	1.6	18.6	5.2	14.1	16.7
Biochemistry:						
Plasma:	Urea	11.1	10.4	13.8	24.2	185.0
	Creatinine	71	133	195	186	ND
	Phosphate	2.1	2.6	2.1	2.1	10.2
	Cholesterol	ND	6.4	ND	7.0	9.1
	Albumin	6	12	23	12	16
	Globulin	56	50	47	47	70
Urine:	Protein	1870	1520	330	ND	280
	Blood	-	-	-	ND	-
	pH	6.0	6.0	6.0	ND	6.5
	SG	1.039	1.035	1.025	ND	1.022
Virology:	FeLV	-				
	URT viruses	ND				
	FIP	ND				
Immunology:	LE preparation	-				

Case No. 66669 DSH 3 years Neutered male

History and presenting signs: FIE vaccination. No previous illness but 2 months prior to referral this cat was boarded for 4 weeks in the same cattery coincident with case no. 62718 and developed diarrhoea during that time. On returning home he was thirsty with a preference for water. After 2 weeks he became dull, ate less, had diarrhoea and developed fluid swellings of the hind limbs and abdomen. For 2 weeks the diarrhoea was controlled with kaolin preparations and the fluid swellings were partially reduced with diuretics.

Initial clinical examination: Alert, thin, T.N. H.R. 200 per min. R.R. 42 per min. Moderate pitting oedema of the lower hind limbs; ascites. Ocular or oral mucous membranes were pale. Kidneys were of normal size, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: "Lasix" for 7 days. Oedema slowly reduced. Poor appetite and persistent diarrhoea. After 3 weeks mild tarsal oedema recurred and responded to a further 3 days treatment with "Lasix". Thereafter appetite and diarrhoea improved and the cat was discharged after 5½ weeks.

Subsequent examinations: Re-admitted after 3 weeks because of uncontrollable diarrhoea and increasing dullness. Very thin and dull. For the following week he passed diarrhoea every day and on the fifth day and subsequently he began vomiting. On the seventh day a mass palpated in the abdomen was diagnosed as an intussusception. In view of the existing illness the cat was euthanased.

Necropsy findings: The carcase was oedematous and pale. The kidneys were slightly enlarged and pale. A 4 inch intussusception of the terminal ileum was present.

Case No. 66669 (Cont'd)

Laboratory test results:		Initial	After 1 month	After 2 months
Haematology:	Hct	0.29	0.24	0.30
	WBC	27.5	9.2	12.3
Biochemistry:				
Plasma:	Urea	12.9	11.8	20.4
	Creatinine	231	ND	170
	Phosphate	1.2	2.5	2.2
	Cholesterol	ND	7.8	ND
	Albumin	5	8	6
	Globulin	60	41	41
Urine:	Protein	5600	1690	526
	Blood	-	++	+
	pH	6.0	6.0	6.0
	SG	1.050	1.033	1.029
Virology:	FeLV	-		
	URT viruses	ND		
	FIP	ND		
Immunology:	LE preparation	ND		

Case No. 70865 DSH 4 years Neutered male

History and presenting signs: FIE vaccination. No previous illness. Fluid swellings developed in all 4 limbs 2 months prior to referral. Otherwise the cat remained normal.

Initial clinical examination: Thin, bright and active. T.N. H.R. 170 per min. R.R. 45 per min. Ocular and oral mucous membranes slightly pale. Pitting oedema of the lower parts of all 4 limbs. Kidneys were slightly enlarged, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (mild).

Management: "Lasix" for 6 days. Oedema was reduced after 3 days. The cat remained otherwise normal and was discharged after one week.

Subsequent examinations: Mild tarsal oedema recurred after 6 weeks. "Lasix" was given for 10 days. Oedema never recurred and the cat was seen at varying intervals over the next 2 years. He behaved normally but remained thin. While apparently not thirsty he was observed drinking water from the toilet on several occasions. Diarrhoea developed after $1\frac{1}{2}$ years and there was a slow response to kaolin preparations. After $2\frac{1}{4}$ years he gradually became very thin, dull and inappetent and diarrhoea recurred. On re-admission he was markedly dehydrated and in terminal renal failure. Both kidneys were small, hard and irregular. Euthanasia was performed.

Necropsy findings: The carcase was emaciated and pale. The kidneys were shrunken and very fibrous with grossly contracted cortices. In addition there was marked oral and lingual ulceration and moderate gastritis.

Case No. 70865 (Cont'd)

Laboratory test results:		Initial	After 4 months	After 1 year	After 1½ years	After 2 years 4 months
Haematology:	Hct	0.35	0.33	0.32	0.29	ND
	WBC	17.8	9.6	18.3	7.8	ND
Biochemistry:						
Plasma:	Urea	16.8	11.3	16.8	19.2	115.0
	Creatinine	150	132	169	282	770
	Phosphate	1.7	1.9	ND	1.5	7.4
	Cholesterol	7.4	11.6	12.9	7.7	7.6
	Albumin	9	9	8	ND	25
	Globulin	44	45	51	ND	40
Urine:	Protein	3500	1630	1850	350	ND
	Blood	+	-	-	-	ND
	pH	7.0	6.0	6.0	6.0	ND
	SG	1.046	1.044	1.031	1.025	ND
Virology:	FeLV	-				
	URT viruses	-				
	FIP	160				
Immunology:	LE preparation	ND				

Case No. 71792 DSH $3\frac{1}{2}$ years Neutered male

History and presenting signs: Unvaccinated. No previous illness. During the 3 weeks prior to referral the cat had lost weight and become dull, inappetent and thirsty. He had developed fluid swellings of the hind limbs and abdomen.

Initial clinical examination: Thin and alert. Coat in poor condition. T.N. H.R. 200 per min., R.R. 36 per min. Slightly pale ocular and oral mucosae. Marked ascites and oedema of all 4 limbs, ventral body wall and sub-mandibular space. Kidneys were not palpated..

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (mild).

Management: "Lasix" for 10 days during which time oedema gradually reduced. The cat was discharged after 3 weeks in the hospital.

Further examinations: Oedema occurred after 2 weeks at home and persisted despite "Lasix" therapy. Re-admitted for 3 weeks and given increased dosages of "Lasix" until oedema was reduced. After 4 weeks at home oedema and ascites recurred and the cat was re-admitted. The fluid was refractory to "Lasix" and during the following 2 weeks the cat's general condition deteriorated. Euthanasia was performed.

Necropsy findings: The carcase was emaciated, oedematous and pale. The kidneys were normal in size but firm and fibrous. No extra renal lesions were found.

Case No. 71792 (Cont'd)

Laboratory test results:		Initial	After 6 weeks	After 4 months
Haematology:	Hct	0.25	0.25	0.21
	WBC	12.5	8.2	3.7
Biochemistry:				
Plasma:	Urea	7.1	22.5	36.1
	Creatinine	ND	163	239
	Phosphate	ND	2.3	5.0
	Cholesterol	ND	ND	5.3
	Albumin	3	6	5
	Globulin	51	48	56
Urine:	Protein	875	760	750
	Blood	-	+	-
	pH	6.0	6.0	6.0
	SG	1.046	1.027	1.022
Virology:	FeLV	-		
	URT viruses	-		
	FIP	ND		
Immunology:	LE preparation	ND		

Case No. 73644 DSH 7 years Neutered male

History and presenting signs: Vaccination history unknown. No previous illness. For 3 weeks prior to referral the cat was dull and lethargic. He lost weight, ate less and developed fluid swellings of the hind limbs and ventral abdominal wall.

Initial clinical examination: Alert, thin coat in poor condition. T.N. H.R. 190 per min. R.R. 36 per min. Ocular and oral mucosae were slightly pale. Pitting oedema of the lower hind limbs and ventral abdominal wall; ascites. Kidneys prominent and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat remained in the hospital for 3 months. "Lasix" therapy was instituted and maintained for 3 weeks as the oedema regressed slowly. He was brighter and ate well but after 2 weeks oedema recurred and "Lasix" was given for a further 3 weeks. A second renal biopsy was performed after 2 months. The cat remained bright but continued to lose weight and was euthanased.

Necropsy findings: The carcase was thin. Kidneys were pale but normal in size and consistency. No extra renal lesions were found.

Case No. 73644 (Cont'd)

Laboratory test results:		Initial	After 2 months	After 3 months
Haematology:	Hct	0.26	0.26	0.27
	WBC	6.1	7.9	5.8
Biochemistry:				
Plasma:	Urea	15.0	10.3	10.0
	Creatinine	133	177	89
	Phosphate	1.7	ND	1.5
	Cholesterol	4.5	5.3	6.3
	Albumin	6	7	8
	Globulin	44	35	44
Urine:	Protein	1100	1150	620
	Blood	+	++	-
	pH	6.5	6.0	6.0
	SG	1.034	1.038	1.027
Virology:	FeLV	-		
	URT viruses	FCV +		
	FIP	ND		
Immunology:	LE preparation	-		

Case No. 74368 DSH 3 years Neutered male

History and presenting signs: Vaccination and full history were not available. Two months prior to referral the cat had begun to lose weight followed by a reduction in appetite and occasional vomiting.

Initial clinical examination: Dull, very thin and coat in poor condition. T.N. H.R. 180 per min. R.R. 40 per min. The ocular and oral mucous membranes were slightly pale. Kidneys normal size, firm and smooth.

Provisional diagnosis: Chronic renal failure. Subsequent urine protein levels were indicative of a protein losing nephropathy.

Biopsy diagnosis: Membranous nephropathy (advanced).

Management: The cat remained in the hospital for 4 weeks. In the first 2 weeks he was quite bright, ate moderately well and was very thirsty. During the following 2 weeks he became increasingly dull and ate very little. Ocular and oral mucous membranes became very pale. Euthanasia was performed after 4 weeks.

Necropsy findings: The carcase was thin and pale. Kidneys were smaller than usual, firm to cut and had narrowed cortices. No extra renal lesions were found.

Case No. 74368 (Cont'd)

Laboratory test results:		Initial	After 2 weeks	After 4 weeks
Haematology:	Hct	0.34	0.34	0.19
	WBC	34.6	32.8	19.4
Biochemistry:				
Plasma:	Urea	31.2	30.9	42.9
	Creatinine	231	274	300
	Phosphate	2.9	4.6	5.8
	Cholesterol	ND	6.0	6.3
	Albumin	8	15	8
	Globulin	54	41	55
Urine:	Protein	159	1050	1230
	Blood	+++	+	+
	pH	6.0	6.0	6.0
	SG	1.020	1.021	1.029
Virology:	FeLV	-		
	URT viruses	ND		
	FIP	ND		
Immunology:	LE preparation	-		

Case No. 78535 DSH 3 years Spayed female

History and presenting signs: FIE vaccination. No previous illness. A full history was not available, but during the week prior to referral the cat was noticed to be thinner, eating less, thirsty and then developed a slightly swollen abdomen.

Initial clinical examination: Very dull, thin and weak. T.N. H.R. 150 per min. R.R. 30 per min. Very pale ocular and oral mucous membranes. Moderate ascites. Ammoniacal halitosis. Occasional twitching of the head muscles. Kidneys felt normal in size, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome; chronic renal failure.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat was admitted and given a subcutaneous infusion of 120 ml normal saline. Her general condition continued to deteriorate and she was euthanased 48 hours after admission.

Necropsy findings: The carcase was thin and pale. There was a small amount of free fluid in the abdomen. The kidneys were small, shrunken and very firm to cut. The renal cortex was irregularly reduced.

Case No. 78535 (Cont'd)

Laboratory test results:		Initial	After 48 hours
Haematology:	Hct	18.2	15.1
	WBC	34.8	14.0
Biochemistry:			
Plasma:	Urea	52.9	63.0
	Creatinine	265	407
	Phosphate	6.5	8.8
	Cholesterol	4.7	3.7
	Albumin	18	21
	Globulin	29	21
Urine:	Protein	1120	224
	Blood	-	++
	pH	6.0	6.0
	SG	1.027	1.020
Virology:	FeLV	-	
	URT viruses	ND	
	FIP	ND	
Immunology:	LE preparation	ND	

Case No. 78897 DSH 2½ years Neutered male

History and presenting signs: Unvaccinated. Tail damaged in road accident at 6 months of age. Two weeks prior to referral the cat developed fluid swellings in the lower hind limbs and ventral body wall. Although bright and quite active he ate less and lost condition. Intermittent diarrhoea occurred during the second week.

Initial clinical examination: Alert, thin. T. 103.5°F. H.R. 180 per min. R.R. 24 per min. Ocular mucous membranes slightly pale. Moderate pitting oedema of the lower hind limbs and very mild ascites. Kidneys were normal in size, firm and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat was given "Lasix" daily for 5 days and during this time the oedema regressed. Although the temperature had returned to normal by the second day the cat remained rather dull and inappetent for 7 days following admission and vomited once on the fourth day. On the fifth day he was given a subcutaneous infusion of 60 ml. of glucose saline. On the eighth day he became much brighter and thereafter ate all food offered. He was discharged after 11 days.

Subsequent report: On returning home the cat remained bright and ate well for 10 days. On the eleventh day he suddenly became dyspnoeic and died 2 hours later.

Necropsy findings: The carcase was thin and there was peripheral oedema and mild ascites. The kidneys were normal in size, smooth and easy to cut. There was a large thrombus in the pulmonary artery.

Case No. 78897 (Cont'd)

Laboratory test results:		Initial	After 1 week
Haematology:	Hct	0.30	0.30
	WBC	25.7	5.8
Biochemistry:			
Plasma:	Urea	31.4	17.9
	Creatinine	177	141
	Phosphate	1.9	1.3
	Cholesterol	5.1	6.3
	Albumin	22	23
	Globulin	27	37
Urine:	Protein	2100	2420
	Blood	++	++
	pH	6.0	6.0
	SG	1.049	1.044
Virology:	FeLV	-	
	URT viruses	ND	
	FIP	ND	
Immunology:	LE preparation	ND	

Case No. 79837 DSH 3 years Neutered male

History and presenting signs: FIE vaccination. No previous illness. Four months prior to referral the cat developed a swollen abdomen which had been partially reduced by intermittent diuretic treatment. Two months later a hind limb also became swollen. The cat remained bright and eating but was increasingly thirsty with a preference for running water.

Initial clinical examination: Bright but thin. T.N. H.R. 230 per min. R.R. 28 per min. Ocular and mucous membranes were slightly pale. Gross ascites. Kidneys prominent and smooth.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome; renal failure.

Biopsy diagnosis: Membranous nephropathy (advanced).

Management: On admission to the hospital the cat was given "Lasix" daily and ascites was reduced quite quickly. The cat was discharged after 7 days.

Subsequent examination: The cat deteriorated during the following 3 weeks. He was very dull, very thin, inappetent and very thirsty. On several occasions the animal was observed to be unaware of his surroundings. Euthanasia was carried out after 3 weeks at home.

Necropsy findings: The carcase was emaciated and pale. The kidneys were slightly smaller than normal and very firm to cut. There was extensive calcification of the aorta and pulmonary arteries.

Case No. 79837 (Cont'd)

Laboratory test results :		Initial	After 4 weeks
Haematology:	Hct	0.28	0.26
	WBC	6.7	13.9
Biochemistry:			
Plasma:	Urea	43.2	68.3
	Creatinine	302	796
	Phosphate	ND	6.1
	Cholesterol	6.5	8.8
	Albumin	19	21
	Globulin	31	53
Urine:	Protein	1300	560
	Blood	-	-
	pH	6.0	5.0
	SG	1.027	1.026
Virology:	FeLV	-	
	URT viruses	ND	
	FIP	-	
Immunology:	LE preparation	-	

Case No. 80204 DSH 1 year Spayed female

History and presenting signs: Unvaccinated. Upper respiratory tract infection was present when first obtained as a very young kitten. Six weeks prior to referral the cat became dull, inappetent and thirsty. Fluid swellings of all 4 limbs, ventral body wall and abdomen developed and became most severe one week prior to referral. At this stage the cat was very dull and had intermittent diarrhoea.

Initial clinical examination: Dull but in good body condition. T.N. H.R. 210 per min. R.R. 48 per min. Marked hind limb and ventral body wall oedema and gross ascites. The kidneys felt normal.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (mild).

Management: On admission to hospital the cat was given "Lasix" daily for 7 days. Oedema cleared quickly and the cat was discharged with an 8 week course of prednisolone therapy.

Subsequent examination: After 6 weeks the cat was very bright, eating well and had gained 1 kg. Oedema had not recurred but the cat was still thirsty. A second biopsy was taken after 5 months when she was well and no longer thirsty. Thereafter the cat remained in excellent health and on examination one year after the second biopsy was found to be only minimally proteinuric. Further examinations over the subsequent $2\frac{1}{2}$ years have confirmed that this cat has made a complete clinical recovery.

Case No. 80204 (Cont'd)

Laboratory test results:		Initial	After 6 weeks	After 5 months	After 20 months	After 4 years
Haematology:	Hct	0.29	0.35	0.46	0.48	0.46
	WBC	20.3	16.8	16.1	8.4	10.0
Biochemistry:						
Plasma:	Urea	12.8	12.9	8.7	12.8	11.3
	Creatinine	124	80	97	150	115
	Phosphate	1.9	2.3	1.9	1.7	1.5
	Cholesterol	4.3	4.4	4.5	ND	4.4
	Albumin	10	19	25	34	36
	Globulin	29	23	39	44	24
Urine:	Protein	2640	2900	905	25	7.5
	Blood	+	+	-	-	-
	pH	6.0	6.0	6.0	6.0	6.0
	SG	1.046	1.050	1.036	1.042	1.023
Virology:	FeLV	-				
	URT viruses	-				
	FIP	ND				
Immunology:	LE preparation	-				

Case No. 80589 DSH 3 years Spayed female

History and presenting signs: Unvaccinated. An accident at 1 year of age necessitated tail amputation. Three weeks prior to referral the cat developed fluid swellings of the limbs and abdomen. Diuretic therapy was effective until the drug was withdrawn. Fluid swellings recurred and were more extensive, involving the head. During this period the cat was less active and inappetent. Diarrhoea occurred intermittently.

Initial clinical examination: Quite bright, coat in good condition. T.N. H.R. 200 per min. R.R. 32 per min. Ocular and oral mucosae slightly pale. Severe pitting oedema of all 4 limbs, ventral body wall and moderate ascites. Kidneys felt normal.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat was admitted and given "Lasix" for 8 days during which time oedema regressed. She was brighter, ate well and was discharged after 2 weeks.

Subsequent examinations: After 3 months the cat continued to be well but was thirsty and had intermittent diarrhoea. She remained thin and her coat had become very dry and harsh. Mild ventral body wall oedema and ascites recurred, the cat was placed on "Lasix" for 3 days and the fluid regressed. After 4 months a second renal biopsy was performed. Thirteen months after the initial referral the cat became quite suddenly dull, inappetent and very thirsty. On re-admission she was found to be very thin, with pale mucous membranes and in chronic renal failure. The kidneys were prominent but very hard and irregular. After 5 days the cat was euthanased.

Necropsy findings: The carcase was very thin and pale. The kidneys were slightly reduced in size and very firm to cut. The cortices were narrowed. Moderate gingival ulceration was present.

Case No. 80589 (Cont'd)

Laboratory test results:		Initial	After 3 months	After 13 months
Haematology:	Hct	0.37	0.35	0.15
	WBC	37.6	42.0	58.6
Biochemistry:				
Plasma:	Urea	7.1	9.6	107.5
	Creatinine	133	115	688
	Phosphate	1.8	1.2	6.8
	Cholesterol	4.5	4.4	7.4
	Albumin	17	18	25
	Globulin	35	33	57
Urine:	Protein	730	1050	625
	Blood	++	-	+
	pH	6.5	6.0	5.5
	SG	1.021	1.030	1.015
Virology	FeLV	-		
	URT viruses	ND		
	FIP	40		
Immunology:	LE preparation	ND		

Case No. 82525 DLH 3 years Male

History and presenting signs: Background history not available. Two weeks prior to referral the cat developed fluid swellings of the hind limbs and ascites. Diuretic tablets were prescribed but ineffective. The cat had lost condition but was alert and eating normally.

Initial clinical examination: Bright; thin and coat in poor condition. T.N. H.R. 160 per min. R.R. 36 per min. Ocular and oral mucous membranes slightly pale. Mucoid diarrhoea was passed during examination. Severe pitting oedema was extensive in all 4 limbs and there was gross ascites. Kidneys felt normal.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (mild).

Management: The cat was admitted and has remained in the hospital ever since. Initial treatment with "Lasix" for 10 days reduced the oedema, which has never recurred. The cat has remained bright and well and has gained weight during the 3½ years of observation. Nevertheless he is still persistently proteinuric. Three further biopsies were performed after 14 months, 2 years and 3 years, respectively.

Case No. 82525 (Cont'd)

Laboratory test results:		Initial	After 6 months	After 1 year	After 2 years	After 3 years
Haematology:	Hct	0.29	0.32	0.47	0.47	0.49
	WBC	41.9	6.3	9.2	8.7	16.2
Biochemistry:						
Plasma:	Urea	7.7	12.8	10.2	11.0	9.6
	Creatinine	88	115	97	133	124
	Phosphate	1.2	1.9	1.7	1.4	1.7
	Cholesterol	4.4	12.2	ND	11.3	3.7
	Albumin	24	29	28	23	31
	Globulin	25	48	46	43	42
Urine:	Protein	920	750	315	400	125
	Blood	+	-	-	-	-
	pH	7.0	6.5	6.0	6.0	7.0
	SG	1.020	1.025	1.025	1.027	1.039
Virology:	FeLV	-				
	URT viruses	-				
	FIP	ND				
Immunology:	LE preparation	-				

Case No. 82987 DSH 2 years Male

History and presenting signs: Unvaccinated. Fight wounds treated on several previous occasions. Two weeks prior to referral the cat developed fluid swellings of the hind limbs, lower body wall and abdomen. He remained bright and fairly active, ate normally but became thirsty. Diarrhoea developed in the few days prior to admission.

Initial clinical examination: Thin and in poor condition. T.N. H.R. 180 per min. R.R. 42 per min. Gross oedema of all 4 limbs, head, ventral abdominal wall, scrotum and marked ascites. Moderate halitosis and gingivitis. Kidneys felt prominent, smooth and firm.

Provisional diagnosis: Protein losing nephropathy, nephrotic syndrome; moderate renal failure.

Biopsy diagnosis: Membranous nephropathy (advanced)

Management: After admission the oedema regressed in 4 days with "Lasix" therapy. The cat became brighter and ate well but had persistent soft or diarrhoeic faeces. He became suddenly dull and died 18 days following admission.

Necropsy examination: The carcase was thin and pale. The kidneys were slightly enlarged and firm to cut. Extra-renal signs of uraemia were not found. No explanation as to the sudden deterioration and death could be given.

Case No. 82987 (Cont'd)

Laboratory test results:		Initial	After 1 week	After 2½ weeks
Haematology:	Hct	0.30	0.24	ND
	WBC	40.7	24.8	ND
Biochemistry:				
Plasma:	Urea	22.3	21.7	59.2
	Creatinine	159	ND	150
	Phosphate	2.1	ND	3.7
	Cholesterol	5.1	4.7	4.8
	Albumin	13	14	14
	Globulin	42	45	41
Urine:	Protein	4000	1000	420
	Blood	+	-	-
	pH	6.0	6.0	6.0
	SG	1.055	1.030	1.030
Virology:	FeLV	-		
	URT viruses	ND		
	FIP	40		
Immunology:	LE preparation	-		

Case No. 83187 DSH 5 years Male

History and presenting signs: The full history was unavailable. There had been weight loss followed by fluid swellings of all 4 limbs and an increasing difficulty in breathing during the previous few weeks.

Initial clinical examination: Dull, thin and dyspnoeic. Coat in poor condition. T.N. H.R. 180 per min. R.R. 36 per min., with marked inspiratory effort. Heart sounds were slightly muffled and bilaterally reduced thoracic resonance. There was marked pitting oedema of all 4 limbs, ventral abdominal wall, ascites and hydrothorax.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome; mild renal failure.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat was gifted for further study and remained in the hospital for 11 months. In the first 12 days he was given "Lasix" and the oedema regressed. The cat was bright and active for much of the remaining time but remained very thin. On 2 occasions in the first 6 months he developed moderate limb oedema which was quickly reduced with further "Lasix" treatment. After 10 months he became dull and emaciated. Three weeks later he developed terminal renal failure and euthanasia was performed.

Necropsy findings: The carcase was emaciated and dehydrated. The kidneys were slightly enlarged, smooth, pale but firm to cut. Extensive oral and lingual ulceration was present.

Case No. 83187 (Cont'd)

Laboratory test results:		Initial	After 4 months	After 9 months	After 11 months
Haematology:	Hct	0.32	ND	0.29	0.34
	WBC	46.0	11.3	10.7	12.5
Biochemistry:					
Plasma:	Urea	22.3	14.4	20.8	149.0
	Creatinine	124	62	248	990
	Phosphate	2.4	2.3	2.8	15.6
	Cholesterol	5.6	ND	ND	10.3
	Albumin	12	24	19	26
	Globulin	58	53	34	67
Urine:	Protein	1580	700	640	500
	Blood	+	-	-	-
	pH	6.0	6.0	6.0	6.0
	SG	1.040	1.035	1.030	1.020
Virology:	FeLV	-			
	URT viruses	-			
	FIP	-			
Immunology:	LE preparation	ND			

Case No. 83976 DSH 3 years Neutered male

History and presenting signs: FIE vaccination. No previous illness. Thirst was increased for several weeks with a preference for water. for 10 days the cat was dull and lost weight. During the 5 days prior to referral he was inappetent and had vomited twice.

Initial clinical examination: Very dull, weak, thin and dehydrated. T. sub-normal. H.R. 200 per min. R.R. 30 per min. The ocular mucous membranes were congested. Oral mucosae were dry and there was an ammoniacal halitosis. Small ulcers were present on the gums and cheeks. The kidneys felt enlarged and very firm.

Provisional diagnosis: Terminal renal failure; possible protein losing nephropathy.

Biopsy diagnosis: Membranous nephropathy (advanced).

Management: The cat did not respond to rehydration therapy and euthanasia was performed after 36 hours.

Necropsy findings: The carcase was thin and dehydrated. The kidneys were enlarged, very firm and hard to cut. Evidence of uraemia was confined oral ulceration. There was calcification of bronchi, bronchioles and pulmonary alveoli.

Case No. 83976 (Cont'd)

Laboratory test results:		Initial
Haematology:	Hct	0.28
	WBC	15.5
Biochemistry:		
Plasma:	Urea	110.0
	Creatinine	610
	Phosphate	5.9
	Cholesterol	8.2
	Albumin	18
	Globulin	43
Urine:	Protein	745
	Blood	-
	pH	5.5
	SG	1.025
Virology:	FeLV	-
	URT viruses	ND
	FIP	-
Immunology:	LE preparation	ND

Case No. 89236 DSH 3 years Male

History and presenting signs: Unvaccinated. Cat owned since a young kitten. He was bitten by a dog at 6 months old and developed a large back and flank abscess which healed slowly. Six weeks prior to referral he was noticed to be losing weight and one week later developed fluid swellings of the abdomen and hind limbs, followed a few days later by the fore limbs and ventral abdominal wall. He was not obviously thirsty. Latterly he was dull and ate less.

Initial clinical examination: Dull and thin, T.N. H.R. 160 per min. R.R. 40 per min. Moderate uraemic halitosis. Ocular and oral mucosae were pale. There was pitting oedema of the lower part of all 4 limbs and ventral abdominal wall, and marked ascites. Kidneys felt normal in size but very firm. The fur coat was in poor condition and fleas were seen.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat was given "Lasix" for 7 days and the oedema gradually regressed. In the first week the body weight was reduced by $1\frac{3}{4}$ kg. A guarded prognosis was given in view of the uraemia and the cat was discharged after 9 days.

Subsequent examination: Ten days after being discharged the cat became dull and vomited twice. He was thirsty and there was a recurrence of mild hind limb oedema. He was re-admitted, improved with further "Lasix" therapy and was discharged 4 days later. After a further 2 weeks he became dull, anorexic and vomited at least once daily, developed diarrhoea and became dirty in the house. One week later he was re-admitted in terminal renal failure, with marked uraemic halitosis, oral and lingual ulceration and pale mucosae. Both kidneys felt very hard. Euthanasia was carried out.

Necropsy examination: The carcase was thin and pale. The kidneys were pale and firm to cut, with granular cortices. There was marked buccal and lingual ulceration and parathyroid hyperplasia.

Case No. 89236 (Cont'd)

Laboratory test results:		Initial	After 3 weeks	After 6 weeks
Haematology:	Hct	0.27	0.21	0.22
	WBC	10.3	14.1	12.8
Biochemistry:				
Plasma:	Urea	32.5	38.4	101.5
	Creatinine	141	213	539
	Phosphate	1.9	2.4	5.4
	Cholesterol	12.4	ND	11.1
	Albumin	16	14	17
	Globulin	35	36	39
Urine:	Protein	505	1000	162
	Blood	-	-	Trace
	pH	6.0	6.0	6.0
	SG	1.050	1.032	1.022
Virology:	FeLV	-		
	URT viruses	ND		
	FIP	ND		
Immunology:	LE preparation	ND		

Case No. 90812 DSH 2½ years Neutered male

History and presenting signs: Unvaccinated. Previously healthy. For 4 weeks prior to referral the cat became thirsty and preferred water. He vomited on a number of occasions. Later he developed fluid swellings of all 4 limbs and abdomen.

Initial clinical examination: Dull and reluctant to move. T.N. H.R. 200 per min. R.R. 46 per min., hyperpnoeic. The cat was thin. Ocular and oral mucosae were pale pink. Pitting oedema was present in the lower part of all 4 limbs, ventral body wall and scrotum. There was moderate ascites and hydrothorax. The kidneys felt enlarged and firm.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: "Lasix" was given daily for 9 days during which time the oedema slowly regressed and the cat lost 2 kg. in body weight. He became brighter and ate better but on the eighth day developed diarrhoea which persisted for one week. The cat became dull, anorexic and dehydrated but responded to fluid therapy and antibiotics. He was discharged after 3 weeks but 2 weeks later was readmitted with a recurrence of oedema and ascites. His condition gradually deteriorated with recurrent diarrhoea, but no vomiting, and euthanasia was carried out 2 weeks later.

Necropsy findings: The carcase was thin and wet. The kidneys were enlarged, pale and smooth. An intussusception of the terminal part of the small intestine was present.

Case No. 90812 (Cont'd)

Laboratory test results:		Initial	After 3 weeks	After 7 weeks
Haematology:	Hct	0.32	0.24	0.28
	WBC	14.3	13.1	17.6
Biochemistry:				
Plasma:	Urea	11.9	11.5	15.4
	Creatinine	115	115	106
	Phosphate	1.4	1.4	1.9
	Cholesterol	5.5	4.2	8.4
	Albumin	23	17	20
	Globulin	38	36	45
Urine:	Protein	1125	1100	1250
	Blood	-	-	-
	pH	6.0	6.0	6.0
	SG	1.030	1.026	1.031
Virology:	FeLV	-		
	URT viruses	ND		
	FIP	-		
Immunology:	LE preparation	ND		

Case No. 91631 DSH 4 years Neutered male

History and presenting signs: Unvaccinated. Previously healthy. Six weeks prior to referral the cat developed an abdominal swelling which improved with diuretic therapy. He continued to eat well but lost weight and became dull and inactive. Later, more extensive fluid swellings recurred and diarrhoea was noted on several occasions.

Initial clinical examination: Dull and thin. T.N. H.R. 200 per min. R.R. 36 per min. The ocular and oral mucosae were pale pink. There was severe pitting oedema in all 4 limbs, in the ventral body wall, and ascites. The kidneys were enlarged and firm. The fur coat was in poor condition.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome; moderate renal failure.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: "Lasix" therapy was given but the fluid swellings regressed very slowly. The cat ate well but had diarrhoea on most days. He was still slightly oedematous when discharged after 11 days and a guarded prognosis was given on account of the persistent oedema and renal failure.

Subsequent examination: Four weeks later the cat was re-admitted with a recurrence of more severe oedema and ascites of 5 days duration, accompanied by dullness and anorexia. There was marked uraemic halitosis and euthanasia was carried out.

Necropsy findings: The carcase was in poor condition, and the abdomen swollen with ascites. The kidneys were enlarged and pale; the cut surface had a granular appearnace. Extra-renal signs of uraemia were not found.

Case No. 91631 (Cont'd)

Laboratory test results:		Initial	After 1 week	After 6 weeks
Haematology:	Hct	0.28	0.23	0.14
	WBC	14.2	28.5	6.7
Biochemistry:				
Plasma:	Urea	33.1	33.0	94.0
	Creatinine	185	238	654
	Phosphate	2.7	2.6	7.1
	Cholesterol	6.1	5.9	4.7
	Albumin	17	21	13
	Globulin	35	38	33
Urine:	Protein	1325	345	500
	Blood	-	Trace	+
	pH	6.0	6.0	6.0
	SG	1.039	1.014	1.016
Virology	FeLV	-		
	URT viruses	-		
	FIP	-		
Immunology:	LE preparation	ND		

Case No. 91890 DSH 2 years Spayed female

History and presenting signs: FIE vaccination. Previously healthy but always rather thin. Four weeks prior to admission the cat developed a swollen abdomen, which was partially reduced with diuretic therapy but then recurred. The cat remained bright and ate well but was thirsty and found jumping to heights difficult..

Initial clinical examination: Thin, bright. T.N. H.R. 180 per min. R.R. 40 per min., hyperpnoeic. Ocular and oral mucosae were smooth, moist and pink. There was mild oedema of the lower hind limbs,ventral abdominal wall and marked ascites. The kidneys were enlarged and firm.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (mild).

Management: "Lasix" was given daily for 2 weeks. The limb oedema was reduced quickly but ascites persisted, although the cat remained bright and ate well. Latterly the dose of "Lasix" was doubled and there was some reduction of the ascites. The cat was discharged and maintained on "Lasix". Ten days later she was re-admitted because of severe relapse of ascites and thereafter she remained in the hospital. Diuretic therapy continued to be only parially effective and on 4 occasions up to one litre of slightly cloudy, watery fluid was drained by paracentesis. At the beginning of the fifth month in the hospital, the ascites suddenly spontaneously regressed and 2 weeks later the cat became increasingly dull, inappetent, vomited frequently and became dehydrated. Latterly there was marked uraemic halitosis and euthanasia was carried out.

Necropsy results: The carcase was emaciated and dry. The kidneys were enlarged but not notably fibrosed. There was a small area of intercostal myositis but no other evidence of extra-renal ureamia. There was moderate calcification of the aorta.

Case No. 91890 (Cont'd)

Laboratory test results:		Initial	After 2 months	After 5½ months	After 6 months
Haematology:	Hct	0.32	0.34	0.28	0.29
	WBC	15.3	21.8	51.1	67.0
Biochemistry:					
Plasma:	Urea	8.8	19.6	50.5	105.0
	Creatinine	106	106	335	574
	Phosphate	1.7	1.7	9.5	14.0
	Cholesterol	5.7	ND	7.7	7.2
	Albumin	13	18	23	21
	Globulin	42	29	44	55
Urine:	Protein	1000	1325	425	462
	Blood	+	-	-	Tr
	pH	6.5	6.5	6.5	6.0
	SG	1.050	1.035	1.015	1.015
Virology:	FeLV	-			
	URT viruses	-			
	FIP	-			
Immunology:	LE preparation	ND			

Case No. 92587 DSH 3 years Neutered male

History and presenting signs: Vaccinated against feline infectious enteritis and feline respiratory viruses. He had a road accident when a kitten and suffered a hind end injury from which he made an uneventful recovery. He had always been a lean cat but in the 2 weeks prior to referral he developed a swollen abdomen, became moderately dull but ate and drank normally.

Initial clinical examination: Alert. T.N. H.R. 210 per min. R.R. 30 per min. Ocular and oral mucosae were slightly pale. Moderate pitting oedema was present in the lower hind limbs, especially the left, and mild ascites. Kidneys were normal in size smooth and firm.

Provisional diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Protein losing nephropathy; nephrotic syndrome.

Biopsy diagnosis: Membranous nephropathy (moderately severe).

Management: The cat was placed on "Lasix" for 5 days. The oedema regressed quickly and the cat was discharged. Two weeks later, hind limb oedema recurred and "Lasix" was given for a further 5 days.

Subsequent examination: Mild hind limb oedema occurred at approximately monthly intervals during the subsequent 3 months but "Lasix" therapy was instituted immediately and oedema regressed in about 48 hours on each occasion. The cat gradually began to drink more water and tended to eat smaller meals. After 4 months he was considerably thinner and the owners requested euthanasia.

Necropsy examination: The carcase was thin. The kidneys were pale and firm to cut. A number of haemorrhagic foci and polyps were present in the urinary bladder and the mucosa was thickened. Sections of bladder revealed chronic cystitis. A non-suppurative cholangitis, with collections of mononuclear cells in the portal areas and around the bile ducts, was also found.

Case No. 92587 (Cont'd)

Laboratory test results:		Initial	After 3 weeks	After 4 months
Haematology:	Hct	0.29	0.28	ND
	WBC	28.8	12.7	ND
Biochemistry:				
Plasma:	Urea	11.1	10.1	18.4
	Creatinine	141	150	257
	Phosphate	2.6	1.5	3.8
	Cholesterol	2.7	6.6	6.4
	Albumin	11	21	16
	Globulin	38	49	56
Urine:	Protein	1000	700	970
	Blood	+	-	Moderate
	pH	6.0	6.0	6.5
	SG	1.036	1.024	1.015
Virology:	FeLV	-		
	URT viruses	-		
	FIP	ND		
Immunology:	LE preparation	ND		

APPENDIX D

RENAL BIOPSY IN THE NORMAL CAT: SUMMARIES OF LABORATORY FINDINGS IN 19 CATS.

Cat No. 1 (Case No. 84812)

DSH 3 years Male

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Slight
Length of sample	15 mm.
Recovery time	Euthanasia before full recovery

Laboratory Data	Pre-biopsy	Post-biopsy 5 min.	Post-biopsy 2 hr.
Bodyweight (kg.)	1.7	ND	ND
Blood clotting time (min.)	6	ND	ND
Haematocrit (l/l)	0.38	ND	ND*
Total WBC (x 10^9/l)	8.6	ND	ND*
Plasma urea (mmol/l)	9.0	ND	12.3
creatinine (µmol/l)	150	ND	177
Urine protein (mg%)	3	0	15
blood	-	-	-
specific gravity	1.035	1.034	1.034

* Sample clotted

Cat No. 2 (Case No. 84504)

DSH 2 years Spayed female

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Moderate
Length of sample	10 mm.
Recovery time	Euthanasia before full recovery

Laboratory Data	Pre-biopsy	Post-biopsy 5 min.	2 hr.
Bodyweight (kg.)	1.8	ND	ND
Blood clotting time (min)	5	ND	ND
Haematocrit (l/l)	0.39	ND	0.36
Total WBC (x 10^9/l)	8.7	ND	9.1
Plasma urea (mmol/l)	8.6	ND	12.2
creatinine (umol/l)	177	ND	168
Urine protein (mg%)	0	21	34
blood	-	++	+++
specific gravity	1.036	1.031	1.020

Cat No. 3 (Case No. 85426)

DSH 3 years Female

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Severe
Length of sample	15 mm.
Recovery time	Euthanasia before full recovery

Laboratory Data	Pre-biopsy	Post-biopsy 5 min.	Post-biopsy 2 hr.
Bodyweight (kg.)	4.1	ND	ND
Blood clotting time (min)	9	ND	ND
Haematocrit (l/l)	0.50	ND	0.44
Total WBC (x 10^9/l)	18.4	ND	25.0
Plasma urea (mmol/l)	9.6	ND	12.1
creatinine (µmol/l)	159	ND	186
Urine protein (mg%)	0	5	200
blood	-	++	+++
specific gravity	1.040	1.040	1.025

Cat No. 4 (Case No. 85597)

DSH 1 year Male

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Moderate
Length of sample	15 mm.
Recovery time	Normal

Laboratory Data	Pre-biopsy	Post - Biopsy 5 min	2 hr.	24 hr.	48 hr.
Bodyweight (kg.)	2.7	ND	ND	ND	2.6
Blood clotting time (min)	4	ND	ND	ND	ND
Haematocrit (l/l)	0.36	ND	0.39	0.42	0.32
Total WBC (x 10^9/l)	6.3	ND	11.9	7.9	6.6
Plasma urea (mmol/l)	6.2	ND	5.1	9.0	8.0
creatinine (μmol/l)	106	ND	124	115	106
Urine protein (mg%)	0	0	0	0	0
blood	-	-	+	-	-
specific gravity	1.010	1.010	1.010	1.035	1 .030

Cat No. 5 (Case No. 85598)

DSH 1 year Male

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Slight
Length of sample	10 mm.
Recovery time	Normal

Laboratory Data	Pre-biopsy	Post - biopsy 5 min	2 hr.	24 hr.	48 hr.
Bodyweight (kg.)	2.6	ND	ND	ND	2.7
Blood clotting time (min)	4	ND	ND	ND	ND
Haematocrit (l/l)	0.35	ND	0.40	0.40	0.36
Total WBC (x 10^9/l)	8.3	ND	15.6	20.2	16.9
Plasma urea (mmol/l)	6.7	ND	6.5	9.6	9.8
creatinine (μmol/l)	115	ND	88	106	71
Urine protein (mg%)	0	0	215	20	12
blood	-	++	+++	++	++
specific gravity	1.018	1.021	1.015	1.025	1.028

Cat No. 6 (Case No. 85935)

DSH 5 years Female

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Moderate
Length of sample	15 mm.
Recovery time	Prolonged

Laboratory Data	Pre-biopsy	Post - biopsy 5 min	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	3.3	ND	ND	3.3	3.3
Blood clotting time (min)	5	ND	ND	ND	ND
Haematocrit (1/1)	0.39	ND	0.42	0.39	0.39
Total WBC (x 10^9/1)	24.4	ND	28.7	45.3	34.6
Plasma urea (mmol/1)	9.2	ND	10.5	8.5	9.0
creatinine (μmol/1)	106	ND	ND	124	ND
Urine protein (mg%)	2	85	27	5	0
blood	-	+++	+++	+	+
specific gravity	1.025	1.025	1.023	1.027	1.010

	Post - biopsy 3 days	6 days	7 days
Bodyweight (kg.)	3.3	3.3	3.3
Haematocrit (1/1)	0.30	0.37	0.33
Total WBC (x 10^9/1	44.8	37.8	18.6
Plasma urea (mmol/1)	9.4	13.0	9.5
creatinine (μmol/1)	141	97	141
Urine protein (mg%)	0	0	5
blood	-	+	-
specific gravity	1.016	1.023	1.032

Cat No. 7 (Case NO. 85936)

DLH 1 year Male

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Slight
Length of sample	10 mm.
Recovery time	Prolonged

Laboratory Data	Pre-biopsy	Post-biopsy 5 min	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	2.7	ND	ND	2.7	2.6
Blood clotting time (min)	4	ND	ND	ND	ND
Haematocrit (l/l)	0.37	ND	0.39	0.38	0.35
Total WBC (x 10^9/l)	50.0	ND	61.0	37.1	42.1
Plasma urea (mmol/l)	10.3	ND	12.7	11.5	10.7
creatinine (µmol/l)	80	ND	ND	ND	ND
Urine protein (mg%)	0	0	0	20	13
blood	-	++	+++	++	++
specific gravity	1.020	1.015	1.020	1.030	1.030

	Post - biopsy 3 days	6 days	7 days
Bodyweight (kg)	2.7	2.7	2.6
Haematocrit (l/l)	0.31	0.36	0.29
Total WBC (x 10^9/l)	52.1	51.8	50.1
Plasma urea (mmol/l)	10.3	9.7	12.4
creatinine (µmol/l)	106	150	115
Urine protein (mg%)	25	0	0
blood	++	+	+
specific gravity	1.025	1.023	1.025

Cat No. 8 (Case No. 87053)

DSH 1 year Male

Biopsy Data

Kidney Pole	Caudal
Number of cuts	One
Haemorrhage	Moderate
Length of sample	6 mm.
Recovery time	Normal

Laboratory Data	Pre-biopsy	Post - biopsy 5 min.	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	2.2	ND	ND	2.1	2.2
Blood clotting time (min)	5	ND	ND	ND	ND
Haematocrit (l/l)	0.35	ND	0.35	0.33	0.33
Total WBC (x 10^9/l)	8.7	ND	7.2	5.3	12.2
Plasma urea (mmol/l)	5.0	ND	6.0	5.4	5.2
creatinine (μmol/l)	115	ND	141	159	115
Urine protein (mg%)	0	0	0	2	0
blood	-	-	-	-	-
Specific gravity	1.020	1.020	1.009	1.040	1.015

	Post - biopsy 3 days	6 days	7 days	14 days
Bodyweight (kg)	2.2	2.3	2.2	2.4
Haematocrit (l/l)	0.31	0.36	0.40	0.35
Total WBC (x 10^9/l)	10.2	11.6	9.1	7.7
Plasma urea (mmol/l)	6.3	5.8	5.1	5.6
creatinine (μmol/l)	106	141	106	106
Urine protein (mg%)	0	0	0	0
blood	-	-	-	-
specific gravity	1.016	1.025	1.014	1.010

Cat No. 9 (Case No. 87054)

DSH 1 year Male

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	None
Length of sample	12 mm.
Recovery time	Normal

Laboratory Data	Pre-Biopsy	Post-biopsy 5 min	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	2.9	ND	ND	2.9	3.0
Blood clotting time (min)	5	ND	ND	ND	ND
Haematocrit (l/l)	0.32	ND	0.40	0.42	0.41
Total WBC (x 10^9/l)	12.8	ND	15.1	11.7	11.4
Plasma urea (mmol/l)	5.6	ND	6.4	10.5	7.8
creatinine (μmol/l)	115	ND	97	74	97
Urine protein (mg%)	8	50	5	0	10
blood	-	+++	+++	-	-
specific gravity	1.015	1.020	1.015	1.015	1.034

	Post - biopsy 3 days	6 days	7 days	14 days
Bodyweight (kg)	3.0	3.0	3.0	3.0
Haematocrit (l/l)	0.39	0.39	0.44	0.27
Total WBC (x 10^9/l)	12.4	11.0	21.8	19.6
Plasma urea (mmol/l)	8.1	7.0	12.0	5.4
creatinine (μmol/l)	133	239	106	115
Urine protein (mg%)	0	0	25	8
blood	+++	+++	-	+++
specific gravity	1.015	1.036	1.050	1.026

Cat No. 10 (Case No. 85371)

DSH 1 year Female

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Slight
Length of sample	20 mm.
Recovery time	Normal

Laboratory Data	Pre-biopsy	Post-biopsy 5 min.	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	2.4	ND	ND	2.3	2.4
Blood clotting time (min)	6	ND	ND	ND	ND
Haematocrit (l/l)	0.40	ND	0.36	0.31	0.35
Total WBC ($x10^9$/l)	71.4	ND	ND	20.2	13.0
Plasma urea (mmol/l)	11.8	ND	14.6	9.0	10.4
creatinine (μmol/l)	124	ND	ND	97	ND
Urine protein (mg%)	0	188	460	18	170
blood	-	+++	++	++	++
specific gravity	1.025	1.025	1.020	1.020	1.040

	4 days	Post-biopsy 1 week	2 weeks	3 weeks
Bodyweight (kg)	2.3	2.4	2.4	2.4
Haematocrit (l/l)	0.37	0.38	0.38	0.38
Total WBC ($x\ 10^9$/l)	16.9	17.6	28.0	19.7
Plasma urea (mmol/l)	10.4	11.7	12.7	10.3
creatinine (μmol/l)	132	115	80	106
Urine protein (mg%)	20	0	5	0
blood	+++	+	+	-
specific gravity	ND	1.035	1.035	1.030

Cat No.10 (cont'd)

Laboratory Data	4 weeks	Post-biopsy 5 weeks	6 weeks	7 weeks	8 weeks
Bodyweight (kg)	2.5	2.5	2.6	2.7	3.0
Haematocrit (1/1)	0.36	0.36	0.36	0.40	0.34
Total WBC (x 10^9/1)	22.0	19.8	15.0	21.1	20.3
Plasma urea (mmol/1)	10.8	11.3	11.9	11.2	10.8
creatinine (μmol/1)	97	97	ND	ND	133
Urine protein (mg%)	0	4	62	2	0
blood	++	-	-	+	-
specific gravity	1.032	1.036	1.037	1.036	1.024

Cat No. 11 (Case No. 85372)

DLH 2 years Female

Biopsy Data

Kidney pole	Caudal
Number of cuts	One
Haemorrhage	Moderate
Length of sample	15 mm.
Recovery time	Normal

Laboratory Data	Pre-biopsy	Post-biopsy 5 min.	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	3.8	ND	ND	3.7	3.8
Blood clotting time (min)	6	ND	ND	ND	ND
Haematocrit (1/1)	0.33	ND	0.32	0.28	0.31
Total WBC (x 10^9/1)	8.8	ND	ND	14.8	15.7
Plasma urea (mmol/1)	7.5	ND	7.4	8.2	7.5
creatinine (µmol/1)	133	ND	ND	124	115
Urine protein (mg%)	0	0	85	200	0
blood	-	-	++	+++	++
specific gravity	1.015	1.010	1.020	1.010	1.015

	Post - biopsy 4 days	1 week	2 weeks	3 weeks
Bodyweight (kg)	3.7	3.7	3.8	3.8
Haematocrit (1/1)	0.31	0.33	0.38	0.39
Total WBC (x 10^9/1)	13.7	14.0	20.4	11.9
Plasma urea (mmol/1)	7.5	10.4	10.5	9.6
creatinine (µmol/1)	106	150	115	133
Urine protein (mg%)	2.5	50	37	1.5
blood	+++	+++	++	-
specific gravity	1.015	1.010	1.020	1.042

Cat No. 11 (Cont'd)

Laboratory Data	Post - biopsy 4 weeks	5 weeks	6 weeks	7 weeks	8 weeks
Bodyweight (kg)	3.8	3.9	4.0	4.1	4.3
Haematocrit (l/l)	0.34	0.36	0.37	0.39	0.33
Total WBC (x 10^9/l)	14.7	12.8	17.3	8.8	12.5
Plasma urea (mmol/l)	10.0	11.0	9.5	10.2	10.8
creatinine (µmol/l)	141	124	133	ND	150
Urine protein (mg%)	3	0	0	0	0
blood	+	+	+	+	+++
specific gravity	1.030	1.019	1.020	1.015	1.014

Cat No. 12 (Case No. 85373) Control Cat

DSH 1 year Male

Control Data

Kidney pole	-
Number of cuts	-
Haemorrhage	Slight (skin incision only)
Recovery time	Normal

Laboratory Data	Pre-biopsy	Post-biopsy 5 min	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	2.3	ND	ND	2.1	2.1
Blood clotting time (min)	5	ND	ND	ND	ND
Haematocrit (l/l)	0.37	ND	0.38	0.37	0.38
Total WBC (x 10^9/l)	11.3	ND	10.1	7.3	11.6
Plasma urea (mmol/l)	7.3	ND	8.0	5.8	5.8
creatinine (µmol/l)	133	ND	ND	124	141
Urine protein (mg%)	2.5	0	0	0	0
blood	-	-	+++	-	-
specific gravity	1.035	1.030	ND	1.034	1.015

	Post - biopsy 4 days	6 days	7 days
Bodyweight (kg)	2.1	2.0	2.1
Haematocrit (l/l)	0.36	0.31	0.35
Total WBC (x 10^9/l)	10.2	11.0	10.9
Plasma urea (mmol/l)	6.5	6.2	5.6
creatinine (µmol/l)	150	133	132
Urine protein (mg%)	25	0	0
blood	++	-	-
specific gravity	1.040*	1.038*	1.015

* catheterised samples

Cat No. 13 (Case No. 85374) Control Cat

DSH 1 year Male

Control Data

Kidney pole	-
Number of cuts	-
Haemorrhage	Slight (skin wound only)
Length of sample	-
Recovery time	Normal

Laboratory Data	Pre-biopsy	Post-biopsy 5 min	2 hr.	24 hr.	48 hr.
Bodyweight (kg)	2.7	ND	ND	2.6	2.6
Blood clotting time (min)	5	ND	ND	ND	ND
Haematocrit (l/l)	0.36	ND	0.39	0.38	0.39
Total WBC (x 10^9/l)	15.1	ND	8.7	8.5	10.4
Plasma urea (mmol/l)	7.1	ND	7.1	5.1	6.5
creatinine (μmol/l)	115	ND	124	ND	115
Urine protein (mg%)	5	157	520	0	5
blood	-	+++	+++	-	+
specific gravity	1.023	ND	ND	1.020	1.030

	Post-biopsy 3 days	6 days	7 days
Bodyweight (kg)	2.8	2.6	2.8
Haematocrit (l/l)	0.38	0.38	0.37
Total WBC (x 10^9/l	12.7	11.8	13.8
Plasma urea (mmol/l)	5.5	7.4	6.5
creatinine (μmol/l)	150	150	168
Urine protein (mg%)	10	0	0
blood	++	+	-
specific gravity	1.025*	1.035*	1.020

* catheterised sample

Cat No. 14 (Case No. 90046)

DSH 1 year Female

Biopsy Data	Biopsy number 1	2	3
Kidney pole	caudal	cranial	caudal
Number of cuts	one	one	one
Haemorrhage	slight	slight	slight
Length of sample (mm)	5	10	5
Recovery time	normal	long	normal

Laboratory Data	Pre-biopsy	Post-biopsy 5 min	24 hr.	48 hr.	1 week
Bodyweight (kg)	3.0	ND	2.9	3.0	3.0
Blood clotting time (min)	5	ND	ND	ND	ND
Haematocrit (l/l)	0.41	ND	0.40	0.39	0.39
Total WBC (x 10^9/l)	11.2	ND	16.0	15.3	17.1
Plasma urea (mmol/l)	9.5	ND	7.9	8.5	9.9
creatinine (µmol/l)	106	ND	97	106	133
Urine protein (mg%)	25	-	2.0	0.5	3.0
blood	-	+++	-	-	-
specific gravity	1.045	1.036	1.049	1.028	1.028

	Post-biopsy First			Second		
	2 weeks	3 weeks	4 weeks	5 min	24 hr.	48 hr.
Bodyweight (kg)	2.9	2.9	3.1	ND	3.0	3.1
Haematocrit (l/l)	0.39	0.41	0.40	ND	0.40	0.40
Total WBC (x 10^9/l)	14.0	23.3	22.8	ND	25.5	29.3
Plasma urea (mmol/l)	12.0	11.0	6.9	ND	10.1	9.2
creatinine (µmol/l)	168	ND	115	ND	ND	124
Urine protein (mg%)	0	0	1.0	ND	0	0
blood	-	-	-	-	-	-
specific gravity	1.030	1.034	1.022	1.023	1.022	1.016

Cat No. 14 (Cont'd)

Laboratory Data	Post - biopsy Second 1 week	2 weeks	3 weeks	4 weeks	Third 5 min.
Bodyweight (kg)	3.0	3.1	3.0	2.9	ND
Haematocrit (l/l)	0.39	0.40	0.36	0.39	ND
Total WBC /x 10^9/l)	31.6	18.4	25.1	16.0	ND
Plasma urea (mmol/l)	10.0	11.2	10.3	10.8	ND
creatinine (µmol/l)	133	124	115	133	ND
Urine protein (mg%)	0	1.5	1.0	2.5	ND
blood	-	-	-	-	+
specific gravity	1.036	1.035	1.032	1.012	1.015

	Post - biopsy 24 hr.	48 hr.	Third 1 week	2 weeks	3 weeks	4 weeks
Bodyweight (kg)	2.7	2.7	2.8	2.9	2.8	3.0
Haematocrit (l/l)	0.40	0.41	0.40	0.43	0.35	0.35
Total WBC (x 10^9/l)	12.8	14.3	24.3	20.7	20.8	22.8
Plasma urea (mmol/l)	10.3	9.4	11.9	12.1	6.2	11..
creatinine (µmol/l)	150	141	133	150	106	106
Urine protein (mg%)	0	5	0	0	0	0
blood	-	-	-	-	-	-
specific gravity	1.029	1.025	1.030	1.021	1.015	1.016

Cat No. 15 (Case No. 90047)

DSH 1 year Female

Biopsy data	Biopsy number 1	2	3
Kidney pole	caudal	cranial	caudal
Number of cuts	one	one	one
Haemorrhage	none	slight	moderate
Length of sample (mm)	5	10	15
Recovery time	normal	normal	normal

Laboratory Data	Pre-biopsy	Post-biopsy 5 min	24 hr.	48 hr.	1 week
Bodyweight (kg)	2.8	ND	2.6	2.7	2.8
Blood clotting time (min)	6	ND	ND	ND	ND
Haematocrit (l/l)	0.44	ND	0.40	0.36	0.36
Total WBC (x 10^9/l)	21.3	ND	35.1	24.9	22.6
Plasma urea (mmol/l)	8.0	ND	8.0	6.4	7.2
creatinine (μmol/)	106	ND	115	97	150
Urine protein (mg%)	0	ND	3.0	0.5	2.5
blood	-	+	-	-	Trace
specific gravity	1.025	1.025	1.047	1.010	1.020

	Post-biopsy First 2 weeks	3 weeks	4 weeks	Second 5 min	24 hr.	48 hr.
Bodyweight (kg)	2.9	2.8	2.8	ND	2.6	2.7
Haematocrit (l/l)	0.39	0.43	0.42	ND	0.39	0.39
Total WBC (x 10^9/l)	18.8	24.7	21.3	ND	29.3	22.0
Plasma urea (mmol/l)	10.1	9.1	10.1	ND	8.5	8.5
creatinine (μmol/l)	71	ND	124	ND	115	124
Urine protein (mg%)	0	0	0	ND	0	0
blood	-	-	-	-	-	-
specific gravity	1.016	1.022	1.025	1.025	1.049	1.017

Cat No. 15 (Cont'd)

Laboratory Data	Post - biopsy Second 1 week	2 weeks	3 weeks	4 weeks	Third 5 min.
Bodyweight (kg)	2.6	2.6	2.4	2.4	ND
Haematocrit (l/l)	0.35	0.38	0.39	0.39	ND
Total WBC (x 10^9/l)	25.8	22.6	25.0	24.4	ND
Plasma urea (mmol/l)	9.7	9.0	8.7	9.5	ND
creatinine (µmol/l)	141	133	124	141	ND
Urine protein (mg%)	1.0	0	0	0	ND
blood	+	-	+++	-	Trace
specific gravity	1.021	1.018	1.010	1.024	1.025

	Post - biopsy 24 hr.	48 hr.	Third 1 week	2 weeks	3 weeks	4 weeks
Bodyweight (kg)	2.3	2.3	2.4	2.6	2.6	2.8
Haematocrit (l/l)	0.39	0.36	0.36	0.39	0.38	0.38
Total WBC (x 10^9/l)	32.9	16.8	26.0	17.2	19.7	28.1
Plasma urea (mmol/l)	8.5	6.1	8.6	11.3	6.3	8.3
creatinine (µmol/l)	168	150	141	141	115	106
Urine protein (mg%)	0	0	0	0	0	0
blood	-	-	-	-	Trace	-
specific gravity	1.047	1.031	1.013	1.013	1.020	1.010

Cat No. 16 (Case No. 90048)

DSH 1 year Female

Biopsy Data	Biopsy Number 1	2	3
Kidney pole	caudal	cranial	caudal
Number of cuts	one	one	one
Haemorrhage	none	slight	profuse*
Length of sample (mm)	5	15	5
Recovery time	normal	normal	normal

* Haemorrhage occurred on incision of the abdominal wall muscles and continued during the biopsy procedure.

Laboratory data	Pre-biopsy	Post-biopsy 5 min	24 hr.	48 hr.	1 week
Bodyweight (kg)	3.1	ND	2.9	2.9	2.8
Blood clotting time (min)	4	ND	ND	ND	ND
Haematocrit (l/l)	0.37	ND	0.43	0.38	0.35
Total WBC (x 10^9/l)	9.5	ND	14.4	14.2	20.7
Plasma urea (mmol/l)	6.0	ND	6.3	7.2	6.1
creatinine (µmol/l)	115	ND	133	141	159
Urine protein (mg%)	0	ND	64	55	65
blood	-	-	Trace	-	+
specific gravity	1.024	1.026	1.032	1.039	1.030

	Post-biopsy First 2 weeks	3 weeks	4 weeks	Second 5 min	24 hr.	48 hr.
Bodyweight (kg)	2.9	2.6	2.8	ND	2.6	2.8
Haematocrit (l/l)	0.34	0.31	0.31	ND	0.36	0.35
Total WBC (x 10^9/l)	17.1	25.6	5.8	ND	11.6	9.3
Plasma urea (mmol/l)	7.3	8.7	11.1	ND	9.4	9.6
creatinine (µmol/l)	80	150	106	ND	106	115
Urine protein (mg%)	10	192	9	ND	11	2
blood	-	+++	Trace	Trace	Trace	-
specific gravity	1.025	1.030	1.025	1.025	1.030	1.020

Cat No. 16 (Cont'd)

Laboratory Data	Post - biopsy 1 week	Second 2 weeks	3 weeks	4 weeks	Third 5 min.
Bodyweight (kg)	2.7	2.8	2.7	2.5	ND
Haematocrit (1/1)	0.37	0.38	0.40	0.33	ND
Total WBC (x 10^9/1)	8.8	9.0	10.5	15.1	ND
Plasma urea (mmol/1)	10.7	9.4	10.7	10.1	ND
creatinine (µmol/1)	141	133	141	133	ND
Urine protein (mg%)	1.0	5.5	20.0	30.0	ND
blood	-	Trace	Trace	Trace	+
specific gravity	1.029	1.029	1.035	1.024	1.024

	Post - biopsy 24 hr.	48 hr.	Third 1 week	2 weeks	3 weeks	4 weeks
Bodyweight (kg)	2.5	2.5	2.4	2.5	2.5	2.7
Haematocrit (1/1)	0.36	0.38	0.29	0.28	0.32	0.38
Total WBC (x 10^9/1)	12.1	15.7	21.3	16.1	14.0	11.6
Plasma urea (mmol/1)	8.4	8.2	6.9	10.1	8.1	13.0
creatinine (µmol/1)	159	168	124	124	115	133
Urine protein (mg%)	20.0	65.0	11.0	70.0	117.5	27.5
blood	-	-	+	++	Trace	Trace
specific gravity	1.030	1.024	1.016	1.020	1.025	1.020

Cat No. 17 (Case No. 93326)

DSH 2 years Female

Biopsy Data

Kidney Pole	B1: caudal	B2: cranial	B3: caudal
Number of cuts		Three	
Haemorrhage		Profuse*	
Length of sample (mm)	B1: 5	B2: 10	B3: 15
Recovery time		Normal	

* Haemorrhage occurred on incision of abdominal wall muscles and continued during the biopsy procedure.

	Pre-biopsy	Post-biopsy 5 min	24 hr.	48 hr.	1 week
Bodyweight (kg)	2.3	ND	2.2	2.3	2.1
Blood clotting time (min)	6	ND	ND	ND	ND
Haematocrit (1/1)	0.40	ND	0.41	0.37	0.40
Total WBC (x 10^9/1)	8.8	ND	7.2	11.2	5.1
Plasma urea (mmol/1)	8.6	ND	8.1	8.0	8.6
creatinine (μmol/1)	106	ND	106	106	106
Urine protein (mg%)	2	2	0	0	32
blood	Trace	+	-	-	-
specific gravity	1.030	1.020	1.040	1.016	1.030

	Post-biopsy 2 weeks +
Bodyweight (kg)	1.9
Haematocrit (1/1)	0.34
Total WBC (x 10^9/1)	19.4
Plasma urea (mmol/1)	13.2
creatinine (μmol/1)	115
Urine protein (mg%)	365
blood	+++
specific gravity	1.031

+ Euthanasia carried out

Cat No. 18 (Case No. 93327)

DSH 1 year Female

Biopsy Data

Kidney pole	B1: caudal	B2: cranial	B3: caudal
Number of cuts		Three	
Haemorrhage		Slight	
Length of sample (mm)	B1: 15	B2: 20	B3: 10
Recovery time		Normal	

Laboratory Data	Pre biopsy	Post-biopsy 5 min	24 hr.	48 hr.	1 week
Bodyweight (kg)	2.5	ND	2.5	2.6	2.4
Blood clotting time (min)	6	ND	ND	ND	ND
Haematocrit (l/l)	0.35	ND	0.30	0.28	0.48
Total WBC (x 10^9/l)	20.0	ND	29.7	22.2	15.5
Plasma urea (mmol/l)	12.5	ND	12.0	9.8	13.1
creatinine (µmol/l)	124	ND	124	115	150
Urine protein (mg%)	0	0	2.0	0	35.0
blood	-	++	Trace	-	-
specific gravity	1.018	1.010	1.040	1.020	1.040

	Post-biopsy 2 weeks	3 weeks	4 weeks
Bodyweight (kg)	2.7	2.6	2.8
Haematocrit (l/l)	0.41	0.44	0.40
Total WBC (x 10^9/l)	21.5	23.5	16.4
Plasma urea (mmol/l)	11.2	10.7	11.7
creatinine (µmol/l)	141	132	97
Urine protein (mg%)	0	2.0	0
blood	+	Trace	-
specific gravity	1.028	1.030	1.041

Cat No. 19 (Case No. 93328)

DSH 2 years Female

Biopsy Data

Kidney pole	B1: caudal	B2: cranial	B3: caudal
Number of cuts	Three		
Haemorrhage	Slight		
Length of sample (mm)	B1: 10	B2: 15	B3: 20
Recovery time	Normal		

Laboratory Data	Pre-biopsy	Post-biopsy 5 min	24 hr.	48 hr.	1 week
Bodyweight (kg)	3.4	ND	3.2	3.4	3.3
Blood clotting time (min)	6	ND	ND	ND	ND
Haematocrit (l/l)	0.33	ND	0.32	0.32	0.35
Total WBC (x 10^9/l)	12.1	ND	16.8	18.2	13.3
Plasma urea (mmol/l)	9.6	ND	7.4	7.3	9.5
creatinine (µmol/l)	106	ND	106	124	141
Urine protein (mg%)	0	0	2	0	28
blood	-	-	+	-	Trace
specific gravity	1.018	1.020	1.025	1.020	1.035

	Post-biopsy 2 weeks	3 weeks	4 weeks
Bodyweight (kg)	3.3	3.2	3.3
Haematocrit (l/l)	0.37	0.35	0.29
Total WBC (x 10^9/l)	14.3	16.6	11.7
Plasma urea (mmol/l)	7.9	5.8	5.8
creatinine (µmol/l)	124	71	106
Urine protein (mg%)	0	2	0
blood	Trace	-	+
specific gravity	1.026	1.049	1.010