Spinal Anaesthesia,

with

Special Reference to Neurological Complications.

A Thesis submitted for the Degree of Doctor of Medicine, University of Glasgow,

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CONTENTS

Section I.

INTRODUCTION AND HISTORICAL SURVEY.

Spinal anaesthesia is a most valuable form of anaesthetic practice, and in the opinion of the author its patent advantages and potentialities are often overlooked because of misunderstanding and misrepresentation of the facts. Two factors, present in the mind of patient and surgeon alike, have been responsible for conferring on this method of anaesthesia a relative unpopularity. These factors are - (1) that there is a danger of residual paralysis or other neurological complication, and (2) that the operative conditions will subject the patient to mental stress and pain.

The object of this thesis is to demonstrate that serious or permanent neurological complications do not occur with proper technique, and that spinal anaesthesia has a valuable and well-defined place in the anaesthetic repertoire. Moreover, in some cases spinal anaesthesia has advantages over general anaesthesia and over other regional techniques. It may be combined with a light general or intravenous supplementary anaesthetic to the complete satisfaction of both patient and surgeon. In addition, spinal block has a useful part to play in the diagnosis and treatment of peripheral vascular insufficiency and other diseases.

It must be understood that it is not advocated that spinal anaesthesia should be used extensively in place of the many other satisfactory anaesthetic methods in current

practice, but only that the employment of a spinal anaesthetic in a suitable case need not be prevented by ill-founded fears.

By spinal anaesthesia is meant the injection of a local anaesthetic drug, such as procaine or amethocaine, into the subarachnoid space in the lumbar region. The expression 'spinal anaesthesia' is neither an exact definition nor a desirable term. In the first place, the result of the injection may be either anaesthesia or analgesia, depending on the intensity of the block. Analgesia is the loss of sensation of pain alone, the other sensations - touch, temperature, pressure, muscle-joint sense - remaining more or less unimpaired, while anaesthesia implies loss of all sensation. In the second place, the word 'spinal' has unfortunately acquired in the lay mind an undue significance, and the author would support the suggestion made by Case (1928) that the expression 'lumbar anaesthesia' be used when it is necessary to refer to this method in the patient's presence. In scientific writing the term subarachnoid nerve block might be better.

The clinical material to be presented was obtained during the period from January 1939 to December 1950, when 1,335 spinal anaesthetics were administered by the author, first as whole-time anaesthetist at Stobhill Hospital (1939 to 1943), then as visiting anaesthetist to The Victoria Infirmary and The Glasgow Royal Maternity and Womens' Hospital (1944 to 1947), and ultimately as whole-time

consultant anaesthetist at The Victoria Infirmary, Glasgow (1948 to 1950). In all these 1,335 cases, no neurological complications were detected during their stay in hospital, apart from transient headache and one case of diplopia lasting a few hours. One further case complained, after her return home, of radiating pains, in the right leg, which persisted for one month and then completely disappeared. These cases will be described later. Further, a careful re-examination of 76 of these patients some months after their discharge from hospital confirmed the belief that neurological complications - meningitis, paresis or weakness of lower limbs, paraesthesiae, areas of sensory loss, incontinence of urine or of faeces, etc. - did not occur in this series. This is in contrast to the published reports of some other workers who report incidences of such complications as high as 13%, and these reports will be critically studied, together with the pathology of the lesions. Catastrophies following spinal anaesthesia have undoubtedly occurred, but only, it is submitted, as the result of faulty technique, or lack of appreciation of the relevant anatomy, physiology and pharmacology. In a similar way, disasters can follow the misapplication of any medical or surgical procedure.

The history of spinal anaesthesia is particularly instructive. It shows that spinal anaesthesia has not been static, but has progressed and improved in all its aspects since its inception in 1885. A short study of its earlier

chequered career does much to explain the survival of some antipathy towards it. It was in 1885 that Leonard Corning of New York produced spinal anaesthesia for the first time by accidentally piercing the dura when experimenting with cocaine on the spinal nerves of a dog. He later gave spinal injections of cocaine in the human subject to pass urethral sounds. In 1898 August Bier, the German surgeon, had 20 mg. of cocaine injected into his own subarachnoid space. Satisfactory anaesthesia of the legs resulted, the only after effect being a headache. Later the same year, Bier administered a spinal anaesthetic to his assistant Schmeiden, again producing anaesthesia of the legs. In the following year, 1899, Tuffier and Sicard extended the scope of spinal anaesthesia to include the performance of operations in the lower abdomen.

The promise of these early experiments so encouraged others, whose knowledge and experience in this field were but slight, that unjustifiable and indiscriminate use was made of this method. Thus in 1902 Morton of San Francisco reported 253 operations under spinal anaesthesia, of which eight were above the diaphragm and one was the excision of the maxilla. The same year Le Filliâtre of France practised total spinal anaesthesia based on a technique which included the withdrawal of very large quantities of cerebrospinal fluid. Jonnesco (1909) attempted to relate the level of anaesthesia to the height of the dural puncture. He recognised four puncture levels - viz., middle cervical,

upper dorsal, middle dorsal and dorsolumbar, thus jeopardising the integrity of the cord and interfering with respiratory function.

As a result of the high toxicity of cocaine and the reckless techniques of some operators, spinal anaesthesia soon acquired a reputation for high morbidity and mortality. In spite of the work done by a few isolated workers of such merit as Dixon (1905) and Barker (1907), spinal anaesthesia now languished until 1921 when it received a stimulus by the work of Gaston Labat, who employed spinal anaesthesia extensively. Dixon made an important contribution to the pharmacology of local anaesthetic drugs by pointing out that cocaine has a greater affinity for sensory nerves than for motor nerves. It is on this fact, now known as Dixon's Law, that much of the later techniques of high spinal analgesia is securely based. Barker realised the significance of the injected solution being heavier than cerebrospinal fluid, and the important part played by gravity, in association with the normal curves of the spine, in the dispersion of the drug.

In 1904 a drug called 'Stovaine' was introduced which, while it was less toxic than cocaine, nevertheless has had an adverse effect on the reputation of spinal anaesthesia because it was capable of damaging the nerve roots and the spinal cord. The use of this agent persisted in some clinics until as recently as 1940, and was responsible for a definite incidence of neurological complications, as will be shown later. It is interesting to note that Stovaine was

synthesised by the Frenchman Fourneau (Fourneau = a stove). With the introduction of procaine by Einhorn in 1905, a suitably non-toxic agent was now available.

A second and greater wave of popularity occurred in America about 1927. This was largely the result of the enthusiasm and persuasive influence of George Pitkin. Pitkin made a very real contribution to the advancement of this form of anaesthesia by the introduction of a fine bore needle with a short bevel. In America at any rate, the method was taken up too widely by those of insufficient experience and knowledge, and for a short while was immensely popular. The inevitable result was that once again spinal anaesthesia acquired a reputation which has done much to delay the appreciation of its true worth in careful hands.

In recent years the increasing tendency to leave anaesthetics in the hands of specialist anaesthetists, the more critical selection of patients, and the introduction of solutions of low concentration and isotonicity, have produced results which justify the claim that spinal anaesthesia be re-assessed as a safe and valuable method.

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Section II.

ANATOMY AND PHYSIOLOGY.

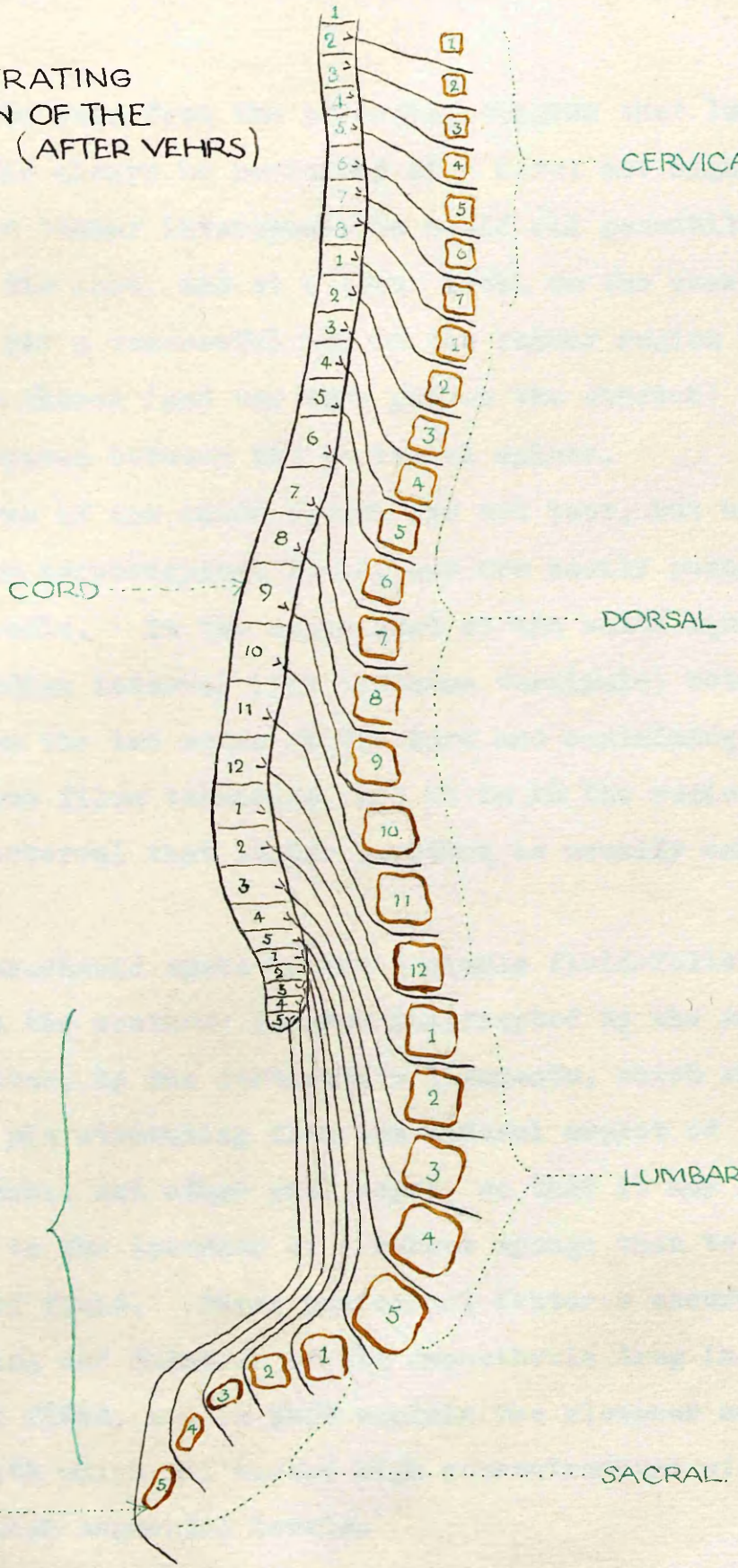
The subarachnoid space filled, as first described by Cotugno in 1764, with a "collection of water about the brain and spine", is the Grand Canal of the central nervous system, across which the radicles of all nerves pass on their way to the periphery. Within the confines of this closed space, impulses to or from any part of the body may be interrupted, and here, easily accessible and in a simple and orderly arrangement, lie the anterior and posterior roots of all spinal nerves, containing motor, sympathetic, and sensory fibres. In this part of their course the nerve roots are devoid of epineural sheath and are therefore readily affected by minimal amounts of local anaesthetic drugs, the cerebrospinal fluid which bathes them providing an ideal medium for bringing the anaesthetic agent into contact with the nerve elements.

The subarachnoid space lies between the pia mater - which closely envelops the brain, spinal cord and spinal nerve roots - and the arachnoid, which is closely applied to the dura mater. The cranial portion of the subarachnoid space extends over the whole brain surface, and communicates with the ventricular system of cerebrospinal fluid through the Foramina of Luschka, situated one on each side of the lateral recesses of the fourth ventricle. It is doubtful whether the mid-line foramen in the roof of the fourth

ventricle, as described by Magendie, exists in man (Merritt and Fremont-Smith, 1938). The spinal portion is in direct continuation with the cranial portion and extends downwards within the bony vertebral canal from the Foramen Magnum to the level of the second sacral vertebra.

The anaesthetist is particularly concerned with the spinal portion, which forms an elongated sac enclosing the spinal cord and nerve roots and conforming to the natural curves of the vertebral column. In the early embryo the nerve roots pass straight outwards to their respective intervertebral foramina which are directly opposite to them. Later in foetal life and in early childhood, the vertebral column increases in length at a greater rate than the spinal cord, so that the latter gradually assumes a higher position within the vertebral canal. By this process the nerve roots require to pass more and more obliquely downwards to reach their foramina of exit. This obliquity is most marked in the case of the sacral and lumbar roots, and least so in the case of the upper thoracic roots. By the time growth has ceased, the spinal cord ends opposite the lower border of the first lumbar vertebra or the body of the second lumbar vertebra. This is represented graphically in the following diagram, which illustrates the lumbar and sacral roots proceeding vertically downwards and forming the Cauda Equina. Exceptionally, the termination of the cord (the conus medullaris) remains as low as the lower third of third lumbar vertebra, even in the adult.(Needles 1935).

DIAGRAM ILLUSTRATING THE FORMATION OF THE CAUDA EQUINA (AFTER VEHRS)

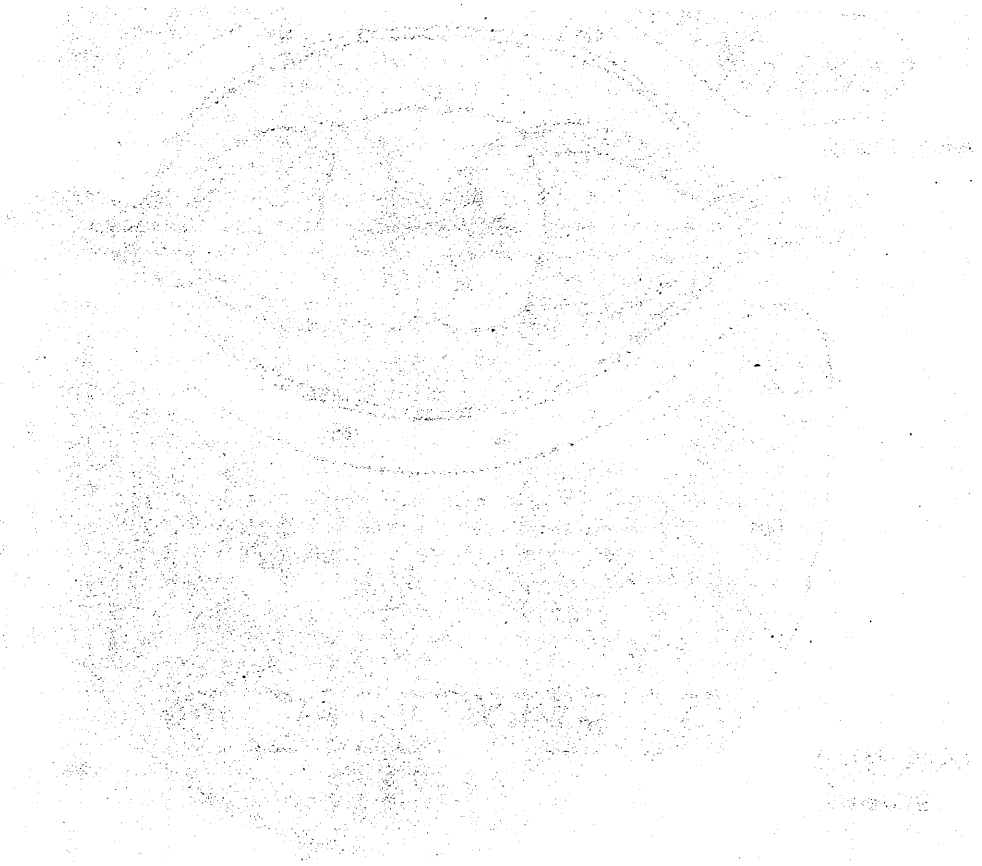


It will be seen from the preceding diagram that lumbar puncture should always be performed at a level not higher than the third lumbar interspace, to avoid all possibility of damage to the cord, and at a lower level in the case of children. For a successful tap in the lumbar region the spine must be flexed (and the dura put on the stretch) to open up the spaces between the vertebral spines.

The nerves of the cauda equina are not taut, but hang loosely in the cerebrospinal fluid, and are easily pushed aside by a needle. In the upper part of the cauda equina there is a median interval (the cisterna terminale) between the roots from the two sides of the cord and containing only the non-nervous filum terminale, and it is in the region of this median interval that lumbar puncture is usually carried out.

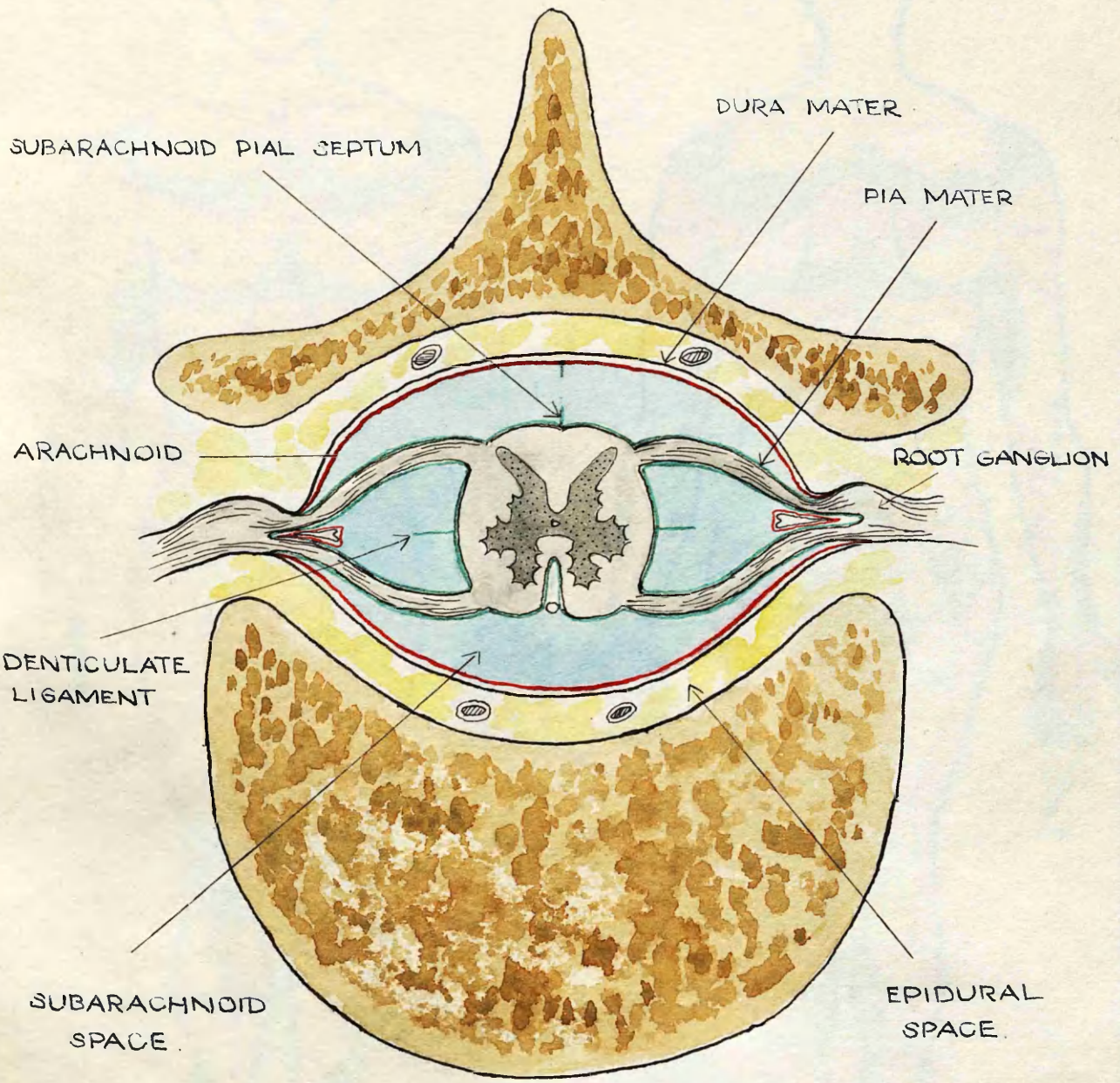
The subarachnoid space is not a simple fluid-filled space, but on the contrary is much interrupted by the nerve roots themselves, by the denticulate ligaments, which are processes of pia stretching from the lateral aspect of the cord to the dura, and other pial septa, so that it may be likened more to the interior of a rubber sponge than to a simple tube of fluid. These anatomical features ensure a thorough mixing and dilution of the anaesthetic drug in the cerebrospinal fluid, and in part explain the slowness and difficulty with which all except high concentrations of drugs reach high segmental levels.

Diagrams illustrating a Transverse Section of the Spine and the Segmental Origins of the Cutaneous Nerve Supply of the Body follow.



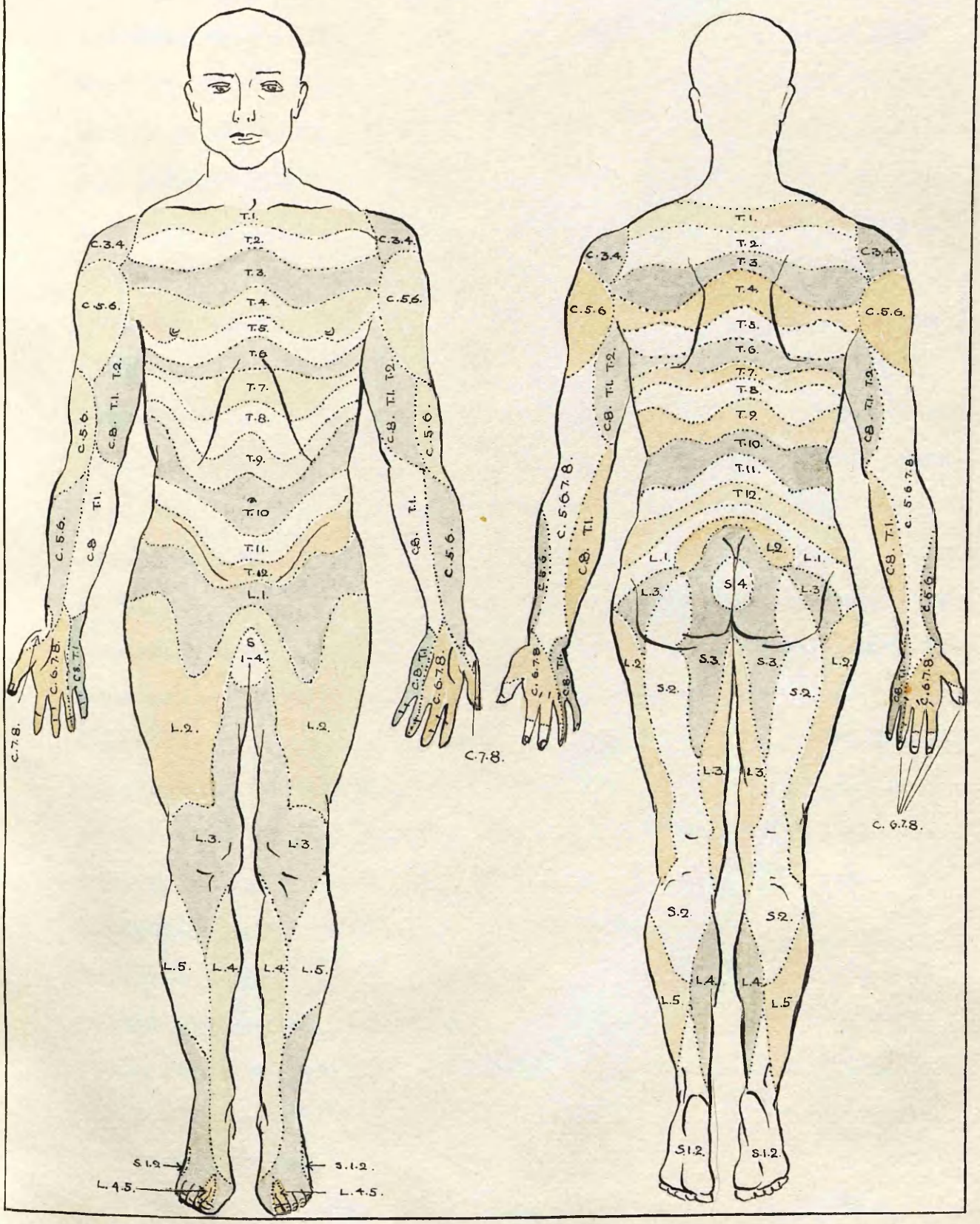
DIAGRAMMATIC REPRESENTATION OF TRANSVERSE SECTION OF SPINE

POSTERIOR



ANTERIOR

DIAGRAMMATIC REPRESENTATION OF THE SEGMENTAL ORIGINS OF THE CUTANEOUS NERVE SUPPLY OF THE BODY.



The cerebrospinal fluid originates from the choroid plexuses within the ventricles. It is now generally held that it is secreted by the cells of the choroid plexus, although previously the view that it was a dialysate in equilibrium with blood plasma, the choroid plexus acting as a dialysing membrane, received consideration. Re-absorption takes place via the Pacchionian bodies and arachnoid villi into the venous sinuses, and also by the spinal veins (Evans 1949). According to Adriani (1945) some is also absorbed into lymph channels along the perineural spaces. While there is no active circulation of cerebrospinal fluid, in the sense that the blood circulates, there is a continuous slow absorption and replacement of the fluid, and the spinal portion of the system shares in this interchange by reason of its communication with the cranial portion and thence with the ventricular system by way of the foramina in the fourth ventricle. Vehrs (1934) believes that there is a slow upward circulation of cerebrospinal fluid through the central canal of the cord into the fourth ventricle. The spinal sub-arachnoid portion is, however, relatively stagnant - an important safety factor in spinal anaesthesia. This relative stagnation is reflected in the fact that cerebro-spinal fluid from the lumbar region normally contains more cells and more protein than fluid from the cisterna magna. Drugs are rapidly absorbed from the cerebrospinal fluid into the blood stream.

The total volume of cerebrospinal fluid is 100-150 ml.,

and Maxson (1938) states that it is renewed about seven times in twenty-four hours. Monrad-Krohn (1948), quoting Masserman, says that renewal is completed three times each twenty-four hours. The exchange is so slow however, that it has no practical bearing on spinal anaesthesia. Pitkin (1927 and 1929) and Vehrs (1934) give the quantity of fluid in the spinal subarachnoid space to the level of the Foramen Magnum as 20 ml.

Cerebrospinal fluid is a clear, colourless, saline fluid, normally at a pressure of 60 to 150 mm. of water, in the recumbent position. It is slightly alkaline, having a pH of 7.6 to 8.1, and has a specific gravity of from 1001 to 1009, average 1004 to 1006. As obtained by lumbar puncture from the normal individual it may contain up to 3 lymphocytes per c.mm., and its chemical composition is as follows (Walshe 1949):-

Protein	20 - 40 mg. per 100 ml.
Glucose	50 - 80 mg. per 100 ml.
Chlorides	725 - 750 mg. per 100 ml.

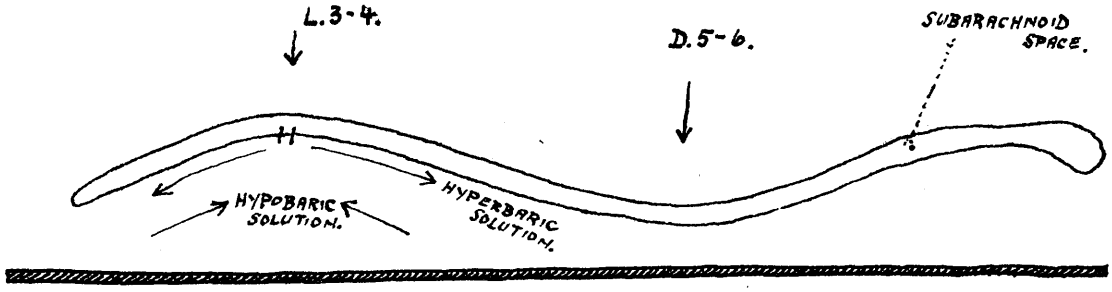
Certain changes are said to occur in the composition of the cerebrospinal fluid as the result of spinal anaesthesia, and will require to be considered because of their possible relation to neurological complications. Lienhoop (1936) found that the albumin content rose until the 18th day, when it was nearly double its normal figure, and there was a

slight rise in globulin. Thorsen (1947) stated that every spinal anaesthetic is followed in the first 24 hours by an increased cell count. Merritt and Fremont-Smith (1938) stated that spinal anaesthesia was almost constantly followed by an inflammatory reaction of the cerebrospinal fluid, evident within a few hours and disappearing in 4 to 7 days. The cell count varied from a few white cells to 2,000 or more per c.mm., chiefly lymphocytes, the protein was normal or increased. The sugar might or might not be increased. The colloidal gold reaction sometimes showed a slight change. Backer-Gröndahl (1934) studied the fluid from 138 cases. He found a pleocytosis in 65% at 24 hours, in 30% at 48 hours, in 18% at 72 hours. The highest cell-count in his series was 1950 per c.mm., the protein content was increased in 33%, the sugar content increased in 69%. Jason, Lederer, and Steiner (1930) examined the cerebrospinal fluid 12 hours after spinal anaesthesia in 14 cases. Only one failed to show a pleocytosis of 12 cells or more per c.mm., the highest count being 800 cells per c.mm. Backer-Gröndahl (1934) demonstrated that patients anaesthetised with Percaine (Nupercaine) had a smaller increase in cells than those in whom procaine was used. It was this temporary rise in the cerebrospinal fluid cell count which led many writers to call the condition chemical or aseptic meningitis. This is the normal meningeal response to mild irritation,

but at the same time there is no dividing line between this state and low degrees of septic meningitis. No symptoms are produced by this cellular increase.

It is interesting to note that in the author's series of 46 cases in which lumbar puncture was performed 24 hours after spinal anaesthesia, these changes just described were not manifest, except in one case. This will be discussed in Section VI, Clinical Section.

The relationship between the specific gravity of the cerebrospinal fluid and the specific gravity of the injected anaesthetic solution is one of importance in the practice of spinal anaesthesia. Thus a solution which is heavier than cerebrospinal fluid (hyperbaric), when introduced into the subarachnoid space, will gravitate towards the lowest point. In the same way a solution lighter than cerebrospinal fluid (hypobaric) will rise towards the highest point in the subarachnoid space. With a patient lying supine on a horizontal table, the third lumbar vertebra marks the highest point of the lumbar curve and the fifth dorsal vertebra the lowest point of the dorsal curve.



This diagram illustrates this principle applied to solutions injected at the third lumbar interspace. A hypobaric solution will tend to remain at the highest parts of the lumbar curve (L.3-4.), while a hyperbaric solution will gravitate in part towards the sacral region and in part towards the lowest point of the dorsal curve (D.5-6.). With a patient in the upright position, hypobaric solutions will naturally rise and hyperbaric solutions fall.

Whilst these simple concepts are fundamental, there are modifying influences. Mention has already been made of the baffle-like action of the nerve roots and the denticulate ligaments. The more thoroughly the injected solution is mixed with the cerebrospinal fluid, the more its specific gravity approximates to that of the cerebrospinal fluid. Further, as it passes on in the direction dictated by gravity, the anaesthetic is removed from solution by fixation in the nerves. These two processes have the same result - viz., that the farther the solution travels the lower its anaesthetic concentration becomes and its specific gravity approaches closer to that of cerebrospinal fluid. This brake action slows and ultimately stops the spread of the anaesthetic. Thus a hyperbaric solution, introduced in the lumbar region of a patient in the Trendelenberg position, cannot reach the upper dorsal segments in the same concentration as that originally injected from the syringe, and this has been demonstrated many times in the author's own experience.

It is the author's practice, for gynaecological abdominal operations, after the injection of a hyperbaric solution immediately to place the patient in a 40° Trendelenberg position. The level of motor paralysis does not exceed the level which would have obtained had the patient remained horizontal, although the level of sensory loss rises two or even three segments higher than would have been anticipated without tilting of the table. The reason for the rise in the sensory level, but not the motor level, is that the sensory fibres are more susceptible to cocaine-substitute drugs than motor fibres, and are therefore affected by weaker solutions. The work of Koster et al. (1936) gives experimental backing to this clinical observation, and this has also been the experience of Minnitt and Gillies (1944).

The anterior and posterior roots contain autonomic fibres passing to and from the sympathetic ganglia. Block of the spinal nerve roots up to the level of the first thoracic segment will include block of the sympathetic chain and the splanchnic nerves, which arise from the fourth dorsal to the first lumbar sympathetic ganglia. A diagram is appended to show the somatic and autonomic connections of the spinal nerve roots.

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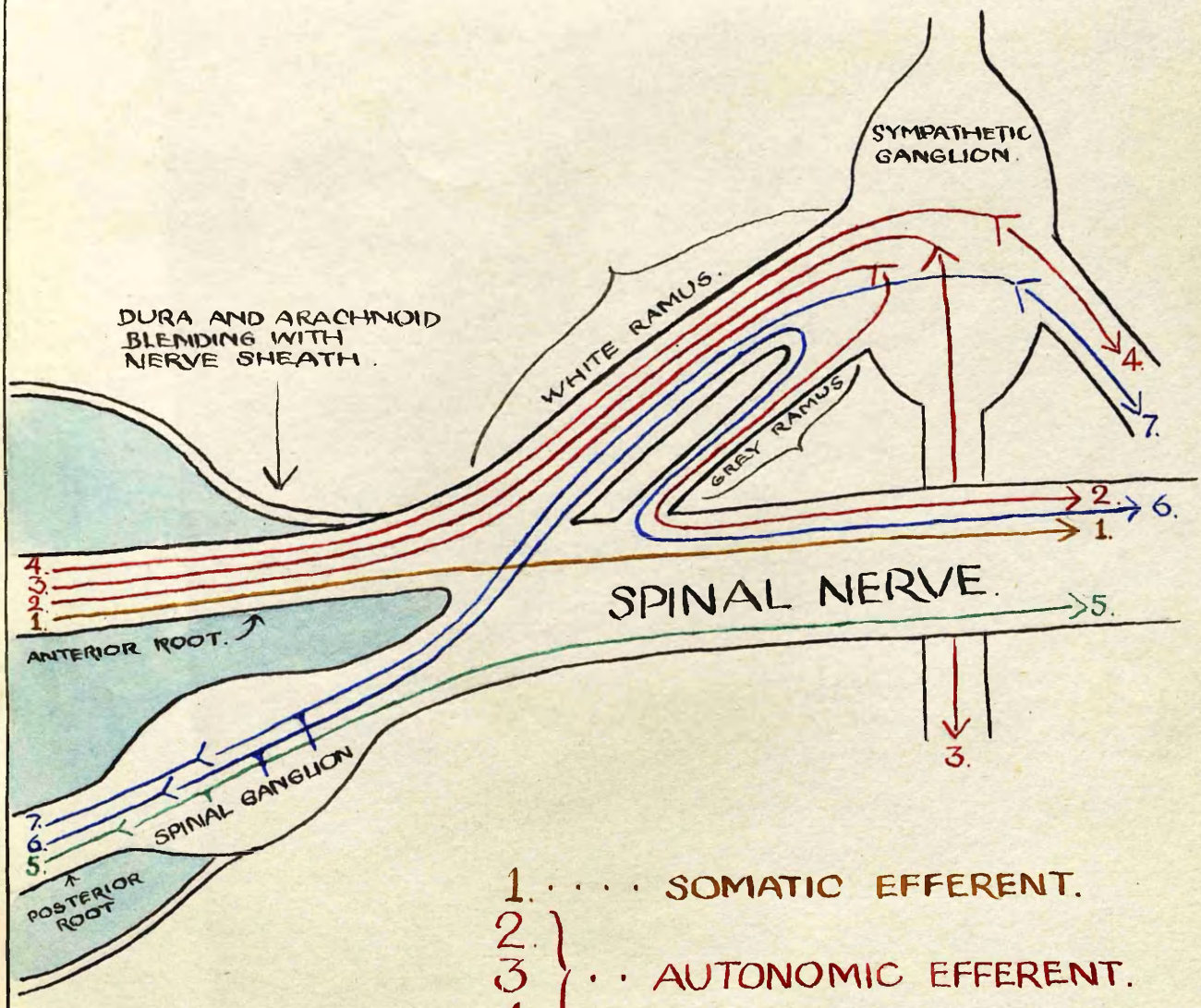
DIAGRAMMATIC REPRESENTATION OF THE SOMATIC AND AUTONOMIC CONNECTIONS OF THE SPINAL NERVE ROOTS.



1. . . . . SOMATIC EFFERENT.

2. }
3. } . . AUTONOMIC EFFERENT.
4. }

5. . . . . SOMATIC AFFERENT.

6. }
7. } . . . AUTONOMIC AFFERENT.

PORTION SHADED THUS REPRESENTS SUBARACHNOID SPACE FILLED WITH CEREBRO-SPINAL FLUID. →

Section III.

PHARMACOLOGY.

1. General Properties of Local Anaesthetic Drugs.
2. Pharmacological Action.
3. Drugs Used for Spinal Anaesthesia.
4. Experimental Pharmacology.
5. Composition of Preparations - Additions and Adulterants.
6. Toxicity of Procaine.
7. Choice of Agent.

Section III.

PHARMACOLOGY.

Since the inception of spinal anaesthesia, numerous local anaesthetic drugs have been used from time to time, but only those which have achieved wide acceptance - viz., Cocaine, Stovaine, Procaine, Nupercaine, Metycaine and Amethocaine, need be considered here.

Each of the synthetic drugs, especially procaine, is known by several synonyms, some of which are commercial trade names which are very similar both in print and to the ear. Thus the hydrochloride of para-aminobenzoyldiethylamino-ethanol is variously called procaine (B.P. and U.S.P.), Novocaine, Ethocaine, Planocaine, Duracaine, Neocaine, Syncaine, Scurocaine, Spinocaine, Kerocaine, but these preparations differ in composition, concentration, total dosage, specific gravity etc., and as a result considerable confusion has arisen and errors have occurred. As this drug is almost universally known among anaesthetists as procaine, this name will henceforward be adhered to in this thesis.

1. General Properties of Local Anaesthetic Drugs.

There are three groups of drugs for spinal anaesthesia.

(i) Esters of benzoic acid: e.g. Cocaine, Stovaine, Metycaine.

(ii) Esters of para-aminobenzoic acid: e.g. Procaine,

Amethocaine, etc.

(iii) Quinoline derivatives: Nupercaine.

Local anaesthetics, except cocaine, are synthetic preparations and not of plant origin. However, they resemble alkaloids closely and respond to some of the tests for alkaloids. All form salts with various mineral acids, usually HCl. They are crystalline, acid in solution and stable. The base is precipitated by alkalis and the 'alkaloidal' bases of local anaesthetic salts are liberated by hydrolysis, and being highly lipoid soluble are readily taken up by the lipoid-rich nervous structures.

2. Pharmacological Action.

Local anaesthetic drugs within the subarachnoid space act upon the fibres of the nerve roots, causing physio-chemical modifications of their functions and temporary physiological section of the roots. Anaesthesia is accompanied by decreased electrical conductivity, by decrease in the action potential and by reduced permeability to salts. A simple concept of anaesthesia is that the local anaesthetic agent stabilises the surface layers of the nerve fibres and thus prevents the changes necessary to the generation and conduction of nervous impulses.

Although Vehrs (1934) states that solutions of procaine cause physiological trans-section of the cord, the majority of anaesthetists do not accept this view (e.g.Evans (1949), Hewer (1948), Minnitt and Gillies (1944)), and define spinal anaesthesia as a blocking of the nerve roots and not of the

spinal medulla. Coloured substances injected into the subarachnoid space only faintly tinge the external surface of the cord, but impregnate deeply the roots which issue from it,(Sebrechts 1934). Anaesthetic drugs behave the same way; the diazo-reaction for procaine shows that procaine penetrates deeply the entire spinal root but affects only the periphery of the cord, up to a depth of 0.25 cm. (Evans, 1949). While this question has not been settled conclusively, it appears to the author reasonable to assume that with the concentrations of drugs ordinarily used, the degree of penetration of the nerve will depend on its diameter. Thus the anterior and posterior roots (and more particularly their rootlets of attachment to the cord) will be penetrated and blocked completely, while the spinal cord with its much greater diameter will be penetrated about its periphery only.

Three types of mammalian nerve fibres are described, and their susceptibility to local anaesthetics is given in the accompanying table (Galley 1950).

Effects of Spinal Anaesthesia upon the Three Types of Mammalian Nerve Fibres.

(After Galley, 1950).

Type of Fibre.	Function.	Effect of blocking Spinal nerve or nerve roots.
"A" FIBRES Large myelinated (1 to 20 μ) Susceptibility to local analgesics +	(a) Skeletal motor fibres. (b) Fibres from touch endings. (c) Proprioceptor fibres, e.g. from muscles, tendons, joints, ligaments and periosteum. (d) Small fibres subserving pain of a sharp shooting nature. (e) Small fibres subserving thermal sensations.	(a) Muscle paralysis. (b) Loss of touch sense. (c) Loss of stretch-reflexes and muscle tone. Loss of joint sense, etc. (d) Analgesia to sharp pain (e.g. cutting and referred shooting pains). (e) Loss of thermal appreciation.
"B" FIBRES Myelinated (1 to 3 μ) Susceptibility to local analgesics ++	Most preganglionic sympathetic fibres (involuntary autonomic motor fibres) such as the white rami.	(a) Vasodilatation. (b) Loss of sweating. (c) No reflex action of pilomotor muscles. (d) Constriction of bowel and relaxation of certain sphincters. (e) Lowering of B.P. if block includes segments above L.I.
"C" FIBRES Unmyelinated, i.e. naked axon cylinders. ($< 1\mu$) 40% of posterior nerve-roots fibres are in this category. Susceptibility to local analgesics +++	(a) Some pre- and all post-ganglionic sympathetic motor fibres (grey rami) (b) Afferents mediating dull aching or burning pain. (c) Afferents mediating thermal sensations.	(a) Some sympathetic paralysis as above (grey rami unaffected by subarachnoid block). (b) Analgesia to pain due to cutting or burning, deep limb pain, and pain from viscera. (c) Loss of thermal appreciation.

It will be seen that some preganglionic fibres and 40% of posterior nerve root fibres are non-myelinated 'C' fibres and are susceptible (+++) to local analgesics. Most preganglionic fibres such as the white rami are myelinated 'B' fibres, susceptible (++) to local analgesics. Nerve fibres to skeletal muscles and proprioceptive fibres are large myelinated 'A', having a susceptibility of one plus only (+) to local analgesics. Heinbecker, Bishop and O'Leary (1934) carried out extensive investigations on nerve blocking with procaine, and they summarise the order in which fibres are blocked with increasing concentrations of procaine. Sensory fibres are blocked in the order - cold, warmth, pain, touch; vasoconstricting fibres before cold; motor fibres between pain and touch; sensibility to deep pressure and muscle-joint sense at the same time as touch. The order is therefore:-

(1) VASOCONSTRICTION.

(2) COLD, WARMTH, PAIN.

(3) MOTOR.

(4) TOUCH, DEEP PRESSURE, MUSCLE-JOINT SENSE.

Gillies (1950) and Griffiths and Gillies (1948) state that 0.2% procaine blocks preganglionic sympathetic fibres, 0.5% procaine blocks sensory fibres, and 1.5% is required to block motor fibres.

The general effects of spinal anaesthesia on the other

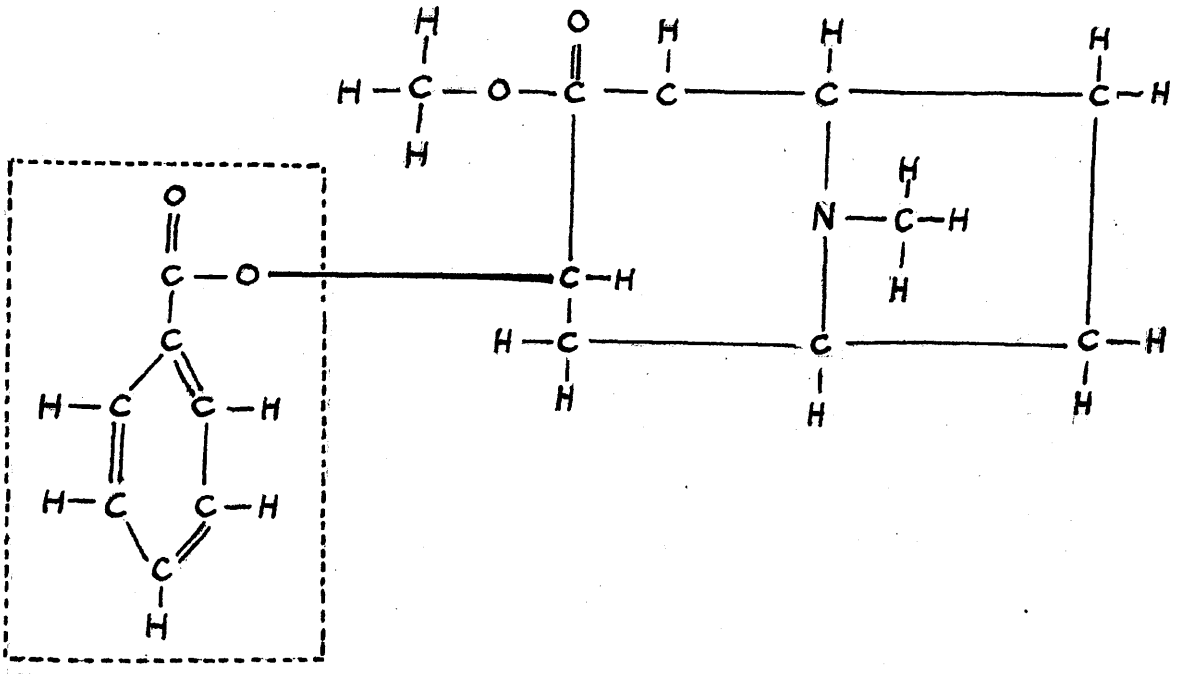
systems of the body are now outlined briefly. There is an early increase in skin temperature below the level of the block. A fall in blood-pressure occurs, probably due to paralysis of the vaso-constrictor fibres with post-arteriolar dilatation, and this fall is roughly proportionate to the height of anaesthesia. Also, when the anaesthesia reaches the upper thoracic segments, the cardio-accelerator nerves arising from T.I. to T.5. are blocked, the action of the vagus is therefore unopposed, and bradycardia results. The respiration becomes slower and more shallow, depending on the height of intercostal paralysis. The gut is contracted, there is increased peristalsis, and the sphincters are relaxed. The sphincters of the bladder, however, are not relaxed, and the penis is often engorged and flaccid due to paralysis of the nervi erigentes (S.2. and 3.).

3. Drugs used for Spinal Anaesthesia.

(i) Cocaine (Methyl benzoylecgonin).

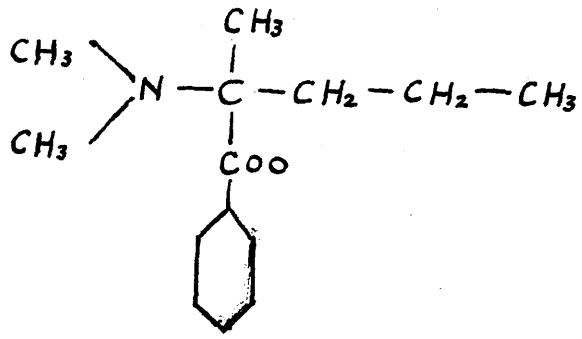
This is a natural alkaloid derived from the leaves of the South American plant Erythroxylon Coca. It is a rapid-acting and potent local anaesthetic, and has a marked affinity for sensory as opposed to motor fibres, but it has many disadvantages as an agent for spinal anaesthesia. Aqueous solutions are unstable and decomposed by heat, boiling, and autoclaving. It is highly excitant to the central nervous system and many patients have an extreme susceptibility to this toxic action. Primary cardiac failure occasionally

occurs in susceptible subjects. It has been entirely abandoned in favour of safer drugs. Its structural formula is -



It was discovered however, that not all of the large cocaine molecule took part in the local anaesthetic action, but that the latter was due to the presence of the benzoic acid radicle, benzoyl (encircled by the dotted line), in combination with a nitrogen-containing group. This benzoic acid radicle forms the keystone on which most of the synthetic local anaesthetics are based, with the exception of Nupercaine which is a quinoline derivative.

(ii) Stovaine (Amylocaine B.P.) is benzoyl - ethyl - dimethylaminopropanol hydrochloride.

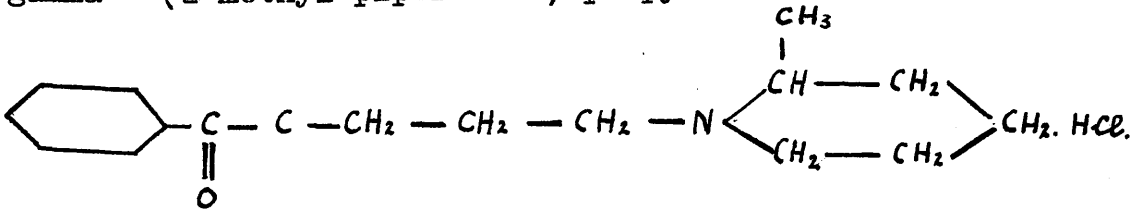


This drug, in aqueous solution and at the strengths used (i.e. 5% and 10%), produces a most intense block of all sympathetic, sensory and motor fibres in the spinal nerve roots. It is still used in some quarters, in spite of the fact that long ago it was shown, (Maxson 1938), that its repeated use could cause permanent paralysis in dogs. The clinical use of Stovaine over the years has left a trail of neurological complications. Pitkin (1928) states that severe pains in the legs ("stovaine tabes") may occur as the anaesthesia is passing off. Ferguson and Watkins (1938), in an examination of the literature prior to 1935 found reports of 16 cases of neurological sequelae attributable to spinal anaesthesia, and of these 7 followed the use of Stovaine, 1 followed the use of procaine, and in 8 the anaesthetic drug was not specified. Dinsdale (1947) reports 6 examples of lesions of the cauda equina, following the use of Stovaine for subarachnoid block. Minnitt and Gillies (1944) make the general statement that there is some evidence that Stovaine, and Duracaine (10% procaine in 15% alcohol with water) are especially liable to produce neurological

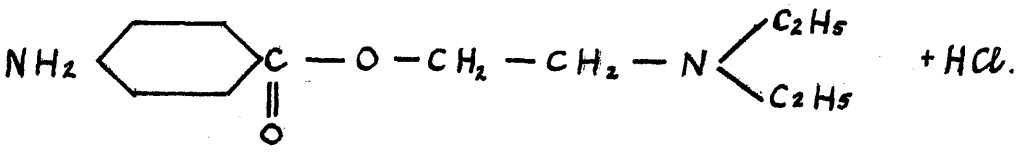
sequelae.

Pitkin (1928) subjected dogs to spinal anaesthesia, with 5% Stovaine solution, and in all cases histological evidence of trauma to nervous tissue was found, i.e. perivascular round-cell infiltration, swollen axis cylinders, and degeneration of the anterior roots was produced; no such reactions occurred with 5%, 10%, or 20% procaine solutions. This latter part of Pitkin's conclusions regarding procaine does not agree with the findings of MacDonald and Watkins (1938) who, experimenting on cats found that 10% of the animals were permanently paralysed by 5% solutions of procaine. Nevertheless, on abundant clinical evidence, Stovaine has been shown to be a more irritating drug than procaine, and has largely been abandoned for this reason.

(iii) Metycaine (Neothesin) was first used for spinal anaesthesia in 1931. It is a little more potent and has a more prolonged action than an equal weight of procaine. It is used as the hydrochloride in 10% solution and is a white, crystalline powder, easily soluble in water, alcohol and chloroform. Its solutions are stable and resist boiling. It has attained a moderate popularity in America, but has not been used extensively in this country. Chemically, it is gamma - (2 methyl piperidino) propylbenzoate.

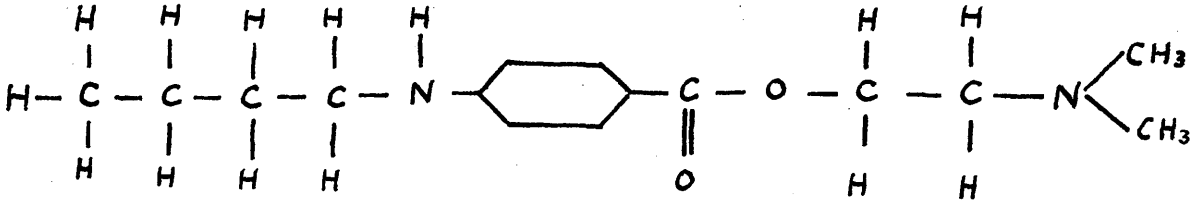


(iv) Procaine is perhaps the drug most frequently used at the present time, and is the one which has been most thoroughly investigated in connection with spinal anaesthesia. It is a synthetic preparation, the hydrochloride of para-aminobenzoyldiethylamino-ethanol,



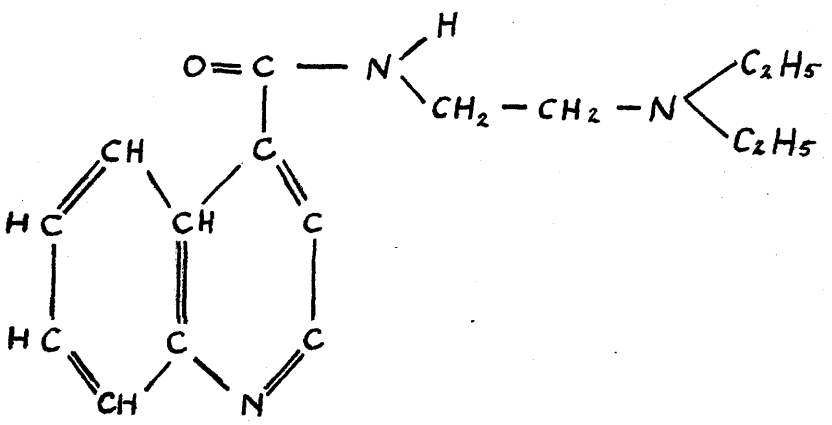
It is a white crystalline substance freely soluble in water and in cerebrospinal fluid. Its solutions are not affected by boiling, although there is some reduction in potency, estimated at 10% following autoclaving at temperatures exceeding 110° centigrade. It is 1/5 to 1/7 as toxic as cocaine. The usual doses employed clinically lie between 50 mg. and 200 mg., dissolved in cerebrospinal fluid to make a 5% solution.

(v) Amethocaine (Pontocaine, Anethaine, Decicaine, Tetracaine). This is one of the more recently introduced (1931) synthetic local anaesthetic drugs of a similar structure to procaine. It is para-butylamino benzoyl dimethylamino-ethanol.



It is used in the form of the hydrochloride which is a white powder, freely soluble in water and in cerebrospinal fluid. Aqueous solutions are stable and can be boiled or autoclaved without decomposition. The potency of amethocaine is approximately ten times that of procaine and the maximum dosage by spinal injection is 20 mg., the concentration used being 1%, or less. It is said to affect the white rami communicantes less intensely than procaine and so produce less fall in blood-pressure.

(vi) Nupercaine (Percaine, Cinchocaine) was introduced in 1929 and belongs to a different chemical group from the drugs already described. It is a quinoline derivative - viz., alpha - butyloxycinchoninic acid diethylethylenediamide.



It is employed either as a 1 in 200 hyperbaric solution or a 1 in 1500 hypobaric solution. This was the first true 'light' solution available. It has a slower onset but more lasting effect than procaine. This drug is highly toxic

but so potent that only very small doses are required, up to 15 mg. It is readily inactivated by traces of alkali which must be carefully excluded from needles and syringes.

The duration of effect of amethocaine is longer than that of procaine but not so long as that of Nupercaine. Bieter, McNeary, Cunningham and Lenz (1936) give the duration of anaesthesia produced by minimal comparable doses in rabbits as -

Procaine	16 minutes.
Amethocaine	25 minutes.
Nupercaine	41 minutes.

In the author's experience, the average duration of effective anaesthesia with these three drugs is 45 minutes with procaine, 90 minutes with amethocaine and 120 minutes with Nupercaine. This statement requires some further elaboration however. Thus after injection of 0.4% amethocaine solution for high spinal block, the anaesthesia rapidly attains its maximum height at the 2nd. thoracic segment. After a short peak period, the level of anaesthesia gradually recedes segment by segment, so that the duration of effective anaesthesia up to the level of the 5th. thoracic segment will be one hour, but up to the level of the 10th. thoracic segment will be as long as two hours.

* * * * * *

4. Experimental Pharmacology.

Lundy, Essex and Kernohan (1933), experimenting with procaine on dogs, have shown that it is the concentration of the procaine solution as it comes in contact with the nerve roots which is the important factor in determining the production of irreversible changes in the nervous structures, and not the total dosage. They produced the following results:-

5 ml. of 17.5% solution (876 mg.procaine) - No permanent paralysis.

5 ml. of 20% solution (1000 mg.procaine) - Permanent effects, extending to mid-thoracic region.

5 ml. of 25% solution (1250 mg.procaine) - Permanent effects, extending as far as the cervical region.

10 ml. of 12.5% solution (1250 mg.procaine) - No permanent effects.

2.5 ml. of 50% solution (1250 mg.procaine) - No permanent effects.

The histological lesions demonstrated were in the periphery of the cord, where there was degeneration of the myelin sheaths, which were swollen, nodular and fragmented, and this was associated with the formation of large vacuoles. The axis cylinders shared in this degeneration. The nerve roots were not affected, and there was no inflammatory

reaction of the meninges. As a result of this work, Lundy recommended that in clinical practice the concentration of procaine solution should not exceed 5%.

MacDonald and Watkins (1938) have shown that the concentrations of procaine which are used clinically in man can produce protracted cauda equina syndromes in cat. They have also shown that the incidence of such palsies in the cat rises with the concentration of procaine employed, as will be seen from the following table:-

Relation of Concentration of procaine HCl. to Incidence of Symptoms. (Cats).

% Concentration.	Number of animals.	Number showing paralysis.	% paralysis
2.5	20	0	0
5.0	20	2	10
10	56	24	43
20	8	4	80*

* 3 died acutely.

5. Composition of Preparations - Additions and Adulterants.

Many of the proprietary preparations for spinal anaesthesia contain, in addition to the anaesthetic drug, adulterants in the form of sugar, alcohol, glycerine and other substances. These substances are added in order to

make the specific gravity of the solution greater or less than that of cerebrospinal fluid, so that advantage may be taken of posture and gravity in controlling the level of anaesthesia. This practice is of doubtful value, particularly if alcohol is added to lighten the solution. The behaviour of such a pseudo-hypobaric solution within the subarachnoid space is problematical, as the alcohol may separate out - part company as it were - from the main solution, transforming it at some indeterminate time from a hypobaric solution to a hyperbaric one. Also, the alcohol may act on the nerve roots chemically or pharmacologically. The use of gum acacia tends to delay the diffusion and dispersion of the anaesthetic solution, and thus keeps the full original concentration of the drug in contact with the cauda equina for an undesirably long time.

6. Toxicity of procaine.

Ferguson and Watkins (1938) reported 14 cases of the cauda equina syndrome following spinal anaesthesia, where 'heavy' Duracaine had been the preparation used in each case. This is made up as follows:-

Procaine HCl	0.1 G. per ml. (i.e. 10% procaine).
Gum acacia	0.002 G. per ml.
Glycerine	0.0416 G. per ml.

In 15% ethyl alcohol, aqueous solution.

The question arose - could the lesion be due to the

alcohol or the glycerine, or was the procaine itself responsible? MacDonald and Watkins (1938) investigated this problem with cats as experimental animals, and obtained the following results:-

	TOTAL INJECTED.	NOT PARALYSED.	PARALYSIS OF BLADDER, ANUS AND TAIL.	PARALYSIS OF TAIL ONLY.	TOTAL PARALYSED.	% PARALYSED.
Alcohol and Glycerin.	23	23	0	0	0	0
'Heavy' Duracaine.	23	10	9	4	13	56
10% Procaine ('Planocaine')	10	5	2	3	5	50
10% Procaine ('Novocaine')	23	17	4	2	6	26
5% Stovaine (Baker)	10	4	0	6	6	60

These workers draw the obvious conclusion that the toxic agent which is responsible for the paralysis is the procaine itself, and that other anaesthetic agents, e.g. Stovaine, can also produce paralysis. One further point was made - viz., that the results tabulated above support the view that the lesion is not caused by the trauma of the needle, as no cases of paralysis occurred following the injection of alcohol and glycerin in 23 cats, while palsies frequently occurred in the other groups injected with anaesthetic drugs. This will be elaborated further in the section devoted to neurological complications.

7. Choice of Agent.

At the present time the choice of an agent for spinal anaesthesia lies between procaine, Nupercaine and amethocaine. Bieter, Cunningham, Lenz and McNeary (1936) give the following therapeutic or safety ratios:-

$$\frac{\text{Minimal Lethal dose \%.}}{\text{Minimal Analgesic dose \%.}}$$ for intrathecal injection in rabbits.

Procaine	6.6 : 1.
Nupercaine	11.4 : 1.
Amethocaine	30 : 1.

It is desirable that a preparation for spinal anaesthesia should be isotonic with cerebrospinal fluid. Maxson (1938) states that either hypotonic or hypertonic solutions are irritating to the meninges and nerve roots. Dinsdale (1927) draws attention to the fact that Chaput's 10% solution of Stovaine is no less than twelve times hypertonic; he gives the following table of physical properties of some common preparations,(to which 5% procaine in cerebrospinal fluid has been added).

Preparation.	Specific Gravity.	pH.	Concentration.	Tonicity in relation to C.S.F.
Stovaine (Chaput)	1080	4.7	10%	12 x
Stovaine (Barker)	1030	-	5%	2 x
Spinocaine	1000.5	4.5	10%	-
'Heavy' Duracaine	1028	-	10%	2 x
Heavy Nupercaine	1024	5.0	0.5%	>1
Light Nupercaine	1003.8	6.0	0.067%	<1
Metycaine	1014.3	4.5	10%	-
Spinal 'D' (amethocaine)	1025	4.9	1%	>1
Spinal 'D' Isotonic (amethocaine)	1018	5.0	0.4%	Isotonic
Procaine in C.S.F.	1015	7.4	5%	2 x

It will be observed from the preceding table that Spinal 'D' Isotonic (i.e. amethocaine 0.4%) is the only isotonic solution listed, and that it is also a dilute solution. The specific gravity is 1018 (i.e. hyperbaric) and the pH 5.0. Each ampoule contains 20 mg. amethocaine hydrochloride in 5 ml. normal saline. Hunter (1945) has shown that the minimum effective spinal concentration of amethocaine is 0.1%. This solution (0.4%), while of greater concentration than the minimum effective concentration, is nevertheless still a dilute solution. A

A solution of 1.0% amethocaine is used successfully by some anaesthetists, but this concentration is unnecessarily high.

Spinal 'D' Isotonic solution satisfies the pharmacological and clinical criteria which a spinal anaesthetic drug should possess. As unduly concentrated solutions in contact with the nerves of the cauda equina appear to be the main case of persisting lesions, and, in addition, as either hypertonic or hypotonic solutions may be irritating, the author believes that this isotonic solution of 0.4% amethocaine is the one least likely to lead to neurological complications.

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Section IV.

NEUROLOGICAL COMPLICATIONS.

1. INTRODUCTION.
2. LITERATURE.
3. LIST OF COMPLICATIONS REPORTED.

Classification: (1) Headache.
(2) Neuro-toxic lesions.
(3) Sepsis
(4) Prolapsed Intervertebral Disc.

(1) Headache: (a) Mode of production.
(b) Types of headache.
(c) Cause of pain.
(d) Character of headache.
(e) Prophylaxis.
(f) Treatment.
(g) Sixth Nerve Palsy.

(2) Neuro-Toxic Lesions: Experimental lesions in animals.
Meningeal Reaction.
The Cauda Equina Syndrome.
Acute Degenerative Myelitis.
Reported Lesions.

(3) Sepsis: Literature - reports of cases.
Medico - Legal Aspects.
Late Proliferative Arachnoiditis.

(4) Prolapsed Intervertebral Disc.

Section IV.

NEUROLOGICAL COMPLICATIONS.

1. INTRODUCTION.

Spinal anaesthesia has been held responsible for such a formidable array of neurological complications, that, if taken at face value, it would be sufficient to deter all but the most intrepid from employing it. Many anaesthetists and surgeons are dissuaded from using spinal anaesthesia because they believe the risks of sequelae are real and appreciable. The author, as a result of his experience, believes that with careful technique, and using low concentrations of drugs, there is no need to fear untoward results.

The literature is confusing and contradictory. On the one hand Sebrechts (1934) writes - "So far as I know, it (paralysis) has never been observed in wards where spinal anaesthesia is a routine method," and "on the basis of our personal experiences and of that of all those who regularly use spinal anaesthesia, we can assert positively that the careful injection into the cerebrospinal fluid of a substance which is little irritant, never causes symptoms of paralysis." On the other hand, Lindemulder (1932) stated - "One must advance the theory that all spinal anaesthesias produce an acute myelitis. This condition lasts a few hours and may leave the patient with complaints of pain and paralysis for a period. The fact that there may be certain definite residuals from this method of anaesthesia must be recognised."

It is said that John B. Murphy so strongly disapproved of spinal anaesthesia that he advocated that it be prohibited by law, but Lundy, from the Mayo Clinic, denies that spinal anaesthesia properly performed can result in any neurological complications.

2. LITERATURE.

Thorsen (1947), basing his figures on 2,493 replies to a questionnaire sent to patients who had a spinal anaesthetic, gives the following incidence of complications:-

Headache	24%
Diplopia	2.4%
Back-pains	19%
Weakness of the legs	7%
Numbness in the legs	13.3%
Disturbances to bladder and rectal function	13%

These figures, as Thorsen himself points out, are higher than the true incidence, as it is impossible to avoid leading questions in a questionnaire. Graham and Brown (1939) put the frequency of headache at 4%, and Jarman (1934) at 1%. Jarman gives the incidence of "paralysis" as 0.01%.

Schildt (1947), in an extensive review of over 60,000 cases of spinal anaesthesia during a three year period, found 6 cases of protracted or permanent neurological lesions, all following the use of 1 in 1500 Nupercaine solution. He therefore assesses the incidence of injury at 0.01%, but concludes that the advantages of spinal anaesthesia are so

great that they counterbalance the risk of injury. He attributes the lesions to a chemo-toxic effect of the local anaesthetic drug on the spinal cord and its membranes.

MacdonaldCritchley (1937) in opening a discussion on the neurological sequelae of spinal anaesthesia at the Royal Society of Medicine, gives it as his opinion that a very significant number of such complications are completely overlooked by surgeons and anaesthetists. Minnitt and Gillies (1944) in their text-book, and referring to such complications, also make a comment along similar lines. They say that to state that one has not seen such complications is only half an answer, because one has probably not looked for them. It was these remarks of Critchley, and of Minnitt and Gillies, which stimulated the writer to undertake a careful follow-up of his spinal cases before their discharge from Hospital, and in some cases by re-examination after a period of 6 months - 2 years.

3. LIST OF COMPLICATIONS REPORTED.

The following complications have been reported:-

Headache.

Paralysis of the sixth cranial nerve.

Bladder and rectal disturbances.

Impotence in the male.

Weakness or paralysis of the legs.

Areas of sensory loss about the perineum, sacrum and legs.

Paraesthesiae of the legs.

Radiating pains in the legs.

Prolapsed intervertebral disc.

Trophic lesions.

Transverse and ascending myelitis.

Late proliferating arachnoiditis.

Septic meningitis.

Before the writer's own clinical material is described, an examination of the reported neurological sequelae will be made. They can be broadly grouped under four headings, viz:

1. Headache.
2. Neuro-toxic lesions.
3. Sepsis.
4. Prolapsed Intervertebral Disc.

(1) Headache.

(a) Mode of Production of Headache.

August Bier, the German surgeon, must have been one of the first to appreciate that headache can occur in association with spinal anaesthesia. In August 1898 his assistant performed lumbar-puncture upon him, with the intention of proceeding to produce anaesthesia with cocaine. Unfortunately the needle and the syringe did not fit; the attempted anaesthesia had to be abandoned, but a large quantity of cerebrospinal fluid escaped as a result. Bier was confined to bed for nine days on account of headache, which became intense when he sat upright. Although Quinke had been

practising lumbar-puncture for seven years before this, and must have observed headache, yet it was left to Sicard in 1902 to postulate that the headache which followed spinal anaesthesia was due to the lumbar-puncture per se, and the consequent leakage of cerebrospinal fluid. This theory has recurred and has been developed in the literature up to the present day, and is now widely accepted as the principal cause of post-spinal headache. As would be expected, many other causes have been suggested, but these have not borne critical study. They range from iodine carried into the cerebrospinal fluid from the skin via the lumbar-puncture, to psychoneurosis (Watson, 1943), and include decomposition products from the anaesthetic substance, puncture haemorrhages, vaso-motor disturbances (Harrison, 1936), and disproportion between the intracranial arterial pressure and the pressure of the cerebrospinal fluid, with increased vascular pulsations (Ericsson, 1947).

It is well known that simple lumbar puncture in patients who had no previous headache, produces headache in a proportion of cases. Parker (1929), Heldt (1939) and Davenport (1939) estimate the frequency of headache following, and as the result of, simple lumbar-puncture at 15% to 44%. Thorsen (1947) reports the incidence of post-spinal headache in his series of 2,493 cases as 24%, while the incidence of headache in 100 control subjects subjected to lumbar-puncture without anaesthesia was 41%. He explains the higher

incidence in the control group, by the fact that, not having had an operation, they were ambulant and active earlier than the spinal anaesthetic group. This early resumption of the upright position would encourage the continued drainage of cerebrospinal fluid away from the puncture-hole in the dura, because the pressure of cerebrospinal fluid in the lumbar region is greater in the vertical position than in the horizontal position. He has further shown that headache in the spinal anaesthetic group was more frequent in those patients who got up within the first three days than in those who remained in bed longer than three days. In contrast to the relative frequency of headache following lumbar-puncture, it is quite unusual following puncture of the cisterna magna.

Two significant facts strongly support the theory of seepage of cerebrospinal fluid as the cause of post-spinal headache. The first (A) is that the dural puncture hole has been proved to remain patent in some cases up to eleven days after the spinal anaesthetic. The second fact (B) is that the epidural space normally exerts a "negative" pressure (i.e. less than atmospheric pressure). These two supporting facts will be considered separately in more detail.

A. Persistance of dural defects.

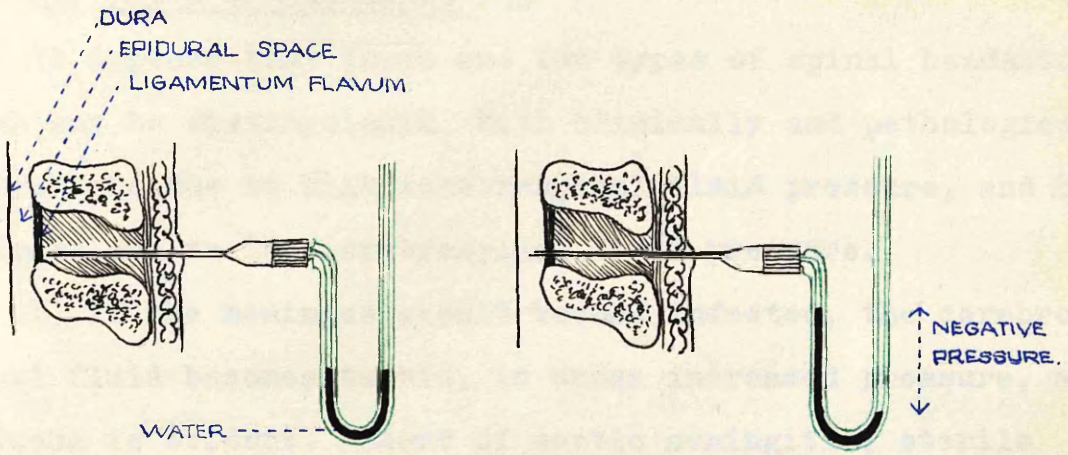
Weed et al (1919) demonstrated that a suspension of lamp-black injected into the subarachnoid space of animals could later be found in the epidural space. Ingvar (1923) injected methylene blue solution intraventricularly and was able to observe that it remained in an intradural position

except when a lumbar-puncture had been performed before the injection of methylene blue, in which case it could be demonstrated staining the fat of the epidural space. In addition, he examined the dura of a seven-year old girl who died of tuberculous meningitis. This girl had lumbar-puncture performed at eight, five and one day before her death. He was able to verify histologically the persistence of a defect in the dura at the site of the last lumbar-puncture. Leriche (1928) observed during the operation of laminectomy that leakage from the dura was visible to the naked eye in two cases where lumbar-puncture had been performed a few days prior to the laminectomy. Thorsen (1947) carried out thorough investigations in order to demonstrate the persistence of dural defects after spinal anaesthesia. Post-mortem examinations were performed on 15 patients who had died 1 to 11 days after spinal anaesthesia. The dural sac was exposed, and a solution of methylene blue injected in the lower thoracic region. When the dural sac became expanded, a blue-coloured jet of fluid was seen to issue, in 10 of the 15 cases, from a point-like dural defect corresponding with the site in the lumbar region of the injection of the spinal anaesthetic. In one case two puncture-holes were detected. In 7 of these 10 cases the fistulae were verified histologically by serial sectioning as a traumatic dural lesion produced during life. As a further experiment Thorsen injected a sterile lamp-black solution into the subarachnoid space of a comatose woman dying of cancer. This

was done seven and a half hours before her death. At post-mortem examination the epidural space was found to be impregnated with lamp-black from the level of the first sacral vertebra to the eleventh thoracic vertebra. The black staining was most concentrated in the areolar tissue under the ligamentum flavum and along the spinal nerves passing out through the intervertebral foramina. Microscopical examination of the epidural tissue showed that intracellular phagocytosis of the black granules had occurred.

B. Negative pressure in the epidural space.

Most anaesthetists are familiar with the fact that the epidural space exerts a "negative" pressure relative to atmospheric pressure, viz:- 750 mm.Hg. The writer has frequently demonstrated to students the sharp hiss of air entering the needle as the point of the needle, with the stilette removed, reaches the epidural space. Odom (1937) devised a small glass indicator containing a fluid meniscus for attachment to the hub of the needle. When the meniscus moves towards the needle the epidural space has been entered. Pitkin (1946) used a small glass U-tube manometer for the same purpose. More recently Macintosh (1950) has introduced a small rubber balloon attached to a male record mount. The spinal needle is partially inserted, the mount attached and the balloon inflated with a small amount of air. The needle is again advanced and as the epidural space is entered the balloon collapses. Heldt and Maloney (1928) show that the negative pressure is from 1 to 18 mm. Hg.



Diagrammatic sagittal section showing needle attached to U-shaped manometer before and after entering peridural space.

The negative pressure is greatest in the thoracic region, and is dependent on that within the thoracic cavity, as pointed out by Macintosh and Mushin (1947).

The influence of such a negative pressure on the seepage of cerebrospinal fluid away from the subarachnoid space following lumbar-puncture is obvious. Granted that the puncture hole in the dura may remain patent for some time, it seems clear that considerable quantities of cerebrospinal fluid may thus be drained away to the epidural space and to the paravertebral spaces with which it communicates. The Peridural space is very adequately supplied with blood vessels, and the facilities for the re-absorption of fluid are good. Franksson and Gordh (1946) draw attention to the fact that the pressure in the epidural space, normally negative, becomes positive after lumbar puncture and spinal anaesthesia, and may remain so for several days.

(b) Types of Headache.

It appears that there are two types of spinal headache, which may be distinguished both clinically and pathologically. i) headache due to high cerebrospinal fluid pressure, and ii) headache due to low cerebrospinal fluid pressure.

i) If the meninges should become infected, the cerebrospinal fluid becomes turbid, is under increased pressure, and headache is evident. Short of septic meningitis, sterile anaesthetic drugs by themselves can produce meningeal irritation, with increased cell count, increased cerebrospinal pressure and headache. This was formerly described as aseptic or chemical meningitis, and was thought to occur frequently as the ordinary response to spinal anaesthesia. Jason et al (1930) state that the cellular content of the cerebrospinal fluid is increased in most cases following spinal anaesthesia, a count of 800 per c.mm. being not infrequent. This hypertension of the cerebrospinal fluid typifies the first type of spinal headache, but it is rare with present day technique and drugs.

ii) The second type of headache is characterised by hypotension of the cerebrospinal fluid, and is due to leakage of the fluid from the dural puncture to the epidural space. It is comparatively common. Thorsen (1947) made determinations of cerebrospinal fluid pressure in 21 patients with post-spinal headache. He took the normal value of the pressure in the horizontal position to lie between 75 and 150 mm. of water. In comparison with these normal values, he found

hypotension present in 17 of the 21 cases, the pressures being between 0 and 50 mm. of water. In one case the pressure was within normal limits, in two cases it was increased (155 and 160 mm.water), and in one case the determination was unsatisfactory.

(c) Cause of Pain.

Ray and Wolff (1940) in America, and Pickering (1939) in this country, have made a considerable investigation into the precise cause of the pain in headache. It has been shown that dilatation and stretching of blood-vessels within the cranium are primarily responsible, but the scalp and meninges play an important part in the mechanism of some headaches. Stimulation of a pain-sensitive vessel situated above the tentorium leads to headache which is mediated by the trigeminal nerve and is referred to the anterior part of the head, while pain provoked in a similar manner from structures below the tentorium is chiefly felt posteriorly, being mediated by the glossopharyngeal nerve and the upper three cervical nerves. A swelling of the brain or a slight descent of the brain causes traction on the cortical veins connecting with the venous sinuses. It would seem reasonable to suppose that either decreased or increased cerebrospinal fluid pressure within the ventricles could result in such traction on vessels. Thus most headaches arise from disturbances of vascular structures, the main mechanisms being distension, stretching, and traction applied to intra-cranial arteries and venous sinuses.

(d) Character of Headache.

A strikingly uniform picture is presented by the cerebrospinal fluid hypotension syndrome following spinal anaesthesia. The onset never occurs during the actual spinal anaesthesia nor in the succeeding few hours. Generally the headache first appears on the second day after operation when the patient begins to move freely in bed or to sit up, and it is relieved by resuming a slight head-down position. It can be demonstrated that the headache can be either relieved or accentuated by alternating a Trendelenburg position with a sitting position. It can nearly always be completely banished by placing the patient prone and raising the foot of the bed, as in this position leakage from the dural sac must be minimal. The headache is most frequently frontal and behind the eyes, or, less commonly, across the vertex. There may be aching at the back of the neck but this does not necessarily imply meningismus. In quality the headache may be described as a feeling of heaviness or of tightness, and is usually of very slight to moderate intensity. The cerebrospinal fluid pressure is low and the cell count is normal. It is rather more common in women under the age of 40. It persists from one to ten days. The mildness of the headache is so typical that any complaint of severe headache following spinal anaesthesia, especially if it is occipital and not relieved by lying down, should make one suspect that one is dealing with the "hypertension" type of headache due to meningeal irritation. Such meningeal irritation may be due to the anaesthetic agent

itself or to infection.

(e) Prophylaxis.

The prophylaxis of spinal headache depends on three main factors - viz., 1. Prevention of sepsis.

2. Reduction of irritation.

3. Limitation of leakage of cerebrospinal fluid.

1. The prevention of sepsis: It is axiomatic that scrupulous asepsis must be preserved.

2. The reduction to a minimum of chemical or physical irritation to the meninges may best be effected by using non-irritating drugs in iso-tonic solutions of low concentration, as hyper- or hypotonic and concentrated solutions are irritating.

3. Limitation of leakage of cerebrospinal fluid. This can be achieved by the following measures.

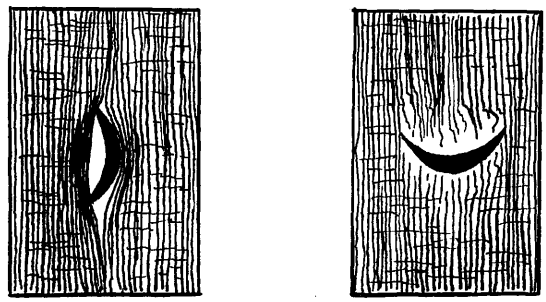
(a) The avoidance of lacerating the dura by multiple punctures.

(b) The employment of fine-bore needles, having a diameter not exceeding 1 mm. will ensure that the puncture-hole is as small as possible and trauma to the dura is minimal.

(c) Both Labat (1928) and Sise (1928) have emphasised that the needle should be inserted with the bevel facing laterally. The dura is composed of white fibrous and elastic tissue, arranged in bands or lamellae, which for the most part are parallel with one another

and have a longitudinal arrangement. If the bevel is directed to one or other side, it can wedge apart the longitudinal fibres without cutting them in its entry through the dura. On the other hand, if the bevel of the needle is transverse, the longitudinal fibres will become divided.

DIAGRAM. (AFTER LABAT.)



A. SHOWING THE BEVEL DIRECTED LATERALLY INSINUATING ITS WAY THROUGH THE LONGITUDINAL FIBRES.

B. SHOWING THE BEVEL IN TRANSVERSE POSITION CUTTING THE LONGITUDINAL FIBRES.

It is important to insist that a horizontal position be maintained for the first 24 hours after lumbar puncture, and also that the patient be confined to bed for the two days following, if this is consistent with the surgical requirements. If, in the interests of a particular patient, the surgeon desires

ambulation by the second post-operative day, then spinal anaesthesia is not the correct choice for that patient. Spinal anaesthesia should never be given to out-patients or 'over-night' cases. It is the author's experience that careful attention to this precaution will do more to prevent the occurrence of spinal headache than any other prophylactic measure.

(f) Treatment.

The treatment of established hypotensive, puncture-leakage, type of headache (and the great majority of spinal headaches are of this type) is first and foremost the post-ponement of sitting up until the symptom has disappeared and does not recur when the patient again elevates his head and shoulders. This, together with a simple analgesic, such as aspirin, phenacetin and caffeine tablet (B.P.C.), is quite sufficient to alleviate these headaches, for they are mild. The intradural injection of normal saline has been recommended by several writers and results in temporary relief. The writer does not support this treatment for the following reasons:- it involves a further dural puncture which might behave in the same way as the original puncture, producing leakage of cerebrospinal fluid and thus prolonging the syndrome; it is more difficult to be confident of complete asepsis with the patient in bed in a ward, rather than in an operating theatre; the effect is only temporary; it seems unnecessary as the symptom is controllable by posture and fades in a few days. Treatment by intravenous injections of

distilled water, and by drugs such as posterior pituitary extracts and ergotamine tartrate, have not been found satisfactory.

If one is convinced that one is dealing, exceptionally, with the hypertensive cerebrospinal fluid type of headache, then lumbar-puncture may provide relief and the intravenous injection of 50 to 100 ml. of 50% glucose or 2 ml. of 50% magnesium sulphate is rational.

(g) Sixth Nerve Palsy.

There is another unusual sequel of spinal anaesthesia of which mention should be made in connection with alterations in the pressure of the cerebrospinal fluid, and that is paralysis of the sixth cranial nerve (abducent). This is quite rare, but in those cases where it has been reported, it always occurs in association with headache. It is impossible to assess the incidence of this complication. Sebrechts (1934) says that it no longer occurs, and Tovell (1933) has seen two instances in 7,000 patients at the Mayo clinic. Macdonald Critchley (1937) has also only come across two cases, both complaining of concomitant headache. Thorsen (1947) has personal knowledge of eight cases, one of which occurred after a diagnostic lumbar puncture (the cerebrospinal fluid was normal). It may be unilateral or bilateral, and, paralysing the lateral rectus muscle of the eyeball, produces a medial squint and

inability to externally rotate the eye. It appears about the second or third day after lumbar puncture, is accompanied or preceded by headache, and always completely resolves in a few days to a few months. It is, therefore, both on account of its rarity and its benign course, more of interest than of importance.

Evans (1949) states that abducens palsy is associated with meningitis, but the writer can find no support in the literature for the cases following spinal anaesthesia having been due to meningitis. As it is always accompanied by headache, and can occur after simple lumbar puncture, it seems reasonable to postulate that it has the same etiology as post-spinal headache - viz., a slight displacement of the brain due to alteration of pressure of the cerebrospinal fluid in the subarachnoid space and ventricles with consequent traction on the nerve as it passes over resistant structures.

The sixth cranial nerve pursues a long and exposed course within the cranial subarachnoid space. It turns sharply over the petrosal ridge of the temporal bone and may suffer temporary pressure and loss of function as a consequence. One thing is certain - it is not due to the direct action of the anaesthetic drug reaching the abducent nerve. There is abundant evidence that only gross overdosage

of anaesthetic drugs can reach the cranial subarachnoid spaces in sufficient concentration to affect sensory fibres, far less this motor nerve. Lesions of the 5th, 7th, 8th, 9th and 11th cranial nerves have also been recorded but even more rarely (Minnitt and Gillies - 1944). The writer has been especially interested in reports of diplopia and squint following spinal anaesthesia, but despite a careful watch for this phenomenon for twelve years, he has observed it but once.

(2) Neuro-Toxic Lesions.

There is now a body of indisputable evidence that local anaesthetic drugs are capable of damaging the cord, the nerve roots and the meninges. This has already been referred to in dealing with the pharmacology of the drugs and some were shown to be more damaging to nervous structures than others. Further, the concentration of the drug was shown to be all important.

Experimental Lesions in animals.

In 1908 Spielmeyer injected Stovaine (amylocaine hydrochloride B.P.) into the subarachnoid space of dogs and apes and found degeneration of the roots and of the peripheral portion of the cord, and retrograde changes in the anterior horn cells. His work has, in the essentials, been confirmed repeatedly by later workers.

Wossidlo (1908) also used Stovaine in rabbits. The lumbar region of the cord was examined from one to twenty-four hours later. Chromolysis and swelling of the cells of the

anterior horn was found, and was maximal in two hours, scarcely any normal cells being seen at this time. Improvement was noted after six hours, and the cells had returned to normal in 24 hours.

Pitkin (1928) confirmed the deleterious reactions following Stovaine (perivascular round-cell infiltration, swollen axis cylinders and degeneration in the anterior roots), but found none after procaine.

Lindemulder (1932) also described degenerative changes in the spinal cord and nerve-roots of patients dying soon after the administration of spinal anaesthetics.

Meningeal Reaction.

Davis et al (1931) carried out extensive investigations into the effects of procaine and Nupercaine when injected into the subarachnoid space of dogs. Each dog was injected with one ampoule or one full human dose - the amount or the concentration was not stated. The dogs were killed and examined at varying periods from one, two or three days up to about ninety days later. The most constant change was a meningeal reaction; it was an inflammatory reaction in the arachnoid with a thickening of the membrane and an exudate of lymphocytes, most marked in the lumbar and sacral regions. Early temporary changes in the ganglion cells of the grey matter were noted, and swelling and fragmentation of the axis cylinders. Degeneration of the myelin sheaths was also observed. (In the dogs killed later, i.e. after ninety days, scarring of the arachnoid was seen.)

Backer-Gröndahl (1934) examined the cerebrospinal fluid of 138 patients operated upon under spinal anaesthesia, using either a 3% solution of procaine or a 1 in 1500 solution of Nupercaine. In 65% of the patients an increased cell-count was found after twenty-four hours. The largest number of cells was 1,950 per c.mm., while three patients had a count of more than 500 per c.mm. The lowest figures were found after the use of Nupercaine. There was no demonstrable relation between increased cell-count and headache.

These lesions then, produced by local anaesthetic drugs within the subarachnoid space, and studied mainly in the experimental animal, consist of the following changes:- (a) Chemico-lytic injuries to the ganglion cells of the spinal cord, particularly in the anterior and antero-lateral horns; they have most often been found to be temporary changes. (b) Similar injuries to the axis cylinders of the nerve-roots and especially to the posterior and lateral columns; they also affect the periphery of the medulla with subsequent demyelinisation. (c) Meningeal abacterial inflammatory reaction, with thickening of the arachnoid and an exudation of lymphocytic cells; this reaction may subside or develop into cicatrisation and fibrosis of the meninges. (d) Perivascular round-cell infiltration.

In assessing the above evidence, the following points must be borne in mind as they modify considerably the conclusions which may be drawn from these researches. In the first place, the earlier workers used Stovaine as the

anaesthetic agent. This is now recognised to be an irritating and toxic drug. The later workers, e.g. Davis et al (1931) employed doses of procaine and Nupercaine in the experimental animal which were excessive compared with the clinical dose on a weight to weight basis. Further, in the experimental animals used (dogs, cats, rabbits) there is considerably less cerebrospinal fluid surrounding the cord and roots than there is in man, even in proportion to size, and therefore a much smaller amount of cerebrospinal fluid is available for the rapid dilution of the injected drug than is available in the human patient. With the less toxic drugs in use at present and their employment in low concentration, the reactions tend to be limited to the meningeal reaction. Nevertheless there are infrequent reports of serious neurological lesions in the literature.

The Cauda Equina Syndrome.

Most of the permanent or protracted nerve lesions reported in the literature (weakness of legs, bladder disturbances, patulous anus, impotence, anaesthesia of perineum and sacral areas, etc.) are indicative of damage to the lumbar and sacral nerves which form the cauda equina. The vulnerability of the cauda equina is due to its proximity to the site of injection, where it receives the full concentration of the drug as it leaves the point of the needle, before dilution and dispersion can take place.

Ferguson and Watkins (1938) record fourteen cases which developed a cauda equina syndrome following the administration

of a spinal anaesthetic ("heavy" Duracaine - 10% procaine with gum acacia and glycerine in 15% ethyl alcohol.) Thirteen of these cases occurred within a period of twenty months. Their first case is quite typical of the series, and is quoted from their paper as an illustrative example:-

Case I, F.J., male, age 17 years, was admitted to Manchester Royal Infirmary, August 18th, 1933, suffering from acute appendicitis and spreading peritonitis. Operation was performed under spinal anaesthesia for which "heavy" Duracaine was employed. Following operation there was absolute retention of urine and incontinence of faeces. Examination revealed - absence of left ankle jerk; diminished sensation to pin-prick over the 'saddle' area; diminished calf tenderness and hypalgesia of the left leg; marked fibrillation in the left lower limb and to a lesser extent in the right; anal sphincter tone absent. The patient made a good recovery from the abdominal condition. Urine was not passed spontaneously till the twelfth day. On September 21st, 1933, the patient reported that there was now no rectal incontinence but, on the contrary, there was a tendency to constipation. He suffered from frequency, passing urine every two hours by day and twice during the night. Within a few weeks urinary function returned to normal.

This patient was examined on four occasions between September 1933 and January 1936, during which time he was well, bowel and urinary function were unimpaired, and good anal sphincter tone had returned.

On examination in January, 1936, it was found that there was no bladder or bowel dysfunction; the left ankle jerk gave only the slightest flicker, and there was diminished sensation to pin-prick in the 'saddle' area.

Ferguson and Watkins conclude that the run of 14 cases within a short period was due to the employment of "heavy" Duracaine. They postulate that the gum acacia and glycerin contained in this preparation results in the procaine being held in contact with the nerves of the cauda equina in high concentration for an undue length of time. The procaine exerts a neuro-toxic effect, possibly in particularly susceptible patients.

The concentration of procaine in heavy Duracaine (i.e. 10%) is unduly high. Lundy (1942) recommends that the concentration used clinically should never exceed 5%. Animal experiments with procaine show that, clinically, the safety margin is too narrow, and concentrations often used to produce spinal anaesthesia in man approach too closely the concentrations shown to produce permanent lesions in dogs.

Macdonald Critchley (1937) describes eight further characteristic cauda equine lesions following spinal anaesthesia. One of these cases (case VII), quite typical of the syndrome, is cited here. - The patient, a man aged 40, had a leg amputated under 'Planocaine' (procaine) anaesthesia. Thereafter retention of urine and foot-drop were noticed. Knee and ankle-jerks were unobtainable on the remaining limb and the plantar response was extensor.

Later the knee-jerk returned. Sensation was impaired over the outer side of the calf and leg. Flexion and extension at the ankle-joint were almost impossible. The abnormal signs, together with difficulty in passing urine and in defaecation, were present when the patient was examined two months later. It should be noted, as pertinent, that the concentration of 'Planocaine' (procaine) employed in this case is not stated by Critchley.

Acute Degenerative Myelitis.

Cases of acute degenerative myelitis have also been recorded as a complication of subarachnoid block. The reports of this serious development are few and the condition has usually resulted in death. Apart from the fact that only a small number of cases of acute myelitis are recorded, it is sometimes difficult to establish a direct connection between the spinal anaesthetic and a myelitis occurring some weeks later. The possibility lies open that it is by mere chance or coincidence that a patient who has received a spinal anaesthetic is struck down some weeks later with an acute ascending myelitis, but in such circumstances it is not unnatural for the physician and the patient to connect the one with the other, and most likely they may be right.

The following case is described by Russell Brain (1937) as one of myelomalacia following spinal anaesthesia. The patient was a man of 33, a pastry-cook. Apart from suffering from chronic bronchitis, his general health was good. He was admitted to hospital on account of a displaced right

semilunar cartilage, and on September 3rd, 1934, this was operated upon under a spinal anaesthetic - Spinocaine (procaine 10%). He had no symptoms until a week after the operation, when he complained of pain in the lumbo-sacral region of the spine. He made a good recovery from the operation and was discharged from the hospital, walking. Nearly a month after the operation, he began to have pain in the left knee and increasing difficulty in walking. He had to go to bed and developed a feeling of numbness in the left foot, which gradually spread up the leg. At the same time the right leg became weak and the pain in the back increased so that he had difficulty in turning in bed. This pain spread upwards and became severe and gripping round the waist. He was re-admitted to hospital on October 24th and on that date developed retention of urine. On examination on 8th November, the fundi, pupils and cranial nerves were normal. In the upper limbs there was slight symmetrical wasting of the small muscles of the hand, with moderate weakness of movement. There was marked weakness of flexion of the spine on the hips and the patient was unable to sit up unaided. The abdominal reflexes were absent. In the lower limbs there was moderate wasting of all muscles and this was symmetrical. Bilateral foot-drop and almost complete flaccid paralysis of both lower limbs had developed. The knee and ankle-jerks were

absent and the plantar responses were very feebly flexor. Slight impairment of appreciation of light touch over the dorsum of both feet and considerable loss of sensibility to pin-prick over all the sacral segmental areas was noted. There was gross loss of postural sensibility in the toes of both feet and the vibration of a tuning fork was not appreciated over the feet or the left shin. Retention of urine and obstinate constipation were present. On October 30th, examination of cerebrospinal fluid yielded the following results: Protein 270 mg. per ml., globulin ++, no excess of cells, Wassermann reaction negative. Subsequently there was no change in the patient's neurological condition and he died on December 24th, 1934, from complicating infection.

Pathological examination showed a massive softening of the spinal cord maximal at the level of the upper part of the lumbar enlargement. There was brownish-grey discoloration and extreme softening of the lower part of the 12th thoracic segment, which extended caudally to the upper part of the 2nd lumbar segment. Below this level the softening gradually diminished. The pia over the posterior surface of the sacral segments was replaced by a plaque of opaque grey exudate. Apart from this there was no macroscopic evidence of meningitis. Sections of the 3rd and 5th lumbar segments showed complete necrosis of the grey, and almost complete necrosis of the white matter. Only occasional myelin sheaths were seen and most of the glial cells were destroyed. The most striking histological changes were those present in the pial blood vessels and in the small perforating arterioles in the periphery of the cord. Both the medium-sized and the smaller arterioles had undergone partial or complete hyaline necrosis which gave a positive reaction for fibrin. The anterior and posterior spinal arteries were unaltered, except over the 5th lumbar segment where each posterior spinal artery contained a crescentic mass of unorganised thrombus. There was endophlebitis of many of the larger pial veins. At higher

levels of the cord, the histological changes were similar but less intense. The portions of peripheral nerves examined showed no abnormality.

The pathologist concluded that the massive softening of the cord was secondary to the severe changes in the pial and perforating vessels. There was no evidence of direct trauma to the cord at the time of the spinal anaesthetic, nor of meningitis nor haemorrhage. As there was no evidence that Spinocaine (procaine) caused vaso-constriction of vessels, the pathologist considered the most likely explanation was that the patient, a pastry-cook, had become sensitised to foreign protein, and that the Spinocaine (containing gliadin, a wheat protein) caused a hyperallergic arteritis. Russell Brain mentions the possibility of a virus infection introduced at the time of the spinal anaesthetic, although the pathological changes described do not appear to support such a view.

Reported Lesions.

Nicholson and Eversole (1946) published details of a case which they took to be due to a virus infection. The patient, a man of 30 years of age, had obvious chicken-pox two days before operation. Immediately following operation, he presented all the symptoms of a transverse myelitis of the upper lumbar region. He had complete motor and sensory loss below the waist, with loss of bladder and rectal function. This patient made a gradual recovery over a period of six weeks. The case was interpreted as a myelitis caused by the chicken-pox virus, with the spinal anaesthetic acting as the exciting agent.

Brock, Bell and Davison (1936) report seven instances which they have personally observed of neurological complications after spinal anaesthesia. They were examples of meningitis, cauda equina lesions and one case of transverse myelitis which had a fatal issue.

Kennedy, Effron and Perry (1950) report 5 cases of the cauda equina syndrome, 6 cases of adhesive arachnoiditis and 1 case of a cerebro-vascular accident, following spinal anaesthesia. These cases came to their attention in a neurological unit serving a large and populous region of America, and in presenting them they conclude that grave paralysis is too often the sequel of spinal anaesthesia. In 6 of these 12 cases the concentration of the local anaesthetic agent is not stated, in 2 cases even the name of the drug is not given, and in only 1 case is the dosage mentioned (concentration omitted). In one case the lesion followed the use of a 5% solution of amethocaine, i.e. a concentration twelve times as great as that employed by the author. In the cases of late adhesive arachnoiditis there is no indication whether or not sepsis had intervened. The cerebro-vascular accident followed a period of cyanosis and apnoea lasting 1 to 2 minutes. Due to the dearth of highly relevant details of administration, it is impossible to assess the true significance of the occurrence of neurological lesions in these cases. The concentration of the anaesthetic drug is so frequently not stated, and without this vital piece of information these reports are valueless, for it has been shown unequivocally that too high a concentration of the drug readily produces permanent damage to nervous tissues.

(3) Sepsis.

It might seem sufficient to say that infection of the cerebrospinal fluid and the meninges should never occur. This is true and obvious, but it is worth while studying the occurrence of meningitis following spinal anaesthesia, its incidence and mode of production, and then considering whether the possibility of this complication arising is sufficiently real to contra-indicate the use of spinal anaesthesia. The exact incidence of infection is not known and reports in the literature are scanty. This may be due to an understandable reluctance to publicise a mishap which reflects on the fastidiousness of the technique, or else the incidence may be very low. The writer's observations of several large series of spinal anaesthetics in the teaching Hospitals of a large city, and his participation in some of them, lead him to think that meningitis need never occur. Nevertheless Ericsson (1947) in Sweden, where spinal anaesthesia is used a great deal - Ericsson puts the number at 25,000 to 30,000 in a year - estimates the incidence of meningitis at 1 in 400 cases.

Literature - Reports of Cases.

Infection of the cerebrospinal fluid comes about in the same way as infection of any other region of the body during a surgical intervention - viz., by contamination. The normal cerebrospinal fluid contains none of the antibodies normally present in the blood, nor do any of the antibodies acquired as the result of vaccination or immunisation by disease enter the cerebrospinal fluid through the intact choroid plexus or

meninges. (Merritt and Fremont-Smith 1938). However, if there is an inflammation of the meninges as the result of infection or the injection of chemicals etc., a small amount of the antibodies in the serum may enter the cerebrospinal fluid. While the cerebrospinal fluid and meninges may cope poorly with infection and the consequences of infection are grave, there is no reason to think that infection (i.e. contamination with organisms) occurs more readily here than elsewhere in the body. The actual technique of spinal anaesthesia is simple and uncomplicated, and the exposure of tissues and fluids could hardly be less.

A study of the available literature reveals some interesting features. The most striking feature is that cases tend to occur in definite outbreaks which cease when the aseptic technique is scrutinised and revised. Barrie (1941) reported eleven cases which occurred within three months among 96 patients operated upon under spinal anaesthesia at a large provincial hospital. The cause was traced to a defective bacterial filter for the sterile water supply. The use of such filters was later abandoned for a more perfect aseptic technique. No definite organisms were identified from the cerebrospinal fluid of these cases, so that the organism must have been attenuated to such a degree that it could not be cultured, or a virus may have been responsible.

Another outbreak occurred in the Middle East in 1942 among British Service personel. Kremer (1945) reported seven cases of meningitis within a year from three Hospitals. All

seven cases eventually came under Kremer's care in the Middle East. Six of them followed spinal anaesthesia with 1 in 1500 Nupercaine, and one followed a diagnostic lumbar puncture (the cerebrospinal fluid was normal at the time of the lumbar puncture). The cases which followed spinal anaesthesia ran a prolonged course, and all but one developed a late arachnoiditis causing blockage at some level of the spinal subarachnoid space, usually in the lumbar region. One patient succumbed, and another, after a long illness, was left with some physical and marked mental deterioration. The organisms cultured were Ps.pyocyanea and atypical B. coli. These cases were carefully investigated with a view to detecting the lapse in asepsis. Ampoules of 1 in 1500 Nupercaine, some from the same batches as those used in the cases which developed meningitis, were examined and found sterile. The extraordinary fact emerged, however, that organisms could be cultured from every other fluid used for spinal anaesthesia. Bacteria were found in the local anaesthetic solution used for anaesthetising the skin prior to lumbar puncture, in the spirit used for sterilising and storing syringes, and in the 'sterile' water used for rinsing the syringes before use.

Frankis Evans (1945) describes two fatal cases of meningitis. The spinal anaesthetics were administered within three days of each other in the same operating theatre, by the same anaesthetist. Ps. pyocyanea was the organism cultured in both cases. The syringes and needles were kept

in spirit and rinsed with cold sterile saline before use. The source of infection was not traced in these two cases, but some time previously in the same Hospital, Ps. pyocyanea had been found in 'sterile' distilled water which was stored in a Winchester jar. Ampoules of heavy Nupercaine from the same batch as that used in the infected cases, were examined and were found to be sterile. Evans suggests that the local anaesthetic solution used for anaesthetising the skin may have been contaminated by a syringe which had been rinsed out in water infected with Ps. pyocyanea.

Medico-legal Aspects.

The proper sterilisation of needles and syringes has now acquired a medico-legal significance. In April 1947 the High Court awarded £12,000 damages against a Hospital Authority to a young man who contracted meningitis after a spinal anaesthetic (B.M.J.1947.1.660, and B.M.J.1948.2.446). This case hinged round the question of aseptic technique and methods of sterilisation of instruments in spinal anaesthesia. The operation, manipulation of a fractured femur, was carried out with the patient in his bed in the ward, the needles and syringes being brought from the operating theatre. The house medical-officer acted as anaesthetist. The patient developed permanent paralysis of both legs and incontinence of urine. Ps. pyocyanea was found in the cerebrospinal fluid.

A nursing sister gave evidence that immediately after use a syringe was rinsed with water, soaked in pure lysol and then in methylated spirit and finally placed in a glass container

with formalin tablets. So far as she knew, the normal procedure had been followed in the present case, but there was no satisfactory evidence of this. A consulting surgeon stated that he considered these precautions inadequate. Complete protection could only be given by sterilisation with superheated steam in an autoclave. Since this accident he had given instructions for sterilisation of needles and syringes by autoclave. He thought that infection could not be introduced into the spinal canal without a breach of technique.

Lord Justice Bucknill stated that there was sufficient evidence that the patient's injury was directly due to the spinal injection and the cause of the disease was negligence and breach of duty by the Hospital Authority's servants in failing to carry out proper aseptic precautions.

As a consequence of this ruling there is a clear inference that Hospital Authorities (and in some cases the practitioners concerned) will find themselves in a dangerous situation if meningitis should develop after spinal anaesthesia where the strictest aseptic technique, including sterilisation by autoclaving, has not been practised.

It has already been shown that spinal anaesthetic drugs, especially the earlier ones used can produce an aseptic meningeal irritation with an increase of protein in the cerebrospinal fluid. Such a condition might well favour the growth of any organisms which gained entrance to the subarachnoid space.

Weed, Wegeforth, Ayer and Felton (1919) put forward experimental evidence to show that if a bacteriaemia is present, lumbar puncture at this time can result in infection of the cerebrospinal fluid with the same organism. These findings were substantiated by Remson (1936), but it has been found that it requires a very heavy bacteriaemia to produce this result. That spinal anaesthesia is contra-indicated in septicaemic conditions is well established. This cannot be the explanation of the cases reported by Kremer, four out of seven of whom were healthy young soldiers undergoing repair of herniae.

Late Proliferative Arachnoiditis.

It has been stated that, without any clinical history of septic-meningitis, symptoms apparently due to a late proliferating arachnoiditis can, very rarely, succeed a spinal anaesthetic. Thorsen (1947) describes one such case, the direct sequel he argues, of the aseptic irritative reaction of the meninges to irritating drugs. This patient was a woman aged 60 who died three years after a gastric-resection performed under spinal anaesthesia (Nupercaine). The nature of the lesion necessitating the gastrectomy is not stated, nor are any further details of the anaesthetic technique. The anaesthetic was uneventful and the patient was completely free from all symptoms for four months. She then complained of weakness of the legs. The cerebrospinal fluid was normal and a diagnosis of neurosis was made. Paraplegia gradually developed, with diminished sensibility

below the 12th thoracic segment, and bladder paresis. Repeated examination of the cerebrospinal fluid was negative. The Queckenstedt test gave no evidence of spinal block. The patient died of bronchopneumonia three years from the date of operation. Post-mortem examination revealed a chronic proliferative arachnoiditis and evidence of a previous myelitis. In the lower thoracic and lumbar regions the cord was alternately thin and thick and of a flaccid consistency. In the lumbar region the cord was surrounded by a thick membrane of fibrous tissue in which the nerve-roots were embedded. In the thoracic region the fibrotic arachnoiditis was not so pronounced.

Hewer (1933), in discussing Ashworth's paper on the late complications of spinal anaesthesia, briefly describes a case anaesthetised with 1 in 1500 Nupercaine, injected at the level of the first lumbar interspace. This patient developed pains and weakness of the right leg, and at laminectomy nine months later, the lower part of the cord and the upper part of the cauda equina was constricted by a fibrous sheath.

The writer has no knowledge of any such late complication developing in his cases, nor did septic meningitis occur in his series. The occurrence of septic meningitis as a sequel to spinal anaesthesia is very rare in this country. Falkner Hill (1945) quotes his series of 8,000 spinal anaesthetics with no evidence of meningitis. Skin sepsis in the lumbar region is an absolute bar to the employment of spinal anaesthesia and septicaemia is a strong contra-indication.

Provided these contra-indications are observed and a fastidious aseptic technique is carried out, there is no justification for avoiding spinal anaesthesia on the grounds that septic meningitis might be a sequel.

(4) Prolapsed Intervertebral Disc.

Wilson (1949) records the case of a young soldier operated upon for a prolapsed intervertebral disc which was apparently the sequel of lumbar puncture and spinal anaesthesia. In November 1945 he was treated in a Military Hospital for the surgical cure of an inguinal hernia, spinal anaesthesia being attempted. At the time of lumbar puncture he experienced shooting pains down both legs, but the subsequent analgesia was unsuccessful. Thereafter he complained of persistent backache and left sided sciatic pain. X-ray examination demonstrated narrowing of the disc space between L.4. and 5. Forward flexion of the spine was greatly diminished, but there was no disturbance of sensation and the reflexes were intact. Laminectomy was later undertaken and revealed marked protrusion of the 4th lumbar intervertebral disc and nuclear material escaping through a pin-hole opening. The 5th lumbar spinal nerve roots were being compressed by the herniation of the disc.

It might be doubted whether a single needle-puncture could of itself be sufficient to produce prolapse of the disc, but if this is so, there is a clear implication that

the technique of lumbar puncture must have been very faulty. It is obvious, when one considers the anatomy of the vertebral column, that lumbar puncture should in no way involve the intervertebral disc, as the needle should never reach the posterior longitudinal ligament of the vertebral bodies, let alone the disc. In order to traumatise the posterior longitudinal ligament and the disc, the needle must completely traverse the subarachnoid space and emerge anterior to it.

* * * * *

Lest the foregoing account of neurological sequelae should leave a distorted impression of their frequency and severity, it is necessary to state that there are many reports of large series of spinal anaesthetics with no serious or permanent complications. Thus Stein and Tovell (1935) state that in over 10,000 cases of spinal anaesthesia undertaken in the Mayo Clinic, there has been no case of permanent palsy and that areas of altered sensation which may occur in the legs are always of a transitory nature. Shimberg (1935) notes that in 14,073 spinal anaesthetics administered to veterans in Washington, there were no permanent paraplegias, two cases of non-specific meningitis, three cases of transitory peripheral neuritis and no cases of permanent sensory loss.

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Section V.

GENERAL ACCOUNT OF SPINAL ANAESTHESIA.

1. The Development and Trend of Spinal Anaesthetic Practice.
2. Covering Anaesthesia.
3. Armamentarium.
4. Lumbar Puncture Technique.
5. Sterilisation.
6. Author's own Technique in detail.
7. Advantages and Disadvantages : Indications and Contra-indications.
8. Psychological Considerations.
9. Opinions of Nursing Staff.
10. Extra-dural Block.
11. Diagnostic and Therapeutic Uses of Spinal Block.

Section V.

GENERAL ACCOUNT OF SPINAL ANAESTHESIA.

1. The Development and Trend of Spinal Anaesthetic Practice.

The evolution of spinal anaesthesia can be traced by reviewing briefly the more important techniques introduced from time to time. These different methods illustrate the many ways in which the anatomical factors, physical and pharmacological principles, and technical details have been combined by successive anaesthetists.

(1) Decompression and Barbotage, with Total spinal anaesthesia.

The technique of Le Filliâtre (1921), which dates from 1902, employed 1 to 3 c.c. of a 1½% solution of cocaine and was based upon dispersion of the initial dose by decompression of the spine and by barbotage. Lumbar puncture was performed in the fifth lumbar interspace and up to 30 ml. of cerebro-spinal fluid was withdrawn and discarded. The cocaine solution was then injected with frequent barbotage. Total spinal analgesia was produced by the maximum dosage. This was a hazardous method because cocaine readily gives rise to acute poisoning; because decompression may produce a 'pressure cone'; because the respiratory effects of high blocks were not appreciated. Such limited success as this method attained was due to the fact that cocaine has a marked sensory selectivity, leaving the motor function comparatively unaffected.

(2) Gravity Control.

Barker (1907). Here for the first time the principles of gravity control were clearly enunciated and beautifully exemplified. Barker used a heavy (hyperbaric) solution of 5% Stovaine (specific gravity 1030). The patient lay first in the lateral position and immediately after the completion of the injection was put horizontal and supine. A pillow was placed under the lumbar spines, and pillows supported the head and shoulders. The dorsal curve was thus exaggerated and the heavy solution flowed slowly towards the most dependant part, i.e. towards the fifth dorsal spine. This technique was a great advance on the preceding ones, but the toxic and damaging Stovaine was the drug employed.

(3) Procaine crystals with Cerebrospinal fluid as solvent.

Labat (1928 and 1930) had a great influence on the development of spinal anaesthesia. Procaine had now come to the fore as the drug of choice and Labat insisted on a simple and straightforward preparation. He recommended .1 to .2 G. procaine crystals dissolved in cerebrospinal fluid, with barbotage for upper abdominal requirements. He varied the height of puncture from the fourth lumbar interspace to the twelfth dorsal interspace, depending on the desired level of anaesthesia. The other outstanding feature of his technique was his avoidance of ephedrine or other vaso-pressor drugs and his reliance on the early adoption of the Trendelenberg position for combating any fall in blood pressure.

(4) Pseudo-hypobaric and viscid solution.

Pitkin (1928) devised a solution of procaine artificially lightened with alcohol to make its specific gravity less than that of cerebrospinal fluid and made viscid by the addition of prolamine (starch paste). The solution, which he called 'Spinocaine' had the formula -

Strychnine sulphate	0.0022 G.
Procaine (Novocaine)	0.195 G.
Prolamine (starch paste)	0.13 G.
Alcohol	0.324 G.
Normal saline q.s. ad 2.2 c.c.	
Specific Gravity 10005. (hypobaric).	

Pitkin claimed that the viscid character of this solution prevented diffusion of the drug in the cerebrospinal fluid and he visualised it floating within the subarachnoid space "like the air bubble of a spirit level". This preparation, which had great popularity in America, permitted the immediate adoption of a Trendelenberg position, although Pitkin's conception of the behaviour of the injected solution was not entirely correct. It seems likely that the alcohol in the solution would very quickly separate out, leaving the active part of the solution nearly iso-baric with cerebrospinal fluid.

(5) Volumetric Displacement.

Howard Jones (1930) introduced the first truly light (hypobaric) solution in the form of a 1 in 1500 solution of

Nupercaine, the specific gravity of which is 10037 at body temperature. The principle of volumetric displacement is applied and a large volume of dilute solution is injected. The injection is made with the patient in the lateral position, no cerebrospinal fluid is withdrawn, and the patient is then placed prone for six minutes. This manoeuvre allows the hypobaric (light) solution to soak the posterior roots. At the end of this period the patient is turned to a supine position with a 5^{o} Trendelenberg tilt. The dosage of the 1 in 1500 solution varies from 10 c.c. to 18 c.c. for upper abdominal surgery. A guide to the volume required to fill the subarachnoid space to the level of the fourth dorsal roots is obtained by measuring in inches the distance from the seventh cervical spine to the interiliac line; this measurements minus 4 gives the volume of light Nupercaine required in cubic centimetres in adult males.

(6) Seventh Dorsal "Sighting" - A Precision technique.

Lake (1932). This is an interesting modification of the preceding technique. It is designed to secure greater precision of control in the placing of the local analgesic solution and to reduce the volume required by placing a smaller volume exactly where the nerve roots which supply the operation area lie. It thus avoids the necessity of filling the entire subarachnoid space up to the level of the highest roots which require to be blocked. The injection

is made with the patient prone, pillows being placed under the lower part of the chest and with the head slightly hanging over the end of the table to produce a well marked dorsal curve. A black horizontal line is painted upon the operating theatre wall and the table is tilted until the seventh dorsal spine, as "sighted" against the black line, is the highest point of the dorsal curve. The considerable variations in the bodily contours may necessitate tilting the table either up or down in order to bring the seventh dorsal spine uppermost. With the seventh dorsal spine accurately placed 9 c.c. of light Nupercaine will fill the subarachnoid space from the first lumbar to third dorsal segment, and will provide adequate anaesthesia for upper abdominal surgery. Both the Howard Jones and the Lake techniques give excellent results, but the amount of manoeuvring involved is time-consuming and they have tended to be replaced by more expeditious and equally satisfactory methods.

7. Timed ascent of light solution.

Etherington Wilson (1934) used an entirely different and intriguing method of controlling the level of analgesia with light Nupercaine. The injection is made with the patient sitting upright and the light Nupercaine deliberately allowed to rise "like smoke up a many-flued chimney" for a predetermined number of seconds, after which the patient is placed in a 15° Trendelenberg position which halts the further ascent of the solution. The dosage and timing for

a patient of average height is given as follows:-

Low block - 12 c.c. - 40 seconds sitting up.

Medium block - 13 c.c. - 60 seconds sitting up.

High block - 14 c.c. - 80 seconds sitting up.

8. Rachi-Sensitivity.

Sebrechts (1934) bases his technique on the theory that individuals vary in their susceptibility to local analgesic drugs. Those who exhibit greater susceptibility than normal he terms "rachi-sensitive" and those who show abnormal resistance he calls "rachi-resistant". This susceptibility to local analgesic agents varies according to race. The Anglo-Saxon is more rachi-resistant than the Latin. Furthermore, there is an individual variation which Sebrechts believes is familial. He quotes the experience of anaesthetising a father and four sons, all of whom proved rachi-resistant. His procedure, in brief, is to administer 5 c.c. of light Nupercaine every five minutes until adequate anaesthesia is attained. The needle is left in situ until the dosage is complete; it is then withdrawn and after a further five minutes the operation is commenced.

(9) Combination of Drugs.

The anatomical and physiological principles on which spinal anaesthesia is based were now well established. The important factors in technique were known to be the location of the spinal puncture, the force and rate of injection, barbotage, volumetric control, gravity control and combinations

of these. The attention of anaesthetists was turning to a search for the best drug. Cocaine had been abandoned, Stovaine almost so, and procaine was holding the field. Nupercaine, Metycaine and amethocaine were now introduced. Romberger (quoted by Maxson 1938) utilised a combination of procaine and Nupercaine in order to benefit both by the prompt onset of anaesthesia induced by procaine and by the prolonged duration of effect of Nupercaine. He dissolved 100 mg. of procaine crystals in 2 c.c. of a 0.5% solution of Nupercaine, the resulting solution being hyperbaric (specific gravity 1018). The principle of gravity control was then employed.

(10) Continuous Spinal Anaesthesia.

Lemmon and Paschal (1942) introduced the method of serial or continuous spinal anaesthesia. A special malleable nickel spinal needle is left in situ throughout the operation and small doses of procaine are introduced from time to time. It enables minimal dosage to be given without fear of inadequate anaesthesia or of the disappointment of the analgesia wearing off before the completion of the operation on the one hand, and the risks of overdosage in a susceptible patient on the other hand. After lumbar puncture in the lateral position, the patient is turned on to his back. A special mattress is required in which there is a gap to receive and protect the projecting hub of the needle. The needle is connected by fine tubing to a

syringe conveniently placed near the head of the table. Lemmon uses a 5% solution of procaine, the initial dose of which is 100 mg. to 150 mg. An average of 50 mg. procaine is required every half-hour to maintain anaesthesia. A modification of this technique is to thread a fine nylon catheter through a special Tuohy needle and withdraw the needle, leaving the catheter in situ within the subarachnoid space. The catheter is then connected by tubing to the distally placed syringe.

The method seems an admirable one, but so far the author has refrained from practising it. There is more opportunity for technical mishaps to occur, such as the needle becoming disconnected from the tubing while in an inaccessible position, with risks of sepsis occurring during the subsequent manoeuvres.

(11) Total Spinal Anaesthesia.

With the advent of the most recent development, total spinal anaesthesia, the wheel has turned full circle and we are back to one of the earliest episodes of spinal anaesthesia. This was the concept of Le Filliâtre in the first decade of the century and is now re-introduced by Griffiths and Gillies (1948), but with significant differences. Their method is based on a fuller and more comprehensive understanding of the problems involved and on neuro-anatomical and pharmacological knowledge which was denied to their predecessor. The necessity of complete control of

respiration to prevent anoxia is now appreciated and the significance of the fall in blood-pressure has been re-assessed. Griffiths and Gillies developed this method primarily for the operation of thoraco-lumbar sympathectomy in order to provide the surgeon with the almost bloodless field which so greatly facilitates his task. This new technique is far removed from the 'shot in the dark' method which Le Filliâtre and others practised, to the jeopardy of their patients, in 1902.

Anaesthesia is induced with intravenous thiopentone. Lumbar puncture is then performed in the second lumbar interspace and 150 mg. to 250 mg. of procaine dissolved in 3 ml. to 4 ml. of cerebrospinal fluid is injected intra-thecally. The patient is turned on his back and the table immediately put in a steep Trendelenberg position. An inhalation of 100% oxygen is then commenced and continued throughout. The greatest importance is attached to respiratory function and this is assisted or controlled as required. No vaso-pressor, such as ephedrine or Methedrine, is used as this would defeat the purpose of the method.

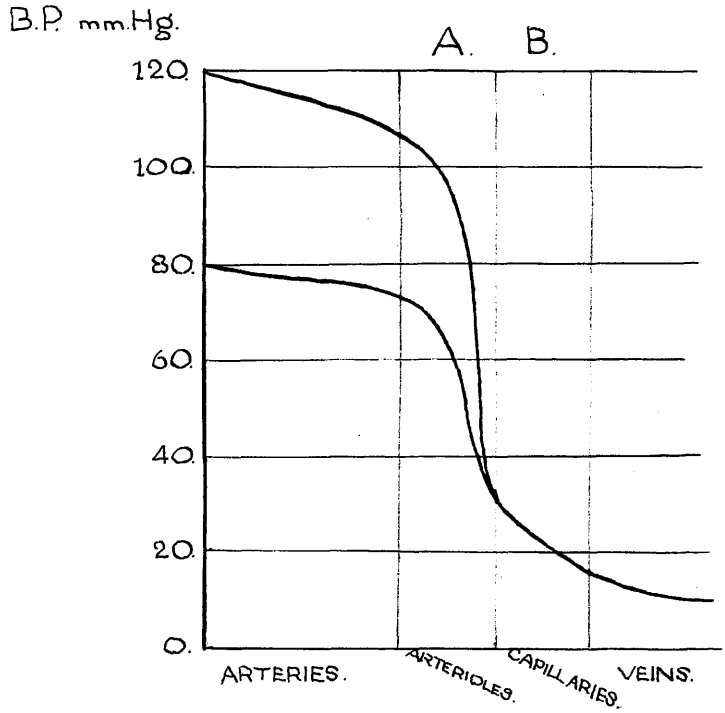
Death as the result of high spinal block is due to paralysis of the motor nerves supplying the muscles of respiration, with consequent anoxia, and not to paralysis of the sympathetic vaso-constricting nerves. Griffiths and Gillies believe that the temporary hypotension of high spinal block is innocuous in the healthy subject, provided that

efficient oxygenation is maintained. Vehrs (1931) states that the heart will continue to function by virtue of its inherent rhythmicity, as long as it receives adequate oxygen. Several thoughtful workers in the past had already held to the belief that respiratory inadequacy was the primary danger in spinal anaesthesia. Amongst them were Fergusson and North (1932), Seevers and Waters (1932), and Maxson (1938).

With correct dilution of local analgesic drugs, differential blocks may be administered to sympathetic and sensory fibres, but leave motor fibres unaffected at least in the higher segments. The method of Griffiths and Gillies is essentially a total sympathetic block, with lesser degrees of sensory and motor paralysis, designed to produce the maximum fall in blood pressure and so permit surgery with the minimum blood loss.

It has been demonstrated by Bradshaw (1936) and by Milwidsky and De Vries (1948) that in high spinal block the resulting fall in blood pressure is due to paralysis of the sympathetic innervation of the arterioles, with consequent arteriolar dilatation. This effect leaves the capillary bed unimpaired, the dilatation of the arterioles actually increasing the blood flow through the arterioles and diminishing peripheral resistance. There is, moreover, a quick return to normal pressure when the effects of the spinal anaesthetic have dissipated. With hypotension due to blood loss and shock the capillary bed is affected and

may be irreparably damaged. It would appear, therefore, that hypotension is of serious clinical import only when the causative factor is haematogenic and when the integrity of the capillaries is imperilled and that it is relatively innocuous when due to neurogenic factors. The clinical experience of Griffiths and Gillies has confirmed this and they have found that an adequate circulation can be maintained, irrespective of blood pressure readings and during extreme hypotension, provided there is a pressure gradient between arterioles, capillaries and veins, and provided also that adequate ventilation of the lungs is ensured. In total sympathetic block, the arteriolar resistance is greatly reduced; under such conditions a pressure of about 30 mm.Hg. suffices to maintain the capillary circulation, provided that the total blood volume is within normal limits and inherent capillary tone remains unaltered. An efficient circulation of oxygenated blood in the capillaries ensures adequate cellular respiration and metabolism, and promotes effective venous filling. These facts are shown diagrammatically on the following page.



DIAGRAMS SHOWING PRESSURES IN THE VARIOUS PARTS OF THE CIRCULATORY SYSTEM, BEFORE AND AFTER TOTAL SYMPATHETIC BLOCK. [AFTER GRIFFITHS AND GILLIES (1948).]

FIG. 1
NORMAL.

A - SITE OF MAXIMUM PERIPHERAL RESISTANCE.
B - SITE OF TISSUE RESPIRATION.

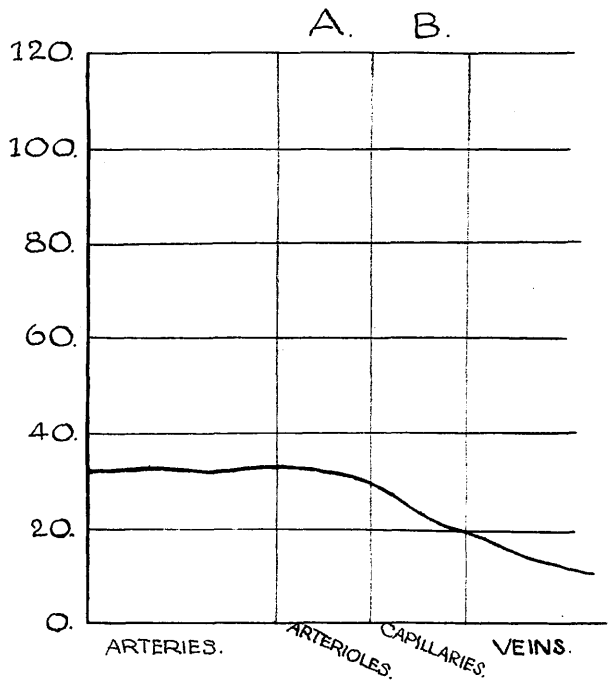


FIG. II
AFTER TOTAL SYMPATHETIC BLOCK.

A. PERIPHERAL RESISTANCE REDUCED.
B. { NORMAL CAPILLARY PRESSURE.
SITE OF TISSUE RESPIRATION.

2. Covering Anaesthesia.

The practice of combining spinal anaesthesia with some form of light general or 'covering' anaesthesia is increasing in frequency and in many units is ordinarily a routine measure. This is a major factor in overcoming the reluctance, frequently encountered, to employ or to submit to spinal anaesthesia. Subarachnoid block is the basis and mainstay of the combined anaesthesia; covering anaesthesia provides relief from mental tension, quietness in the operating theatre and control over the oxygenation of the patient.

The general anaesthetic agents used for this purpose are short-acting intravenous barbiturates and nitrous oxide. In the small doses required to produce the lightest levels of unconsciousness - for complete analgesia and relaxation are secured by the spinal block - these are innocuous and non-toxic. They produce none of the disadvantages of complete and deep general anaesthesia. The most recent development is to produce unconsciousness with intravenous thiopentone before the lumbar puncture is performed and thereafter to continue the state of light sleep with nitrous oxide and oxygen. Thus the very real psychological barrier to spinal anaesthesia is removed from the minds of patients, many of whom remain unaware of the nature of the anaesthetic administered. However, in the overriding interests of their safety, the advantages of unconsciousness must be denied to patients with a full stomach or vomiting as the

result of intestinal obstruction.

3. Armamentarium.

The armamentarium required for spinal anaesthesia is of the simplest character - viz., a lumbar puncture needle, a syringe and an ampoule of local anaesthetic agent. This very simplicity of apparatus might lead one to assume that the procedure itself is stereotyped and inflexible. But indeed the possibilities of variation are very great. The selection of suitable needle, syringe and drug; the wide variety of techniques used to control the resultant anaesthesia; the various methods of sterilisation of hands, skin and agents - all these provide a number of variables, the permutations and combinations of which allow the anaesthetist considerable flexibility. It follows therefore that not only must the anaesthetist have a sound knowledge of the anatomy and physiology of the subarachnoid space and of the pharmacology of the drugs used, but also considerable discernment is required that the correct choice may be made and all factors combine to produce the optimum effect with the least disturbance to the patient. Moreover, the finesse and dexterity with which the manoeuvre is performed must obviously influence the results, both immediate and remote. It is too often assumed that the administration of a spinal anaesthetic consists only of taking a syringe and needle, finding the third lumbar interspace and injecting therein the appropriate amount of anaesthetic agent.

It is this deceptive simplicity which encourages an inexperienced person to attempt this method on occasions when he is aware that he is not sufficiently skilled to produce satisfactory anaesthesia by other means. Any bad effects which follow are then conveniently attributed to the method and not to the administrator.

The lumbar puncture needle should be 7 cms. long and made of stainless steel. Its external diameter should not exceed 1 mm. (22 British Wire Gauge). It should have a sharp point and a short bevel cut at an angle of 45°, and have a well fitting stilette. Both the Howard-Jones and the Pitkin needle conforming to the above requirements are satisfactory. All-glass syringes are ideal but the glass nozzles are fragile and easily damaged. Syringes with glass barrels and all-glass pistons but with metal end pieces are very satisfactory. The unequal rate of expansion with heat between a metal piston and a glass barrel is apt to cause difficulties. The syringes used for spinal anaesthesia should be strictly reserved for this alone, and used for no other purpose whatever (and especially not for diagnostic lumbar-puncture).

A Hagedorn needle is useful for making a preliminary nick in the skin, or an introducer may be used. An additional hollow needle may be required for aspiration and mixing.

4. Lumbar Puncture Technique.

The technique of lumbar puncture does not require detailed description here. It suffices to say that the third lumbar interspace (Quincke's point) or the fourth lumbar interspace (Tuffier's point) should be chosen. It is unnecessary to consider higher interspaces as at these levels a spinal anaesthetic can be made to attain any desired height and the spinal cord is not exposed to the possibility of injury. The middle line should be adhered to strictly throughout. The subarachnoid space is reached at a depth of 5 cms. in the average adult. The anaesthetist soon learns to appreciate the sudden feeling of lessened resistance when the tough interspinous ligament has been passed, and the second but less marked feeling of 'give' as the dura is pierced. The author has occasionally heard a district crack-like sound as the dura is pierced.

The approach through the midline of the back is the one most commonly used, but a lateral approach is also described - viz., the needle is inserted half-an-inch to one side of the midline, with the object of avoiding the tough interspinous ligaments. This was Quincke's original recommendation and the lateral approach is still preferred by some experienced anaesthetists, but it has two disadvantages. Firstly, the network of veins surrounding the dura is denser here than in the midline, consequently puncture of a vein is more apt to occur. However, as it has been shown by Pitkin (1928)

that the cerebrospinal fluid pressure is greater than the pressure in the dural veins, puncture of a vein will produce minimal bleeding into the cerebrospinal fluid. Nevertheless, even a drop of blood entering the needle, if it is not allowed to be washed clear, will by its alkalinity neutralise some of the acid anaesthetic solution and the red blood cells may be irritating to the meninges. Secondly, the point of the needle is more liable to touch one of the posterior roots of the cauda equina, causing a momentary shooting pain down one limb. The writer has found the strictly median approach satisfactory in every way.

Lumbar puncture is carried out with the patient either in the lateral position or in the sitting position, depending partly on the subsequent technique of spinal anaesthesia to be carried out and partly on the individual preference of the anaesthetist. It is usual to place some simple dressing over the skin puncture wound, although Babcock (1928) with his extensive experience of 25,000 cases and who applies no dressing whatsoever, has never seen sepsis of the puncture wound.

5. Sterilisation.

The sterilisation of the necessary equipment, the anaesthetist's hands and the skin of the patient's back is of the highest importance. The routine must allow no opportunities for lapses in aseptic technique. In the

author's opinion 'dry' sterilisation must be used. Wet needles and syringes, such as those presented in a dish of water after boiling, and wet hands,may introduce a medium for bacterial growth. Dry sterilisation in an electric oven or autoclaving the complete requirements (including ampoules and files) are both satisfactory. The anaesthetist's arms and hands must be thoroughly washed and dried on a sterile towel, and most authorities recommend the use of sterile rubber gloves. The patient's back must also be washed with soap and water and dried, preferably by a nurse or assistant. It is then swabbed with an antiseptic such as amino-acridine or 'Cetavlon' (Cetrimide B.P.C.) followed by spirit and finally dried with a sterile swab.

6. Author's Technique in Detail.

The technique the author has evolved to suit his personal requirements is as follows:-

(a) Sterilisation. Kilner glass jars containing the complete armamentarium are autoclaved at a pressure of 5 lbs.per sq.in. for half-an-hour. A temperature between 105° Centigrade and 110° Centigrade is attained. The contents of the Kilner jar are as follows:-

Pitkin lumbar puncture needle, size 22 B.W.G., 7 cms.in length.
5 c.c. glass syringe.
Ampoule of Spinal 'D' Isotonic solution, 5 c.c. (amethocaine 20 mg.).
File. Hagedorn needle or Introducer.
Hypodermic needle, size number 2.

PHOTO I.
KILNER JAR AUTOCLAVED AND READY FOR USE.

The shaft of the lumbar puncture needle is enclosed in a piece of glass tubing slightly longer than the shaft of the needle and of an internal diameter which does not admit the hub of the needle. The object of this glass tubing is to protect the point of the needle during the packing of the Kilner jar before sterilisation and again when the sterilised contents of the jar are emptied on to a sterile towel before use.

A small trolley-table is covered with a sterile rubber sheet and a sterile towel; on top of these is placed a sterile swab. The anaesthetist, wearing a cap, mask and clean plastic apron, opens the Kilner jar and carefully decants the contents on to the sterile towel. PHOTO II.

The anaesthetist then proceeds to wash his arms and hands for 5-7 minutes, which are then immersed in a deep bowl of fresh spirit for ½ minute and carefully dried on a sterile towel. The author does not wear sterile gloves but adopts a stringent 'no touch' technique. At no time does he touch with his hands the distal half of the shaft of the needle or the patient's back. The ampoule is picked up in the sterile swab, opened, and the contents aspirated into the syringe. He then turns his attention to the preparation of the patient's back. Using swabs held in sterile swab-holders, the whole back from the mid-thoracic region to the sacrum is swabbed with amino acridine, or cetrimide, followed by spirit, and finally dried with a dry swab. An assistant palpates the highest point of the iliac crest. The skin over the chosen interspace is punctured with the Hagedorn needle or the introducer. The spinal needle is then inserted, lumbar puncture completed and the injection made.

(b) Drug. In the last three years (1948-50) the preparation known as Spinal 'D' Isotonic was used almost exclusively. This is a 0.4% solution of amethocaine hydrochloride, with 4.6% dextrose, isotonic with cerebrospinal fluid. Its action is prolonged (1½ - 2 hours), covering the duration of most operations. The technique is simple, requiring neither dilution nor barbotage, and the clinical results are satisfactory.

(c) Premedication and Covering Anaesthesia. Premedication is administered in every case. This is most commonly 'Omnopon' gr.1/3, with Scopolamine gr.1/150, which is given subcutaneously one hour before operation. In patients over the age of 60, the author prefers to substitute Atropine gr.1/100 in place of the Scopolamine.

Covering anaesthesia is provided in all cases except where the operative procedure is short and trivial, e.g. cystoscopic examination, or where the general condition of the patient contra-indicates it. A small minority of patients express a wish to remain conscious throughout, but this is unusual. In most cases, the patient is first anaesthetised with intravenous thiopentone in the ante-room to the operating theatre, a dose of 0.5 G. to 0.6 G. being sufficient for the average case. Thereafter the patient is transported to the operating table. He is then sat up, carefully supported by two assistants, and lumbar puncture performed, after which he is returned to the supine position and light anaesthesia continued with nitrous oxide 70% and oxygen 30%, using a semi-closed method with a Boyle's machine. Further small intermittent doses of thiopentone will usually be required in the course of an operation lasting longer than 30 minutes. If the patient is frail and elderly, the author prefers to perform spinal anaesthesia first and induce general anaesthesia later, but this is not the type of patient for whom one would commonly choose spinal anaesthesia.

(d) Lumbar puncture and spinal injection. The author performs all lumbar punctures in the sitting position at the third lumbar interspace in the midline. In this position lumbar puncture is easiest, and a rapid, clean and atraumatic puncture is more certain. In this position also, the back can be arched naturally, and in the conscious patient it is less psychologically disturbing than assistants holding the back well flexed in the lateral position. The sitting position is the logical position for low block, to allow the hyperbaric solution to gravitate downwards. High blocks are easily attained by placing the patient in a 10^{o} Trendelenberg position immediately the spinal injection is completed. Skin puncture is effected with a Hagedorn needle. The spinal needle is inserted with the bevel directed to one or other side. A few drops of cerebro-spinal fluid are allowed to escape to confirm that the needle is really within the subarachnoid space.

Guide to dosage in average cases (without dilution or barbotage) -

Level of Block.	Spinal 'D' isotonic (.4% amethocaine).
Perineum (S. & L.2)	2 ml. (8 mg. amethocaine H Cl)
Lower Abdomen (T.10)	3-4 ml.(12-16 mg. ")
Upper Abdomen (T.2)	5 ml. (20 mg. ")

The injection is made moderately slowly for low blocks, but more rapidly for higher blocks.

A dry sterile swab only is placed over the skin puncture wound but no occlusive dressing is applied. No infection of the puncture wound has ever occurred.

A steep Trendelenberg position is permitted two minutes after injection for operations within the pelvis, e.g. hysterectomy. Vaso-pressor drugs are not used routinely, but 'Methedrine' (d-N-methylamphetamine Hydrochloride) 10-20 mg., is administered intramuscularly if there is any anxiety about the patient's condition. The author used to take routine blood pressure readings throughout the course of anaesthesia, but does not do so now, preferring to be guided by other clinical signs of at least equal importance. If the patient's respirations are regular and of moderate rate and sufficient amplitude to ensure good oxygenation, if his skin remains dry and warm and the capillary refill brisk, then the actual systolic and diastolic levels are of subsidiary importance.

7. Advantages and Disadvantages; Indications and Contra-Indications.

Advantages. With spinal anaesthesia, the nerves supplying the operative field can be blocked with the minimum of toxicity and the least possible disturbance to biochemistry. As little as 150 mg. of procaine or 20 mg. of amethocaine can be placed within the subarachnoid space to provide effective analgesia and unsurpassed abdominal relaxation in

the most robust of individuals. The introduction of curare and other muscle relaxants has undoubtedly offered an alternative to the use of spinal anaesthesia in many cases, but, even so, spinal block retains the advantages, not shared by the muscle relaxants, of reduced bleeding, contraction of the gut and the blocking of harmful stimuli.

Disadvantages. Headache must have a prominent place among the disadvantages. In this series the incidence of very slight headache has been 13.2%. These headaches are so very mild and transitory that careful questioning has been necessary to establish the incidence. Very frequently the patient has not spontaneously complained of headache and it has therefore little more than a nuisance value. The incidence of moderate headache however has been 6%, and this must be considered the main drawback. The limit on operating time imposed by spinal anaesthesia, except of course by continuous spinal anaesthesia, is occasionally a disadvantage. A few major operative undertakings within the abdomen will exceed the 2 hours' analgesia and relaxation provided by amethocaine or Nupercaine. These cases can be completed without break in tranquility by deepening the covering anaesthesia. As already discussed, the fall in blood pressure need not be reckoned a disadvantage if the whole anaesthetic is efficiently conducted, but on the contrary it may be an advantage by reducing blood loss and

and also thereby facilitating the surgeon's task.

Indications. Spinal anaesthesia is seen at its best when administered to robust muscular patients undergoing an operation requiring profound muscular relaxation. The view that spinal anaesthesia is indicated for patients too ill to withstand a general anaesthetic has nothing to commend it. It is particularly suitable for operations deep within the pelvis, such as hysterectomy and abdomino-perineal resection of the rectum. It is also well adapted for the repair of herniae, the subjects of which are so frequently bronchitic and resistant to general anaesthesia. It is valuable in the presence of diabetes, as the upset to carbohydrate metabolism is reduced to a minimum. In emergency surgery its use, without covering anaesthesia, avoids the danger of aspiration of vomitus.

It is sometimes stated that pregnant women are particularly susceptible to spinal anaesthesia and that cases for Caesarean section should not be anaesthetised by this method (Hewer, 1948; Minnitt and Gillies, 1944; Montgomery, 1937; Sebrechts, 1940). There is, however, no evidence to support this. The belief probably arose from the fact that, at term, the large gravid uterus has the effect of splinting the diaphragm, and the additional lower intercostal paralysis due to the spinal block has the added effect of producing respiratory inadequacy. Respiratory failure is dramatic and unmistakable, but respiratory inadequacy is insidious and may

be overlooked. Without expert supervision of the respiratory function and aided respiration with oxygen if necessary, pregnant women so anaesthetised may become anoxic and collapsed. Fairfield (1938) condemns the use of spinal anaesthesia for Caesarean section in a review of the records of the maternity units of London County Council for a six year period, 1931 - 36. Out of a total of 79,254 deliveries, 3 women died as a result of spinal anaesthesia ('Stovaine' was the drug used in 2 of these cases). Eight other women died as a result of general anaesthesia during the same period, yet these 8 deaths are dismissed entirely without comment. This seems an illustrative example of an illogical bias against spinal anaesthesia. With proper management the method is safe and reliable. The child is completely unaffected, which is not always the case with an infant delivered under the influence of even a light general anaesthetic, and the uterus retracts briskly. Resnick (1945), reporting 137 Caesarean Sections and 257 operative vaginal deliveries under spinal analgesia, recommends this form of anaesthesia.

Anderson (1950), in a personal communication, states that during the last 9½ years he has personally administered spinal anaesthesia to 624 patients - 553 for Caesarean Section, 53 for hysterotomy and sterilisation, and 18 for other operations. In the first 18 months of this period there were two deaths, both occurring in severely shocked patients

who, it is now realised, were unsuitable cases for this method. During the last 8 years, he has used spinal anaesthesia regularly for Caesarean Section and has found it satisfactory in every way; all patients were in good condition at the close of operation and there were no complications attributable to the anaesthetic.

Contra-Indications. The contra-indications to spinal anaesthesia must be meticulously observed if its reputation is to be upheld. The absolute contra-indications are:-

All diseases of the central nervous system.

Insanity or mental instability.

Sepsis in the region of lumbar puncture (such as acne spots)

Septicaemia.

Deformity and disease of the spinal column.

Moderate to severe shock, especially when associated with haemorrhage.

Advanced intestinal obstruction with collapse and abdominal distension.

The relative contra-indications are:-

The express wish of the patient to avoid spinal anaesthesia.

The extremes of age.

Marked debility from any cause.

Recent coronary thrombosis.

Advanced arteriosclerosis.

Gross hypertension.

Pernicious anaemia and severe microcytic anaemia.

Inexperience on the part of the anaesthetist or surgeon-anaesthetist.

8. Psychological Considerations.

A more indefinable but nevertheless real objection to spinal anaesthesia is the fear which many people possess of

interference with the spine. This appears to the writer to be more than an awareness of possible neurological sequelae. It is an inherent, subconscious fear of injury to one of the vital parts comparable with the heart. "Or ever the silver cord be loosed, or the golden bowl be broken.....then shall the dust return to the earth as it was." (Ecclesiastes XII, 6). This psychological barrier may be overcome by tact, consideration and light covering narcosis, for spinal anaesthesia is too valuable a method to be abandoned on this account. Certainly a direct request from a patient not to be given a spinal anaesthetic is a contra-indication, and the art of anaesthesia is sufficiently versatile to provide a satisfactory alternative.

9. Opinions of Nursing Staff.

The opinions of experienced Nursing Staff regarding anaesthetics are well worthy of attention. The Sisters stand in a neutral position between the patient on the one hand and the surgeon and anaesthetist on the other. By their close contact with patients they secure their confidence in a way often impossible to the anaesthetist, and their knowledge of post-operative care makes them competent critics. Accordingly the writer secured the comments of ten senior Nursing Sisters, those most concerned with the surgical wards and the operating theatre. Their opinions fall easily into three groups.

Group A. (Number of Sisters - ONE). This Sister was definitely averse to spinal anaesthesia. She considered the

after-effects appalling, e.g. headaches and stiffness in the limbs. She had seen one case of permanent paraplegia in another hospital some years previously. She would not have a spinal anaesthetic herself; something about it terrified her. She would not even permit a diagnostic lumbar puncture under any circumstances. (Comment - Even those surgeons and anaesthetists who do not favour spinal anaesthesia do not find it necessary to be so sweeping in their condemnation.)

Group B. (Number of Sisters - ONE). This Sister considered spinal anaesthesia superior to other forms of anaesthesia. Her patients did better, convalesced more rapidly and comfortably than with other anaesthetics. There was only occasional very mild headache which she thought a small price to pay for the advantages conferred. (Comment - Some months previously this Sister's father died the day following a transurethral prostatectomy, an operation usually carried out in her experience under spinal anaesthesia, but performed on this occasion under continuous intravenous thiopentone, and she was inclined to lay the whole responsibility on the anaesthetic.).

Group C. (Number of Sisters - EIGHT). This group was surprisingly uniform in their reactions, which can be quite fairly integrated and summarised as follows:- The results are good and no serious complications have been seen. The incidence of headache, variously estimated at from 1 in 3

to 1 in 20, is annoying but not a great disadvantage. Almost all spontaneously stated that patients were easier to nurse compared with those anaesthetised by other means. Not one mentioned any increased difficulty with post-operative retention of urine. There was expressed a general background of apprehension regarding "spinals", which all admitted was without justification in the light of their experience. The patients were well satisfied with their anaesthetic. Only one Sister recalled one patient who felt aggrieved at the anaesthetic employed. Remarks such as "I would be quite willing to have one myself if it were preceded by 'Pentothal'", and "My father had one and was quite satisfied", were typical.

10. Extra-Dural Block. - Epidural, Caudal and Paravertebral Sympathetic Block.

There are two other forms of regional block which are related to subarachnoid block - viz., epidural block and caudal block. Both these methods are, of course, extra-dural (peri-dural, epidural) in site, but the effects are similar to intra-dural (subarachnoid) block. A larger dose and a larger volume of solution is required, and the level of sensory loss obtained is always much higher than the level of motor paralysis. The time required to reach a given segmental level is much greater than with subarachnoid block. These methods are virtually "spinal anaesthesia" in slow motion. They are open to the objection that accidental entry

into the subarachnoid space, always possible, results in overwhelming overdosage. These methods are more difficult of execution and less certain of effect than spinal anaesthesia, which achieves the same result.

It is the author's opinion that sympathetic and splanchnic blocks also may be more easily and more certainly achieved, and with more comfort to the patient, by spinal anaesthesia than by posterior paravertebral approaches. In his experience, paravertebral sympathetic blocks are painful, and one is sometimes left in doubt whether or not sympathetic block has been successfully effected.

11. Diagnostic and Therapeutic Uses of Spinal Block.

The role of spinal block is not limited to anaesthesia. It has found a useful application in other fields, notably in the diagnosis and treatment of certain conditions of circulatory or sympathetic derangement. In cases of vascular insufficiency of the lower limbs, such as thrombo-angeitis obliterans and Raynaud's disease, a spinal block will indicate whether the thrombotic or the vaso-spastic element predominates and determine the advisability of surgical sympathectomy. In the normal individual, spinal block to the level of the second thoracic segment will produce a rise in temperature of about 8° Centigrade in the lower limbs, due to vaso-dilatation. After diagnostic spinal block, a very small rise in temperature indicates the presence of a

thrombotic lesion and therefore that surgical sympathectomy would be valueless. On the other hand, a marked rise in temperature denotes the preponderance of the spastic element and strongly favours surgical treatment.

Therapeutically, spinal block can be used with good effect in conditions of neuro-muscular inco-ordination, e.g. paralytic ileus, cardiospasm,and congenital megacolon (Telford and Simmons, 1939). The rationale of this treatment is that the temporary, but complete, paralysis of the sympathetic supply to the affected parts may bring the two components of the autonomic nervous system once more into step. Other conditions which benefit from spinal block are:- eclampsia, anuria following the crush syndrome, post-partum haemorrhage, indolent ulcers of the leg and peripheral arterial embolism.

It will thus be seen that spinal anaesthesia is not divorced from the interests of general medicine, and the liaison between physician and anaesthetist could be strengthened and encouraged to their mutual benefit.

* * * * * * *

Section VI.

CLINICAL SECTION.

1. Selection of Cases.

2. Interview and Examination.

3. Results of Interview and Examination.
   a) Transient sequelae.
   b) Post-operative retention.
   c) Patients with neurological signs or symptoms not due to spinal anaesthesia.
   d) Two interesting cases.

4. C.S.F. Cell Counts and Biochemistry.

5. Discussion on Cell Counts.
   a) Increased Cell Counts.
   b) Headache after second lumbar puncture.
   c) Comparison with reports of other workers.
   d) 'Normal' Cell Count.

6. Diagnostic and Therapeutic Block.

1. Selection of Cases.

An investigation was carried out to determine whether or not spinal anaesthesia was attended by any neurological complications. In the twelve year period 1939 to 1950 inclusive, the author has administered 1335 spinal anaesthetics. The year by year distribution of these cases is shown in Table I, which also shows that of these 1335 cases, 799 were patients in Stobhill Hospital in the years 1939 to 1943, and 536 were patients in the Victoria Infirmary and Glasgow Royal Maternity Hospital in the years 1944 to 1950.

Table I.

	Year.	No. of spinal anaesthetics.	
Stobhill Hospital	1939	126	
	1940	228	
	1941	201	
	1942	131	
	1943	113	799
Victoria Infirmary and Royal Maternity & Womens' Hospital	1944	47	
	1945	94	
	1946	93	
	1947	66	
	1948	67	
	1949	78	
	1950	91	536
		Total:	1335

In the first half of this series (799 cases), all patients judged unsuitable for spinal anaesthesia were anaesthetised by other means; in the second half of the

series (536 cases) the selection of suitable subjects was carried out with particular care.

No deaths attributable to spinal anaesthesia occurred. No serious or permanent neurological sequelae were detected.

Table II indicates the types of operations performed.

Table II.

Herniorrhaphy	272
Cystoscopy	126
Transurethral Prostatectomy	97
Colpoperineorrhaphy	116
Hysterectomy	108
Appendicectomy	88
Haemorrhoidectomy	86
Gastrectomy and Gastro-enterostomy.	81
Cholecystectomy	48
Colostomy and Caecostomy	54
Resection of Bowel	43
Abdomino-perineal excision of Rectum	49
Hysterotomy and Sterilisation	44
Caesarean Section	32
Forceps Delivery	4
Amputation of lower limb	15
Diagnostic and Therapeutic	19
Sigmoidoscopy	20
Thoraco-lumbar Sympathectomy	8
Nephrectomy	9
Cystectomy and Transplantation of Ureters	5
Drainage of Empyema (Unilateral)	2
Others	9
Total:	1335

The spinal anaesthesia was clinically satisfactory and the features of quiet breathing, minimal bleeding, good relaxation and absence of shock were noted.

These cases formed the smaller part of the routine work of the author, the greater part being concerned with

other forms of anaesthesia.

In the first 799 cases the author benefited by anaesthetising the general surgical cases of a neuro-surgeon, a surgeon who fostered a respect for the delicacy of nervous tissue and an appreciation of the inherent logical orderliness of spinal anaesthesia. All cases anaesthetised by this method in this clinic were visited personally at least once in the succeeding post-operative period. While no systematic examination of the central nervous system was carried out, it can be clearly stated that no patient left the hospital with any nervous lesion attributed to spinal anaesthesia. No neurological complication, apart from headache, was brought to notice during their stay in hospital. This, it should be noted, in a fastidious 'spinal conscious' unit, where high and exacting standards were demanded and where any neurological complication would have attracted attention.

At the commencement of the latter half of the series, performed in different surgical units, the author became aware of a background of distrust in the minds of surgeons concerning the late results of spinal anaesthesia. The excellence of the operating conditions which spinal anaesthesia could provide was appreciated, butthe doubt lingered. The author therefore determined to question and to examine systematically, before their discharge from

hospital all patients so anaesthetised. Accordingly, the 536 patients in the second half of the series were interviewed and examined, and 76 of them were re-examined at a follow-up some months later.

102 patients were selected for re-examination by the following criteria -

(a) Patients who were in hospital in the years 1948 and 1949, as it was thought that these more recent patients would be likely to respond and to remember their experiences of operation.

(b) Patients who lived within easy access of the hospital in Glasgow or its environs.

(c) Patients unlikely to have died in the interim as the result of the disease which necessitated operation.

A letter was sent to the 102 patients so selected - 76 reported for examination; 1 was ill in bed (malignant disease); 1 was incapacitated (diabetes); 2 had gone abroad, and 22 failed to respond. A copy of the circular letter is inserted. (Page 117).

CONFIDENTIAL.

Victoria Infirmary,
Langside,
Glasgow. S.2.

No.....

Dear

I am carrying out an investigation in this Hospital to find out the value and results of lumbar anaesthesia. As you had a lumbar anaesthetic on... .....it would be most helpful if you would be good enough to report back to the Hospital to answer a few questions and perhaps to have a very brief examination.

Come to.....

on.....

or.....

and bring this letter with you.

Yours faithfully,

(Dr.)

P.S. If you are unable to come for any reason connected with your operation or anaesthetic, would you please write the reason at the foot of this letter and return it to me in the enclosed envelope?

No.....Name.....Date of Spinal.....

Date of Examination.....

EXAMINATION OF THE NERVOUS SYSTEM IN SPINAL FOLLOW-UP

1. HISTORY

1. Were you quite satisfied with your anaesthetic?
2. Any symptoms or complaints due to the spinal?
3. Was the injection in the back painful?
4. Did you have any pain or discomfort during the operation?
5. Were you asleep during the operation?
6. If you had to have another operation, would you have a spinal anaesthetic?
7. Were you upset in any way afterwards as a result of the anaesthetic?
8. Sickness?
9. Headache? Did you suffer from headaches before your operation?
10. Retention of urine? How long?
11. Backache? Did you suffer from backache before your operation?
12. Did you "see double" afterwards?
13. Did you feel your legs numb, heavy or tingling afterwards?
14. How long did these feelings of numbness, etc., last?
15. Have they quite gone now?
16. Have you any remaining weakness of the legs?
17. Have you any remaining unusual feelings or sensory loss in legs?
18. Have you had any difficulty with passing water since operation?
19. Have you had any difficulty with bowels since operation? Incontinent after purgatives? Constipation?
20. Impotence since operation?

II. CRANIAL NERVES

Pupils - light and on accommodation.

Diplopia?

Mystagmus?

III. MOTOR SYSTEM

Limbs - wasting

- muscle tone

- voluntary power

- gait. (? Rombergism).

IV. SENSORY SYSTEM

(a) Paraesthesia.

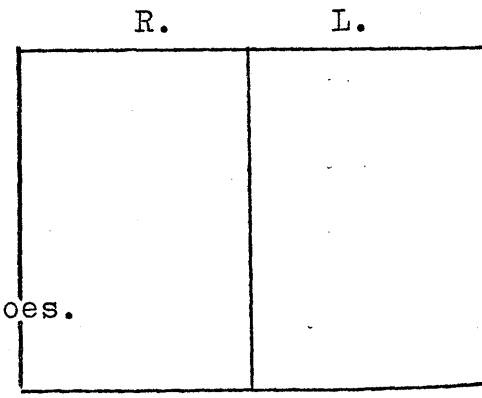
(b) Touch

Pain

Temperature

Position of limbs, toes.

Vibration.



V. REFLEXES

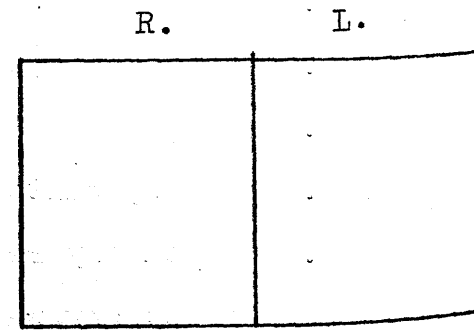
Knee

Ankle

Plantar

Abdominal I

Abdominal II.



2. Interview and Examination: (536 patients).

The routine examination was carried out about seven to fourteen days after operation, usually when the patient was again ambulant, towards the end of the period in hospital. In the early stages of the investigation the foregoing questionnaire was read to the patient and his answers noted. A neurological examination was carried out at the same time and the results recorded on the reverse side of the sheet. A specimen questionnaire is appended. (Page 118).

This method was later abandoned as it was found that the answers tended to be too stereotyped and insufficiently informative. The ultimate form of examination was as follows, individual notes being kept on the routine 'Nosworthy' charts:-

The form of the questions on the original questionnaire was altered to suit the temperament, intelligence and circumstances of the individual patient, but the field covered by the questions was the same. Careful enquiry was made as to the occurrence of headache, its severity, location, duration and time of onset, and if it disappeared spontaneously, or was relieved by recumbency, by aspirin or other simple analgesic drug, by recumbency and aspirin, or not relieved by any of these measures. It might be remarked here that the severity of the headache could be fairly gauged by ascertaining whether or not it had been brought to

the attention of the Sister. Any previous history of headache was noted. Particular attention was paid to any upset of bowel or urinary function, such as a recent tendency to constipation, incontinence after purgatives and impairment of sphincter control; retention or incontinence of urine, and urgency. While impotence in the male has been described as a sequel of spinal anaesthesia, the number of patients to whom a question of this nature could reasonably be put was limited, e.g. most were still in hospital and many were old men. However, among the 76 patients who reported back for re-examination some months later, the question of impotence was raised where applicable. The patient was also asked whether he 'saw double' at any time. Routine examination of the eyes was then carried out - pupils, motor function, nystagmus and strabismus. The limbs were inspected for wasting (though this applies more to patients re-examined some months after operation). Muscle tone, voluntary power and co-ordination were assessed. The lower limbs, sacral area and perineum were examined to test the appreciation of temperature, pain, light touch, pressure, muscle-joint sense and vibration. The knee, ankle, plantar and abdominal reflexes were tested. Finally, the tone of the anal sphincter was estimated in most cases. Where the operation was haemorrhoidectomy, perineal repair, excision of rectum and the like, estimation of anal sphincter tone was obviously

impracticable in the immediate post-operative period, and in a few other cases it was deemed inadvisable for psychological reasons.

It was appreciated that gross lesions of the nervous system, such as paraplegia or incontinence of urine or of faeces, would readily present themselves, but that, if the investigation was to be of value, the occurrence of less obvious lesions, such as small areas of diminished sensibility, or patulous anus, would have to be sought out in a painstaking manner.

Specimen 'Nosworthy' charts follow. Included are the charts of some of the patients mentioned in the text (Nos.1, 3 and 12), the others being selected to illustrate the typical case of the common operations in this series.

The following symbols are used on the 'Nosworthy' chats:-

C.S.F.	=	Cerebrospinal fluid.
H−	=	No headache.
H+	=	MILD "
H++	=	MODERATE "
H+++	=	SEVERE "
R−	=	No retention of urine (or self-retaining catheter left in situ at operation).
R+	=	Retention of urine for longer than 24 hours.
+++	=	Exaggerated knee and ankle jerks.
++	=	Normal " " " "
+	=	Diminished " " " ";normal abdominal
−	=	ABSENT " " " " reflexes.
↓	=	Plantar flexor.
↑	=	Plantar extensor.
C/C	=	C.S.F. cell counts done.

OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HÆMORRHAGE
FINAL COMMENT. PH. REFLEX YES NO.

AGE: 10 0 20 30 40+

SITE OF OPERATION: SPINE & BACK; INTRA-CRANIAL; MOUTH, NOSE & THROAT; THYROID; OTHER HEAD & NECK; INTRA-THORACIC; CHEST-WALL; LUMBAR; UPPER ABDOMEN; LOWER ABDOMEN; INGUINAL; PERINEAL; EXTREMITIES — H — R —

A / B SUB. DIV. OF SITE; MINOR; NO. OP.; ½ 1 2 3 ANÆS. TIME IN HOURS; SPECIAL INTEREST

SEX: M. F.

PHYSICAL STATE: 1. GOOD; 2. FAIR; 3. POOR; 4. SERIOUS; EMERGENCY

PREOPERATIVE COMPLICATIONS: INCOMPLETE DATA; CIRCULATORY; RESPIRATORY; NEUROLOGICAL; UROLOGICAL; ALIMENTARY; METABOLIC; OTHER

PREMEDICATION: ATROPINE OR SCOPOLAMINE A. 1/100; OPIATE M. 1/4; BROMETHOL; BARBITURATE; OTHER

OPERATIVE COMPLICATIONS: EMERGENCIES; CIRCULATORY; RESPIRATORY; OTHER; NONE; I.V. FLUIDS; SEV. TRAUMA OR HÆMORRHAGE

CHIEF DEPTH OF ANÆS. 1 2 3 4

TIME OF REMARKS ETC.

INDEX NO. 1.

ANÆSTHETIC RECORD

DATE 13/11/46.

NAME JOHN ARMOUR AGE 63

HOSP. & WARD 5 WT.

B.P. 160/90 mm Hg. HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS: OPERATION:

10 Dean Terrace, Kilmarnock.

BENIGN PROSTATIC HYPERTROPHY.

TRANSURETHRAL PROSTATECTOMY.

MR. T. L. CHAPMAN.

SPINAL BLOCK

100 mg. 'PLANOCAINE' (PROCAINE).

DISSOLVED IN 2ml C.S.F. (= 5% PROCAINE).

THIOPENTONE 0·4 G., ADDED IN FRACTIONAL DOSES TO INTRAVENOUS N. SALINE DRIP.

DR. SINCLAIR.

MORPHINE gr. 1/4, ATROPINE gr. 1/100: EPHEDRINE gr i INTRAMUSCULARLY IMMED. BEFORE SPINAL.

2 PINTS. INTRAVENOUS NORMAL SALINE, OVER A PERIOD OF 4 HOURS.

RESULT

THE ANÆSTHETIC: INHAL. TECHNIQUES: OPEN OR INSUFFLATION; ABSORPTION; SEMI-OPEN OR CLOSED; ENDOTRACHEAL; REGIONAL; SPINAL; I.V.; N₂O; C₃H₆; ETHER; OTHER

AGENTS USED: ONE; TWO

POSTOPERATIVE COMPLICATIONS: TECHNICAL; CIRCULATORY; RESP. MINOR; RESP. MAJOR; ?? NEUROLOGICAL; UROLOGICAL; ALIMENTARY; METABOLIC; OTHER; NONE

VOMIT NONE + ++

TIME & CAUSE OF DEATH: LATER; 1 WK; A; OTHER; EXISTING DISEASE; CIRC. RESP. INFECTION

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069. 297992. 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANÆSTHETIST DR. SINCLAIR. SURGEON MR. CHAPMAN

PREMEDICATION SATISFACTORY (YES) NO

TIME 10 A.M. 11 A.M.

N_2O C_3H_6 ETHER

1 2 3 4 PLANE

500 400 300 200 100 O_2%ORC/MIN

180 160 140 120 100 80 60 40 20 0 B.P. X: PULSE •: RESP. O: ANÆS. X: OP ⊙

OPERATION 1 HOUR.

CONDITION SATISFACTORY AT CLOSE OF OPERATION

TIME OF REMARKS ETC

26/11/46.

Satisfied with anaesthetic; no complaints. No sickness. No headache. No diplopia. No retention of urine (retaining catheter in situ for several days.) Bladder control now very satisfactory – no retention and no incontinence. Bowel control good. Anal sphincter tone appears normal. No paraesthesiae. Muscle tone and voluntary power normal. Gait rather stiff, but patient makes no comment about this.

ORO/NASOTRACHEAL R. L. BLIND

CUFF PACK UNDER MASK DIFFICULTY

GRAVE OXYGEN WANT CARDIAC ARREST

CONVULSION EXPLOSION DEATH

ARRHYTHMIA CYANOSIS STAGNATION

BRADY/TACHYCARDIA SEV. B.P. FALL/RISE

PALLOR SKIN COLD/SWEATING OTHER

RESP. DEPRESSION TRACHEAL/OU COUGH

EXCESS MUCUS BLOOD PUS VOMIT

PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO

MAINTENANCE SATISFACTORY YES NO

OVERDOSE REFLEXES IRRITABLE OTHER

I.V. FLUIDS TRAUMA HAEMORRHAGE

FINAL COMMENT. PH. REFLEX YES NO.

Sensation.

HEAT	+	LEGS PERINEUM SACRUM.
COLD	+	
PAIN	+	
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION	+	

Reflexes.

	R.	L.
KNEE	++	++
ANKLE	+	+
ABDOMINAL	+	+
PLANTAR	↓↑	↑↓

Touch: No neurolog. sequelae.

ANÆSTHETIC RECORD

INDEX NO. 2. DATE 30/5/48.

NAME GEORGE FRASER. AGE 37.

HOSP. & WARD 5. WT

B.P. 108/74 HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS: OPERATION:

26, Cairnhill Road, Airdrie.

STRANGULATED FEMORAL HERNIA.

HERNIORRHAPHY.

MR. IAN GORDON.

SPINAL 'D' ISOTONIC (0.4% AMETHOCAINE), 3 mls.

SITTING UP → 5° TRENDELENBERG.

NO VASO-PRESSOR DRUG. DR. SINCLAIR.

Well built, previously healthy man, vomiting, but in fair condition.

Analgesia was completely satisfactory and the operation was completed without incident.

1 PINT GLUCOSE-SALINE.

RESULT

11/2/50. Re-examined. Well. CNS. normal. No metatence. No complaints.

1/6/48 - Well. Retention of urine for 20 hours. No headache.

SITE OF OPERATION H- R?-

SPINE & BACK; INTRA-CRANIAL; MOUTH, NOSE & THROAT; THYROID; OTHER HEAD & NECK; INTRA-THORACIC; CHEST-WALL; LUMBAR; UPPER ABDOMEN; LOWER ABDOMEN; INGUINAL; PERINEAL; EXTREMITIES; A; B SUB. DIV. OF SITE

AGE: 10, 20, 30+, 40

SEX: M, F.

PHYSICAL STATE: 1. Good; 2. Fair; 3. Poor; 4. Serious; Emergency

PREOPERATIVE COMPLICATIONS: Incomplete Data; Circulatory; Respiratory; Neurological; Urological; Alimentary; Metabolic; Other

PREMEDICATION: Atropine or Scopolamine S. 1/150; Opiate O. 1/3; Bromethol; Barbiturate; Other

OPERATIVE COMPLICATIONS: Emergencies; Circulatory; Respiratory; Other; None; I.V. Fluids; Sev. Trauma or Hæmorrhage

THE ANÆSTHETIC: Regional; Spinal; I.V.; N_2O; C_3H_6; Ether; Other; Agents Used: One, Two

INHAL. TECHNIQUES: Open or Insufflation; Absorption; Semi-Open or Closed; Endotracheal

POSTOPERATIVE COMPLICATIONS: Technical; Circulatory; Resp. Minor; Resp. Major; Neurological; Urological; Alimentary; Metabolic; Other; None

MINOR; NO. OP.; ANÆS. TIME IN HOURS: ½, 1, 2, 3

SPECIAL INTEREST

NONE; VOMIT: ++, +; LATER: 1 WK

TIME & CAUSE OF DEATH: A. Circ. Resp Infection; Existing Disease; Other

CHIEF DEPTH OF ANÆS.: 1, 2, 3, 4

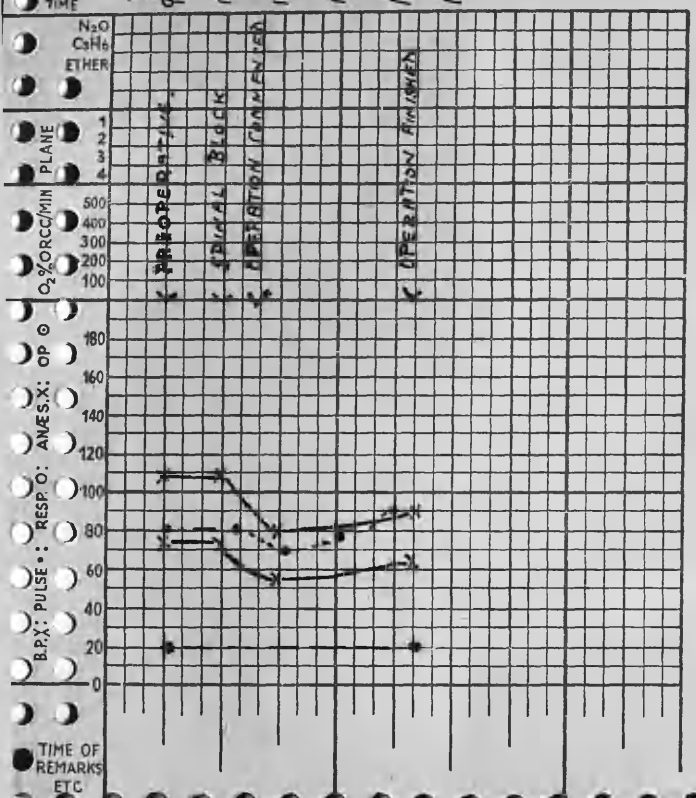
THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225089, 287992, 47/C.C. 31537K | ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30

ANAESTHETIST. DR. SINCLAIR. SURGEON MR. IAN GORDON. 18/6/48.

PREMEDICATION SATISFACTORY (YES) NO



Satisfied with anaesthetic; would be willing to have spinal again - in fact prefers spinal to general. (He has had several general anaesthetics.) No further sickness after operation. No headache, no diplopia. Retention of urine for 20 hours, and some difficulty for two days, but now quite normal. Muscle tone and voluntary power good. Gait normal. - No Rombergism. Bowels normal. Anal sphincter tone good. No paraesthesiæ.

ORO/NASOTRACHEAL R. L. BLIND
CUFF PACK UNDER MASK DIFFICULTY
GRAVE OXYGEN WANT CARDIAC ARREST
CONVULSION EXPLOSION DEATH
ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER
RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER
INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO
OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HÆMORRHAGE
FINAL COMMENT. PR. REFLEX YES NO.

Sensation.

HEAT	+
COLD	+
PAIN	+
TOUCH	+
MUSCLE JOINT	+
VIBRATION	+

LEGS
PERINEUM
SACRUM.

Reflexes.

	R.	L.
KNEE	++	++
ANKLE	++	++
ABDOMI I	+	+
" II	+	+
PLANTAR	↓	↓

Vomit: No nausea. Sequelæ.

ANÆSTHETIC RECORD

INDEX NO. 3.

DATE 17/8/48.

NAME CHARLES WEIR AGE 64.

HOSP. & WARD 17. WT.

B.P. 146/92 mm Hg. HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS: OPERATION:

Address: 125, Allison Street, S.I.

BENIGN PROSTATIC HYPERTROPHY.

SUPRAPUBIC PROSTATECTOMY.

MR. HINTON ROBERTSON.

SPINAL 'D' ISOTONIC, 3 ml.

(12 mg. AMETHOCAINE, 0.4% SOLUTION).

DR. SINCLAIR.

Rather decrepit man; looks more than his age.

Morphine gr. 1/4
Atrophine gr. 1/100.

1 pint. intravenous N. saline.

RESULT

AGE: 10, 20, 30, 40+

SEX: M. F.

PHYSICAL STATE: 1. Good; 2. Fair; 3. Poor; 4. Serious; Emergency

PREOPERATIVE COMPLICATIONS: Incomplete Data; Circulatory; Respiratory; ? Neurological; Urological; Alimentary; Metabolic; Other

PREMEDICATION: Atropine or Scopolamine; Opiate; Bromethol; Barbiturate; Other

OPERATIVE COMPLICATIONS: Emergencies; Circulatory; Respiratory; Other; None; I.V. Fluids; Sev. Trauma or Haemorrhage

SITE OF OPERATION: Spine & Back; Intra-cranial; Mouth, Nose & Throat; Thyroid; Other Head & Neck; Intra-Thoracic; Chest-Wall; Lumbar; Upper Abdomen; Lower Abdomen; Inguinal; Perineal; Extremities; A; B; Sub. Div. of Site

MINOR; No. Op.; Anaes. Time in Hours: ½, 1, 2, 3

SPECIAL INTEREST

INHAL. TECHNIQUES: Open or Insufflation; Absorption; Semi-Open or Closed; Endotracheal

THE ANÆSTHETIC: Regional; Spinal; I.V.; N_2O; C_3H_6; Ether; Other; Agents Used: One, Two

POSTOPERATIVE COMPLICATIONS: Technical; Circulatory; Resp. Minor; Resp. Major; ? Neurological; Urological; Alimentary; Metabolic; Other; None

NAUSEA & VOMITING: None; + Vomit; ++ Later; I.V.K.

TIME & CAUSE OF DEATH: Other; Existing Disease; A Circ. Resp. Infection

CHIEF DEPTH OF ANAES.: 1, 2, 3, 4

"PARAMOUNT" REGD. TRADE MARK 49/C.C. 57868 K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANAESTHETIST DR. SINCLAIR | SURGEON MR. HINTON | PREMEDICATION SATISFACTORY (YES) NO

TIME | N_2O | C_3H_6 | ETHER | PLANE | O₂ | NORCURIN | OP. | ANES. | RESP. | PULSE | B.P.

TIME OF REMARKS ETC.

ROBERTSON.

28/8/48. Satisfied with anaesthetic. No sickness.

No headache nor diplopia; prefers spinal to general anaesthetic. No complaints, except that legs felt "shaky" when first got up. On exam'n:-

No impairment of muscle tone detected; voluntary power good. Gait normal for age.

No hyperaesthesiae. No retention of urine (retaining catheter).

Pupils react to light and on accommodation.

Sensation:

HEAT	+	LEGS
COLD	+	PERINEUM
PAIN	+	SACRAL AREA.
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION	+	

Reflexes:

	R.	L.
KNEE	+	+
ANKLE	?	?
ABDOMINALS: not done (abdominal wound).		
PLANTAR	↓	↑

Anal sphincter tone Good.

RESP. DEPRESSION TRACHEALTIC COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO

OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HAEMORRHAGE

FINAL COMMENT: [illegible] YES NO.

Conclusion: Very doubtful findings — not attributable to spinal anaes.

R. L. BLIND
CUFF PACK UNDER MASK DIFFICULTY
WAVE OXYGEN WAIT CARDIAC ARREST
CONVULSION EXPLOSIVE DEATH
ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER

INDEX No. 4. ANAESTHETIC RECORD DATE 6/10/48.

NAME JAMES CHALMERS AGE 57.

HOSP. & WARD 17. WT

B.P. HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS: OPERATION:

41. Stamfordland Hill, Clarkston.

ANAL FISSURE

EXCISION OF ANAL FISSURE.

MR. HINTON ROBERTSON.

SPINAL 'D' ISOTONIC (0.4%) Amethocaine. 2 mls.

SITTING UP - TWO MINUTES.

- THEN LEVEL AND LITHOTOMY POSITION.

THIOPENTONE 0.5 G.

Large plethoric man; good analgesia and anaesthesia; no difficulties encountered.

DR. SINCLAIR.

RESULT

Site of Operation: H- R+

Spine & Back; Intra-cranial; Mouth, Nose & Throat; Thyroid; Other Head & Neck; Intra-Thoracic; Chest-Wall; Lumbar; Upper Abdomen; Lower Abdomen; Inguinal; Perineal; Extremities

A / B Sub. Div. of Site

Minor No. Op.

Anes. Time in Hours: ½ 1 2 3

Special Interest

Age: 10 20 30 40+

Sex: M. F.

Physical State: 1. Good 2. Fair 3. Poor 4. Serious — Emergency

Preoperative Complications: Incomplete Data; Circulatory; Respiratory; Neurological; Urological; Alimentary; Metabolic; Other

Prenedication: Atropine or Scopolamine A. ½₀; Opiate M. ¼; Bromethol; Barbiturate; Other

Operative Complications: Emergencies; Circulatory; Respiratory; Other; None

I.V. Fluids None; Sev. Trauma or Hæmorrhage

Chief Depth of Anes. 1 2 3 4

Nasal Techniques: Open or Insufflation; Absorption; Semi-Open or Closed; Endotracheal

Regional; Spinal; I.V.; N_2O; C_3H_8; Ether; Other

The Anaesthetic Procedure — Second Anaesthetic

Agents Used: One; Two

Postoperative Complications: Technical; Circulatory; Resp. Minor; Resp. Major; ? Neurological; Urological; Alimentary; Metabolic; Other; None

None; Vomit ++ + ; Time & Cause of Death; 1 Wk Lates; A. Circ. Resp. Infection; Existing Disease; Other

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069, 297992, 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANÆSTHETIST DR. SINCLAIR. SURGEON MR. HINTON ROBERTSON.

TIME

N_2O
C_3H_6
ETHER

PLANE 1 2 3 4

O_2 %ORCC/MIN 500 400 300 200 100

B.P.: PULSE •: RESP O: ANÆS.: OP ⊙ 180 160 140 120 100 80 60 40 20 0

TIME OF REMARKS ETC

PREMEDICATION SATISFACTORY (YES) NO

14/10/48. Satisfied with anaesthetic; would be willing to have same type of anaesthetic again. No headache. No diplopia. Retention of urine for 2 days, requiring catheterisation; now completely better – both bladder and rectal function and control again normal. No paraesthesiae. Voluntary muscular power good. Gait normal. No Romberg's sign.

ORO/NASOTRACHEAL R. L. BLIND
CUFF JACK UNDER MASK DIFFICULTY

GRAVE OXYGEN WANT CARDIAC ARREST
CONVULSION EXPLOSION DEATH
ANAPHYLAXIS CYANOSIS STAGNATION
BRADYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER

RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO

OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HÆMORRHAGE

FINAL COMMENT. PH. REFLEX YES NO.

Sensation:

HEAT	+	LEGS
COLD	+	LEGS
PAIN	+	PERINEUM
TOUCH	+	PERINEUM
MUSCLE-JOINT	+	SACRUM
VIBRATION	+	SACRUM

Reflexes.	R.	L.
KNEE	+	+
ABDOMI I	+	+
ABDOMI II	+	+
ANKLE	?+	?+

(very sluggish)

PLANTAR R. ↓ L. ↓

Concl: No neurolog. sequelae.

INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO

ANAESTHETIC RECORD

INDEX No. 5. DATE 8/10/48.

NAME MRS. ELIZ. BOYD. AGE 49.

HOSP. & WARD 16. WT 14 stones.

B.P. 130/90. HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS:	OPERATION:
2 Sharp Street, Govan.	
VENTRAL HERNIA	REPAIR. MR IAN GORDON.
SPINAL 'D' Isotonic 4 c.c., sitting up → immed. 10° Trendelenburg. THIOPENTONE · 4G N2O + O2	DR. SINCLAIR.
Very stout. Satisfactory anaesthesia. 9/10/48. Well. 10/10/48. Well; no complaints.	

RESULT

AGE: 10 20 30 (40+)

SITE OF OPERATION: Spine & Back; Intra-cranial; Mouth, Nose & Throat; Thyroid; Other Head & Neck; Intra-Thoracic; Chest-Wall; Lumbar; Upper Abdomen (H+); Lower Abdomen; Inguinal; Perineal; Extremities (R−); A / B Sub. Div. of Site

M. SEX: (F.)

PHYSICAL STATE: (1. Good) 2. Fair 3. Poor 4. Serious Emergency

PREOPERATIVE COMPLICATIONS: Incomplete Data; Circulatory; Respiratory; Neurological; Urological; Alimentary; Metabolic; Other

PREMEDICATION: Atropine or Scopolamine A 1/100; Opiate M 1/4; Bromethol; Barbiturate; Other

OPERATIVE COMPLICATIONS: Emergencies; Circulatory; Respiratory; Other; (None)

I.V. Fluids NIL.

Sev. Trauma or Hæmorrhage

NOP Minor / No. Op.

ANES. TIME IN HOURS: ½ (1+) 2 3

SPECIAL INTEREST

INHAL. TECHNIQUES: Open or Insufflation; Absorption; Semi-Open or Closed; Endotracheal

THE ANAESTHETIC: Regional; (Spinal); I.V.; (N2O 5); C3H6; Ether; Other

AGENTS USED: One (+ Two)

POSTOPERATIVE COMPLICATIONS: Technical; Circulatory; Resp. Minor; Resp. Major; Neurological; Urological; Alimentary; Metabolic; Other; (None)

NONE; ++ VOMIT; T WK LATER

TIME & CAUSE OF DEATH: A. Circ. Resp. Infection; Existing Disease; Other

CHIEF DEPTH OF ANES. 1 2 3 4

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069. 297992. 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

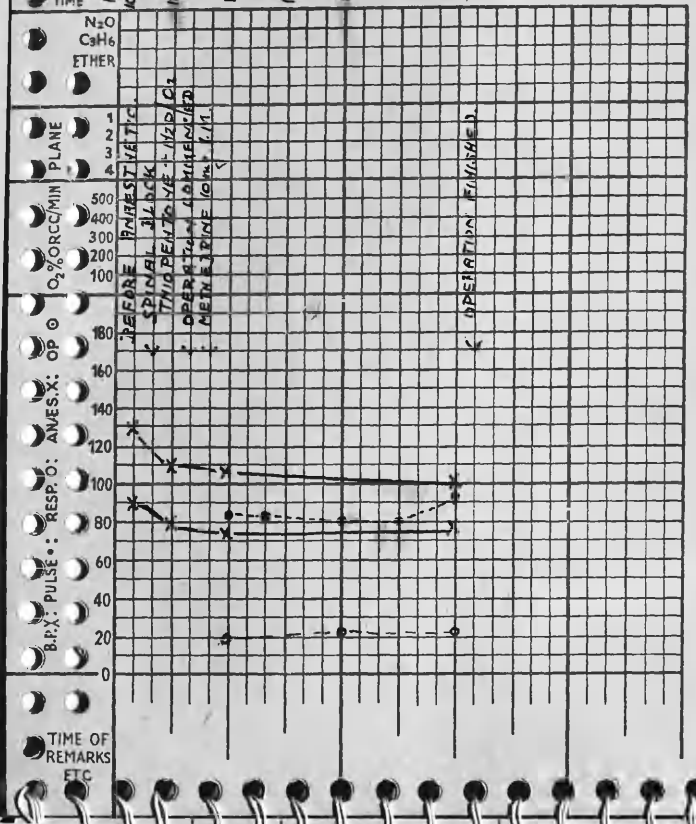
PRIVATE CODE

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30

ANÆSTHETIST DR. SINCLAIR

SURGEON MR. IAN GORDON

PREMEDICATION SATISFACTORY YES NO



22/2/50. Very satisfied with spinal; would be willing to have same again.

Had slight frontal headache for one forenoon only (3rd. post-operative day), which went away on lying flat. No diplopia

No post-operative retention of urine.

Bladder and bowel function quite normal

No weakness of legs. No paraesthesiae.

Muscle tone normal. Anal sphincter tone good.

Sensation.

HEAT	+	LEGS PERINEUM SACRUM.
COLD	+	
PIN	+	
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION	+	

Reflexes.

	R.	L.
KNEE	++	++
ANKLE	++	++
ABDOMS.	not done. (dressings still on)	
PLANTAR	↓	↓

AGENTS & TECHNIQUES

ORO/NASOTRACHEAL R. L. BLIND

PACK UNDER MASK DIFFICULTY

SEVERE OXYGEN WANT CARDIAC ARREST

CONVULSION EXPLOSION DEATH

ARRHYTHMIA CYANOSIS STAGNATION

BRADY/TACHYCARDIA SEV. B.P. FALL/RISE

PALLOR SKIN COLD/SWEATING OTHER

RESP. DEPRESSION TRACHEALTUG COUGH

EXCESS MUCUS BLOOD PUS VOMIT

PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO

MAINTENANCE SATISFACTORY YES NO

OVERDOSE REFLEXES IRRITABLE OTHER

I.V. FLUIDS TRAUMA HÆMORRHAGE

FINAL COMMENT. PH. REFLEX YES NO.

Cured : No neurolog. sequelae

ANÆSTHETIC RECORD

INDEX NO: 6. DATE 8/12/48.

NAME HUGH COYLE AGE 26.

HOSP. & WARD 17. WT heavy

B.P. 125/80 mm. Hg HB. T.P.R. K.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS:

C/o. Stewart, 714 Springfield Road, Parkhead.

OPERATION:

RIGHT INGUINAL HERNIA.

HERNIORRHAPHY.

MR. HINTON ROBERTSON.

THIOPENTONE 0.6 G.

SPINAL 'D' ISOTONIC 3.5 ml. (0.4% Soln.)
SITTING UP → 5° TRENDELENBERG POSITION.
+ THIOPENTONE 0.25 G.

DR. SINCLAIR

Satisfactory and uneventful anaesthesia; no vaso-pressor drug used; no obvious fall in B.P.; condition of patient very good throughout.

RESULT

10/12/48 - Well - No complaints.

SITE OF OPERATION H + R −

AGE: 10, 20 +, 30, 40

SEX: M. F.

PHYSICAL STATE: 1. Good, 2. Fair, 3. Poor, 4. Serious, Emergency

PREOPERATIVE COMPLICATIONS: Incomplete Data, Circulatory, Respiratory, Neurological, Urological, Alimentary, Metabolic, Other

PREMEDICATION: Atropine or Scopolamine 1/150. 5/150. Opiate D 3, Bromethol, Barbiturate, Other

OPERATIVE COMPLICATIONS: Emergencies, Circulatory, Respiratory, Other, None

I.V. FLUIDS NONE.

SEV. TRAUMA OR HÆMORRHAGE

SPINE & BACK; INTRA-CRANIAL; MOUTH, NOSE & THROAT; THYROID; OTHER HEAD & NECK; INTRA-THORACIC; CHEST-WALL; LUMBAR; UPPER ABDOMEN; LOWER ABDOMEN; INGUINAL; PERINEAL; EXTREMITIES

A B SUB. DIV. OF SITE

MINOR NO. OP.

ANÆS. TIME IN HOURS: ½, 1, 2, 3

SPECIAL INTEREST

INHAL. TECHNIQUES: Open or Insufflation, Absorption, Semi-Open or Closed, Endotracheal

THE ANÆSTHETIC: Regional, Spinal, I.V., N_2O, C_3H_6, Ether, Other

AGENTS USED: One, Two

POSTOPERATIVE COMPLICATIONS: Technical, Circulatory, Resp. Minor, Resp. Major, Neurological, Urological, Alimentary, Metabolic, Other, None

VOMIT: None, +, ++, 1 WK LATER

TIME & CAUSE OF DEATH: A. Circ. Resp. Infection, Existing Disease, Other

CHIEF DEPTH OF ANÆS. 1 2 3 4

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069. 297992. 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30

ANÆSTHETIST DR. SINCLAIR. SURGEON MR. HINTON ROBERTSON. PREMEDICATION SATISFACTORY (YES) NO

TIME

N_2O
C_3H_6
ETHER

PLANE 1 2 3 4

O_2%ORCC/MIN 500 400 300 200 100

B.P.X: PULSE •: RESP.O: ANÆS.X: OP ⊙ 180 160 140 120 100 80 60 40 20 0

TIME OF REMARKS ETC

19/12/48. Pleased with anaesthetic; would be willing to have same type of anaesthetic again if required.
No sickness. Very slight frontal headache for few hours on morning of 11/12/48, but not repeated.
No diplopia. Eyes normal on examination.
Urine passed without difficulty afternoon of operation.
Bowel and bladder control normal
(Has been constipated for few days but frequently is)
Anal sphincter tone good.
No paraesthesiae.

Sensation.

HEAT	+	LEGS, PERINEUM, SACRUM.
COLD	+	
PAIN	+	
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION	+	

Reflexes	R.	L.
KNEE	+++	+++
ANKLE	++	++
PLANTAR	↓	↓

Touch: No neurolog. sequelae

ORO/NASOTRACHEAL R. L. BLIND
PACK UNDER MASK DIFFICULTY
GRAVE OXYGEN WANT CARDIAC ARREST
BRONCHOSPASM EXPLOSION DEATH
ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA REV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER
RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER
INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO
OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HÆMORRHAGE
FINAL COMMENT. PH. REFLEX YES NO.

AGE: 10 20 30 (40+)

SITE OF OPERATION: Spine & Back; Intra-cranial; Mouth, Nose & Throat; Thyroid; Other Head & Neck; Intra-Thoracic; Chest-Wall; Lumbar; Upper Abdomen; (Lower Abdomen); Inguinal; Perineal; Extremities; A; B Sub Div. of Site: H– R–

MINOR OP. NO.: ½ 1 2 3 ANÆS. TIME IN HOURS

SPECIAL INTEREST

M. SEX (F.)

INDEX NO. 7.

ANÆSTHETIC RECORD

DATE 7/2/49.

NAME THOS. BROWN. AGE 61

HOSP. & WARD 5. WT

B.P. 148/80 mm Hg. HB. T.P.R.

PHYSICAL STATE: 1. Good; (2. Fair); 3. Poor; 4. Serious; Emergency

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS:	OPERATION:
6, Millar Road, Saltcoats.	
PAPILLOMATA OF BLADDER.	SUPRAPUBIC EXPOSURE. DIATHERMY TO PAPILLOMATA. MR. T. L. CHAPMAN.
SPINAL 'D' ISOTONIC (0.4% amethocaine), 4 ml. (16 mg.) DR. SINCLAIR. Excellent analgesia; no trouble.	

RESULT

PREOPERATIVE COMPLICATIONS: Incomplete Data; Circulatory; Respiratory; Neurological; (Urological); Alimentary; Metabolic; Other

PREMEDICATION: Atropine or Scopolamine A 1/100; Opiate M 1/4; Bromethol; Barbiturate; Other

OPERATIVE COMPLICATIONS: Emergencies; Circulatory; Respiratory; Other; (None)

I.V. Fluids Nil.; Sev. Trauma or Hæmorrhage

INHAL. TECHNIQUES: Open or Insufflation; Absorption; Semi-Open or Closed; Endotracheal

THE ANÆSTHETIC: Regional; (Spinal); I.V.; N_2O; C_3H_6; Ether; Other

AGENTS USED: (One); Two

POSTOPERATIVE COMPLICATIONS: Technical; Circulatory; Resp. Minor; Resp. Major; Neurological; Urological; Alimentary; Metabolic; Other; (None)

(None) VOMIT + + +

TIME & CAUSE OF DEATH: 1 WK LATER; A. Circ. Resp. Infection; Existing Disease; Other

SECTION BOARD

PRINCIPAL

CHIEF DEPTH OF ANÆS. 1 2 3 4

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069. 297992. 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANÆSTHETIST DR. SINCLAIR SURGEON MR. T.L. CHAPMAN. PREMEDICATION SATISFACTORY YES NO

TIME

N_2O C_3H_6 ETHER

O_2 % ORC/MIN PLANE 1 2 3 4

500 400 300 200 100

B.P. X: PULSE •: RESP. O: ANÆS. X: OP ⊙

180 160 140 120 100 80 60 40 20 0

TIME OF REMARKS ETC

13/2/49. No specific complaint about spinal; but would have preferred general anaesthetic. L.P. was painless and operation uneventful. Nervous about interference with "spine". Quite reasonable and pleasant in attitude.

No headache. No diplopia. No retention of urine.

Bowel control normal.

No paraesthesiae.

Muscle tone and voluntary power good.

AGENTS & TECHNIQUES

ORO/NASOTRACHEAL R. L. BLIND

CUFF PACK UNDER MASK DIFFICULTY

GRAVE OXYGEN WANT CARDIAC ARREST

CONVULSION EXPLOSION DEATH

ARRHYTHMIA CYANOSIS STAGNATION

BRADY/TACHYCARDIA SEV. B.P. FALL/RISE

PALLOR SKIN COLD/SWEATING OTHER

RESP. DEPRESSION TRACHEALTUG COUGH

MUCUS BLOOD PUS VOMIT

PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO

MAINTENANCE SATISFACTORY YES NO

OVERDOSE REFLEXES IRRITABLE OTHER

I.V. FLUIDS TRAUMA HAEMORRHAGE

FINAL COMMENT. PH. REFLEX YES NO.

Sensation.

COLD	+	LEGS
HEAT	+	PERINEUM
PAIN	+	SACRUM
TOUCH		
MUSCLE. JOINT	+	
VIBRATION	+	

Reflexes.

	R.	L.
KNEE	++	++
ANKLE	++	++
ABDOMS.	not done	(abdom. wound.)
PLANTAR.	↓	↓

Cough: No neurolog. sequelae.

AGE: 10 20 30 (40+)

SITE OF OPERATION: Spine & Back; Intra-cranial; Mouth, Nose & Throat; Thyroid; Other Head & Neck; Intra-thoracic; Chest-Wall; Lumbar; Upper Abdomen; Lower Abdomen; Inguinal; Perineal; Extremities — A / B Sub. Div. of Site: H- R-

Minor / No. Op.: ½ 1 2 3 Anæs. Time in Hours

Special Interest

SEX: M. F.

INDEX NO. 8.

ANÆSTHETIC RECORD

DATE 2/3/49.

NAME JOHN CRAWFORD AGE 49

HOSP. & WARD 17. WT 12 ST.

B.P. 148/90 HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS:

49 Meikle Road Crescent, Pollock.

RIGHT INGUINAL HERNIA.

OPERATION:

HERNIORRHAPHY.

MR. HINTON ROBERTSON.

THIOPENTONE 0·5G.

SPINAL 'D' ISOTONIC (0·4% AMETHOCAINE 3·5 ml. 14 mg)

+ SITTING UP, THEN 5° TRENDELENBERG.

+ THIOPENTONE 0·25 G.

No vaso-pressor drug.

Anaesthesia uneventful.

4/3/49. Well; no complaints.

19/3/49. Examined in ward (see over).

1/6/50. Reported back for follow up – no neurological sequelae. (Gait normal

RESULT

bladder and bowel control normal, muscular tone and power good; no impotence. Sensation normal, and Reflexes normal.)

PHYSICAL STATE: 1. Good; 2. Fair; 3. Poor; 4. Serious-; Emergency

PREOPERATIVE COMPLICATIONS: Incomplete Data; Circulatory; Respiratory; Neurological; Urological; Alimentary; Metabolic; Other

PREMEDICATION: Atropine or Scopolamine S/150; Opiate 0.1/3; Bromethol; Barbiturate; Other

OPERATIVE COMPLICATIONS: Emergencies; Circulatory; Respiratory; Other; None

I.V. Fluids NIL.

Sev. Trauma or Hæmorrhage

THE ANÆSTHETIC: Regional; Spinal; I.V.; N_2O; C_3H_6; Ether; Other — Agents Used: One / Two

POSTOPERATIVE COMPLICATIONS: Technical; Circulatory; Resp. Minor; Resp. Major; Neurological; Urological; Alimentary; Metabolic; Other; None

None; Vomit ++ + +; Time & Cause of Death; 1 Wk Later

Circ. Resp. Infection; Existing Disease; Other

Chief Depth of Anæs. 1 2 3 4

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225089. 297992. 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANÆSTHETIST DR. SINCLAIR | SURGEON MR. KINTON ROBERTSON | 19/3/49.

PREMEDICATION SATISFACTORY YES NO

TIME

N_2O
C_3H_6
ETHER

PLANE 1 2 3 4

O_2 %ORCC/MIN 500 400 300 200 100

B.P. ○ PULSE • RESP. O: ANÆS. X: OP ⊙ 180 160 140 120 100 80 60 40 20 0

TIME OF REMARKS ETC

Satisfied with anaesthetic - no complaints - would be willing to have same type of anaesthetic again. No sickness. No headache. No diplopia. No retention of urine. Bladder and bowel control normal. No paraesthesiae. Muscle tone good. Anal sphincter tone good. Voluntary power good.

AGENTS & TECHNIQUES

ORO/NASOTRACHEAL R. L. BLIND
CUFF PACK UNDER MASK DIFFICULTY

GRAVE OXYGEN WANT CARDIAC ARREST
CONVULSION EXPLOSION DEATH

ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER

RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO

OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HÆMORRHAGE

* FINAL COMMENT. PH. REFLEX YES NO.

Sensation:

HEAT	+	LEGS PERINEUM SACRUM.
COLD	+	
PAIN	+	
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION.	+	

Reflexes:

	R.	L.
KNEE	++	++
ANKLE	++	++
ABDOM I	+	+
ABDOM II	+	+
PLANTAR	↓	↓

Toned: No neurolog. sequelae.

SITE OF OPERATION: H — R —

SPINE & BACK · INTRA-CRANIAL · MOUTH, NOSE & THROAT · THYROID · OTHER HEAD & NECK · INTRA-THORACIC · CHEST-WALL · LUMBAR · UPPER ABDOMEN · LOWER ABDOMEN · INGUINAL · PERINEAL · EXTREMITIES · A · B SUB. DIV. OF SITE · MINOR · NO. OP. · ½ · 1 · 2 · 3 · ANÆS. TIME IN HOURS · SPECIAL INTEREST

AGE 10 20 30 40 · M. SEX · F.

INDEX No. 9.

ANÆSTHETIC RECORD

DATE 29/12/49.

NAME MRS. MARGARET BRUCE. AGE 42.

HOSP. & WARD 12 A. WT

B.P. 118/78 HB. T.P.R.

PREOPERATIVE | COMMENTS | POSTOPERATIVE

DIAGNOSIS: SUBINVOLUTION.

OPERATION: HYSTERECTOMY. (SUBTOTAL)

72, Chalmers Street, Ardrishaig.

MR. HECTOR McLENNAN.

THIOPENTONE ('PENTOTHAL') 0·65 G.

SPINAL 'D' ISOTONIC 3·5 ml. (14 mg. AMETHOCAINE)

SITTING UP

10° TRENDELENBERG IMMEDIATELY.

40° TRENDELENBERG AFTER 10 MINUTES.

DR. SINCLAIR.

30/12/49. Well.

31/12/49. Well; no headache, no retention of urine.

RESULT

PHYSICAL STATE: 1. GOOD · 2. FAIR · 3. POOR · 4. SERIOUS · EMERGENCY

PREOPERATIVE COMPLICATIONS: INCOMPLETE DATA · CIRCULATORY · RESPIRATORY · NEUROLOGICAL · UROLOGICAL · ALIMENTARY · METABOLIC · OTHER

PREMEDICATION: ATROPINE OR SCOPOLAMINE 1/150 · OPIATE D ½ · BROMETHOL · BARBITURATE · OTHER

OPERATIVE COMPLICATIONS: EMERGENCIES · CIRCULATORY · RESPIRATORY · OTHER · NONE

I.V. FLUIDS NONE.

SEV. TRAUMA OR HÆMORRHAGE

INHAL. TECHNIQUES: OPEN OR INSUFFLATION · ABSORPTION · SEMI-OPEN OR CLOSED · ENDOTRACHEAL

THE ANÆSTHETIC — PREMEDICATION — INDUCTION — MAINTENANCE: REGIONAL · SPINAL · I.V. · N_2O · C_3H_6 · ETHER · OTHER · AGENTS USED: ONE · TWO

POSTOPERATIVE COMPLICATIONS: TECHNICAL · CIRCULATORY · RESP. MINOR · RESP. MAJOR · NEUROLOGICAL · UROLOGICAL · ALIMENTARY · METABOLIC · OTHER · NONE

NONE · VOMIT ++ + · LATER · 1 WK

TIME & CAUSE OF DEATH · A. · CIRC. RESP. · INFECTION · EXISTING DISEASE · OTHER

CHIEF DEFIN. OF ANÆS. 1 2 3 4

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069. 297992. 47/C.C. 31537K

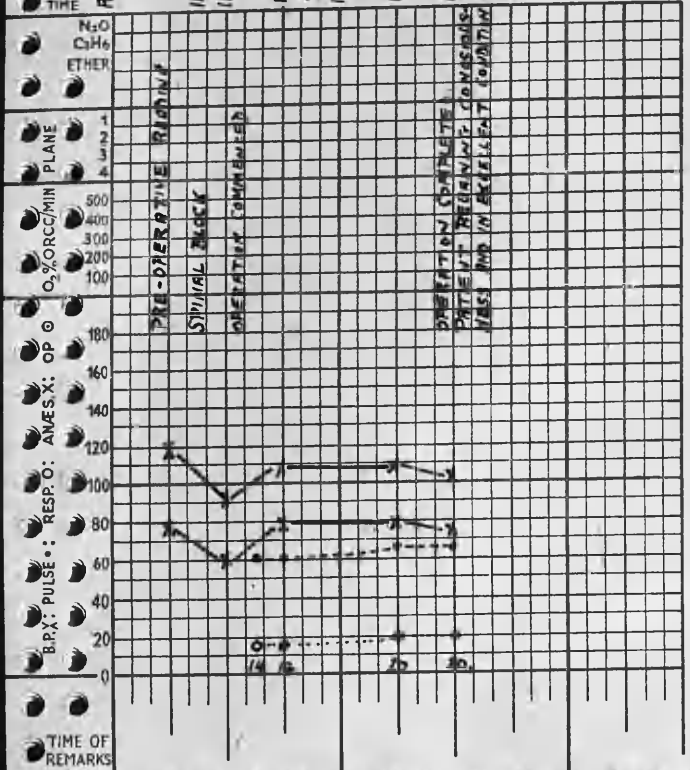
ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANAESTHETIST R.N. SINCLAIR. SURGEON MR. HECTOR McLENNAN. PREMEDICATION SATISFACTORY YES NO



14/1/50. Very pleased with anaesthetic; I doubt if patient is aware she had a spinal anaesthetic.

AGENTS & TECHNIQUES

No headache. No diplopia. No retention of urine.

No paraesthesiae. No sickness. No backache.

Muscular powers in legs good; no wasting.

Bladder and bowel function normal.

Anal sphincter tone good.

Sensation.

HEAT	+	LEGS PERINEUM SACRUM.
COLD	+	
PAIN	+	
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION	+	

Reflexes.	R.	L.
KNEE	++	++
ANKLE	++	++
ABDOMI I		
" II		
PLANTAR	↓	↓

OROTRACHEAL R. L. BLIND
CUFF PACK UNDER MASK DIFFICULTY
GRAVE OXYGEN WANT CARDIAC ARREST
CONVULSION EXPLOSION DEATH
ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER
RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER
INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO
OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HAEMORRHAGE

not done (abdominal wound). COMMENT: PIN REFLEX YES NO.

Concl: No neurological sequelae

AGE: 10 20 30+ 40 — SEX: M. F.

SITE OF OPERATION: Spine & Back; Intra-cranial; Mouth, Nose & Throat; Thyroid; Other Head & Neck; Intra-thoracic; Chest-Wall; Lumbar; Upper Abdomen; Lower Abdomen; Inguinal; Perineal; Extremities — C/C. H— R— — A / B Sub. Div. of Site

MINOR OP. — ANÆS. TIME IN HOURS: ½ 1 2 3

SPECIAL INTEREST

INHAL. TECHNIQUES: Open or Insufflation; Absorption; Semi-Open or Closed; Endotracheal

PHYSICAL STATE: 1. Good; 2. Fair; 3. Poor; 4. Serious; Emergency

PREOPERATIVE COMPLICATIONS: Incomplete Data; Circulatory; Respiratory; Neurological; Urological; Alimentary; Metabolic; Other

PREMEDICATION: Atropine or Scopolamine S 1/150; Opiate O ⅓; Bromethol; Barbiturate; Other

OPERATIVE COMPLICATIONS: Emergencies; Circulatory; Respiratory; Other; None; I.V. Fluids; Sev. Trauma or Hæmorrhage

THE ANÆSTHETIC: Regional; Spinal; I.V.; N_2O; C_3H_6; Ether; Other — Agents Used: One / Two

POSTOPERATIVE COMPLICATIONS: Neurological; Circulatory; Resp. Minor; Resp. Major; Neurological; Urological; Alimentary; Metabolic; Other; None — Vomit: None; ++ Later; Time & Cause of Death; Existing Disease; Chrc. Resp. Infection; Other

INDEX No. 10.

ANÆSTHETIC RECORD

DATE 14/4/50.

NAME MRS. ALMA FLEMING AGE 38.

HOSP. & WARD 16. WT

B.P. 124/80 mm. HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS: CARCINOMA OF RECTUM. (RECTO-SIGMOID).

OPERATION: ABDOMINAL CONSERVATIVE EXCISION OF RECTUM. MR. MAILER.

10 Bain Street, Cambuslang.

THIOPENTONE 0.5G.

SPINAL 'D' ISOTONIC (0.4% amethocaine) 4.5 mls = 18 mg. amethocaine

SITTING UP → 10° TRENDELENBERG.

THIOPENTONE 0.5G. in saline drip.

$N_2O + O_2$ SEMI-CLOSED TECHNIQUE.

DR. SINCLAIR.

15/4/50 - Very well.

20/4/50 - Very well; no headache.

[redacted]

1. C.S.F. cell count at time of anaesthetic = NIL.

2. C.S.F. cell count, 21 hours later = <1 (one lymphocyte seen in field).

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069, 297992, 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

CHIEF DEPTH OF ANÆS. 1 2 3 4

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANÆSTHETIST DR. SINCLAIR | SURGEON MR. MAILER | PREMEDICATION SATISFACTORY (YES) NO

TIME

N_2O C_3H_6 ETHER

PLANE 1 2 3 4

O_2 %ORCC/MIN 500 400 300 200 100

B.P. PULSE ● RESP. O ANÆS. X OP ⊙ 180 160 140 120 100 80 60 40 20 0

TIME OF REMARKS ETC

11/5/50. Very pleased with anaesthetic – no knowledge of having spinal anaesthesia.
Little sickness first day. No headache. No diplopia.
Had self-retaining urethral catheter inserted at time of operation. No paraesthesiae.
No abnormality of micturition
Bowel function and control satisfactory.
Muscle tone and voluntary power normal.
No wasting of limbs. Gait normal. No tremor.

Sensation:

HEAT	+	LEGS PERINEUM SACRUM.
COLD	+	
PAIN	+	
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION.	+	

Reflexes:

	R.	L.
KNEE	++	++
ABDOM I	+	+
" II		
ANKLE	++↓	++↓ PLANTAR.

ORO/NASOTRACHEAL R. L. BLIND
CUFF PACK UNDER MASK DIFFICULTY
GRAVE OXYGEN WANT CARDIAC ARREST
CONVULSION EXPLOSION DEATH
ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER

RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO

OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HAEMORRHAGE

FINAL COMMENT. PH. REFLEX YES NO.
Concl: No neurolog. sequelae.

INDEX No. 11.

ANÆSTHETIC RECORD

DATE 5/5/50

NAME MRS. ISABEL ALEXANDER. AGE 37.

HOSP. & WARD 16 WT

B.P. 125/80 HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS: 16, Riverside Drive, Stirling.

OPERATION: GASTRIC ULCER. PARTIAL GASTRECTOMY. MR. MAILER.

THIOPENTONE 0·5 G.
$N_2O + O_2$ (SEMI-CLOSED)
ENDOTRACHEAL.
SPINAL 'D' ISOTONIC 5 ml. (20 mg. AMETHOCAINE)
SITTING UP → IMMED. 10° TRENDELENBERG.
+ D·5 G. THIOPENTONE IN SALINE INTRAVENOUS DRIP.
NO VASOPRESSOR DRUG.

6/5/50. Very well, apart from a little sickness. Complains of paraesthesiae L. arm. (Brachial plexus lesion – left arm was abducted for intra-venous fluids.)

8/5/50. Very well. L. arm completely recovered. No headache. No retention of urine. No diplopia.

RESULT

I.V. FLUIDS → 1 PINT NORMAL SALINE
1 PINT BLOOD.

SITE OF OPERATION H– R–

AGE: 10, 20, 30+, 40

M. SEX: F.

PHYSICAL STATE: 1. GOOD; 2. FAIR; 3. POOR; 4. SERIOUS; EMERGENCY

PREOPERATIVE COMPLICATIONS: INCOMPLETE DATA; CIRCULATORY; RESPIRATORY; NEUROLOGICAL; UROLOGICAL; ALIMENTARY; METABOLIC; OTHER

PREMEDICATION: ATROPINE OR SCOPOLAMINE S. 1/150; OPIATE O 1/3; BROMETHOL; BARBITURATE; OTHER

OPERATIVE COMPLICATIONS: EMERGENCIES; CIRCULATORY; RESPIRATORY; OTHER; NONE

I.V. FLUIDS; SEV. TRAUMA OR HÆMORRHAGE

SPINE & BACK; INTRA-CRANIAL; MOUTH, NOSE & THROAT; THYROID; OTHER HEAD & NECK; INTRA-THORACIC; CHEST-WALL; LUMBAR; UPPER ABDOMEN; LOWER ABDOMEN; INGUINAL; PERINEAL; EXTREMITIES

A B SUB. DIV. OF SITE

MINOR NO. OP.

½ 1 2 3 ANÆS. TIME IN HOURS

SPECIAL INTEREST

INHAL. TECHNIQUES: OPEN OR INSUFFLATION; ABSORPTION; SEMI-OPEN OR CLOSED; ENDOTRACHEAL

THE ANÆSTHETIC: SEQUENCE OF ADMINISTRATION — PRIMARY, SECONDARY; REGIONAL; SPINAL; I.V.; N_2O; C_3H_8; ETHER; OTHER

AGENTS USED: ONE; TWO

POSTOPERATIVE COMPLICATIONS: TECHNICAL; CIRCULATORY; RESP. MINOR; RESP. MAJOR; NEUROLOGICAL; UROLOGICAL; ALIMENTARY; METABOLIC; OTHER; NONE

VOMIT: NONE; ++; + LATER; 1 WK

TIME & CAUSE OF DEATH: A. CIRC. RESP. INFECTION; EXISTING DISEASE; OTHER

CHIEF DEPTH OF ANÆS.: 1 2 3 4

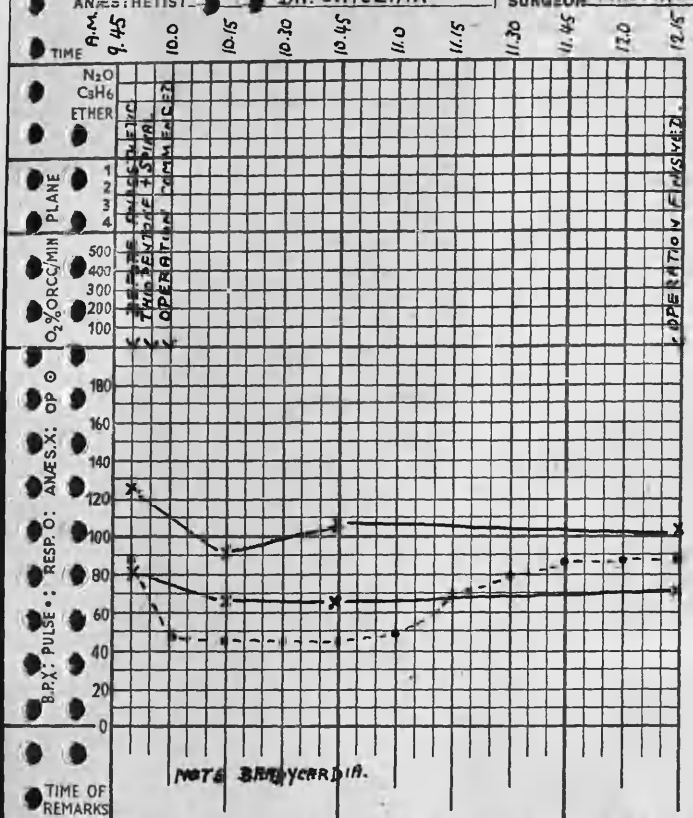
THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069, 297992, 47/C.C. 31537K

ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.

PRIVATE CODE

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

ANÆSTHETIST DR. SINCLAIR SURGEON MR. MAILER.



PREMEDICATION SATISFACTORY YES NO

AGENTS & TECHNIQUES

20/5/50: Very pleased with anaesthetic; would be satisfied to have same type of anaesthetic again. ! No headache. No diplopia. No retention of urine. No paraesthesiae of legs. Bladder and bowel control normal. Anal sphincter tone good.
Gait normal; voluntary power good.

ORO/NASOTRACHEAL R. L. BLIND
CUFF KINK UNDER MASK DIFFICULTY

GRAVE OXYGEN WANT CARDIAC ARREST
CONVULSION EXPLOSION DEATH

Sensation:

HEAT	+	LEGS
COLD	+	PERINEUM
PAIN	+	SACRUM.
TOUCH	+	
MUSCLE-JOINT	+	
VIBRATION.	+	

ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER

Reflexes:

	R.	L.
KNEE	++	++
ANKLE	++	++
ABDOMINAL		
PLANTAR	↓	↓

RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER

INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO

NOT DONE (ABDOMINAL WOUND).

OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HÆMORRHAGE

FINAL COMMENT. PH. REFLEX YES NO.

Conch: No neurolog. sequelae.

INDEX No. 12. ANÆSTHETIC RECORD DATE 27/9/50.

NAME JOHN CAMPBELL AGE 50.

HOSP. & WARD 17. WT.

B.P. 130/75. HB. T.P.R.

PREOPERATIVE COMMENTS POSTOPERATIVE

DIAGNOSIS: OPERATION:

83 Sandyfauld's Street, C.S.

RIGHT INGUINAL HERNIA. HERNIORRHAPHY MR. HINTON ROBERTSON.

THIOPENTONE .6G.
SPINAL 'D' Isotonic 3.5 ml. DR. SINCLAIR.

Heavy smoker - cough.
Anaesthesia uneventful. L.P. easy.
No vasopressor drug given; condition excellent throughout.

27/9/50.
CELLS .. less than 1 per c.m.m.
(1 lymphocyte, 1 polymorph, in field).

28/9/50. 28 HOURS LATER.
CELLS ... 5 per c.m.m.
(2 lymphocytes, 4 polymorphs)

PROTEIN 48 : 60 mg. per 100 ml.
SUGAR 61 : 64
CHLORIDES 728 : 683

AGE: 10 20 30 40+
SEX: M F
SITE OF OPERATION: Spine & Back; Intra-cranial; Mouth, Nose & Throat; Thyroid; Other Head & Neck; Intra-thoracic; Chest-Wall; Lumbar; Upper Abdomen; Lower Abdomen; Inguinal; Perineal; Extremities — A B Sub. Div. of Site — c/c. H++ R—
MINOR OP. ½ 1 2 3 ANÆS. TIME IN HOURS
SPECIAL INTEREST

PHYSICAL STATE: 1. Good; 2. Fair; 3. Poor; 4. Serious; Emergency

PREOPERATIVE COMPLICATIONS: Incomplete Data; Circulatory; Respiratory; Neurological; Urological; Alimentary; Metabolic; Other

PREMEDICATION: Atrofine or Scopolamine S. 1/150; Opiate O. 1/3; Bromethol; Barbiturate; Other

OPERATIVE COMPLICATIONS: Emergencies; Circulatory; Respiratory; Other; None

I.V. FLUIDS NIL.
SEV. TRAUMA OR HÆMORRHAGE

INHAL. TECHNIQUES: Open or Insufflation; Absorption; Semi-Open or Closed; Endotracheal

THE ANÆSTHETIC: Regional; Spinal; I.V.; N2O; C3H6; Ether; Other — AGENTS USED: One; Two

POSTOPERATIVE COMPLICATIONS: Technical; Circulatory; Resp. Minor; Resp. Major; ? Neurological; Urological; Alimentary; Metabolic; Other; None

VOMIT: None; + ++ +

TIME & CAUSE OF DEATH: TWK A. LATER; Circ. Resp. Infection; Existing Disease; Other

CHIEF DEPTH OF ANÆS. 1 2 3 4

THE COPELAND-CHATTERSON PARAMOUNT CARD. PAT. NOS. 225069, 297992. 47/C.C. 31537K
ENCIRCLE OR MARK ALL POSITIVE FACTORS ON BOTH SIDES OF CARD BEFORE PUNCHING.
PRIVATE CODE

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30

ANÆSTHETIST DR. SINCLAIR SURGEON MR. HINTON ROBERTSON PREMEDICATION SATISFACTORY YES NO

TIME

N_2O
C_3H_6
ETHER

PLANE 1 2 3 4

O_2%ORCC/MIN 500 400 300 200 100

B.P.X. PULSE ·:· RESP. O: ANÆS.X: OP ⊙ 180 160 140 120 100 80 60 40 20 0

TIME OF REMARKS ETC

9/10/50. Very pleased with anaesthetic,
No complaints, prefers it to gas. AGENTS & TECHNIQUES
No sickness.
2 days Moderate occipital headache, also back of neck; only once required analgesic drug; quite cleared up now. Does not regard it as very much at all. "Blurred" vision (not diplopia) for hours or two day after operation. No retention of urine. Bowels normal; anal tone normal.
No paraesthesiae. No wasting.
Muscle tone normal. Eyes normal.

Sensation

HEAT COLD PAIN TOUCH MUSCLE-JOINT VIBRATION	Normal	LEGS PERINEUM SACRUM.

Pressure on Tendo-Achilles painful.

Reflexes

	R.	L.
Knee	++	++
Ankle	+	−
Abds.	‡	‡
Plantar.	↓	↓

ORO/NASOTRACHEAL R. L. BLIND
CUFF PACK UNDER MASK DIFFICULTY
GRAVE OXYGEN WANT CARDIAC ARREST
CONVULSION EXPLOSION DEATH
ARRHYTHMIA CYANOSIS STAGNATION
BRADY/TACHYCARDIA SEV. B.P. FALL/RISE
PALLOR SKIN COLD/SWEATING OTHER
RESP. DEPRESSION TRACHEALTUG COUGH
EXCESS MUCUS BLOOD PUS VOMIT
PARTIAL/COMPLETE OBSTRUCTION OTHER
INDUCTION SATISFACTORY YES NO
MAINTENANCE SATISFACTORY YES NO
OVERDOSE REFLEXES IRRITABLE OTHER
I.V. FLUIDS TRAUMA HÆMORRHAGE
FINAL COMMENT. PU. REFLEX YES NO.

Conch: No neurological sequelae.

3. Results of Interview and Examination.

On questioning, no patient expressed dissatisfaction with the anaesthetic, the majority were appreciative and a few were enthusiastic, but one patient who had undergone diathermy for papillomata of the bladder with spinal block alone said that he would have preferred general anaesthesia. He had no specific complaint, but was uneasy at the thought of any interference with the spine. Six patients with previous experience of inhalation anaesthesia said they had been agreeably impressed by the absence of nausea and sickness, and preferred spinal anaesthesia. Of the 536 patients interviewed, 535 would be willing to have the same type of anaesthetic again should they ever require another operation. The exception was the patient quoted above.

No permanent or serious neurological lesion attributable to spinal anaesthesia was found in the 536 patients examined.

In three cases inconclusive evidence of a neurological lesion was detected but was held to be due to causes other than spinal anaesthesia. These will be described presently, (Page 131). Also, in one instance where the patient was unable through illness to report back, a history suggestive of a cord lesion as the result of spinal anaesthesia was obtained, but on careful investigation this assumption proved to be incorrect, as will be shown (Page 130).

a) Transient Neurological Sequelae.

The findings were:-

(1)	Headache	103 cases	(19.2%)	
(2)	Diplopia	1 case	(0.18%)	(or 0.07% in the whole series of
(3)	Leg pains	1 case	(0.18%)	1335 cases).

All of these were of short duration.

(1) Headache. In assessing the incidence of headache, this symptom was arbitrarily divided into three categories of severity - viz., mild, moderate and severe.

Mild headache. (71 cases). Frequently the patient did not spontaneously complain of headache. Most often its occurrence was elicited only by careful questioning, the patient thinking it too trivial or too ordinary for comment or complaint. The typical story was that, on the forenoon of the second or third post-operative day, the patient had a mild, dull headache, frontal and behind the eyes. This lasted about two hours and was relieved completely by a simple analgesic, or when he lay down after lunch. This mild episode may or may not have been repeated on the succeeding day, but not oftener. Headache of this mild degree may have been due, in a few cases, to the general upset occasioned by the operation.

Moderate headache. (32 cases). With this degree of severity, the patient definitely complained, but not bitterly, and the ward Sister knew about it and reported it. With the

resumption of a horizontal position and the administration of a simple analgesic, the headache was markedly relieved or abolished. The distribution was also frontal and behind the eyes. It might persist on and off for 2 to 4 days but not longer.

Severe headache. (None). This category comprises severe commanding pain, occipital or frontal, with some stiffness of the neck muscles, and perhaps photophobia. The patient lies flat with closed eyes and prefers to be left undisturbed. Morphia, intravenous Magnesium Sulphate (2 ml. of a 50% solution) or other measures are required for relief. A severe headache may cause distress for a week and persist with lessening severity for even longer.

Judged by these standards, the incidence of headache in this series of 536 patients was:-

NO HEADACHE	433 cases	(80.8%)
MILD HEADACHE	71 cases	(13.2%)
MODERATE HEADACHE	32 cases	(6.0%)
SEVERE HEADACHE	NIL	(0.0%)
	536	100%

(2) Diplopia. Of the 1335 patients in the whole series under consideration, only one patient had transient diplopia, although a careful enquiry had always been made for this complication. This patient was a healthy male, aged 38 years, admitted to hospital for interval appendicectomy. Anaesthesia was induced with 0.6 G. intravenous thiopentone, followed by a block with Spinal 'D' Isotonic 4 ml. The anaesthesia was satisfactory and the operation uneventful. After operation the patient was very well and got up on the fourth day, temperature, pulse and respiration being normal. On that day he had a slight frontal headache but did not mention this, and this information was only forthcoming on questioning nine days later, when he also admitted seeing double on the third post-operative day, though this lasted only a few hours, and again no complaint was made at the time. There was no stiffness of the neck or back. When examined nine days after operation he was well, had no complaints, and was ready for discharge. There was no history of post-operative retention of urine; bladder and bowel control were unimpaired; muscle tone, muscular power, co-ordination and gait were normal; tendon reflexes intact. Sensation was unaffected in the legs, perineum and sacral region, and anal sphincter tone was good. Examination of the eyes revealed no abnormality and there was no defect of vision. A specimen of cerebrospinal fluid had been obtained at the time of operation, before injection of the anaesthetic

solution, and again 22 hours later. (See Table IV., 32.) The results of examination of these two specimens are:-

	I.	II.
CELLS	1 per c.mm.	2 per c.mm.
PROTEINS	42 mg. per 100 ml.	38 per 100 ml.
SUGAR	40 " " " "	69 " " "
CHLORIDES	720 " " " "	710 " " "

It will be seen that there is no significant change in the cerebrospinal fluid, the cell count in specimen II being within normal limits. The increase in the sugar content is consistent with the findings of other workers and is only of academic interest. This patient reported back on request four months later. He had been well until two months after operation when he had an acute attack of lumbago lasting four days. He still feels a slight "weakness" in the small of his back but this is improving. He has frequently had "fibrositis" before, which he attributes to his work. He is a painter and his work involves much bending and stretching and he is out in all weathers. There has been no further complaint of headache or diplopia. Examination at this time (7.10.'50) showed that the patient was healthy and normal in every way.

(3) Leg Pains. One patient complained of pain radiating from the right buttock down the right leg and lasting for

one month. This lady, unmarried, aged 42 years, was admitted to hospital with a strangulated right femoral hernia of a few hours duration. The patient was in very good condition and was not vomiting. Lumbar puncture was easy and uncomplicated, and 4 ml. of Spinal 'D' Isotonic solution were injected at the third lumbar interspace. Excellent operating conditions were achieved, the patient's condition was very satisfactory and gave rise to no anxiety. She complained of moderate frontal headache twelve hours after operation, while still lying flat, but this headache had completely disappeared by the next morning and she made no further complaint while in hospital. When she was visited on the fourth day she was well and had no headache, and examination did not reveal any evidence of nervous dysfunction.

Two weeks later, after she was home, she again complained of mild headache, frontal in distribution, and also of pains in the right leg. The pain was first felt in the right buttock, was shooting in character and radiated down the back of the leg. It was of slight degree, but the patient was worried about it. The author visited the patient in her home a month after operation as the headache and leg pains had persisted, and her doctor had consulted the surgeon about these symptoms at the patient's request. On examination, there was no wasting of the limb and no swelling or oedema. Muscle tone, voluntary power,

co-ordination and sensation were normal. The tendon reflexes were brisk on both sides. Forward and lateral flexion of the spine was free, and flexion of the leg on the trunk, with the knee straight, was normal and evoked no pain (Lèsèque's Test). There was slight tenderness in the right calf, and a large fibrositic nodule was present in the right buttock, for which massage was recommended. The circulation to the limb was unimpaired. The patient was reassured, and thereafter there was a rapid disappearance of the symptoms. On communication with her doctor five months later, it was learned that the patient was completely well and had quite forgotten the incident until reminded of it by the doctor's enquiry. The doctor also proffered the information that the lady had been rather worried by the examination of the nervous system carried out by the author after operation, and had not understood that this was a routine practice.

Apart altogether from complications which might be due to spinal anaesthesia, abnormal neurological findings in the patients examined were relatively rare. This was perhaps due to the fact that spinal anaesthesia is contra-indicated for patients known to have any disease of the central nervous system - disseminated sclerosis, tabes dorsalis, paralysis agitans etc., and also for the mentally unstable and the senile. Such patients, therefore, were not encountered in this series.

(b) Post-operative Retention of Urine.

The incidence of immediate post-operative retention of urine in this series was no greater than is usual in operations in the perineum and within the pelvis. It is impossible to assess the true incidence of this complication as, in a large number of cases, a catheter was retained within the urethra for two days or more as a routine measure following operation. This applies to the majority of cases in which the operation was transurethral prostatectomy, colpoperineorrhaphy, or excision of rectum. Of the remaining patients, 27 (or 5% of 536) had retention of urine lasting longer than 24 hours, the longest period of retention being five days in one case. These cases required treatment by drugs of the acetyl-choline series, or by catheterisation. The operations which were followed by retention are given in Table III.

Table III.

Haemorrhoidectomy	6 cases.
Herniorrhaphy (Inguinal)	5 "
Hysterectomy	4 "
Abdomino-perineal excision of rectum	3 "
Appendicectomy (acute)	3 "
Excision of anal fissure	2 "
Colpoperineorrhaphy	2 "
Repair of strangulated Femoral hernia	2 "
	27 cases (5%)

The retention of urine in these cases excited no comment in the surgical wards and were regarded by all concerned as

what might be expected post-operatively, regardless of the anaesthetic used, although it is possible that spinal anaesthesia may have been a contributory factor. One case, an abdomino-perineal excision of the rectum, died of peritonitis and cardiac failure eight days after operation. In the remainder, bladder function and control became completely normal, and examination of the nervous system before discharge from hospital revealed no abnormalities.

In none of the 19 cases in which spinal block was used for diagnostic or therapeutic purposes, and where, therefore, there was no operative interference, did retention of urine follow.

(c) Patients with Neurological Signs or Symptoms not due to Spinal Anaesthesia.

(1) Mrs. Currie, aged 50 years, was admitted 4.11.'48 for surgical treatment of uterine prolapse. She was a known diabetic of many years duration. This patient was stout and only moderately fit. The blood pressure was 182/104 mm.Hg., and spinal anaesthesia was chosen on account of the diabetes. She made a good recovery from operation, after some initial diarrhoea. There was no evidence of any neurological lesion on examination, and she was well on discharge. This was one of the patients chosen for re-examination some time after operation (15 months). In reply to the circular letter requesting the patient to report back,

the following communication was received from her husband and caused considerable perturbation:-

> "In answer to your note re Mrs. Currie's operation on 4th November, 1948, I may state that it has not been successful since that time she has never had proper use of her legs through losing the power from the lower part of the back down."

The patient's doctor was consulted and it was learned that Mrs. Currie had been well for some months after operation and had been visited on several occasions. Subsequently she complained of "jittery" feelings in her legs, but there was no muscular weakness and the doctor diagnosed diabetic peripheral neuritis. In February, 1950, she had a cerebral haemorrhage which resulted in paraplegia, though this now showed some improvement.

(2) The three patients referred to on page 122 displayed on examination a solitary, slight and inconclusive neurological abnormality of doubtful aetiology - viz., absence of ankle-jerk on one side, sluggish knee-jerks and variable plantar response, respectively. None had any complaint or symptom referable to the nervous system and were not inconvenienced or incapacitated in any way. A further investigation of these was considered to be outwith the scope of this thesis, as these signs alone are not suggestive of a cauda equina lesion, the typical form of complication after

spinal anaesthesia. Each case of this kind was carefully considered and the findings as a whole assessed. In none of them was spinal anaesthesia considered to be the aetiological factor. The Nosworthy charts of these three patients are included with the others.
(Names - John Campbell (12), Charles Weir (3), and John Armour (1)).

(d) Two other interesting cases came to light during this investigation.

(a) Mrs. McDonald, age 39 years; operation - hysterectomy. During the routine post-operative examination, this patient volunteered the information, for the first time, that she was suffering from disseminated sclerosis and had previously had attacks of blurred vision. There were no signs or symptoms of this disease during her stay in hospital. Examination failed to reveal any abnormality of the nervous system and this finding was confirmed by a physician. An examination of the eyes carried out by an ophthalmologist showed that the fundi were normal, vision was good, nystagmus and diplopia were absent.

(b) Alex. Colquhoun, age 41 years; operation - bilateral inguinal herniorrhaphy, (two stage - the right side under spinal anaesthesia and the left side, a week later, under general anaesthesia). When this patient returned for re-examination three months later he reported that he had been

back to see the surgeon with a complaint of stomach trouble and symptoms suggestive of duodenal ulcer. He was informed by the surgeon that these symptoms were due to the type of anaesthetic (viz., spinal) which he had been given on the first occasion. This remark was made in the presence of the Registrar, who confirmed that the surgeon had in fact made this suggestion to the patient.

4. Cerebrospinal Fluid Cell Counts and Biochemistry.

From September 1949 to November 1950, as opportunity presented, a second lumbar puncture was carried out in 46 patients, between 20 and 30 hours after operation, a control specimen of cerebrospinal fluid having been obtained immediately before the spinal anaesthetic. In the first 22 patients, cerebrospinal fluid cell-counts alone were carried out; in the remainder cell-counts and biochemical estimations of the protein, sugar and chloride contents were made. The results are tabulated in Table IV., pages 134/135.

The cell-counts were carried out by the author, but the biochemical estimations were undertaken by the Department of Biochemistry, Victoria Infirmary of Glasgow.

TABLE IV

TABLE IV

CEREBROSPINAL FLUID — CELL COUNT AND BIO-CHEMISTRY.

HEADACHE
− = NONE
+ = MILD
++ = MODERATE
+++ = SEVERE

[IN THE FOLLOWING TABLE, THE FIRST FIGURE GIVEN REFERS TO THE CONTROL SPECIMENS OF CEREBROSPINAL FLUID (I) AT THE TIME OF OPERATION, IMMEDIATELY BEFORE THE INJECTION OF THE SPINAL ANAESTHETIC; THE SECOND FIGURE (II) REFERS TO THE SECOND SPECIMEN TAKEN A STATED NUMBER OF HOURS LATER.]

NO.	DATE	NAME	AGE	OPERATION	HOURS BET. I&II	CELLS per c.m.m. I : II	LYMPHOCYTES / POLYMORPHS PER FIELD	PROTEIN mg per 100ml I : II	SUGAR mg per 100ml I : II	CHLORIDE mg per 100ml I : II	HEADACHE
1	15·9·49	M.B. ♀	62	ACUTE OBSTRUCTION & VENTRAL HERNIA	26	2 : 1	6/1 : 2/1	NOT DONE	NOT DONE	NOT DONE	−
2	10·11·49	J.P. ♀	65	HERNIORRHAPHY (STRANGULATED HERNIA)	27	1 : 4	4/0 : 8/4	"	"	"	−
3	14·11·49	J.L. ♀	55	URETHRAL SLING OPERATION	27	1 : 1	2/1 : 4/0	"	"	"	+
4	11·11·49	A.R. ♂	42	CYSTOSCOPY	24	NIL : NIL	0/0 : 0/0	"	"	"	−
5	27·12·49	T.L. ♂	52	COLOSTOMY (CARCINOMA OF RECTUM)	28	<1 : <1	2/0 : 1/0	"	"	"	−
6	8·4·49	J.W. ♀	36	CAECOSTOMY (CARCINOMA OF COLON)	24	<1 : 2	1/1 : 3/2	"	"	"	±
7	6·4·49	H.D. ♂	58	HERNIORRHAPHY	27	1 : 1	3/0 : 3/1	"	"	"	−
8	28·7·49	J.M'K. ♂	80	HERNIORRHAPHY (STRANGULATED HERNIA)	30	1 : <1	2/0 : 1/0	"	"	"	−
9	12·1·50	W.G. ♂	56	HERNIORRHAPHY	24	NIL : NIL	0/0 : 0/0	"	"	"	−
10	14·1·50	C.M. ♂	40	SIGMOIDOSCOPY & HAEMORRHOIDECTOMY	24	NIL : NIL	0/0 : 0/0	"	"	"	−
11	16·1·50	A.ÓN. ♀	19	APPENDICECTOMY (ACUTE)	30	4 : 1	8/5 : 2/2	"	"	"	−
12	15·2·50	L.D. ♂	36	BILATERAL HERNIORRHAPHY	24	NIL : NIL	0/0 : 0/0	"	"	"	−
13	4·2·50	W.C. ♂	50	HERNIORRHAPHY	25	1 : 1	3/0 : 2/1	"	"	"	−
14	22·3·50	W.J. ♂	46	HERNIORRHAPHY	28	<1 : 1	0/1 : 1/2	"	"	"	−
15	23·3·50	A.J. ♂	51	HERNIORRHAPHY (STRANGULATED HERNIA)	24	<1 : <1	1/0 : 0/1	"	"	"	−
16	14·4·50	A.F. ♀	38	ABDOMINAL EXCISION OF RECTUM	21	NIL : <1	0/0 : 1/0	"	"	"	−
17	22·3·50	A.F. ♀	42	VENTRAL HERNIA REPAIR	28	<1 : NIL	0/1 : 0/0	"	"	"	++
18	29·5·50	F.S. ♂	50	HERNIORRHAPHY	24	1 : 3	2/2 : 6/3	"	"	"	+
19	8·5·50	J.M'L. ♂	64	REPAIR OF HYDROCOELE	20	<1 : <1	1/1 : 2/0	"	"	"	−
20	8·5·50	A.R. ♂	28	HERNIORRHAPHY	24	NIL : NIL	0/0 : 0/0	"	"	"	−
21	12·5·50	J.G. ♂	33	URETEROTOMY AND REMOVAL OF STONE	26	1 : 1	3/0 : 4/0	"	"	"	+
22	25·5·50	S.L. ♀	43	LAPAROTOMY	27	1 : 1	1/2 : 0/3	"	"	"	−
23	3·2·50	E.J. ♀	57	VENTRAL HERNIA REPAIR	24	1 : 390	1/2 : 129/1050	20 : 23	35 : 37	754 : 750	−
24	22·2·50	T.F. ♂	45	GASTRECTOMY (ULCER)	28	<1 : <1	2/0 : 1/0	28 : 22	67 : 70	654 : 715	−
25	8·3·50	D.M'I. ♂	32	GASTRECTOMY (ULCER)	25	<1 : NIL	0/1 : 0/0	62 : 64	52 : 78	722 : 696	+
26	10·3·50	C.C. ♀	63	ABDOMINAL EXCISION OF RECTUM.	30	NIL : NIL	0/0 : 0/0	38 : 23	59 : 60	707 : 734	−
27	12·4·50	C.W. ♂	56	HAEMORRHOIDECTOMY	24	<1 : <1	1/0 : 1/0	38 : 35	51 : 78	720 : 708	−
28	24·5·50	A.M'G. ♀	53	LAPAROTOMY & COLOSTOMY (CARCINOMA OF RECTUM)	24	NIL : <1	0/0 : 2/0	35 : 36	56 : 66	758 : 733	+
29	22·5·50	H.W. ♂	72	HERNIORRHAPHY	21	NIL : 1	0/0 : 2/1	56 : 43	56 : 76	728 : 730	+
30	5·6·50	H.K. ♂	48	HERNIORRHAPHY	24	4 : 7	10/1 : 10/10	32 : 52	54 : 46	710 : 688	+
31	12·6·50	A.C. ♂	41	HERNIORRHAPHY	24	1 : 1	3/0 : 4/0	40 : 36	75 : 76	705 : 706	−
32	19·6·50	J.M'G. ♂	38	APPENDICECTOMY (INTERVAL)	22	1 : 2	3/0 : 3/2	42 : 38	40 : 69	720 : 710	+
33	26·6·50	A.M'G. ♂	48	SIGMOIDOSCOPY & HAEMORRHOIDECTOMY	21	NIL : <1	0/0 : 1/0	33 : 45	53 : 52	720 : 700	−
34	26·6·50	S.M'S. ♂	38	HAEMORRHOIDECTOMY	21	NIL : 8	0/0 : 24/0	34 : 27	49 : 49	728 : 710	+
35	28·6·50	J.D. ♀	65	HERNIORRHAPHY (FEMORAL)	30	NIL : NIL	0/0 : 0/0	32 : 29	51 : 73	744 : 737	−
36	10·7·50	S.H. ♂	48	HERNIORRHAPHY (INGUINAL)	21	<1 : <1	1/0 : 1/0	32 : 36	48 : 53	750 : 753	−
37	10·7·50	J.A. ♂	18	HERNIORRHAPHY (INGUINAL)	21	NIL : NIL	0/0 : 0/0	18 : 19	53 : 55	736 : 728	+
38	18·9·50	G.M'K. ♂	71	TRANSURETHRAL PROSTATECTOMY	24	<1 : NIL	2/0 : 0/0	31 : 26	48 : 88	725 : 733	−
39	18·9·50	G.M. ♂	78	TRANSURETHRAL PROSTATECTOMY	24	NIL : <1	0/0 : 1/0	30 : 27	64 : 93	755 : 745	−
40	27·9·50	H.S. ♂	56	BILATERAL HERNIORRHAPHY	28	NIL : 1	0/0 : 1/2	35 : 36	69 : 73	722 : 704	++
41	27·9·50	J.C. ♂	50	HERNIORRHAPHY (INGUINAL)	27	<1 : 5	1/1 : 12/4	48 : 50	61 : 64	728 : 683	++
42	4·10·50	T.B. ♂	50	HERNIORRHAPHY (INGUINAL)	27	NIL : NIL	0/0 : 0/0	42 : 67	68 : 100	711 : 706	−
43	4·10·50	D.C. ♂	28	HERNIORRHAPHY (INGUINAL)	25	<1 : 1	2/0 : 3/0	30 : 30	52 : 104	703 : 729	−
44	20·10·50	D.F. ♂	29	HAEMORRHOIDECTOMY	24	NIL : 1	0/0 : 2/1	21 : 22	75 : 77	721 : 705	−
45	20·10·50	J.M'K. ♂	43	HAEMORRHOIDECTOMY	25	NIL : <1	0/0 : 0/1	35 : 27	56 : 77	718 : 705	−
46	13·11·50	R.M'K. ♂	38	HERNIORRHAPHY	24	NIL : 1	0/0 : 3/0	42 : 36	54 : 78	720 : 720	+

5. Discussion on Cell Counts.

a) Increased Cell Counts.

Taking the upper limit of normal cellular content of the cerebrospinal fluid as not more than 3 cells per c.mm., it will be seen that by this criterion 5 patients had an increased cell count in the second specimen. (Table IV, numbers 2, 23, 30, 34, and 41).

(1) No.23. A cell count of 1 per c.mm. in the first spcimen and 390 per c.mm. in the second specimen was obtained.

The cerebrospinal fluid findings in this case are given below:

Specimen 1: (At operation, before spinal anaesthetic solution was injected).

3.2.'50.	Total Protein	= 20 mg. per 100 ml.
	Sugar	= 35 mg. glucose per 100 ml.
	Chlorides	= 754 mg.Na.Cl. per 100 ml.
	Cell Count	= Not more than 1 per c.mm.
	Wassermann Reaction	= Negative.

Specimen 11: (24 hours later).

4.2.'50.	Total Protein	= 23 mg. per 100 ml.
	Globulin	= No increase.
	Sugar	= 37 mg. per 100 ml.
	Chlorides	= 750 mg. per 100 ml.
	Cell Count	= 390 per c.mm.
	Differential count	= approximately 90% polymorphs.
	Direct smear	= no obvious organisms.
	Cultures	= Sterile.

Clinical examination of the patient at this time, the day after operation, showed that she was very well and had no complaints whatsoever. She was alert, cheerful and co-operative. Her temperature was 99.2° Fahrenheit (axillary), pulse rate 102 per minute, on the morning after operation but had returned to normal by evening and there was no further elevation. She had not vomited and had no headache. There was no photophobia nor nuchal rigidity. Kernig's sign and Brudzinski's sign were absent. The blood pressure was 180/120 mm.Hg. No sulphonamides nor penicillin were given and convalescence was completely satisfactory and uneventful. It is presumed that the increased cell-count must have been due to meningeal irritation, but the signs and symptoms of

meningism were not presented.

In view of the reports in the literature of symptoms due to a late proliferating arachnoiditis occurring months after a spinal anaesthetic, this patient was asked to report back 9 months after operation. When examined then (8.11.'50), she was well, had no complaints, and careful examination of the nervous system revealed no abnormal findings.

(2) No.30. In this case the cell count in specimen I was 4 per c.mm. and in specimen II was 7 per c.mm., so that, using 3 as the standard of normal, the first count was slightly raised also, cause unknown (? chronic bronchitis). There was some increase in the protein content of specimen II (32 : 52); sugar was slightly diminished (54 : 46), and chlorides also slightly reduced (710 : 688).

The patient had a slight frontal headache for a few hours the day following operation. Examination revealed no abnormality and convalescence was uninterrupted.

(3) No.34. The cell count in specimen II was 8 per c.mm. but there was no change in the biochemistry. This patient also had a mild frontal headache. In all other respects his progress was very satisfactory and examination of the nervous system gave normal results.

(4) No.41. This patient had a count of 5 cells per c.mm. (12 lymphocytes, 4 polymorphs, seen) in specimen II. There

was no significant change in the biochemical findings. However, he suffered from mild to moderate occipital headache and stiffness of the back of the neck for about two days, but he did not think this in any way worthy of attention and described it as "nothing much at all". He also said that his sight was blurred for an hour or two on the day after operation, but there was no diplopia. On examination it was found that the ankle-jerk could not be elicited on the left side. There was no other abnormality, and he was very well. The headache in this case appears to be of the true meningeal type, due to irritation.

(5) No.2. The cell count was 4 per c.mm. in specimen II but there was no other abnormal finding.

b) Of the 5 patients who had an increased cell count 3 also had headache, mild in 2 cases, moderate in 1. However, it is worthy of remark that patient No.23, with a cell count of 390 per c.mm. did not suffer from headache. In this series of 46 patients who had a second lumbar puncture, 14 had headache (30.4%); mild headache 10 cases (21.7%); moderate headache 4 cases (8.7%). As the incidence of headache in the total series was 19% and after two lumbar punctures was 30.4%, this supports the theory that the headache is due to leakage of cerebrospinal fluid from the dural puncture hole into the peridural space.

c) The results of this investigation into the cell-count after spinal anaesthesia are not in accord with the results of other workers, who report an almost constant rise in cell-count. These reports were discussed in Section II, pages 13 and 14 . The author did not find any marked pleocytosis (except in one case, No.23) and he attributes this to the low concentration and isotonicity of the anaesthetic solution, with relative freedom from irritating effects, and perhaps also to the rigorous aseptic precautions which were constantly maintained. Although the cell-count series is not a large one, the results may be fairly taken as a representative sample of the series as a whole. The management and clinical history of these 46 patients differed in no way from that of the other 490 patients under consideration, and the cases for repeat lumbar puncture were chosen mainly according to convenience and whenever time was available to carry out the work.

d) As an interesting facet of this short research into the cerebrospinal fluid cell-count, the author puts forward the suggestion that the normal count in healthy individuals is lower than is generally taught. Various authorities give different figures - viz.,

Standing Committee on Laboratory Methods, University of Glasgow (1949) - up to 6 cells per c.mm.

Walshe (1947), Hewer (1948) - up to 5 cells per c.mm.

Maxson (1938); Dunlop, Davidson & McNee (1949))
Dible & Davie (1947)) - up to 3 cells per c.mm.

Hutchison & Hunter (1950))
Lange (1939)) - Less than 1 to 1 cell per c.mm.

In the 46 control specimens taken at the time of the spinal anaesthetic, only three had a cell-count of more than 1 cell per c.mm. No.1 (Mrs. Martha Blair), Specimen I = 2 cells/c.mm. had an acute intestinal obstruction. No.11 (Miss Agnes O'Neill), Specimen I = 4 cells/c.mm. had acute appendicitis. No.30 (Mr. Hugh Kilpatrick), Specimen I = 4 cells/c.mm. suffered from moderately severe chronic bronchitis.

The tentative suggestion is made that these infective conditions may have had some influence on the first cell count.

Apart from these three exceptions, the finding in this investigation is in agreement with that given by Hutchison and Hunter and by Lange, that the normal count in the healthy individual is about 1 cell per c.mm. or less, or not more than 3 cells per field. The other figures would appear to be rather high.

It will be seen that the sugar content tends to show an increase after spinal anaesthesia, but this is not constant. Black (1947) also made this observation, but its significance,

if any, is not understood.

6. Diagnostic and Therapeutic Spinal Block.

Spinal block has been employed for diagnostic and therapeutic purposes on 19 occasions in this series.

Diagnostic purposes.

In 16 cases of vascular impairment of the lower limbs, spinal block was used to assist in the diagnosis and prognosis. An example is given below.

Arthur Greenwood, age 60 years, suffered from intermittent claudication for two years and became so incapacitated that he could walk only 100 - 200 yards before being brought to a standstill by severe pain in the left calf. His work is concerned with the supply of building materials to factories and he has to do a lot of walking. A diagnostic spinal block was carried out with 5 c.c. Spinal 'D' Isotonic (amethocaine 20 mg.) with the following results:-

TIME.	RIGHT LEG TEMPERATURE.	LEFT LEG TEMPERATURE.	B.P.	LEVEL OF SENSORY BLOCK.
p.m.	Fh.	Fh.	mm.Hg.	
1.45	74°	71°	145/80	-
2.0	74°	71°		
2.15	SPINAL BLOCK			
2.30	84°	73°	102/74	T.4.
2.45	89°	74°	88/70	T.2.
3.0	90°	74°	88/70	T.2.
3.15	93°	74°		
3.30	95°	72°		
4.0	95°	71°		
5.0	94°	70°		
6.0	91°	70°		

The level of sensory block reached the second thoracic segment on both sides and therefore the total sympathetic outflow was blocked. The blood pressure fell to 88/70 mm.Hg. There was no response in the left leg as assessed by skin-temperature readings, though the right leg showed a good response with a rise of temperature from 74° Fahrenheit to 95° Fahrenheit. Despite the fact that there was no apparent improvement in the vascular supply to the left leg, some clinical improvement resulted. Two days after spinal block the patient was able, without distress, to walk 14 times round the ward, where previously pain in the calf would

compel him to stop after walking 3 times round the ward. This would imply that there was some vasodilatation of the deep vessels of the limb which was not manifest in the superficial vessels of the skin. Plethysmographic facilities, which were not available, would be required to confirm this.

Therapeutic Purposes.

An example of spinal block in the treatment of congenital megacolon is described.

Thomas Brodie, age 13 years, had suffered from intractable constipation all his life and had for many years required the services of the district nurse to administer enemata twice weekly. He was sallow and rather small for his years, but well-nourished and in moderate health. He was able to attend school regularly and was a very intelligent boy. On examination the abdomen was slightly distended. X-ray examination, after a barium enema, showed that the lower bowel was greatly dilated.

Spinal block was carried out (16.12.'49) using 80 mg. procaine dissolved in 2 ml. Cerebrospinal fluid (i.e. a 4% solution). The level of sensory block rose rapidly to the 1st thoracic segment; he had paraesthesiae of the fingers and slight difficulty in breathing for a few minutes. This latter symptom he described as a feeling of a heavy weight lying on his chest. Oxygen inhalation was commenced, and

10 mg. of 'Methedrine' given intramuscularly as he was nauseated on account of the fall in blood pressure. At the end of 15 minutes he was breathing easily and his blood pressure was 126/78 mm.Hg.

He returned one month later and reported improvement in the bowel function. He has been seen four times in all, each time stating that the improvement was maintained, and on the last occasion spinal block was repeated, eight months after the first one. He now says that, if he takes Cascara on alternate nights, he has a motion either once or twice daily (this is confirmed by his mother). There is no incontinence of faeces nor of urine. He has not required enemata since the first spinal block and his general health has improved. Barium enema reveals no change in the X-ray appearance of the colon, but the radiologist reports that the evacuation of the barium is now much more efficient.

* * * * * * *

Section VII.

CONCLUSION AND SUMMARY.

CONCLUSION.

The following conclusions are drawn from the material set forth in this thesis:

1. Spinal anaesthesia is a valuable method, and provides unexcelled relaxation, protection against shock, and minimal bleeding.
2. This method of anaesthesia, when used with discrimination, skill, and knowledge, is perfectly safe and does not result in neurological sequelae of a serious or permanent nature.
3. Spinal anaesthesia should not be used as a routine, in place of other anaesthetic methods, but much benefit may accrue from its exhibition where unequivocal indications for its use are presented.
4. There are definite contra-indications, which it is imperative to observe, to the employment of spinal anaesthesia.
5. Spinal anaesthesia, administered with consideration, is acceptable to patients, and their immediate post-operative comfort is enhanced.
6. The incidence of neurological lesions reported in the literature is alarming, but these complications need never occur.
7. Neurological lesions are due to the direct action of the

local anaesthetic drug on the nervous structures within the subarachnoid space, and are of a neuro-toxic character.

8. The concentration of the anaesthetic solution is of the utmost importance, as too high a concentration can readily produce serious and permanent damage to nerve tissue.

9. The tonicity of the solution may be an additional factor in the production of such lesions; an isotonic solution is less likely to produce irritation of the meninges.

10. Absolute asepsis is essential, and for this purpose dry sterilisation, by autoclave or electric oven, of all instruments used, together with the ampoule of anaesthetic drug, is the only safe method.

11. Post-spinal headache of the common type is characterised by hypotension of the cerebrospinal fluid, and is due to seepage of cerebrospinal fluid via the dural puncture-hole.

12. The incidence of headache in the author's series of 536 patients was - mild headache 13.2%; moderate headache 6%; severe headache, nil; no headache, 80.8%.

13. In this series, headache was definitely more common after two lumbar punctures (30.4%).

14. The occurrence of headache can be minimised by strict recumbency for 24 hours following spinal anaesthesia, and recumbency will also relieve the symptoms.

15. Headache of moderate severity is a drawback to spinal anaesthesia, but this disadvantage is outweighed by the patent advantages of the method.
16. Post-operative retention of urine is no commoner following spinal anaesthesia than following other methods.
17. The normal cerebrospinal fluid cell-count is 1 cell per c.mm., or less.
18. When a low concentration of isotonic amethocaine solution is used, there is, as a rule, no increase of cells in the cerebrospinal fluid.
19. A light 'covering' general anaesthetic should accompany spinal anaesthesia in most cases.
20. Spinal anaesthesia can be used to assist in diagnosis, and for therapeutic purposes.

SUMMARY.

The studies reported in this thesis were undertaken because the author believed that the merits of spinal anaesthesia were being obscured by prejudice, and that a reassessment of the method was indicated. Consideration of the history of spinal anaesthesia, with the earlier reckless use of imperfect techniques, explains in part the persistence of distrust of the method.

A survey of the literature revealed many clinical reports of serious neurological complications following spinal anaesthesia, but critical study of these reports showed that many were of doubtful value and could largely be discredited because either the details of administration were not divulged or the technique was at fault.

The relevant Anatomy, Physiology and Pharmacology is discussed. Experimental proof is quoted that the incidence of cauda equina lesions in cats is in direct proportion to the concentration of the anaesthetic solution. Stovaine was shown to be a damaging drug.

The nature of neurological lesions after spinal anaesthesia, both experimental and clinical, is studied, of which a cauda equina lesion is the most common. The damage to the nervous tissues is directly due to a neuro-toxic effect of the anaesthetic drug. Reports of histological examinations showed that the changes were mainly in the

nerve roots and in the periphery of the cord. These changes consisted of swelling and fragmentation of the axis cylinders and degeneration of the myelin sheaths. There was also a meningeal reaction with leucocytic infiltration, which reaction may proceed to fibrosis.

The development of spinal anaesthetic practice is traced, showing its evolution and the continuous improvements in technique. The use of covering anaesthesia, for example, has removed a previous objection to the method, without loss of any of its advantages. The rationale of total sympathetic block is set forth.

It is not uncommon to find a vague, subconscious disquietude concerning spinal anaesthesia, and this is reflected in the opinions expressed to the writer by the Nursing Staff, and given in the text, although the general impression is favourable.

The methods of sterilisation are reviewed and medico-legal aspects of meningitis following spinal anaesthesia discussed.

The author's technique of spinal anaesthesia is described in detail, and the need for scrupulous asepsis is emphasised. The use of a 0.4% isotonic solution of amethocaine was recommended.

There is presented a personal series of 1,335 spinal anaesthetics. Of these patients, 536 were examined in detail before their departure from hospital, in order to

disclose any evidence of neurological dysfunction, either overt or unsuspected, which may have been due to the spinal anaesthetic, and 76 patients were also re-examined six months to two years later, with the same purpose in view. The examination included a careful enquiry for headache, diplopia, retention of urine, incontinence of faeces, paraesthesiae and weakness of the lower limbs. Sensation was tested in the legs and sacral area, the reflexes examined, and anal sphincter tone estimated. The results confirmed the author's belief that no neurological sequelae of any import were arising in his cases. Spinal headache was divided into three grades of severity, and it was found that very slight headache occurred in 13.2%, and moderate headache in 6%, of these cases. Severe headache was not encountered and 80.8% of the patients did not suffer from headache at all. One case of fleeting diplopia was noted, and also one case of transient leg pains which may have been due to the spinal anaesthetic. No infective meningitis occurred.

A short investigation into the effects of spinal anaesthesia on the cerebrospinal fluid was undertaken. The results did not substantiate the finding, quoted frequently in the literature, that spinal anaesthesia in nearly every case produces a definite rise in the cerebrospinal fluid cell-count, due to meningeal irritation. Specimens of

cerebrospinal fluid from 46 patients were examined before the spinal anaesthetic was administered, and again about 24 hours later. In only one specimen was there a marked rise in the cell-count after spinal anaesthesia (390 per c.mm.) This patient was quite symptomless and afebrile, she made an uninterrupted recovery from operation and was well when re-examined nine months later.

It was concluded that spinal anaesthesia is a satisfactory method of anaesthesia and there is no need to fear neurological complications following its use. Furthermore, the concentration of the anaesthetic solution was shown to be of the greatest consequence, and it was pointed out that there is a definite low and safe level of concentration, at which uncomplicated and effective anaesthesia can be achieved and which it is unnecessary and undesirable to exceed.

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