Notes on local anaesthesia in general surgery / by J.W. Struthers.

LOCAL ANÆSTHESIA
IN
GENERAL SURGERY

J. W. STRUTHERS.

With the
Author's Compliments

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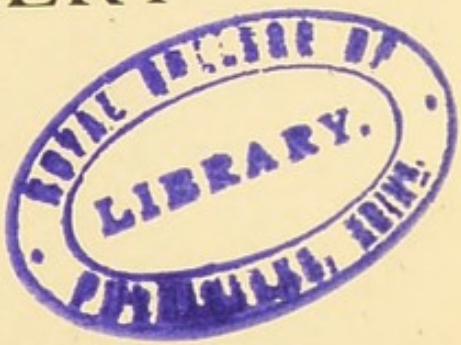

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PREFACE

In recent years local anæsthesia has come much into use, especially in Germany, France, and America. It has been shown that in minor, and to a less extent in major surgical operations it can often take the place of a general anæsthetic, and save the patient the risk and discomfort attending the administration of chloroform or ether; while with its help many small but painful operations, often done without any anæsthetic, can be done painlessly. Owing to the fact that local anæsthesia has, till recently, been little used in this country, and that most work on the subject has been done by German, French, and American surgeons, knowledge of the possibilities attending its use, and of the various methods of inducing it, is by no means general.

The following notes have been prepared in the hope that they may be of use in indicating the scope and limitations of infiltration, regional and spinal anæsthesia, at least to those who have neither time nor opportunity to study the extensive literature of these subjects for themselves.

J. W. STRUTHERS.

5 Lynedoch Place,
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NOTES ON LOCAL ANÆSTHESIA IN GENERAL SURGERY

CHAPTER I

DRUGS SUITABLE FOR INDUCING LOCAL ANÆSTHESIA: COCAINE, EUCAINE, STOVAINE, TROPA-COCAINE, ETC.

A NUMBER of drugs are now known which have the property of abolishing or dulling sensibility to pain at the site of their application to mucous membranes or their injection under the skin, or of blocking the transmission of sensory impulses along nerve trunks when injected into or immediately round them. Four of these drugs, cocaine, tropa-cocaine, eucaine B, and stovaine, have, after extended trial, proved to be of real value clinically for inducing local anæsthesia.

Cocaine ($C_{17}H_{21}NO_4$ methylbenzoylekgonin) is an alkaloid obtained from the leaves of Erythroxylum Coca. It is insoluble in water, and is almost exclusively used, for medicinal purposes, in the form of the hydrochlorate. Following the general custom, cocaine hydrochlorate will be termed simply "cocaine" in the succeeding pages. The salt occurs as fine, colourless, acicular crystals or a crystalline powder, freely soluble in water or alcohol, the solutions being neutral

to litmus. It is said to be sometimes contaminated with other alkaloids from the same plant which have undesirable properties, and, therefore, it is essential, in order to ensure the best results from its use, to procure the drug from a reliable source. Of the various tests which may be employed to detect impurities, the most generally useful and easily applied appear to be Maclagan's and the potassium permanganate test. Maclagan's test is as follows:—1 grain of cocaine hydrochloride is dissolved in 2 fluid ounces of water. To this is added 3 drops of solution of ammonia (B.P.), and the mixture is stirred with a glass rod. In a few minutes a crystalline precipitate is thrown down, leaving no turbidity in the supernatant liquid. The permanganate test is carried out as follows:—$\frac{1}{2}$ a cubic centimetre of $\frac{1}{10}$th per cent. solution of potassium permanganate is added to $\frac{1}{10}$th gramme of cocaine hydrochloride dissolved in 5 cubic centimetres of water, acidified with sulphuric acid. The colour should not disappear within an hour.

If solutions of cocaine are kept for long or heated to boiling point, the cocaine is apt to break up into the inert alkaloid ekgonin and other compounds, and therefore solutions should invariably be freshly prepared just before use, and should not be sterilised by boiling. Some observers affirm that fresh solutions may be boiled for a short time without any ill effect, but there is some uncertainty on this point, and, as a matter of fact, if the drug is handled with ordinary care, it is unnecessary to boil the solutions after they are made up. Cocaine may be kept in tablet form or in powder, and if it is transferred with clean hands or instruments to freshly boiled, normal saline solution, no fear need be entertained that pathogenic organisms will be introduced into

the solutions with it. Great care must be taken to avoid introducing any alkali into the solutions, for the cocaine is thereby rendered inert. Instruments which have been boiled in soda solution must, therefore, not be used to stir the cocaine mixture, and syringes and needles to be used for injecting the cocaine must be boiled in plain water or physiological salt solution. This precaution must also be observed in using eucaine B and stovaine.

When injected hypodermically, cocaine acts powerfully as a local anæsthetic. A ½ per cent. solution injected into a nerve trunk causes an almost immediate physiological block on the nerve, the conduction of afferent or efferent impulses being completely arrested. Operations in the area of distribution of the affected nerve may be done without pain and, what is important in some cases, without shock, the block lasting long enough for the performance of any ordinary surgical operation. Crile,[1] in a long series of experiments on animals, and by clinical observations on patients, proved that while afferent impulses from the area of operation caused shock when general anæsthesia was used, blocking of the nerves supplying an operation area by cocaine, effectually prevented the transmission of such impulses. When employing this method clinically, he was able to amputate the leg after cocainising the anterior crural and sciatic nerves, to amputate through the arm at the shoulder joint, and to remove half the shoulder girdle with the arm, by cocainising the trunks forming the brachial plexus, all painlessly and without shock.

The same effects may in some cases be obtained by

[1] G. W. Crile, *Problems relating to Surgical Operations*, J. B. Lippincott Co., Philadelphia, 1901.

injecting cocaine or cocaine-adrenalin solutions into the immediate neighbourhood of nerve trunks, which can be easily located and reached through the skin. Braun[1] of Leipzig has devoted special attention to this method of producing anæsthesia, and has been able to reach the median, ulnar, radial, external popliteal, and other nerves in this way, using solutions of 1 per cent. or ½ per cent. strength, combined with suprarenin or other preparation of the active principle of the suprarenal gland. The anæsthesia produced in this way is generally termed regional anæsthesia.

When cocaine solutions are injected into the skin and subcutaneous tissues at the actual site of an operation, so as to infiltrate more or less completely the whole field of operation, analgesia is readily produced by solutions varying in strength from 1 in 500 to 1 in 1000, or even weaker. The cocaine acts on the nerve endings or the finer nerve twigs, large nerve trunks being practically unaffected, at least by the weaker solutions. The term analgesia is deliberately used here instead of anæsthesia, because absolute anæsthesia is not always produced by infiltration of the tissues. Many patients retain the sense of touch in the field of operation, and can tell when a knife is being used and when stitches are being put in, etc., these procedures, however, not causing any pain. The term "infiltration anæsthesia" is generally used in describing the effects of purely local cocaine injections.

The strength of the various solutions which may be used will be indicated more fully later, but it may be said here that the use of any solution containing more

[1] H. Braun, "Experimentelle Untersuchungen und Erfahrungen über Leitungsanæsthesie," *Archiv für klinische Chirurgie*, Berlin, 1903, Band 71.

than ½ per cent. of cocaine for subcutaneous injection is quite unnecessary. Solutions containing 5 per cent. or 10 per cent. are still recommended for use by some. Not only are such solutions unnecessarily strong, but they are dangerous, toxic symptoms frequently following their use. All that can be accomplished by the injection of cocaine can be attained by the use of ½ per cent. or weaker solutions, and there can be no doubt that the continued use of stronger solutions has been responsible for many accidents which might have been avoided had the results of using weak solutions been earlier appreciated, and has retarded progress in the use of local anæsthesia, at the same time giving rise to the erroneous idea that cocaine, when used in sufficient quantity to produce a satisfactory anæsthesia, is a dangerous drug.

In addition to its power of producing anæsthesia, cocaine acts as a vaso-constrictor. This is of advantage in most surgical procedures, as it tends to make the field of operation bloodless. A certain amount of reactionary hæmorrhage is doubtless liable to take place when the effect of the cocaine wears off, but is so trifling in amount that it may be disregarded, for it is controlled by the pressure exercised by an ordinary dressing and bandage.

The local anæsthetic action of cocaine may be intensified by arresting the circulation of the part into which it is injected by means of an elastic tourniquet. Corning appears to have been the first to note this, and Oberst of Halle seems to have been among the first to apply it clinically. He found that if a solution of cocaine was injected round the nerves supplying a digit, and an elastic band was applied simultaneously proximal to the area of injection, to arrest the circula-

tion, the cocaine acted more quickly, more powerfully, and for a very much longer time than if no band were applied. The resulting anæsthesia was absolute. It was also found that the risk of the absorption of the cocaine into the general circulation with resulting unpleasant symptoms was very much lessened

Braun in some experimental observations, found that an otherwise lethal dose of cocaine injected into the leg of a rabbit after a tourniquet had been put on, had little or no toxic effect if the tourniquet were allowed to remain for half an hour after the injection had been made. He supposes that the cocaine combines in some way with the tissues during the arrest of the circulation, and is not set free in its original form when the blood is allowed to enter the part again. Another possible explanation is, that the cocaine is released so slowly after the circulation begins again that elimination begins before a toxic dose accumulates in the system, and goes on quickly enough to prevent any such accumulation. Whatever the explanation, there is no doubt of the fact that arrest of the circulation by tourniquet markedly increases the analgesic power of cocaine, and advantage can frequently be taken of it in operating on the hand and arm or foot and leg under local anæsthesia.

Another and more generally applicable method of increasing the local action of cocaine, and at the same time diminishing its general toxicity, is to inject along with it the active principle of the suprarenal gland. To Braun[1] belongs the credit of having recognised the

[1] H. Braun, "Ueber den Einfluss der Vitalität der Gewebe auf die örtlichen und allgemeinen Giftwirkungen lokalanæsthesierender Mittel und über die Bedeutung des Adrenalins für die Lokalanæsthesie," *Archiv für klinische Chirurgie*, Berlin, Band 69.

advantages which might follow the combination of the suprarenal active principle with cocaine and allied drugs, and of having fully worked out the subject and shown the advantages of this, the most notable advance in the technique of local anæsthesia since Schleich's demonstration of the analgesic properties of very dilute solutions of cocaine. By a number of experimental and clinical observations on himself, on others, and on animals, Braun showed that the addition of adrenalin to solutions of cocaine and eucaine increased and prolonged their analgesic action to a very marked degree and at the same time diminished their general toxicity, acting, in fact, very much like the application of a tourniquet in this respect. This action of adrenalin is probably due to the marked local ischæmia which follows its injection into the tissues, this ischæmia causing delay in the absorption of the cocaine, and therefore localising and increasing its analgesic action. It is manifested even when adrenalin is used in the most minute doses and in extreme dilution, and is of such advantage that it should be a universal rule to combine it with all solutions for producing local anæsthesia, unless it is desired to avoid the production of an ischæmia in the area of operation.

As the analgesic action of cocaine wears off, there is sometimes a considerable degree of what may be termed reactionary pain. Little reference is made to this by writers on local anæsthesia, but its occurrence is undoubted. Schleich[1] maintained that one of the advantages of adding minute doses of morphia to his solutions was that the after-pain was thereby diminished, but, apart from this, he makes little reference to the

[1] Schleich, *Schmerzlose Operationen*, Julius Springer, Berlin, 1898, 3rd edition.

point. Others have maintained that the after-pain is no worse than the wound-pain experienced after operations done under general anæsthesia, and that in many cases it is due to the use of solutions which are not isotonic with the tissue fluids, and which therefore irritate the tissues. As the result of considerable experience, I have come to the conclusion that in many cases there is a considerable degree of after-pain following the use of cocaine and eucaine, and that this is what may be termed a reactionary pain, coming on as it does after the analgesia produced by the drug wears off. It has occurred alike in cases where the cocaine was dissolved in boiled water without the addition of sodium chloride, and in cases where the drug was dissolved in normal saline solution, in cases where adrenalin was and was not used, and in cases where a tourniquet was used to arrest the circulation, and where no tourniquet was used. In cases of infiltration anæsthesia with solutions of cocaine-adrenalin or eucaine-adrenalin the pain comes on from one to several hours after operation and lasts for five to ten hours. It is usually described by patients as a burning, steady pain. In some few cases it is so severe as to call for the administration of opium to relieve it, but this is fortunately rare. It is, of course, difficult to estimate the severity of pain in individual cases, and it is open to anyone to maintain that what I have termed reactionary pain is in reality entirely due to the operative procedure and not to any reaction following the use of drugs producing local anæsthesia. Careful observation of patients after such operations as the radical cure of hernia, removal of fatty tumours, prepatellar bursæ, varicocele, etc., both under local and general anæsthesia, has convinced me, however, that cocaine and eucaine

injections are occasionally followed by pain due to their use, arising from a temporarily increased irritability of the sensory nerve endings in the injection area in association with the congestion which follows the anæmia induced by the cocaine-adrenalin mixture. In cases where the circulation has been arrested by a tourniquet this reactionary pain is longer in coming on, but is much more severe and lasts longer than after infiltration anæsthesia, and is worst when injections have been made in inflamed tissues. The administration of morphia is sometimes called for in such cases to tide the patient over the painful period, which lasts on an average for five to ten hours.

General Action of Cocaine—Cocaine Poisoning.—It is sometimes urged against the use of cocaine for inducing local anæsthesia that the risk of its producing general toxic symptoms is very great. If it is used for subcutaneous injection in solutions stronger than 1 per cent., and especially if it is used in solutions of 5–10 per cent., as is sometimes advised, toxic symptoms are liable to follow. If it is used in dilute solution of 1 in 1000 or thereby, toxic symptoms may also arise if more than 3 grains are injected at one time.

The idea that cocaine is a dangerous drug in whatever way it is used probably depends largely on the numerous accidents which attended its use soon after its introduction as a local anæsthetic, when its properties were not fully understood and it was used in large doses and concentrated solutions. A number of cases of death from cocaine poisoning have been recorded, and a very large number of cases in which serious toxic, but not fatal, effects followed its use. Reclus[1] has made a careful study of the reported fatal

[1] P. Reclus, *L'Anæsthesie localisée par la Cocaine*, Masson et Cie, Paris, 1903.

cases, and has shown that they were due to improper use of the drug in doses and in solutions, which are admittedly unnecessary and dangerous and would never be used by anyone familiar with the properties of cocaine. Thus cases of death are reported following the use of 4 grammes of 20 per cent. solution for intra-urethral injection, *i.e.* 12 grains of cocaine, of 20 grammes of a 2 per cent. solution for injection into the tunica vaginalis, *i.e.* 6 grains of cocaine. As Reclus truly remarks, these are instances of the abuse of cocaine, not of its rational use. Cases of serious trouble following the use of small doses of cocaine in dilute solution are so very rare that they may justly be attributed to idiosyncrasy on the part of the patient. Just as some people are specially susceptible to the action of morphia and other alkaloids, so occasional instances of susceptibility to the action of cocaine may be met with, and the occurrence of these rare and exceptional cases should not be allowed to interfere with the general use of cocaine, provided it is used in a rational way in accordance with rules which experience has shown make it a safe and satisfactory drug for inducing local anæsthesia. The only case I am aware of in which a fatal result followed the use of an apparently safe dose of cocaine is that reported by Simon [1] (since the publication of M. Reclus' work), where a man aged 24 years, an extremely sensitive subject, suffering from sexual neuræsthenia, died shortly after the injection of 7 cm. of 1 per cent. cocaine into the urethra. The quantity used in this case was just over 1 grain of cocaine, but probably less than this amount was absorbed as some of the solution was allowed to escape when symptoms of poisoning set in two minutes after the injection.

[1] O. Simon, *Münchener medicinische Wochenschrift*, 19th July 1904.

Were such cases of frequent occurrence, the use of cocaine would be unjustifiable. Fortunately, however, they are so rare as to be practically negligible in estimating the risks attending the use of the drug. M. Reclus[1] has a record of over 7000 cases in which cocaine has been used without serious symptoms arising, and there is in his record, and Schleich's work on infiltration anæsthesia, along with numerous less extensive records, ample evidence that cocaine may be used with safety and satisfaction for inducing local anæsthesia.

The symptoms which have been noted in cases of poisoning following the use of massive doses of cocaine are mental excitement, the patient becoming very talkative and emotional in mild cases, sometimes maniacal and delirious in severe cases; general muscular tremor, sometimes passing on to generalised convulsions of an epileptic character or to severe tonic spasms, which may be specially dangerous if the diaphragm is involved; cardiac weakness accompanied by marked pallor: in severe cases, syncope; profuse perspiration; nausea, with vomiting; feeble shallow breathing: and in fatal cases, cardiac and respiratory paralysis. In many cases the mental excitement is not seen, and the patient first complains of a feeling of oppression, turns very pale, is bathed in perspiration, and the pulse is found to be feeble and quick, and the breathing shallow. The treatment consists in laying the patient horizontal and the employment of general stimulating measures, such as the administration of brandy, strychnine, sal volatile, hot coffee, etc. There is no specific antidote to cocaine, and amyl nitrite, which was at one time said to have a specially beneficial

[1] *Loc. supra cit.*

action, should never be administered, as it has been shown to be harmful rather than useful in cases of cocaine poisoning. In very severe cases, artificial respiration has to be employed and kept up for some time.

It must be understood that the foregoing remarks on the toxicity of cocaine refer to its use for inducing anæsthesia by subcutaneous injection, and not for inducing spinal anæsthesia by lumbar puncture. Although it can be used for spinal anæsthesia without danger to life when combined with adrenalin, it often causes toxic symptoms and very often disagreeable after effects, and its use should therefore be entirely given up, and stovaine, which has proved much less objectional for this special purpose, used in its place.

Dose of Cocaine.—No statement of the dose of cocaine which does not indicate the strength of solution to be employed is complete. Reclus, Schleich, Braun, Pouchet, and others have shown clinically and experimentally that much larger quantities of cocaine may be safely injected in dilute than in strong solution. Reclus goes so far as to say that while 10 centigrammes (1½ grains approx.) of cocaine should be the limit in 1 per cent. solution, 20 centigrammes may be safely used in ½ per cent. solution. Braun states that while the limit of 5 centigrammes should not be passed in using 1 per cent. solution, twice that amount may be safely used when the solution is as weak as 1 in 1000. Schleich puts the maximum dose of cocaine in 1 in 1000 solution at 5 centigrammes, although he suggests that that dose may be safely exceeded, as a good deal of the injected solution escapes when the incision into the œdematised tissues is made. Schleich's recommendation certainly

errs on the side of extreme caution, for others have found that in 1 in 1000 solution a good deal more than 5 centigrammes may be injected without the least fear of symptoms of intoxication arising. The dose named by Reclus, on the other hand, is considerably larger than that recommended by anyone else, and although his large experience entitles him to express a positive opinion which cannot be lightly set aside, one is inclined to regard 20 centigrammes (3 grains) in ½ per cent. solution as a large dose, which certainly verges on the dangerous.

It is to be noted, however, that all these doses were fixed before the introduction of adrenalin, and it has been amply demonstrated that the combination of adrenalin with cocaine markedly diminishes the general toxic action of the drug, and therefore allows of the use of larger doses with safety. Exactly how far the dose may be increased by this means it is difficult to say, but it is probably well within the mark to put the safe dose of cocaine in ½ per cent. solution at 1 grain, and in 1 in 1000 solution at 2 grains. As a matter of fact, it will be found that the great majority of operations which can be suitably done under local anæsthesia can be done with smaller doses than those suggested, so that the question of the maximum safe dose rarely arises. I have on several occasions used as much as 2 grains of cocaine in 1 in 1000 solution, but have never found it necessary to use more.

Eucaine.—Eucaine is the name given to the synthetic product benzoyl-vinyldiaceton-alkamin, discovered by Merling, and first studied by Vinci in Liebreich's laboratory.

Two forms of the drug were for some time used, known respectively as eucaine A and B, but it was

soon found that only eucaine B was suitable for inducing local anæsthesia, the A preparation being found irritating and unsatisfactory. Eucaine B is accordingly the only form now in use. The hydrochlorate and the lactate are both used for medicinal purposes. The hydrochlorate is soluble in water or saline solution at room temperature to the extent of $3\frac{1}{2}$–4 per cent., while the lactate is soluble to the extent of 29 per cent. Of the two salts, the lactate therefore seems undoubtedly the more convenient for general use, on account of its greater solubility. It occurs as a white non-hygroscopic powder, melting at 155° C. Its solutions are stable, and can be sterilised repeatedly by boiling without change.

The properties of eucaine are similar to those of cocaine, with this exception, that it produces a slight vaso-dilatation instead of a vaso-constriction when injected subcutaneously or applied to mucous membranes. It is claimed by some that the local anæsthetic power of eucaine is equal to that of cocaine, while its general toxicity is very much less. It is exceedingly difficult to estimate accurately the relative value of the two drugs in these respects. Experimental observations on animals are, of course, useless in estimating their analgesic properties, and the value of experiments on animals is at the best doubtful in estimating the toxic action of the drugs on the human subject, for human beings and animals such as rabbits or guinea-pigs, may react in a very different manner to drugs which exert their action chiefly on the central nervous system. It seems to me that the only true test is that of clinical experience, and when we turn to the records of those who use local anæsthesia extensively, we find that many have used one drug to the exclusion of the

other, and yet do not hesitate to express opinions as to their relative value.

Marcinowski[1] in 1902 published an elaborate article on the use of eucaine in all branches of surgery, and basing his views on his own observations, on the results of experimental observations on animals, and on a study of clinical reports by others, he held that eucaine is undoubtedly much less toxic than cocaine, that it is nearly equal to cocaine in analgesic power, and that, therefore, it should be invariably used in preference to cocaine. His argument was, however, incomplete, for he failed to show that cocaine, though toxic in large doses, can not be safely used when ordinary care is exercised. Barker,[2] in reporting a number of operations done under eucaine-adrenalin analgesia, expressed surprise that anyone continued to use cocaine in view of the excellent results to be obtained from eucaine. He stated, however, that he had no experience of the use of cocaine, and his condemnation of the drug, which gives excellent results in the hands of others, seemed uncalled for. Soon after the introduction of eucaine, Reclus endeavoured to test the relative value of cocaine and eucaine in a number of precisely similar operations. He concluded that eucaine was rather less powerful as an analgesic than cocaine. Basing his views on Pouchet's experiments on animals, he held that the drugs were equally toxic. In his use of them clinically he never observed toxic effects from either, and the general conclusion he formed was, that eucaine presented no advantages over cocaine. Although carefully carried out, his comparative observations were few in

[1] Marcinowski, "Das Eukain B," *Deutsche Zeitschrift für Chirurgie*, Leipzig, 1902, Band 65.

[2] Barker, *British Medical Journal*, London, 24th December 1904.

number, and Pouchet's observations are certainly at direct variance with those of the majority of observers as to the relative toxicity of cocaine and eucaine. Most reliance is, I think, to be placed on the opinions of Braun, who has made extensive trial of both drugs, and the following may be quoted from his paper on regional anæsthesia, as indicating the relative value of the two drugs. "The action of eucaine B on nerve trunks (when injected round them) is slower than that of cocaine and tropa-cocaine; one must almost double the concentration of the eucaine solution to get equal effects to those of the latter drugs, and it cannot be satisfactorily used without arresting the circulation. If, on the other hand, eucaine B solutions are injected directly into nerve trunks they prove, according to Crile, just as powerful as cocaine solutions of equal strength. This agrees entirely with what I have often emphasised—that when they are brought into direct contact with nerve substance by infiltration, the drugs show little difference; but when a diffusion action is desired, cocaine is found to be much more effective." Crile's observations, to which Braun refers, were made, as noted above, on the effects of injecting cocaine and eucaine directly into nerve trunks, and they certainly support Braun's view that when eucaine is brought into immediate relation with nerve substance it acts as powerfully as cocaine.

The important points in Braun's view seem to me to be, first, that the two drugs are of equal power only when brought into the most direct relation with nerve substance, and second, that cocaine diffuses more readily than eucaine among the tissues. In producing anæsthesia by infiltration, the chief difficulty is undoubtedly to bring the solution into direct relation

with the whole field of operation, more especially when the attempt is made to infiltrate the deeper tissues of any part before beginning an operation. If, therefore, cocaine diffuses among the tissues more readily than eucaine, it seems plain that it is to be preferred for infiltration, this property tending to make it act more completely and more quickly. Further, when adrenalin is combined with either drug, it has been found that smaller quantities of the solution may be used for infiltration than when it is not used, if time is given for the drug to act and to diffuse. As Braun[1] also points out, this combination does not abolish the difference in action between cocaine and eucaine, but rather increases it, and this again gives the preference to cocaine over eucaine for infiltration anæsthesia.

The question then really turns on the relative toxicity of the two drugs. It must be admitted that eucaine seems to be less toxic than cocaine. All clinical observations point conclusively in this direction, and Reclus is, as far as I am aware, the only clinician who maintains that the two drugs are equally toxic. As we have seen, his opinion is based on Pouchet's experiments on animals, and little or no value is to be attached to it for that reason.

What the exact relation of the two drugs is, as regards their toxic action, it is difficult to say. Eucaine was introduced after cocaine, and after the lesson had been at least partly learnt that care is necessary in

[1] "Es lässt sich leicht erkennen, dass die anaesthesierenden Wirkungen die mit Adrenalin versetzten Cocainlösungen im Grossen und Ganzen, ich möchte sagen, imposanter sind als die der Eukainlösungen. Die Differenz in der örtlichen Wirkung beider Mittel, an und für sich nicht gross, wird durch den Adrenalinzusatz nicht ausgeglichen, soudern eher zu Gunsten des Cocains etwas vergrössert." —Braun, *Archiv für klinische Chirurgie*, Berlin, 1903, Band 69.

using drugs producing local analgesia. Even had the drugs been equally toxic, eucaine would probably never have acquired the evil reputation which cocaine acquired owing to its indiscriminate and careless use, and would probably have been regarded as a less dangerous drug. The fact, however, that eucaine is habitually used without ill effect in doses which would be dangerous in the case of cocaine, proves it to be the less toxic drug of the two. As was pointed out earlier, however, there are limits within which cocaine may be used with complete safety. It will be found that the great majority of operations suitable for local anæsthesia may be done with doses of cocaine within these limits, and, therefore, it seems to me that the preference should only be given to the weaker drug for the few operations in which very large quantities of solution are required. The dose of eucaine beyond which it is unwise to go when combined with adrenalin may be stated at 1½–2 grains in ½ per cent. solution, and 6 grains in 1 in 1000 solution.

The properties and relative value of the two drugs for local anæsthesia may be summed up as follows:— Both drugs act powerfully as local analgesics. Cocaine acts as a vaso-constrictor: eucaine as a vaso-dilator. For intraneural injection they give equal results. Cocaine diffuses among the tissues more readily than eucaine, and is therefore preferable for perineural injection and infiltration anæsthesia, acting more surely and more quickly than eucaine.

Cocaine is more toxic than eucaine, and should not be used in doses of more than 1 grain in ½ per cent. solution or 2 grains in 1 in 1000 solution when combined with adrenalin, while eucaine may be used in doses of 2–6 grains in corresponding solutions. Eucaine should

be used where very large quantities of solution are likely to be required for infiltration. Both drugs may with advantage be combined with small doses of adrenalin. Eucaine possesses an advantage over cocaine in that its solutions may be boiled repeatedly without losing their analgesic power. Both drugs are unsuitable for inducing spinal anæsthesia.

Stovaine.—A recently introduced drug for inducing local anæsthesia, which has been definitely proved to be of value, is the hydrochlorate of amylene, termed stovaine. It is a synthetic product elaborated by Fourneau, a French chemist, and derived from tertiary amylic alcohol. It occurs as a white crystalline substance, freely soluble in water. Its solutions are fairly stable, and may be sterilised by boiling without undergoing chemical change. Experiments on animals have shown it to be less toxic than cocaine, and, as far as they have gone, clinical observations support the view that it is also less toxic in the human subject than cocaine. Pouchet,[1] who experimented with stovaine soon after its discovery, found that it had feeble bactericidal properties. So far, stovaine has mainly been used by French observers, and reports on its use are not very numerous. Reclus,[2] in a communication to the Academy of Medicine, reported that after nine months' use of stovaine he was satisfied that the drug was almost, if not quite, equal to cocaine in analgesic power. He admitted the possibility of a slight difference in the power of the two, "mais c'est vraiment une différence infinitésimale, si elle existe, et la vérité est que la stovaine vaut la cocaine."

[1] Pouchet, *Bulletin de l'Académie de Médecine*, 12th June 1904.

[2] P. Reclus, *Bulletin de l'Académie de Médecine*, Paris, 1904, vol. ii. p. 7.

In a discussion at the Société de Chirurgie in 1904, Delbet[1] expressed the opinion that its analgesic power was less than that of cocaine. Tuffier, who used the drug for inducing spinal anæsthesia, said he had formed the impression that the anæsthetic zone was less extensive and the analgesia less profound, but that the after effects were much less unpleasant than with cocaine. Chaput,[2] who had used stovaine in 150 cases of spinal anæsthesia, expressed complete satisfaction with the results. Bier,[3] at the German Surgical Congress in 1905, expressed himself as entirely satisfied with the results of the use of stovaine for inducing spinal anæsthesia, and maintained that it was by far the best drug for the purpose. He recommended that it should be combined with paranephrin. Czerny expressed similar opinions. Braun tested stovaine in experiments on himself and others, and concluded that it was weaker in analgesic power than cocaine, and that it presented no advantages whatever as a local anæsthetic (excluding its use for spinal analgesia) over cocaine, eucaine, or tropa-cocaine. On examining these reports, one is struck by the fact that the reports on the use of stovaine for infiltration and regional anæsthesia are too few to enable a positive opinion on its value to be formed, and one notes the suggestion by some observers that its analgesic power is less than that of cocaine. Reports on its value in inducing spinal anæsthesia are numerous and definite enough to show that it is the best drug for that purpose. It must be noted, however, that the dose necessary for inducing

[1] *Revue de Chirurgie*, Paris, 1904, vol. xxx. p. 803.

[2] *Ibid.*

[3] See Report of Congress, *Centralblatt für Chirurgie*, Leipzig 29th July 1905.

spinal anæsthesia is larger than the dose of cocaine which sufficed for that purpose, a fact which supports the view that stovaine is less powerful than cocaine. Very few reports have yet appeared to show whether stovaine and adrenalin may be suitably combined or not for ordinary purposes, though Bier advises the combination for spinal anæsthesia. Further experience will show whether stovaine can displace cocaine and eucaine to any extent for infiltration and regional anæsthesia. It seems unlikely that any drug will be found to have a powerful enough action on nerve trunks and endings to produce a satisfactory local anæsthesia, which will not also have a markedly toxic action on the central nervous system when absorbed into the general circulation in any quantity. It is to be hoped that those who use stovaine for infiltration or regional anæsthesia will report their results fully, in order that its real value may be determined. In the meantime, cocaine and eucaine may be commended to those who prefer not to experiment, as satisfactory drugs for regional and infiltration anæsthesia, while stovaine may with advantage be preferred for spinal anæsthesia.

Tropa-cocaine, a drug closely allied to cocaine, derived from the leaves of the Java coca plant, has been much used for inducing local anæsthesia, especially in Germany. It appears to be intermediate in strength and toxicity between cocaine and eucaine, and possesses no advantages which make it preferable to these drugs. It has one decided disadvantage, namely, that it appears to neutralise the action of adrenalin when combined with it, and therefore its analgesic power cannot be increased by using that drug along with it. There are no circumstances under which tropa-cocaine seems

specially indicated, and it is therefore unnecessary to discuss it further.

Within the last few months two new drugs have been introduced and lauded by their proprietors as powerful local anæsthetics, and as being less toxic than cocaine. These are alypin and novocaine, both manufactured by German firms. As far as they have been tested they appear, like so many other drugs which have been tried and given up, to produce a fairly satisfactory local analgesia, but to be weaker than cocaine, and consequently the supposed advantage of their relatively low toxicity disappears, for they have to be used in larger doses and stronger solutions than cocaine. Careful study of what has been written on local anæsthesia leaves no doubt that cocaine still remains by far the most useful drug we have for inducing local anæsthesia, and also shows beyond reasonable doubt that it is not only satisfactory but safe, when used with ordinary care.

Adrenal Preparations.—As noted above, the addition of adrenal preparations in small quantities to solutions of cocaine and eucaine very markedly increases their power of inducing local anæsthesia, and also markedly diminishes their liability to produce toxic symtoms. This action is probably entirely due to the marked local ischæmia which follows the injection of adrenalin subcutaneously. This ischæmia interferes with the absorption of the cocaine or eucaine, and therefore localises their action. According to Braun's view the drugs, when finally absorbed into the circulation, are possibly not in their original form, but are broken up or combined with other substances, forming in either case relatively innocuous compounds. Therefore, larger doses of cocaine and eucaine are tolerated with than without adrenalin. This action of adrenalin is manifested even

when it is used in minute doses and extreme dilutions. For infiltration anæsthesia, for example, a solution containing 1 part of adrenalin chloride to 200,000 produces a marked ischæmia in the area of injection, lasting at least an hour and often much longer. The maximum dose of adrenalin which it is advisable to inject varies, like that of cocaine and eucaine, with the strength of the solution employed. More than ½ a milligramme of adrenalin chloride should not be used in any case for injection at one sitting, that is, about 15 drops of the 1 in 1000 solution which is commonly supplied by the manufacturers, and if a quantity approaching that is used, care should be taken that it is very largely diluted, for otherwise it is apt to cause palpitation and feelings of oppression and precordial distress.

It has been shown experimentally[1] and confirmed clinically that cocaine when mixed with adrenalin interferes very little with the vaso-constrictor action of adrenalin, while eucaine considerably lessens its power in this respect. This accounts for the fact that adrenalin, instead of diminishing for practical purposes the difference in anæsthetic power between cocaine and eucaine, increases it, cocaine-adrenalin mixtures being considerably more powerful than eucaine-adrenalin mixtures. It is on this account that Braun,[2] formerly an enthusiastic advocate of the use of eucaine for infiltration anæsthesia, has in his latest work recommended cocaine-suprarenin solutions for regular use and not solutions containing eucaine.

There are now a number of preparations of the active principle of the suprarenal gland on the market under

[1] Laewen, *Deutsche Zeitschrift für Chirurgie*, 1904, Band 74, p. 163.
[2] H. Braun, *Die Lokalanaesthesie*, Leipzig, 1905

various names. The one selected for use should be definitely standardised and sterile. In using such a powerful drug it is essential to know as exactly as possible what one is dealing with, and therefore no extract which is not definitely standardised should be made use of. The drug is easily decomposed, and its solutions should not be boiled, and therefore it is well to use a preparation which is supplied sterile. It may conveniently also be used in tablet form.

CHAPTER II

INFILTRATION ANÆSTHESIA, RECLUS' METHOD, SCHLEICH'S METHOD, INFILTRATION WITH COCAINE-ADRENALIN OR EUCAINE-ADRENALIN MIXTURES

Infiltration Anæsthesia.—In the present chapter the methods of inducing local anæsthesia by injecting solutions of cocaine, etc., directly into the tissues to be operated on, and generally termed "infiltration anæsthesia," will be described. In the following chapter, operations which may be suitably done under infiltration anæsthesia will be indicated, and illustrative cases will be briefly described.

Reclus' Method.—The oldest method is that generally associated with the name of Paul Reclus, who developed it first and still continues to use it with marked success. The following is his plan. He uses a syringe holding 2 c.c., with a needle about $3\frac{1}{2}$ centimetres long. The syringe must be one readily sterilised, and with a strong finger-grip on the barrel, for considerable pressure has to be used in making injections into dense tissues, such as those of the scalp, palm of the hand, etc. The strength of the cocaine solution used is $\frac{1}{2}$ per cent., *i.e.* 1 grain in 220 minims. In $\frac{1}{2}$ per cent. solution a dose of 20 centigrammes (3 grains) may, according to Reclus, be injected without danger. He has exceeded that dose several times

without inconvenience, but it is sufficient for all operations which can be done under local anæsthesia. Before making the injections the patient is made to lie down. Reclus makes this an invariable rule in using cocaine, in order to minimise any tendency to syncope. He also recommends that the patients should not rise till one hour after the first injection, and that they should drink a little coffee or milk or soup before walking away. He advises also that patients should have a light meal not long before operation. In making the injections, Reclus pinches up the skin at one end of the proposed incision, introduces the needle into the *dermis*, not the subcutaneous tissue, and injects the solution slowly into the true skin, pushing the needle slowly further along in the same layer the while. When the needle is fully inserted the syringe is generally empty, and is withdrawn. The injection produces a band, 1–2 c.m. broad, of œdematised skin, marked on the surface by a blanching and slight swelling along the line of injection. This manœuvre is repeated till the whole length of the proposed incision has been thus treated. For the second and succeeding injections the needle is entered just within the area covered by the preceding one, which will be found already analgesic. In this way a band of analgesic skin, 1–2 c.m. broad, is almost instantly produced. Succeeding layers of tissue must be infiltrated as they are exposed in the same manner, each layer being treated by itself, with the exception of the subcutaneous fat, which when scanty needs very little treatment, but when abundant may be dealt with before incising the skin. The method may perhaps be more easily understood from Reclus' description of his technique in performing a radical cure of inguinal hernia. An analgesic band is first made in the skin as

described above, 8 c.m. long. A second is then made in the subcutaneous fat, special attention being paid to the region of the external abdominal ring. The skin and cellular tissue are then divided down to the external oblique aponeurosis. The external ring is defined. The needle is then insinuated under the aponeurosis into the transversalis and internal oblique muscles, and these are anæsthetised. Before cutting down to the internal ring some of the solution is injected along the length of the cord and to its right and left, one syringeful sufficing for this. After dividing the external oblique aponeurosis to the internal ring, the sac is isolated. Should any firm adhesions between it and the surrounding tissues be found, these may be injected as they are met with. When the sac is isolated, and before opening it, two syringefuls of solution may be injected into it to anæsthetise the peritoneum, and any contents which may be in the sac. The sac is then opened, the contents reduced, and the sac tied and removed below the ligature. The canal is strengthened by Bassini's method and the wound closed. This description will serve to illustrate the chief points in M. Reclus' method. Each layer of tissue must be treated separately, successive layers being dealt with as they are exposed. Therefore, repeated injections are necessary in any operation involving tissues deeper than the subcutaneous fat. It is also necessary to incise exactly in the line of the injections made, and conversely to inject exactly along the line of proposed incision. It is further necessary to be careful when inserting stitches not to insert the needle beyond the narrow analgesic band, 1, or at most, 2 c.m. broad, produced by the injections. The method thus requires great care and precision. With practice excellent results may be

obtained with it, as evidenced by the list of operations which M. Reclus is in the habit of doing under local analgesia. The list includes almost every operation which can be suitably done under local analgesia, and to avoid unnecessary repetition they will not be enumerated here, but will be mentioned later when other methods of inducing infiltration analgesia, and their relative advantages, have been described.

Before leaving the description of M. Reclus' method, however, it must be noted that in his most recent work, since the publication of his book on cocaine, he has been using stovaine instead of cocaine, the strength of the solution used being $\frac{3}{4}$ per cent. He finds the solution as active as the $\frac{1}{2}$ per cent. cocaine solution recommended in his book, and apparently prefers it on account of the lessened risk of toxic symptoms being produced when very large doses have to be used. He apparently never uses adrenal preparations along with cocaine or stovaine.

Schleich's Method.—At the time when accidents following the use of strong solutions of cocaine were frequent, Schleich set himself to find out how far solutions of cocaine could be diluted without losing their power of inducing analgesia. In his investigation he performed a large number of experiments on himself and others, not only with solutions of cocaine but also with other drugs, with plain water, and saline solutions of varying concentration. His observations were the starting-point of an entirely new departure in the method of inducing infiltration anæsthesia, and although some of his contentions were disputed by subsequent investigators, and have, in fact, been disproved, he undoubtedly deserves great credit for having been the first to show that analgesia could be effectively

produced with exceedingly weak solutions of cocaine. The observations which formed the basis of the method which he ultimately developed, and which bears his name, may be summarised as follows.

If 3 or 4 c.c. of any fluid are injected into the *cutis*, a localised œdematous swelling of the skin, an "endermic wheal" (the "endermatische quaddel" of the Germans) is produced. The sensibility of this wheal varies according to the substance injected, and the concentration of the solution. Taking the sensibility of such a wheal as his standard of comparison, Schleich compared the action of a number of drugs and solutions on it, and obtained the following results:—

1. Injection of physiological salt solution allows of the production of an endermic wheal painlessly, but the sensibility of the œdematised skin *remains unaltered.* Therefore the injection of physiological salt solution is painless and *produces no analgesia.*
2. Injection of distilled water causes a burning pain, succeeded in a few seconds by complete insensibility of the œdematised area.
3. Saline solution of ·2 per cent. strength causes, during its injection, a very slight discomfort, quickly followed by complete analgesia of the wheal raised.
4. Cocaine in solution of ·02 per cent. in distilled water can be painlessly injected, and produces an insensitive wheal. Weaker solutions of cocaine in water have not this effect.
5. The power of cocaine is increased if it is dissolved in ·2 per cent. salt solution, so that even a solution containing ·01 per cent. (1 in 10,000) of

cocaine and ·2 per cent. of sodium chloride can produce an insensitive wheal.

6. Morphia in solutions of ·1 per cent. also produces an insensitive wheal.

Schleich also believed that the pressure produced by the injection diminished the conducting power of the sensory nerves and their endings, and further that cold solutions were more effective than solutions warmed to body temperature. Basing himself on these observations he devised his method of producing local anæsthesia, the essential feature of which is the production of a complete œdema of all the tissue to be cut with weak solutions of cocaine which are *not* "isotonic," but what may be termed "subtonic," to the tissue fluids. He recommended three standard solutions for use, which were made up as follows:—

No. 1.

Cocaine,	0·2 gram.
Hydrochlorate of morphia,	0·025 „
Sodium chloride,	·2 „
Distilled water,	100 c.c.

No. 2.

Cocaine,	0·1 gram.
Hydrochlorate of morphia,	0·025 „
Sodium chloride,	·2 „
Distilled water,	100 c.c.

No. 3.

Cocaine,	0·01 gram.
Hydrochlorate of morphia,	0·025 „
Sodium chloride,	·2 „
Distilled water,	100 c.c.

It will be noted that these vary only in the amount of cocaine which they contain. No. 2 is that recommended for general use, and is what is generally known

as "Schleich's solution." Nos. 1 and 3 are only used in exceptional cases. No. 1 for hyperæsthetic tissues, and No. 3 for occasions when very large quantities of solution are required in comparatively insensitive parts.

Other observers, notably Braun, maintained that the analgesic power of Schleich's solutions depended entirely on their cocaine content. Braun repeated and amplified Schleich's experiments, and maintained, what seems to be very generally admitted, that the use of non-isotonic solutions for injection is not only useless but harmful,

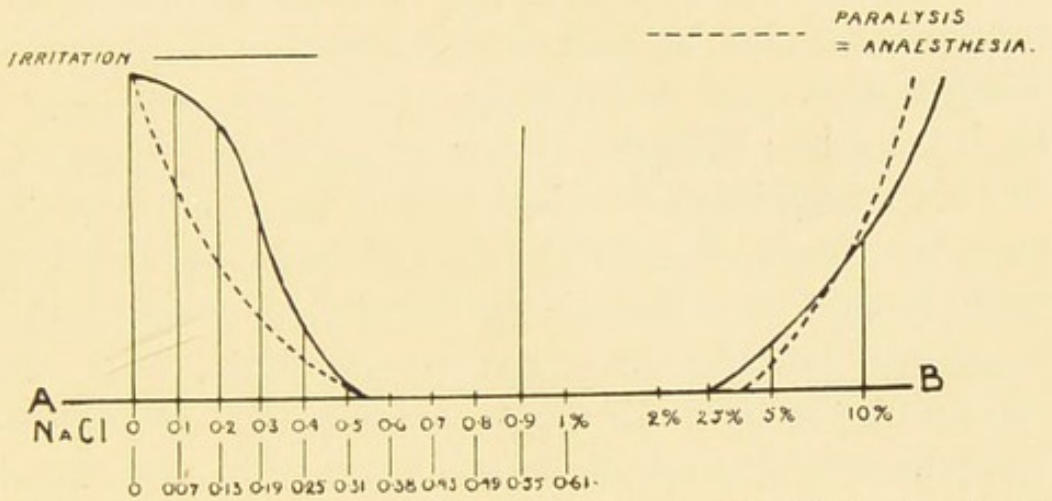

FIG. 1.—Diagram (after Braun). To illustrate the effect of endermic injections of different strengths of NaCl solution, referred to in the text.

for they irritate the tissues and lower their vitality, and so tend to interfere with healing, and possibly even cause sloughing. Heterotonic solutions of certain strengths do produce slight analgesia, but only after acting as irritants, and the slight analgesic power they possess is of no practical value in inducing effective local analgesia for surgical operations. Their analgesic power is in direct proportion to their irritating properties, a point which Braun established and depicted graphically in the accompanying diagram (fig. 1).

Along the line A.B. are indicated the percentage

strengths of solutions of sodium chloride. Below is indicated the difference between the freezing-point of each concentration and that of distilled water. The continuous and dotted curves indicate, approximately, the irritation and subsequent paralysis of sensory nerve endings following the production of an endermic wheal with the various concentrations, and it will be seen that the irritation curve rises in close relation to that indicating the subsequent paralysis.

The diagram is intended to illustrate the effect of injections in healthy skin, and it will be noted that solutions varying in concentration from ·55 per cent. to 2·5 per cent. produce neither irritation nor analgesia. In inflamed or irritated tissues, however, only isotonic, or very nearly isotonic, solutions are free from irritating properties according to Braun, and he maintains very strongly that only isotonic solutions should be used for injections intended to produce analgesia. He has determined the freezing-point of cocaine solutions of different strengths to determine how much salt should be added to them to make them isotonic, and advises that ·8 per cent. sodium chloride be added to the weaker solutions of cocaine and ·6 per cent. to the stronger. For practical purposes all requirements are met by using ·75 per cent. salt solution to dissolve cocaine, eucaine, or stovaine for analgesic purposes. The solution which he recommends, corresponding to Schleich's No. 2 solution, is :—

Cocaine, ...	·1 gram.
Sodium chloride, ...	·8 gram.
Distilled water, ...	100 c.c.

The cocaine may be replaced, according to Braun, by eucaine B without loss of analgesic power if the

tissues operated on are *completely* infiltrated with the solution.

It will be noted that Braun does not include morphia in his solution. He found in the course of his experiments that morphia had no local anæsthetic action whatever, and had on the contrary a tendency to cause a troublesome after-œdema of the tissues. The contention of Schleich that the addition of morphia diminishes the after-pain sometimes following injections he disputes, and maintains that in any case this could only be attributed to its action after absorption into the general circulation, for its local analgesic action is nil. If after-pain occurs, it is much better controlled by an ordinary hypodermic injection of morphia given at some other point than the seat of operation.

It will thus be seen that while Schleich lays stress on the osmotic tension of the solvent of the cocaine in his solutions, maintaining that fluids of a particular osmotic tension have an important analgesic action independent to a certain extent of their chemical constition, Braun maintains that all solutions used for injection should be isotonic, partly because non-isotonic solutions are harmful, and partly because he believes that the analgesic power of weak cocaine solutions is almost, if not entirely, due to the chemical action of the cocaine. It matters little which view is correct, as for all practical purposes an effective analgesia can be produced with solutions prepared in either way. Braun's view, however, that the solutions for injection should be isotonic, or very nearly so, is generally accepted, and is very probably sound. It seems, therefore, advisable always to dissolve cocaine or other drugs used for inducing analgesia in saline solution, and solution of the strength of ·75 per cent. meets all requirements

for general use. The common plan of dissolving 60 grains of sodium chloride in a pint of water to produce a "normal saline solution" gives a solution slightly weaker than this, between ·6 and ·75 per cent., but the difference is so slight as to be almost negligible. When, however, injections have to be made into inflamed and very sensitive tissues care must be taken to make the solutions absolutely isotonic.

Whether Schleich's original solution or Braun's modification of it is used, the method of injecting is exactly the same, and may be briefly described as follows. All the tissue to be cut through must be thoroughly œdematised with the solution. The cutis, subcutaneous fat, muscles, fasciæ, periosteum, etc., must all be treated separately. As in Reclus' method, cutis and subcutaneous tissue may be successfully treated before any incision is made, but deeper layers must be œdematised as they are exposed. Repeated injections are therefore necessary during any operation involving tissues below the subcutaneous fat. Analgesia follows *as soon as* the tissues are œdematised, and lasts for about twenty minutes. It does not extend at all beyond the œdematised area.

In inexperienced hands the method is apt to give unsatisfactory results, as a rule because the tissues are not rendered sufficiently œdematous. According to Schleich, "the infiltrated area must project high over the normal level of the surrounding tissues, taking the form of an œdematous, broad based, sessile tumour. On incision the tissues should have a glassy or jelly-like appearance, the tissue fibrils being spread out, and the cut surface weeping like that of a cucumber or over ripe melon. An infiltrated penis, lip, or ear lobule must appear as if affected with elephantiasis, and pen-

dulous tumours, such as hæmorrhoids, fibromas, sarcomas, become often ten times their former size. The skin over such tissues becomes like silky paper and almost transparent like glass. The tough elastic cutis naturally opposes considerable resistance to this distension, but even with it a sufficient œdema is much more intense than that seen in pathological conditions."

In inducing analgesia by Schleich's method, it is well to bear in mind that the tissues must be distended to their utmost to produce analgesia, and that only œdematised tissue is analgesic. Tissues in which incision is to be made must be completely œdematised, and only the tissue to be incised must be œdematised. If these points are attended to, very satisfactory results can be obtained with Schleich's method.

Infiltration with Cocaine-Adrenalin or Eucaine-Adrenalin Mixtures. — Although satisfactory results can be got by using either of the methods described above, both leave a good deal to be desired in several respects. With Reclus' method extreme care and precision in making injections is necessary, and even the maximum dose of cocaine which he uses, large as it is, barely allows of the distribution of the solution over the whole field of many operations. Especially is this the case when, as so often happens, incision reveals a state of affairs more complicated than was expected at the beginning of an operation. Schleich's method, on the other hand, is a little unsatisfactory because of the difficulty of completely infiltrating every portion of an operation field, and because the extreme œdema necessary is apt to obscure anatomical details and render dissection difficult and tedious.

The discovery of the properties of adrenalin-cocaine or adrenalin-eucaine mixtures has allowed of important

modifications of both methods, and has resulted in the development of a plan which is in a sense intermediate between the two older ones, although giving very much more satisfactory results. It may be emphasised once more that adrenalin intensifies the action of local analgesics, prolongs their action, and lessens their general toxicity. As the result of this, weaker solutions may be used than M. Reclus recommends with equal effect, and on the other hand a very much less complete œdema than Schleich's method requires, suffices to produce analgesia which lasts, as a rule, for two or more hours.

Stated generally, it may be said that complete analgesia of tissues may be produced by injecting into them weak cocaine-adrenalin or eucaine-adrenalin solutions, in sufficient quantity to produce a moderate distention or œdema. One important point may be noted here in amplification of this general statement, with reference to the skin. Endermic injections are not necessary to render the cutis analgesic. In using older methods endermic injections were always necessary for this, but with cocaine-adrenalin solutions injection into the subcutaneous tissue close below the true skin renders the cutis quite analgesic if time is given for the solution to take effect.

Solutions of the following strengths are recommended for inducing infiltration anæsthesia :—

No. 1.

Cocaine hydrochloride, . . .	1 grain.
Solution adrenalin chloride (1 in 1000), .	12 drops.
Solution sodium chloride (·75 per cent.), .	2 ounces.

No. 2.

Eucaine lactate, ...	1 grain.
Solution adrenalin chloride (1 in 1000), .	5 drops.
Solution sodium chloride (·75 per cent.), .	10 drachms.

No. 3.

Cocaine hydrochloride, . . .	1 grain.
Eucaine lactate, ...	1 grain.
Solution adrenalin chloride (1 in 1000), .	12 drops.
Solution sodium chloride (·75 per cent.), .	3 ounces.

These solutions, particularly solution 1, are recommended because they have been thoroughly tested and found satisfactory. Looking to the fact that it is difficult to produce an absolutely perfect anæsthesia by infiltration, it seems to me that the strongest solution which can be used with complete safety should always be used. After testing various strengths of solution, I have found that with solution 1 most operations can be done with a dose of cocaine well within the limits of safety, while it is strong enough to produce a most satisfactory anæsthesia if properly used. It may be prepared by pouring 2 ounces of warm sterilised salt solution into an aseptic wide-mouthed measure glass, graduated in drachms and ounces, and adding a 1 grain tablet of cocaine and 12 drops of adrenalin chloride, 1 in 1000, to the solution.

Solution 1 is recommended for general use: as much as 4 ounces of it may, I believe, be safely used. Solution 2 is recommended for those who prefer to use eucaine instead of cocaine. It may also be used when it is anticipated that a very large quantity of solution will be required for any operation and it is desired to avoid using a possibly toxic dose of cocaine. Solution 3 combines to a certain extent the advantages of cocaine and eucaine. It acts almost as quickly and as powerfully as a pure cocaine solution, and allows of the use of 3 ounces of solution without using more than 1 grain of cocaine, a dose which some do not care to exceed. The metric system has purposely been avoided in the recipes for

these solutions. Till the metric system has been universally adopted, it is much more convenient to deal with the usual system of weights and measures in use in this country, clumsy as it is.

The solutions should always be made up freshly for each operation. Sodium chloride, cocaine, and eucaine can be kept in tablet form; sterile normal saline solution is readily prepared by adding a tablet to the right quantity of boiling water, and allowing the water to boil till the tablet is dissolved. The desired quantity is then poured into the measure glass, and one or more tablets of cocaine or eucaine added to it, as may be necessary. The adrenalin should next be dropped carefully out of its bottle without fully withdrawing the stopper, and after a preliminary cleansing of the lip with 1 in 20 carbolic solution. The mixture is then allowed to cool, during which time the syringe to be used may be washed out and thoroughly tested to see that it is in working order.

Syringes are often a source of endless trouble. Those which I have found give most satisfaction are made entirely of metal, and for infiltration anæsthesia should be of 10 c.c. capacity, to avoid frequent withdrawal for refilling. The needles should be the finest compatible with strength. The best are those made of seamless steel tubing, with a soft metal expansion at the upper end. The needles fit into a special mount which screws on to the syringe, the end of which presses firmly against the soft metal part of the needle and so prevents all leakage. Several sizes of these needles are made, and as the mounts have all the same size of screw, the different sizes can be used with the same syringe. Any good instrument maker will supply a syringe fitted with these needles, but every syringe should be

thoroughly tested before purchase, and any which allows the slightest leakage should be rejected. It is surprising how much pressure is required to infiltrate dense tissues, and satisfactory results can only be got with a syringe which works perfectly. Some prefer glass syringes because the solution can be seen in them and its escape watched. The eye should watch the effect of the injection as it enters the tissues, not the solution as it leaves the syringe. Glass syringes are more easily broken, and often more costly than metal ones. There are many good patterns on the market: one of the best is the syringe known as the "Record." It can easily be modified to take the seamless steel tubing needles recommended above.

In fig. 2 is indicated a convenient outfit for local anæsthesia. It consists of a small metal tray on which are fitted clips for a large and small syringe, for two glasses, each holding 2 ounces of fluid, graduated in drachms and cubic centimetres, for a glass rod to stir the solutions, and a spiral spring to take needles of various sizes. The tray fits into a small metal steriliser and the whole can be boiled before use. The clips are convenient for holding glasses, etc., firmly in position, so that the steriliser and contents may be carried in a bag without fear of breakages and damage to needle points.

The syringe and needles, as also the glass measure for preparing the solutions, must be sterilised in plain water or saline solution and not in soda solution, for soda breaks up the cocaine or eucaine and destroys their analgesic properties. As steel needles are apt to rust a little during boiling they must be carefully wiped and washed through with sterile lotion, preferably carbolic, before use.

When the syringe to be used has been thoroughly tested, the needles cleansed, and the patient's skin finally washed, freshly made solution will have cooled to about body temperature and will be ready for use. In making injections, the skin at the site of the needle puncture should be made taut by pinching up a fold between the finger and thumb, and the needle passed through the cutis into the subcutaneous tissue with a quick stab. Its introduction causes very trifling

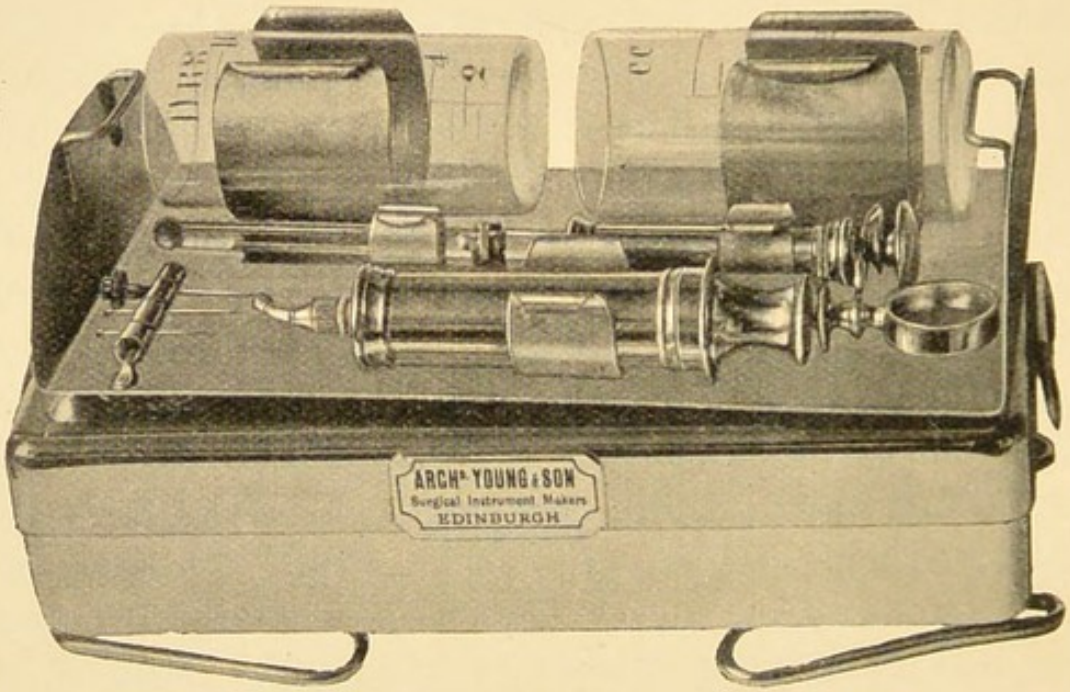

FIG. 2.

pain, and it is, as a rule, unnecessary to freeze the puncture spot in order to lessen the slight discomfort caused. The syringe should then be held almost horizontally, close to the skin, so that the needle may be pushed on in the subcutaneous tissue, close below the skin. As soon as the needle is introduced, the injection should be begun, then the needle should be slowly pushed on in the line of proposed incision, the solution being injected slowly all the time. The

solution should be injected in sufficient quantity to produce a slight but distinct swelling along the line of injection. When the needle has been entered in its whole length it should be partly withdrawn and pushed to one and then to the other side of its original track, so as to produce an anæsthetic area not only in the line, but to either side, of the proposed incision. Renewed punctures may then be made so as to introduce the solution all along the line of proposed incision, beyond it, at either end, and on either side. Special importance is attached to this overlapping. It is often found that original incisions need to be enlarged a little, or that skin must be reflected to one or other side to give more room. I have frequently seen trouble arise when local analgesia was being used, because a wide enough area had not been covered by the injections. It is a safe working rule always to provide a wide margin in case unexpected difficulties are met with.

It is difficult to convey by description the amount of fluid which must be injected for a given length of skin incision. 3–4 drachms suffice, as a rule, for an incision 2½–3 inches long. If a slight but uniform swelling is produced over the whole area of injection, enough will probably have been used.

When the subcutaneous fat is very abundant, a second set of injections may be made at a deeper level than the first to render it analgesic: as a rule this is unnecessary. In operations involving tissues deeper than the subcutaneous fat, the question then arises as to whether these should be infiltrated before or after exposure. In Reclus' and Schleich's methods the deeper tissues must, as a rule, be dealt with after they are exposed. In using cocaine-adrenalin solution, however, it is often possible to infiltrate sufficiently muscles,

fasciæ, periosteum, the cellular tissue round tumours, etc., through the skin. Provided there is no risk of puncturing large arteries and veins, there is no reason why the needle should not be pushed through fasciæ, into muscles and down to periosteum, the solution being slowly injected as this is done. In doing this it must be borne in mind that the deeper tissues, except perhaps the parietal peritoneum and other serous membranes, are much less sensitive than the skin, and that less solution is necessary to render them analgesic: also that although cocaine-adrenalin solution of the strength recommended for infiltration is too weak to affect large nerve trunks, it is strong enough to paralyse fine sensory nerve twigs, and therefore its action extends some distance beyond the actual area of injection if time is given for it to act. An endeavour should therefore be made to make injections specially complete at the point or points where nerves supplying the field of operation enter it. In doing a radical cure of inguinal hernia for instance, special attention should be devoted to the outer and upper part of the field of operation where the ilio-inguinal nerve and twigs of the ilio-hypogastric nerve are met with under the external oblique aponeurosis. When there is no risk of wounding important vessels the infiltration of deeper tissues may often be successfully carried out from the surface and the attempt should always be made, for it is a great convenience to be able to finish an operation once it is begun without making repeated injections and waiting for them to act. When, however, there is any risk of wounding an important artery or vein, and so injecting solution in any quantity directly into the blood stream, injection of deeper tissues must be deferred till they are exposed and the course of the injecting needle

can be accurately controlled. In this connection it may be stated that bathing the deeper tissues with solution after their exposure, in the hope that they may be thereby rendered analgesic, is quite useless. If sensitive tissues have to be cut through, they must be infiltrated and not merely bathed with solution.

When the injections have been completed, time must be allowed for the cocaine or eucaine to act. In the case of the cocaine mixture ten minutes from the time of finishing the injections is enough; when eucaine is used twenty minutes or sometimes even half an hour must be allowed for the drug to take full effect. Marked blanching of the skin over the injection area appears in three or four minutes after the injection, due to the powerful vaso-constrictor action of the adrenalin in the solution. If no blanching appears, it may be concluded that the adrenalin used has been decomposed and has not acted, and imperfect anæsthesia may be expected. This blanching lasts for a varying time according to the amount of the adrenalin in the solution. With the strength recommended it lasts for one and a half hours at least, and often much longer. When sufficient time has been allowed for the cocaine or eucaine to act, the operation should be begun. It is well not to pinch or prick the skin over the injection area and ask the patient if pain is felt. A certain amount of tactile sensibility is nearly always retained, and patients are apt, when nervous, to misinterpret their sensations and mislead the operator. If the injections have been properly made the skin will be absolutely analgesic though not anæsthetic. It is a good rule, after waiting the necessary time, to cover the patient's face with a handkerchief or towel to prevent a view of the operation, and to make the incision at once without asking any questions. It is also a good working

rule to ask no questions as to pain during operation, in order to avoid any suggestion that one is uncertain of the power of the cocaine to prevent pain. Should real pain be felt the patient may safely be trusted to intimate it by word or gesture, without being asked.

In order to obtain the best results while operating under local anæsthesia it is necessary to work as far as possible by careful dissection with very sharp instruments. All blunt dissection, pulling, or tearing should be carefully avoided, for they are liable to cause pain by pulling on structures outside the anæsthetic area. In excising the tumica vaginalis, for example, in doing a radical cure of hydrocele, the coverings should be dissected and not torn or pulled off the tumica; or in doing a radical cure of inguinal hernia, the sac should be carefully dissected and not torn off the cord. The blunt dissector and fingers should be used as little as possible, and their place be taken by the knife and dissecting forceps.

Owing to the action of the adrenalin, bleeding, as a rule, is very slight. When the vaso-constrictor action of the drug wears off, slight reactionary hæmorrhage may take place, especially in places where firm pressure cannot be exerted by a bandage. It is well, therefore, to ligature any points which show the least tendency to bleed during operation, and in places where little or no pressure can be applied it is often wise to insert a small drain for the first twenty-four hours after operation, in order to prevent any accumulation of blood in the wound. The analgesia produced by cocaine or eucaine adrenalin solutions lasts, as a rule, for at least one and a half hours; often very much longer, and, in any event, quite long enough for the performance of any operation which can be suitably done under local anæsthesia. As

the anæsthesia wears off, a burning or smarting pain is felt in the wound, which lasts for several hours. This is rarely severe, but occasionally is bad enough to call for the administration of a sedative. In such cases a hypodermic injection of morphia should be given: $\frac{1}{6}$–$\frac{1}{4}$ grain in an adult. This controls the pain, and by the time the effect of the morphia has worn off, the reactionary pain has gone.

Wound healing is in the great majority of cases in no way interfered with by the injection of solutions used to produce local anæsthesia. The strictest asepsis is of course necessary in preparing and injecting the solutions, for the injection of a solution containing pathogenic organisms would almost certainly be followed by suppuration, and possibly necrosis, in the area of injection. A few cases of necrosis of the skin have been recorded after the use of solutions of cocaine, eucaine, and stovaine for producing local anæsthesia. The necrosis has been variously attributed to the use of non-isotonic solutions, to infection, and to the lowering of the vitality of the tissues by the poisonous action of the drugs used. Two of these supposed causes can be excluded with certainty in preparing the solutions, the third cannot. The occurrence of necrosis is fortunately, however, so very rare that it may almost be neglected in estimating the possible disadvantages attending the use of local anæsthesia. In a long series of cases operated on under local anæsthesia, I have never seen it occur.

CHAPTER III

OPERATIONS WHICH MAY SUITABLY BE DONE UNDER INFILTRATION ANÆSTHESIA

It must be clearly understood that although the operations named in the following pages may be done under local anæsthesia, it is not intended to suggest that they should always be done in this way. Opinions differ widely as to the extent to which local anæsthesia may legitimately be employed in the interests of the patient. Some patients, though very few, are so constituted that a general anæsthetic is necessary for almost any operative treatment of them, however trivial. Some operators have neither time nor patience to give local anæsthesia a fair trial, and would restrict its use to cases of trivial importance which may often be done without any anæsthetic at all, general or local. There are, however, a large number of patients who will prefer local anæsthesia if the relative advantages and disadvantages of local and general anæsthesia are fairly put before them, and the object in compiling the following lists of operations suitable for local anæsthesia is not to show what ought to be done, but what can be done with it, the discomfort and the risk attending the administration of a general anæsthetic being thereby avoided. Each case must be judged on its own merits, and the issues involved vary so much that no

general rules can be laid down, and everyone must judge for herself or himself as to whether local or general anæsthesia should be employed in any given operation.

Speaking generally, it may be said that the operations which may suitably be done under local anæsthesia are those in which the field of operation is comparatively limited, comparatively superficial, and in which its limits can be outlined with certainty before the operation is begun. Operations in deeply seated tissues, on tumours, etc., of uncertain extent and attachments are unsuitable for local anæsthesia, and if it is used in such cases the almost invariable result is either the infliction of severe pain on the patient, or the performance of an incomplete and therefore bad operation. The removal of apparently isolated and superficial tubercular glands in the neck or elsewhere may be cited as a typical illustration of a class of cases where there is often a temptation to use local instead of general anæsthesia, and where local anæsthesia should rarely or never be used. Very moderate experience is enough to teach that the extent of such operations can very rarely be defined before the parts are exposed, that deep dissections involving important vessels are often unexpectedly necessary, making the field of operation larger than was anticipated, and so complicated that all parts of it cannot be rendered anæsthetic by injections of cocaine. The same remarks apply with even greater force to the removal of glands infected with malignant disease. In estimating the possibilities attending the use of local anæsthesia it must be borne in mind that the sensibility of different tissues in the body varies greatly. The subcutaneous fat, muscles, tendons, and fasciæ are very much less sensitive to pain than the skin, and are, in fact, *per se*, almost insensitive, for surgical purposes at

least. Sensory nerves, however, run in and through them and branch in them, and hence they must, as a rule, be infiltrated with the anæsthetic solution, unless the presence of sensory nerves in any particular part can be definitely excluded; hence also the importance of specially infiltrating along the line in any part where nerves are known to run. Periosteum is highly sensitive, bone denuded of periosteum is insensitive, hence ribs bared of periosteum may be painlessly divided in operating for empyema, and exostoses may be painlessly chiselled off when the periosteum has been rendered analgesic by the cocaine-adrenalin solution.

Cocaine-adrenalin solution of the strength recommended in solution 1 is strong enough to paralyse small sensory nerves, the size of the ilio-inguinal as it lies in the inguinal canal, if the solution has been in contact with the nerve for ten minutes or thereby. Larger nerves, with denser sheaths, must be treated separately, and may be almost instantly paralysed by injecting into them a few drops of $\frac{1}{2}$ per cent. cocaine-adrenalin solution. If it is anticipated that large nerves will be met with in the course of any operation, a small quantity of solution should be prepared beforehand, to be ready when wanted. If 1 grain of cocaine be dissolved in 4 drachms of normal saline and 8 drops of adrenalin be added, a solution very slightly weaker than $\frac{1}{2}$ per cent. cocaine solution is made. Enough of this should be injected *into* the nerve with a fine needle, to produce a small fusiform swelling on the nerve. In a minute or two the nerve will be found absolutely analgesic, and may be freely handled or even divided, without any pain being felt. In tissues infiltrated with Schleich's solution the clamping and

ligaturing of small vessels is apt to be painful. When cocaine-adrenalin solution is used, the clamping and ligaturing of arteries and veins is painless. In the abdomen special conditions are present.

Lennander's[1] observations have shown that the stomach and intestines, with their visceral peritoneal covering, the mesentery, the anterior edge of the liver, the gall bladder, the surface and substance of the kidney, the peritoneum covering the bladder, etc., are insensitive, and may be handled, cut, or burnt with the thermo-cautery without pain. The parietal peritoneum on the other hand is very sensitive to touch, pain, etc. As the result of his observations, Lennander has concluded that those organs and tissues of the body which are innervated exclusively by the sympathetic or vagus below the origin of the inferior laryngeal nerve have no nerve apparatus for the perception of pain, or heat and cold. He has further formulated the hypothesis that diseases of the abdominal organs only cause pain when they give rise to mechanical, chemical, or inflammatory (bacillary or toxic) irritation of the cerebro-spinal nerves. The practical outcome of these observations has been, so far, that some abdominal operations can be done without general anæsthesia and without paining the patient, provided the abdominal incision can be made painless by anæsthetising the abdominal walls along its line, and that the subsequent operation involves no handling or traction of the parietal peritoneum. The number of such operations is obviously limited, but the discovery of the fact that any abdominal operation can be done without general anæsthesia, and without paining the patient, marks a great advance in the history of abdominal surgery. Apart from their practi-

[1] Lennander, *Deutsche Zeitschrift für Chirurgie*, Band lxxiii. s. 297.

cal application, the scientific interest of Lennander's observations and views is great, and it is to be hoped that those who operate under local anæsthesia will take the opportunities offered them of confirming and extending his observations on nerve distribution all over the body.

Regarding the use of local anæsthesia in patients of varying temperaments and ages there is little to be said. As a rule, children are not suitable subjects for it. There are exceptions, however, to this rule. I have on several occasions used both infiltration and regional anæsthesia on children, and the following are brief summaries of some cases where infiltration anæsthesia has been successfully used.

CASE I.—I. C., girl, *æt.* 5½ years, with small tubercular ulcer on skin of arm. Schleich's No. 1 solution was injected so as to raise the ulcer on a bed of injection. The injection was made from one puncture. The ulcer was dissected off painlessly. The amount of solution used was not noted.

CASE II.—L. R., girl, *æt.* 6 years, with needle embedded in palm of right hand, which had been there for ten weeks. The needle was lying to the ulnar side of the palmar arch, nearly one inch below the pisiform bone, deep in the palm. Solution containing 1 grain of eucaine B, with 8 drops of adrenalin to 1 ounce of normal saline was injected so as to infiltrate the tissues proximal to and round the needle. 1½ drachms = ⅕ grain of eucaine (approximately) were used. A broad elastic band was then applied round the wrist to arrest the circulation. In fifteen minutes the incision was made, and after a dissection involving the retraction of the nerves running to supply the little finger, and the palmar arch, the needle was found and removed. The

whole proceeding was painless. The wound healed by first intention.

CASE III.—B. G., male, *æt.* 11 years, suffering from a ganglion on the dorsal aspect of the right wrist. Cocaine-adrenalin solution was injected over and round the ganglion; $\frac{1}{4}$ grain of cocaine was used. A tourniquet was applied at the wrist. The ganglion was incised and removed and the skin stitched. The operation was painless, and the wound healed by first intention.

CASE IV.—L. S., male, *æt.* 12 years, suffering from a ganglion on the dorsal aspect of the wrist. Eucaine-adrenalin solution was injected in the usual way. A tourniquet was applied at the wrist. The ganglion was removed after fifteen minutes waiting. The operation was painless. Healing took place by first intention.

CASE V.—A. M., boy, *æt.* 12 years. Same as above in every respect.

CASE VI.—J. H., girl, *æt.* 15 years, suffering from an exostosis on the dorsal aspect of the radius at the wrist. Cocaine-adrenalin solution was injected subcutaneously, chiefly on the proximal side of the exostosis, also at its base and over it. A tourniquet was applied. $\frac{1}{4}$ grain of cocaine was used. In twenty minutes the exostosis was exposed and snipped off with bone forceps. The operation was painless. Healing took place by first intention.

In cases such as the above where minimal quantities of cocaine or eucaine are needed, where the children are not excitable or nervous, local anæsthesia may be used with success. If possible, in such cases, a tourniquet should be applied to prevent absorption. When an elastic bandage 2–$2\frac{1}{2}$ inches broad is used, and applied with sufficient firmness just to arrest the circulation, it is perfectly well borne and causes no pain

in the majority of cases. In none of the cases in which I have used local anæsthesia in children has there been the slightest sign of toxic symptoms from absorption of cocaine or eucaine. These cases may, however, be looked on as exceptional, and it is probably unwise to attempt the use of local anæsthesia in patients under fifteen years of age as a general rule. In adults, local anæsthesia may be used without fear in health, and there are no diseases in which its use is as, or more, dangerous than general anæsthesia. In cases of extreme weakness, however, from whatever cause, cocaine and eucaine must be used with care and large doses avoided.

No special preparation of the patients is necessary before operation under local anæsthesia. Operation is perhaps most suitably undertaken two hours after a meal, if there is a possibility of choice in the matter. If in cases of emergency patients are suffering from exhaustion or weakness, due to loss of blood, want of food, or any other cause, it is well to give something to relieve this before operation, such as a drink of hot milk, hot coffee, or soup, with a little bread or toast. A meal may be taken as soon after operation as the patient feels inclined.

To get the best results from local anæsthesia sharp instruments and delicacy and lightness of touch in operating are essential. Clean cutting should always be used instead of blunt dissection and tearing, and forcible retraction should be avoided, for anything tending to drag on tissues outside the anæsthetic area may cause pain.

Constant questioning of the patient as to whether pain is being felt or not should be avoided. After the injections have been made, and the time for them to act has passed, the operation should be quietly begun and

continued without questions being asked. If serious pain is felt, the patient may be trusted to make it known; on the other hand, if questions are asked, the suggestion that pain may be felt and that the operator is uncertain of the effect of the injections is apt to make patients nervous and apprehensive, and cause them to exaggerate any trifling pain which may be caused.

Operations Involving the Skin and Subcutaneous Tissue.

Skin grafting, by Thiersch's or other method.
Excision of patches of tubercular or lupoid skin.
Excision of ulcers, with or without subsequent skin grafting.
Removal of warts, moles, epitheliomata.
Removal of sebaceous and dermoid cysts.
Removal of fatty, fibrous, sarcomatous, and other tumours.

Thiersch Grafting.—The injection should be made as close to the skin, without being actually endermic, as possible, and the attempt made to distribute an even uninterrupted layer of solution just below the skin. An area of about 6 square inches can easily be rendered analgesic with 3 ounces of solution. In ten minutes grafts may be removed in the ordinary way. Care must be taken not to go outside the area covered by the injection, for the removal of Thiersch grafts from skin which has not been anæsthetised is exceedingly painful.

CASE VII.—Miss B., *æt.* 40 years, suffering from large ulcer following a burn of third degree on dorsum of hand, dorsal aspect of fore-arm, and, to a less extent, palmar aspect of fore-arm. Burn caused by patient falling against the fireplace during an epileptic fit.

3 ounces of cocaine-adrenalin solution = 1½ grains of cocaine were injected subcutaneously close to the skin on the left thigh. The solution was distributed over an area about 6 × 6 inches. Ten minutes after the injection was finished Thiersch grafts were painlessly removed from the whole area reached by the injection. The grafts were transferred directly to the surface of the ulcer, which had been previously freshened by rubbing with a dry gauze swab. Some took and some died.

A general anæsthetic need never be given for the removal of Thiersch grafts unless the area to be covered is so large that a dangerous dose of cocaine or eucaine would be necessary to render it analgesic.

Removal of Warts, Epitheliomata, Ulcers, etc.—In removing warts, epitheliomata, ulcers, etc., the injection should be introduced so as to make a subcutaneous ring of it all round the object to be removed, broad enough to extend beyond the limits of the proposed incision. The needle should then be passed under the tumour or ulcer and the solution distributed carefully under it, so as to cut off the nerve supply to the area of skin from which it is derived. The final result is that the epithelioma or ulcer is raised on a bed of solution and surrounded by it. With small rodent ulcers and warts this may generally be effected from one puncture by pushing the needle in various directions, but in cases where a considerable area is involved several punctures may be required. Additional punctures should always be made just within the area covered by injection from a previous one.

CASE VIII.—Mrs B., *æt.* 51 years, suffering from a rodent ulcer about ½ × ¼ inch on the right cheek just beside the ala of the nose. About 4 drachms of cocaine-adrenalin solution = ¼ grain of cocaine were

injected round and below the ulcer. In ten minutes the ulcer, with a surrounding margin of healthy skin, was painlessly removed, and the edges brought together with stitches.

Case IX.—A. B., sailor, *æt.* 51 years. The patient had a circular, ulcerated, fungating epithelioma, about 1 inch in diameter, on the left temporal region at the hair margin, no evident glandular involvement. About 4 drachms of cocaine-adrenalin solution were injected round and under the tumour. Twenty minutes later the tumour was fully excised. One or two slight twinges of pain were felt during the operation. Considerable difficulty was found in making the injection travel in the dense subcutaneous tissue of the scalp. The injection had to be made slowly, under considerable pressure.

Removal of Sebaceous and Dermoid Cysts and Subcutaneous Tumours.—In removing cysts or tumours from the subcutaneous tissue the cocaine solution should be distributed carefully all round, below, and above the cyst or tumour. It is well to make the injections on a definite plan, beginning say by completely surrounding the cyst or tumour with a ring of solution in the subcutaneous tissue, then passing the needle below it and injecting there, and finally injecting solution between it and the overlying skin. In this way all the tissue to be cut through is infiltrated with solution. Except when very small cysts are being removed, several punctures are required in making the necessary injections.

Case X.—X. Y., male, *æt.* 80 years. The patient had three sebaceous cysts on the vertex: one as big as a walnut, the others about the size of hazel nuts. A ring of cocaine-adrenalin solution was made in the sub-

cutaneous tissue round each cyst. The needle was then passed just through the skin over the convexity of each cyst, and the solution made to travel between it and the cyst wall, which it did readily. In ten minutes the cysts were transfixed, emptied, the capsules picked up and dissected out. A little pain was felt during the removal of one of the smaller cysts; the removal of the others was painless. It will be noted that no attempt was made to pass the needle below the cysts in this case, so as to infiltrate the tissue below them directly. Subsequent experience has shown that although the solution injected round the base of a cyst usually travels under it, this is not always the case, and it is, therefore, wiser to make a rule of passing the needle below a cyst so as to reach the underlying tissue directly, as well as round it and over it. The difficulty of making the injection travel in the subcutaneous tissue of the scalp, noted in the last case, is always met with in dealing with sebaceous cysts, but with care and patience a complete infiltration and analgesia can be produced. In the above case, 6 drachms of solution, *i.e.* less than $\frac{1}{2}$ a grain of cocaine, were used altogether.

Case XI.—Mrs V., *æt.* 48 years, suffering from a fatty tumour in the right posterior triangle of the neck, extending nearly to clavicle in front and over supra-scapular fossa behind, measuring 5 inches in its long axis and $2\frac{1}{2}$ inches transversely. 3 ounces of cocaine-adrenalin solution = $1\frac{1}{2}$ grains of cocaine were used. The solution was injected first of all round the base of the tumour, then over the surface of it, between it and the skin, and lastly some was injected on the deep aspect, care being taken to avoid passing the needle near important vessels in the posterior triangle.

In ten minutes an incision the length of the tumour was made, and it was carefully dissected out. No additional injections were made during the operation, but the whole proceeding was painless. It was found that the connective tissue on the deep aspect of the tumour was only partially infiltrated with solution, and the fact that no pain was felt in dividing it illustrates the fact that the subcutaneous tissue is, as a rule, almost insensitive, provided that sensory nerves are not met with and stimulated during operation. This patient was very nervous before operation, and just before the incision was made she felt a little faint and shaky. A small dose of brandy was given by the mouth, and she recovered in a few minutes. When she found that the operation was really painless, she lost her nervousness completely. Incidents such as this are liable to occur with nervous and sensitive patients, and are, I believe, sometimes erroneously attributed to the action of cocaine, eucaine, or any drug which is being used. They occur as frequently, I believe, when no anæsthetic is being used at all, and it is well to make patients lie down before any operation, however trivial, to guard against the possibility of syncope occurring. I have seen two other instances of threatened syncope in a long series of operations under local anæsthesia, both in women, and in both cases the symtoms passed off in a few minutes, when the patients found that the operation was, contrary to their expectation, painless and free from discomfort.

Enough has been said to show how local anæsthesia may be induced in dealing with tumours, cysts, etc., involving the skin and subcutaneous tissue. The cases briefly noted have been selected as typical instances of common lesions which are met with in everyday work.

They will serve to show what can be done in such conditions with local anæsthesia. General anæsthetics are often administered in similar cases, but their use is, I believe, rarely necessary or justifiable.

Operations on Vessels, Tendons, Bursæ, etc.

Ligature of arteries.
Ligature or excision of varicose veins.
Tendon suture: tenotomy.
Excision of ganglia.
Removal of enlarged bursæ, etc.

The ligature of an artery as a set operation is comparatively seldom done nowadays. Still such operations are by no means unknown, and certain arteries which lie near the skin can easily be tied under local anæsthesia. Such are the common carotid immediately below its bifurcation, the subclavian in its third part, the brachial artery in any part of its course, the radial and ulnar in their lower thirds, the common or superficial femoral in Hunter's canal, etc., etc. Any artery, in fact, which lies near the surface and does not require a difficult or complicated dissection to expose it, can quite well be tied without paining the patient by infiltrating the superficial tissues over and alongside it. When a sensory or mixed nerve lies over or beside the artery, it can be cocainised directly, with ½ per cent. cocaine, when it is exposed.

Ligature or Excision of Varicose Veins.—Varicose veins may conveniently be rendered prominent before making injections near them by applying an elastic bandage round the leg or thigh, just above the dilated veins. Injections can then be made without fear of the needle entering a large vein. Solution

should be injected in the subcutaneous tissue along both sides of the dilated vein and must be distributed along the whole length of the skin over the portion of vein or veins to be dealt with. The veins can then be exposed, and divided, excised, or ligatured as preferred. Some cases of varicose veins are too extensive and too complicated for efficient treatment without a general anæsthetic, but on the other hand, local anæsthesia gives excellent results in a large number of cases.

Case XII.—A. B., male, *æt.* 40 years, with left internal saphenous vein very varicose for 6 inches just above the knee, and a large bunch of tortuous dilated thin-walled veins over the inner aspect of the tibia and the adjacent muscles at the middle of the leg. Cocaine-adrenalin solution was injected all along the dilated portion of the saphenous vein above the knee, and also all round and above the bunch of dilated veins in the leg. In ten minutes 5 inches of the saphenous vein were removed and numerous entering branches ligatured, all without pain. The skin was then partly reflected from the bunch of veins in the leg, and some of them were excised and the rest divided and ligatured. Owing to the extreme thinness of the veins here, there was a good deal of trouble from bleeding, and owing to the fact that the veins lay directly on the periosteum of the tibia, some pain was felt when they were dissected off as no effort had been made to infiltrate under the veins. The case was an unusually difficult one, but in spite of that the pain felt was trifling. The result was good; the wounds healed by first intention, and the bunch of veins in the leg was obliterated.

Tendon Suture: Tenotomy.—Tendons themselves are insensitive and may be divided or stitched, once they are exposed, without pain. All that is necessary

in dealing with them is to infiltrate the over-lying tissues, so that they may be painlessly exposed.

Case XIII.—Mrs B. S. Patient came to hospital several days after receiving a cut on the dorsal aspect of the right thumb opposite the metacarpo-phalangeal joint, which had divided the extensor longus pollicis tendon and thus rendered full extension of the thumb impossible. The wound was suppurating freely, so antiseptic dressings were applied for some days till the wound was healthy and granulating well. An attempt was then made to unite the divided tendon. Cocaine-adrenalin solution was injected subcutaneously all along the dorsal aspect of the metacarpal bone of the thumb and along the first phalanx, *i.e.* proximal and distal to the wound. The wound edges and the granulating surface were then excised, and, thereafter, incisions were made exposing the divided ends of the tendon which were slightly adherent to the surrounding tissues. The ends were freed, refreshed, and brought together with silk sutures, and the skin united over them. The operation was painless. Unfortunately, suppuration occurred, and the union eventually broke down. Doubtless the operation should not have been done till after the wound had healed for some time, when there would have been less risk of infection occurring. The case is reported because it showed that the operation was easily done under local anæsthesia, and because it showed the unwisdom of opening up tissues in the neighbourhood of an apparently healthy wound.

Ganglion.—Many methods of treating ganglion have been recommended from time to time, from the simple plan of bursting the ganglion with a smart blow, to the more complicated method of exposure and complete excision of the sac. An easy and satisfactory plan is to

infiltrate the subcutaneous tissue over and round the ganglion with cocaine-adrenalin solution and then distribute some solution round its base. After waiting for the cocaine to act, the ganglion may be exposed and partly cleared. It should then be opened, and the jelly-like contents expressed when the interior may be inspected and the relations of the ganglion made out. The greater part of the wall can then be removed without disturbing the tendon or tendons which lie in its neighbourhood. Many ganglia are not simple sacs, but are to a certain extent multilocular, there being generally in such cases a main sac, superficially placed, communicating with smaller and deeper diverticula which may pass down to the ligaments of the wrist or other joint near which the ganglion is lying. The whole sac and any diverticula from it should be laid freely open, and as much of the wall clipped away as can be reached without disturbing the synovial covering of tendons near which the ganglion is growing. The wound should then be closed without drainage and a firm bandage applied. This procedure is easy, painless, and always, I believe, gives satisfactory results.

Case XIV.—Mrs B., *æt.* 33 years. Patient had a ganglion the size of a small tangerine orange over the extensor longus digitorum tendon in front of the left ankle joint. The ganglion had been punctured and emptied some months before, but had filled up again almost immediately afterwards. A solution containing 1 grain of cocaine, 1 grain of eucaine, 12 drops of adrenalin chloride solution 1 in 1000, to 3 ounces of normal saline solution (Solution iii.) was used. 14 drachms of this solution were injected over and round the ganglion, special attention being paid to distributing the solution round the base of the swelling. After

waiting twelve minutes the ganglion was exposed and opened. The jelly-like contents were stained brown, presumably by blood pigment from blood which had escaped when the ganglion was punctured some months before. The wall of the ganglion was then cut away. No connection with any tendon was apparent, the ganglion lying apparently on the anterior annular ligament. The whole operation was painless, and was followed by moderate after-pain coming on three to four hours after the injections were made. The wound healed without suppuration.

Bursal Enlargements.—Enlarged bursæ, over the patella, the olecranon, etc., are best treated, if causing inconvenience, by excision under local anæsthesia. The usual rules must be followed in making the injections, the solution being made to travel all over the bursa, between it and the skin, and then more deeply, especially round the base of the bursa, where it is in contact with the underlying aponeurosis or periosteum.

CASE XV.—Mrs S., *æt.* 52 years. Patient had an enlarged prepatellar bursa on the right knee, which caused her much inconvenience in her work as a housekeeper. The bursa measured 3×2 inches, and was filled with fluid, the walls being apparently not much thickened. Cocaine-adrenalin solution was injected all over the bursa, between it and the skin, all round it, and a little finally injected on to the patella on the deep aspect of the bursa. 2 ounces = 1 grain of cocaine were used. In fifteen minutes the skin was incised, and the bursa dissected out. A little pain was felt as the bursa was dissected off the patella, apparently because enough solution had not been injected in this region. The pain was very slight and easily tolerated, although the patient was a nervous and excitable

woman. The remainder of the operation was painless. As a matter of fact, too much solution was used in this case for the subcutaneous tissue round the tumour, the skin being made anæsthetic far beyond the limits of the incision or the subsequent dissection. After-pain was slight, and the wound healed by first intention.

Case XVI.—R. L., male, *æt.* 20 years. Patient had an enlarged bursa containing fluid over the tibial tubercle. Cocaine-suprarenin solution was injected round and over the bursa. After waiting for the cocaine to act, the bursa was excised without any pain. The wound healed by first intention.

Case XVII.—A. B., male, *æt.* 50 years. Patient had a rounded fluctuating swelling over the right olecranon process due to an enlarged bursa. Cocaine-adrenalin solution was injected over and round the tumour. 10 drachms were used. Twelve minutes later the bursa, with an elliptical piece of skin to which it was adherent, was dissected out. The operation was quite painless. The wound healed by first intention.

Some Operations on the Head and Neck Suitable for Local Anæsthesia.

Tongue: Removal of simple tumours, of ulcers of doubtful nature or small epitheliomata, towards the front of the tongue.
Removal of small, superficially placed, simple parotid tumours.
Opening of maxillary antrum.
Removal of salivary calculi.
Removal of small or moderate sized rannulæ.
Removal of small, malignant ulcers of the lip.
Tracheotomy in adults.
Thyroidectomy.

Operations on the Tongue.—The anterior half of the tongue, or a limited portion of it, can easily be

rendered analgesic by infiltration with cocaine-adrenalin solution. The solution travels readily and diffuses readily in the loose submucous and muscular tissue of the organ, and the injections are painless except for the initial puncture. Simple tumours such as papillomata and fibromata can then be painlessly excised or shelled out, or small malignant ulcers excised with a wide margin of healthy tissue round them. Small portions of doubtful ulcers can also be removed for diagnostic purposes by the same means.

The ischæmia produced by adrenalin is usually very marked in the tongue, and when this passes off there is apt to be a good deal of oozing of blood. This can be guarded against by ligaturing any small vessels or oozing points on the cut surface during operation. Small vessels which are apt to escape notice may sometimes be shown up by gently squeezing the infiltrated part of the tongue, when a drop of blood will exude from them and show where a ligature may be applied with advantage.

If the part requiring operation occupies a central position, say the tip, the needle should be introduced well behind it, at the side of the tongue, and pushed transversely across the tongue, the solution being injected steadily all the time. Care must be taken to distribute the solution close to the mucous membrane on the upper and also on the under aspect, and to ensure this it is well to nearly withdraw the needle after the first and more central injection, and then push it across again close to the mucous membrane on each aspect of the tongue. In this way an analgesic band is produced behind the area of operation, and working from this the injection should be made to infiltrate the portion of the tongue in front of it. If

the lesion occupies a lateral position, the solution may be introduced all round it without including the whole breadth of the tongue. Enough solution should be introduced to produce a moderate uniform swelling of the part infiltrated. During the injections the tongue should be steadied by gently grasping it at the tip with a dry gauze swab. In ten minutes incisions may be made painlessly through the infiltrated portion. To steady the tongue during operation it is well to introduce one or two stout silk threads through the infiltrated part, outside the line of proposed incision. With these the tongue may be steadied without being too strongly pulled on and without hurting the patient in any way.

CASE XVIII.—*Removal of the tip of the tongue.*—J. B. *æt.* 68 years. The patient presented himself with a superficial ulcer, 1 inch long, on the tip of the tongue, which had been present for eight weeks and refused to heal. There was no history or other indication of syphilis, no induration of the base or edges of the ulcer, and no enlarged glands could be felt. A thorough course of treatment with iodide of potassium and careful mouth cleansing, in hospital, produced no improvement, and removal of the ulcer was decided on. The point of the tongue was infiltrated with cocaine-adrenalin solution well beyond the ulcer. Two silk threads were then passed through the tongue to either side of the ulcer, and the ulcer with a surrounding margin of healthy tissue removed with scissors. The raw edges were then brought together with chromic catgut stitches. The whole operation was painless. 5 drachms of solution were used. Healing took place slowly, but completely, and six months later the patient was in perfect health. Microscopic examination of the ulcer showed no malignant or specific appearances of any kind.

Case XIX.—T. R., *æt.* 70 years. Patient had had a wart on the left side of his tongue for four months The wart projected markedly from the tongue, and had long filiform processes of a whitish colour, suggesting an anemone in appearance. Its base measured $\frac{2}{3} \times \frac{1}{2}$ inch. There was no sign of induration of the tongue substance. The tongue was infiltrated all round and below the wart. The tip of the tongue was transfixed with a silk thread and thereby steadied. The wart, with a surrounding area of mucous membrane, was then dissected off, and the raw surface occluded by stitching. There was no pain and no bleeding. Healing took place rapidly.

The two cases related are examples of what may be suitably done on the tongue under local anæsthesia. Only cases in which the lesion is small and within easy reach should be dealt with in this way. Lesions towards the back of the tongue cannot be satisfactorily treated under local anæsthesia, and attempts to deal with them in this way will only result in disappointment.

Parotid Tumours.—Small, freely movable, superficial parotid tumours may easily be removed under local anæsthesia. The tumours should be treated in the same way as a sebaceous cyst, and carefully surrounded on all sides with a layer of cocaine-adrenalin solution. If there is the least doubt about the depth to which the tumour goes or the possibility of adhesions rendering a tedious deep dissection necessary, removal under local anæsthesia should not be attempted.

Case XX.—R. Y., male, *æt.* 46 years. The patient was suffering from a small parotid tumour, the size of a large hazel nut, which had been present for twenty years, and was slowly growing larger. It lay just behind the ramus of the jaw, and was superficial and freely movable

on the underlying tissues. Cocaine-adrenalin solution was injected round, over, and below the tumour, 4 drachms, *i.e.* ¼ grain of cocaine, being used. Ten minutes later the tumour was dissected out. It was found to adhere fairly firmly to the parotid gland and to a branch of the great auricular nerve, which was divided in the dissection. During the operation the patient felt a dragging sensation in the wound, but it was not painful. There was no after-pain, and the wound healed by first intention.

Maxillary Antrum.—Drainage of the maxillary antrum in the canine fossa may be established as follows:—A small pledget of wool soaked in 5 per cent. cocaine solution should first be applied over the site of the needle puncture at the reflection of the mucous membrane from the jaw to the cheek above the canine tooth on the affected side. In five minutes the needle may be painlessly introduced, and the line of incision along the mucous membrane rendered analgesic by infiltrating freely the submucous tissue below it. The needle should then be passed down to the periosteum at the site of intended puncture and all round it. In ten minutes the incision may be made and the wall of the antrum bored through without pain, the usual method of drainage being then employed.

For the removal of salivary calculi, rannulæ, small malignant lip ulcers, no special directions are necessary. They may be treated on ordinary lines by carefully infiltrating the tissues all round them with cocaine-adrenalin solution.

Tracheotomy.—In adults tracheotomy should rarely require a general anæsthetic. The tissues overlying the trachea can easily be infiltrated from the surface, allowing the trachea to be exposed and opened pain-

lessly. The introduction of the tube may cause some irritation, but with a well-shaped tube this will soon pass off.

Thyroidectomy.—Many operators prefer not to give a general anæsthetic for thyroidectomy and to operate under local anæsthesia. As a matter of fact the only parts of the operation field which are usually rendered analgesic in such cases are the skin and subcutaneous tissue, and possibly the muscles overlying the goitre. The rest of the field is too complicated to allow of satisfactory infiltration being carried out, and no attempt is usually made to do this. In spite of this, goitres may often be removed with little pain after the skin and subcutaneous tissue have been anæsthetised, and the operator must decide for himself in each case whether the risk of respiratory failure is great enough to contra-indicate the use of general anæsthesia.

The foregoing list of conditions in the region of the head and neck which may be operated on under local anæsthesia will serve to indicate the nature of operations in this region which may be satisfactorily done with cocaine-adrenalin injections. Operations for the removal of lymphatic glands affected by tubercular or malignant disease should never be attempted under local analgesia. Their scope can rarely be accurately defined before the glands have been freely exposed. Unexpected adhesions and difficulties are, as everyone with experience knows, often met with, and attempts to operate under local anæsthesia so often lead to the performance of incomplete operations or to the infliction of severe pain that it should be made a rule never to attempt the removal of diseased lymphatic glands under local anæsthesia, however simple the operation promises to be before it is begun.

Operations in the Regions of the Thorax and Abdomen.

Rib resection for empyema.
Enucleation of simple mammary tumours.
Removal of tumours of the abdominal wall.
Gastrostomy, colostomy, etc.
Radical cure of inguinal, femoral and umbilical hernia.
Relief of strangulated hernia.

Rib Resection for Empyema.—Local anæsthesia is of the greatest value in operating for empyema. The majority of cases in adults and well-grown boys and girls, where a portion of a rib has to be removed to drain an empyema, can be operated on under local analgesia. The obvious dangers of general anæsthesia when the respiration and circulation are embarrassed can thereby be avoided, and the operator can work single-handed or with unskilled assistance. The patient may be laid on the sound side and the portion of rib to be removed carefully defined. The subcutaneous tissue is then infiltrated in the ordinary way over an area extending well beyond the proposed incision at each end and about 1½ inches broad. The needle is then gently pushed on and the muscular layer infiltrated over the same area, and afterwards the needle is pushed down to the periosteum and a layer of solution carefully injected all along and at the edges of the portion of rib to be removed. In some cases the inner aspect of the rib can be reached with a syringe provided with a right-angled mount or a right-angled needle, but this is often not possible. Full time should be given for the cocaine-adrenalin to act. The skin, muscle, and periosteal incision may then be made quite painlessly, and the periosteum can be reflected

from the outer surface of the rib. An attempt may then be made to infiltrate the periosteum on the deep aspect of the rib. Whether this is successful or not, the periosteum may then be stripped in the ordinary way from the inner aspect of the rib. Pain is sometimes felt during this, but not always. The rib when denuded of periosteum may be divided without pain, and the parietal pleura opened in the ordinary way. It is sometimes of value to give a hypodermic injection of morphia some minutes before beginning the operation when dealing with nervous patients.

Case XXI.—A. B., male, *æt.* 32 years, suffering from chronic empyema on the right side, associated with phthisis. The pleural cavity had been aspirated several times, and a discharging sinus was present in the seventh interspace in the mid axillary line. The whole of the right side was dull on percussion, and the patient's breathing was considerably embarrassed. The patient was given $\frac{1}{6}$ grain of morphia hypodermically a few minutes before coming into the operating theatre. Cocaine-adrenalin solution was injected all along the line of proposed incision over the seventh rib just above the sinus, first subcutaneously, then deeply on to the periosteum, and along the edges of the seventh rib. In fifteen minutes the incision was made and a portion of rib removed in the ordinary way. The pleural cavity was then opened and 105 ounces of pus escaped. The cavity was explored with the finger, but the collapsed lung could not be felt. Two large drainage tubes were introduced, and the patient sent back to bed. No pain whatever was felt during the operation. The patient was much relieved, but died some months later of phthisis.

Case XXII.—R. L., male, *æt.* 21 years, suffering from

acute right-sided empyema following pneumonia. The patient was very nervous and anxious to have a general anæsthetic, which was promised if it was found necessary during the operation. Without previous administration of morphia, cocaine-adrenalin solution was injected along the ninth rib in the scapular line, the injections being made as described above. The operation was easily completed without a general anæsthetic. Some pain was felt on reflecting the periosteum from the inner aspect of the rib, but it was only slight, and the patient lay perfectly still during the whole operation. He was discharged from hospital four weeks later, having made a good recovery.

Mammary Tumours.—Small, simple, well-defined mammary tumours can easily be exposed and enucleated painlessly under infiltration anæsthesia, the injection being made all round them in the usual way. If the tumour is not well defined from the rest of the gland, infiltration is apt to mask its outline and should not be used.

Abdomen.—Fibrous or fibro-sarcomatous tumours not infrequently grow from the aponeuroses of the abdominal muscles. When small or moderate in size they may be removed under infiltration analgesia. Special care should be taken to infiltrate the surrounding tissues thoroughly on the outer side, from which the nerve supply of the involved area comes.

Gastrostomy, Colostomy, etc. — Lennander's observations, which have been confirmed by other operators, have shown that the visceral peritoneum is insensitive and may be freely handled without causing pain. The parietal peritoneum, on the other hand, is highly sensitive when handled or dragged upon. The abdominal wall, including the parietal peritoneum, can

be rendered analgesic by infiltration with cocaine-adrenalin solution, and the abdomen may then be painlessly opened. Any operation which does not involve handling or dragging on the parietal peritoneum can then be done without paining the patient. The number of such operations is obviously limited, and gastrostomy and colostomy have been selected as perhaps the most typical of these. The whole length of the abdominal incision must be carefully infiltrated with cocaine-adrenalin solution, first, the subcutaneous tissue, then the muscular or aponeurotic layer, and lastly, the extra-peritoneal tissue. Should it be found on dividing the muscles or linea alba that the extra-peritoneal tissue has not been successfully infiltrated, this should be done before dividing it, and the solution should be spread to either side of the incision line as far as possible to allow of the application of retractors if necessary.

The manipulations necessary in doing a simple gastrostomy, colostomy, intestinal anastomosis, resection of intestine, appendicectomy, ovariotomy, etc., can be carried out without causing the patient pain or serious discomfort. The routine adoption of this method is not advisable, even when a simple operation is anticipated, for it is often found on opening the abdomen that the viscera are not so easily reached as was expected; incisions have often to be enlarged, forcible retraction of wound edges to be employed, and adhesions involving the parietal peritoneum to be dealt with. In these circumstances a general anæsthetic has to be given to allow of the operation being carefully and thoroughly done. In no operation is the unexpected more often met with perhaps than in appendicectomy. Although cases have been reported where the appendix has been successfully removed under local anæsthesia, it is

probably wise never to attempt this without general anæsthesia, unless general anæsthesia is absolutely contra-indicated. The impossibility of foretelling accurately the condition, situation, and relations of the appendix makes it necessary, if the best work is to be done, that the surgeon should not be hampered in any way in his manipulations, as he undoubtedly is when operating under local anæsthesia in such cases. For the other abdominal operations mentioned it is also wise to restrict the use of local anæsthesia to those cases in which it is specially desirable to avoid using chloroform or ether. Disappointment and tedious delay in giving a general anæsthetic after an operation is begun will thus be often avoided, and in the majority of cases the best interests of the patient and operator promoted.

Hernia.—With many cases of hernia, particularly inguinal hernia, it is quite otherwise. Here the field of operation is superficial, can be accurately defined before operation, and all parts of it can be readily reached with the injecting needle before or during the operation. Although the use of local anæsthesia for the radical cure of hernia or the relief of strangulated hernia is by no means general, there is not the least doubt that many cases can be efficiently operated on under it. Cushing, Lennander, Reclus, Schleich, Braun, Barker, and many other surgeons of repute have shown this. Before the introduction of adrenalin, Schleich's and Reclus' methods were used with success. With cocaine-adrenalin or eucaine-adrenalin solutions a satisfactory analgesia can be obtained more easily than by either of the older plans.

Herniæ of small or moderate size, in adults of both sexes, of the inguinal, femoral, or umbilical variety, reducible, irreducible, or strangulated, can be operated

on satisfactorily under local anæsthesia. Herniæ of large size are not suitable, for the area of operation is so large that all parts of it cannot be sufficiently infiltrated without using a dangerous dose of cocaine or eucaine. Large herniæ should therefore be dealt with under general, or possibly under spinal anæsthesia if a general anæsthetic is contra-indicated.

The advantages of operating under local anæsthesia are double. In the first place, the patient is spared the discomfort and risk of general anæsthesia. Although the risk is in reality not great, it undoubtedly exists, and many patients decline operation because of it. In the second place, the vomiting which so frequently follows the administration of chloroform or ether does not occur after local anæsthesia, and the strain on the stitches which vomiting causes is thus avoided.

Against the use of local anæsthesia it is urged that an efficient radical cure cannot be done under it, and that the œdema caused by the injections is confusing and unnecessarily complicates the operation. The names of the surgeons who use local anæsthesia in operating on hernia is sufficient evidence that the first objection is groundless. Bassini's operation or modifications of it can be carried out in every detail under local anæsthesia. Failure to produce a satisfactory analgesia is the result of a faulty method of injection, and a very little practice will enable anyone who is anxious to use local anæsthesia to distribute the solution in such a way as to render the whole field of operation analgesic. Some experience, however, is undoubtedly necessary before the best results can be got, and one or two initial failures or partial failures should not discourage those who are inexperienced.

Kocher's and MacEwen's operations are certainly less

suited than Bassini's operation for local anæsthesia, and are perhaps best not attempted under it. It must also be emphasised that in using any method, clean and methodical dissection with sharp instruments must be used, and all tearing and blunt dissection avoided, for these latter are apt to drag on tissues outside the analgesic area and cause pain.

The second objection, that the œdema resulting from the injections complicates the operation, is, I believe, also groundless. The moderate œdema necessary when cocaine-adrenalin solution is used does not really complicate the operation in my experience at all. In fact it has occasionally proved of real service, as the outline of the sac is sometimes distinctly shown up in the œdematised tissues in front of the spermatic cord, and is therefore more easily found than in ordinary cases.

Inguinal Hernia, Radical Cure.—In cases of reducible inguinal hernia, or where the sac contains only omentum, the injections may be made as follows. Beginning 1 inch outside the internal abdominal ring the solution should be distributed immediately under the skin along the line of incision as far as the root of the penis in the male and into the labium majus in the female; it should also be distributed laterally to the incision line over an area about 1½ inches broad, slightly overlapping Poupart's ligament below. If the subcutaneous fat is very abundant a second series of injections may be made at a deeper level close to the aponeurosis, but in most cases this is unnecessary. Enough solution should be introduced to produce a slight but distinct and uniform swelling over the area covered by the injections. 4–6 drachms of the solution are usually quite sufficient for this purpose. The

needle must then be pushed through the external oblique aponeurosis and the solution distributed along the cord, and on either side of it and in it. The best way of gauging exactly the depth to which the needle is to be pushed is to introduce the left index finger into the inguinal canal in front of the cord, and push the needle gently on to it. The syringe should then be held as nearly horizontal as possible, and the needle pushed upwards along the cord and then in other directions so as to distribute the solution along and on either side of the cord and over the edge of the internal oblique. Special attention should be directed to the region round the internal ring where the neck of the sac lies. 3–4 drachms of solution may be injected under the external oblique in this way. A drachm or two of solution may finally be injected beyond the external ring round the sac cord. After waiting the necessary time, which may be devoted to hand washing and arranging instruments, etc., Bassini's operation may be done in the usual way. If, after dividing the external oblique over the cord and sac, it is found that the tissues of the cord, especially the upper part, have not been successfully infiltrated, it is well to do this and wait a few minutes for the cocaine to act. Dabbing the solution on tissues which are to be cut is useless; they must be moderately œdematised to render them analgesic. The ilio-inguinal and twigs of the ilio-hypogastric nerve are nearly always seen overlying the coverings of the cord and sac and bathed in solution. They will be found completely analgesic and may be held aside or divided at will. The genital branch of the genito-crural nerve is also frequently met with joining the cord on its under aspect, and if it has not been surrounded with solution by the original injection a little

solution should be injected into or on to it, when it quickly becomes insensitive.

If the above directions are attended to, Bassini's operation can be done in every detail without paining the patient. When injections have not been carefully made, the part of the operation most liable to cause pain is ligaturing the neck of the sac, and therefore the suggestion that special attention should be paid to infiltrating it and the tissues round it. Even if this has not been successfully done, the pain caused by the ligature is momentary and slight. Barker suggests that the sac may be cut across and ligatured without dissecting out its peripheral part. This certainly saves time and trouble, and should be done if the sac is long. Leaving the peripheral portion *in situ* in the scrotum does not interfere with the success of the operation in any way.

In dealing with irreducible or strangulated herniæ containing bowel, the deeper injections should be made after the parts are exposed, unless the bowel can be certainly avoided in introducing the needle. This entails delay during the operation, but with patience as good results can be got as in operating on reducible herniæ.

Femoral and Umbilical Herniæ. — In dealing with femoral herniæ, the tissues over and to the inner side of the sac may be infiltrated before incising. The sac may then be exposed, partly freed, and the tissues to its outer side and below it injected, the femoral vein being then easily avoided with care. Umbilical herniæ, as large as a medium-sized orange, may be operated on under local anæsthesia by distributing the solution all over the sac and round its neck, going as close to the peritoneum at the neck as is possible without risking

puncture of any contained bowel. Supplementary injections may be made, especially at the neck of the sac after it is exposed.

Case XXIII.—X. Y., male, *æt.* 55 years, suffering from a recurrence of a right scrotal hernia, which had been operated on seven years before under chloroform. The patient had weak abdominal walls and was not a good subject, but he was very anxious to have an attempt made to cure his hernia. The operation was done under local anæsthesia. Cocaine-adrenalin solution was injected as described above. After ten minutes' waiting the incision was made, and the sac exposed and isolated in its upper part. It was then cut across at the top of the scrotum, the neck ligatured and dropped back. The scrotal portion was left *in situ*. As the result of the scar formation following the first operation the lower edges of the internal oblique and transversalis had become fibrous. The fibrous edges were stitched to Poupart's ligament with chromic catgut. The external oblique was then united over the cord and the wound closed without drainage. The patient said when questioned that he had felt one or two "jags" during the operation, but they were not worth mentioning. After-pain came on an hour or two after the operation, but was slight, and the patient said that he thought it was less than that following the first operation. The wound healed by first intention and a firm scar resulted.

Case XXIV.—J. S., male, *æt.* 50 years, suffering from double inguinal hernia. Bubonocele on right side, scrotal hernia on left. The right one was giving him considerable pain and he wished it only to be operated on. Cocaine-suprarenin solution was injected subcutaneously and under the external oblique. In twenty minutes incision was made down to the external oblique,

and this divided; additional injection was then made into the proximal part of the cord towards the internal ring. The sac was then isolated, opened, tied at the neck, and cut off, and the operation completed in the ordinary way. The patient felt a slight twinge of pain when the sac was ligatured, and on one occasion when the cord was inadvertently pulled too hard. He said that otherwise he felt the various manipulations, but that the parts seemed quite dead and the manipulations caused no pain. The wound healed by first intention. A year later he returned to have the left side operated on. The result of the former operation was perfect, a firm unyielding scar being present. The second operation was also done under local anæsthesia with an equally good result.

Case XXV.—Mrs T. W., *æt.* 50 years. Patient had been treated in a medical ward for several weeks for cardiac disease, and was about to be discharged when an old-standing inguinal hernia which had not been down for some time came down and became strangulated. Owing to the heart lesion present the administration of a general anæsthetic would have been distinctly dangerous, and the operation was done under local anæsthesia. The hernia of the left inguinal variety was the size of a large hen's egg. Cocaine-adrenalin solution was injected all over and round the sac, at first subcutaneously, and then as close to it as possible. After waiting the usual time the incision was made, the sac exposed and opened, and a loop of claret-coloured but shiny small intestine found in it. The constriction was at the external abdominal ring, which was divided and the intestine returned. The parts were brought together with catgut stitches and the wound closed without drainage. Less than 1 grain of cocaine was

used. The patient felt some pain when the neck of the sac was manipulated and tied. Otherwise the operation caused no pain. This was the first case of hernia which I had operated on under local anæsthesia, and I was somewhat astonished to find how easily the operation could be done without seriously inconveniencing the patient. Further experience has shown how, by infiltrating the neck of the sac and the tissue round it, the pain of ligaturing it can be abolished or so much diminished as to be unimportant. The wound healed by first intention, and the patient was discharged well a few weeks later, all the better for her additional rest in bed.

Case XXVI.—L. S., *æt.* 52 years, suffering from a strangulated femoral hernia, the size of a hen's egg, which had come down twelve hours before his admission to hospital. The patient had a very irregular pulse and very atheromatous arteries. Operation was done immediately after his admission to hospital under local anæsthesia. Cocaine-adrenalin solution was injected all over and round the hernia as far as possible, the femoral vein being carefully avoided. In ten minutes the sac was exposed, opened, and a knuckle of small intestine, purplish black in colour but shiny, was found in it. A director was passed up alongside the bowel and the constricting band, Gimbernat's ligament, nicked in several places with a probe-pointed knife, passed along the director. The bowel was then pulled down to examine the constriction grooves, and being viable was returned to the abdomen. After its return a quantity of clear, yellowish fluid escaped from the abdominal cavity. A small drainage tube was passed into the peritoneal cavity, and the sac and wound closed round it. No attempt was made to do a radical cure. Fluid continued to escape for two days. The tube was

then removed, and the wound healed without suppuration. In spite of the fact that no injections were made after the incision into the deeper parts round the neck, or to the inner side of the sac, the operation caused almost no pain. Six weeks after the operation and four weeks after the wound had healed and the patient had been allowed up, he took an attack of acute nephritis from which he died.

Case XXVII.—T. H., male, *æt.* 63 years, suffering from a left-sided reducible femoral hernia of recent appearance, about the size of a bantam's egg. The patient was anxious for operation. Cocaine-adrenalin solution was injected all over and round the sac as far as possible. In fifteen minutes the incision was made and a very thin sac exposed; a little doubt as to the real nature of the supposed sac was cleared up by asking the patient to cough, when some omentum came down into it. The neck of the sac was infiltrated, after which it was opened and cut off and the neck sutured with chromic gut. Sutures were put in to narrow the ring, and the wound closed without drainage. Considerable oozing took place in spite of the adrenalin, and several ligatures were applied during the operation. The whole proceeding was painless. The wound healed by first intention.

Case XXVIII.—Mrs W., *æt.* 53 years. Patient had suffered from umbilical hernia for fifteen years, and had had several attacks of threatened obstruction, manifested by pain in the hernia, vomiting, and constipation, passing off after a day or two's illness. She came for advice immediately after one of these attacks, and operation was advised. The hernia was the size of a small orange and contained irreducible, and therefore probably adherent, omentum. At the operation a solution con-

taining 1 grain each of cocaine and eucaine, with 16 drops of suprarenin, to 2 ozs. of sterile saline solution was used and injected all over the hernia, subcutaneously. In fifteen minutes the hernia was exposed and the sac opened. Numerous firm adhesions between the sac and the contained omentum were found and divided, and the omentum returned. The sac was then freed, tied at the neck, and the excess removed, the edges of the opening of the aponeurosis were united with silk, and the wound closed without drainage. Slight pain was felt during the manipulation of the sac, but was easily tolerated. The wound healed by first intention and a firm scar resulted.

Case XXIX.—K. L., *æt.* 15 years. A well-grown lad, 5 feet 11 inches in height. Patient had a small umbilical hernia, present since birth, which was easily controlled by a truss. He was, however, refused entry into a company's service which he wished to enter, unless it was operated on. At the operation cocaine-adrenalin solution was used and the subcutaneous tissue over and for some distance round the hernia was infiltrated with it. Some solution was injected more deeply round the neck of the sac and close to the aponeurosis. 10 drachms of solution = $\frac{5}{8}$ grain of cocaine, were used in all. In ten minutes the sac with the overlying skin was excised, and the opening closed with chromic catgut. There was considerable oozing, so a small drain was inserted. Two and a half hours after operation after-pain came on and was fairly severe, lasting well into the night after the operation. The wound healed without suppuration.

The cases related have been selected as fair examples of what may be achieved in operating on hernia under local anæsthesia. More cases might be cited and the

more extensive records of other writers quoted, but space will not permit of this. My own comparatively limited experience is only confirmatory of what has already been amply demonstrated by others, that many cases of hernia may be operated on, to relieve strangulation or to do a radical cure, under local anæsthesia, without causing the patient any, or only trifling, pain.

The following may be quoted from Cushing[1] as the opinion of a surgeon who was not specially interested in local anæsthesia, who had no special method of his own to advocate, and who may therefore be fairly regarded as unbiassed in his opinion of its merits and demerits:—

"Almost all cases of hernia, with the possible exception of those in young children, could undoubtedly be subjected to the radical operation under similar local methods, but when a general anæsthetic can safely be administered, for various reasons it is much to be preferred by both patient and operator." In a footnote to this, however, he adds:—"Since this paragraph was written, the above statements may be qualified to a considerable extent. During the fall of 1899, twenty-four herniotomies with cocaine or eucaine B have been performed in young men practically without pain, and this procedure has become so popularised in the ward where our hernia cases are admitted that the operation under the local anæsthetic has become the operation of choice."

Cushing, it should be noted, used Schleich's method, and also specially cocainised the ilio-inguinal and ilio-hypogastric nerves when they were exposed. With cocaine-adrenalin solution this is unnecessary. The operation he did was Halsted's. Lennander, writing in 1904, on the observations he had made on the sensibility

[1] Cushing, *Annals of Surgery*, January 1900.

of the abdominal and other viscera, said that for the last three and a half years all strangulated inguinal herniæ and the majority of other inguinal herniæ in his clinic at Upsala had been operated on under local anæsthesia. The operation done by him was Bassini's.

Operations on the Male Genital Organs.

Circumcision.
Radical cure of hydrocele.
Excision of cysts of epididymis.
Castration.
Radical cure of varicocele.

In adults and in well-grown lads over fifteen years of age or thereby the above operations can all be done most satisfactorily under infiltration anæsthesia, and the cure of hydrocele, castration (or vasectomy), and removal of cysts of the epididymis or cord can often be carried out in subjects to whom one would hesitate to give a general anæsthetic on account of age, respiratory or cardiac affections, etc.

Circumcision.[1]—In cases of non-inflammatory phimosis the prepuce should be freely infiltrated. This should be done by stretching it gently, and entering the needle at its anterior margin on the dorsal aspect. The injection is then begun and the needle gradually pushed back towards and a little past the level of the corona, the solution being expelled all the time. Working from the band of injection thus produced, the needle should be pushed in various directions so as to infiltrate thoroughly the whole prepuce. It is surprising how much solution the loose connective tissue of the prepuce will hold, and care must be taken to

[1] See also p. 107.

distribute it not only near the outer layer but also near the inner layer, so often erroneously termed the mucous layer. After the injections the whole prepuce looks enormously swollen, but it will be found that a great part of the solution escapes when the incisions are made. In many cases of phimosis in adults, all that is really necessary for relief is a dorsal incision carried back to the corona, and in such cases the solution need only be distributed along and a little way on either side of the middle line. In cases of inflammatory phimosis where the inflammation extends over the whole penis, the injections are apt to cause a good deal of pain, and it is often wise not to attempt to produce local anæsthesia in such cases. When, however, the inflammation is limited to the prepuce and its immediate neighbourhood, anæsthesia can be produced without discomfort by entering the needle behind the inflamed area and working forward. The injection, if made slowly and with isotonic solution, causes no pain and produces a satisfactory anæsthesia, as in non-inflammatory cases.

Radical Cure of Hydrocele.—In operating on hydrocele an inguinal or scrotal incision can be employed. If it be desired to excise a portion of the skin of the scrotum along with the tunica vaginalis a scrotal incision will of course be made. Otherwise an inguinal incision about $1\frac{1}{2}$–2 inches long and reaching to the top of the scrotum is preferable, for the skin in this region is more easily cleansed, the edges of the wound can be more accurately brought together, and dressings can be more easily retained on an inguinal than on a scrotal wound, and therefore primary union is more easily obtained.

Winkelmann's method of slitting and everting the tunica vaginalis and fixing it in this position is simple,

but is sometimes followed by recurrence, and is less certain than the plan of cutting away the parietal layer of the tunica as far as its reflection on to the epididymis and testis. The latter plan is therefore recommended, and may be carried out as follows:— Infiltrate the subcutaneous tissue along the line of incision close to the skin. Then pass the needle more deeply on to the cord, and distribute some solution round and into it. Next distribute a layer of solution under the skin of the scrotum all over the hydrocele, beginning at the upper end and working down and round it. In ten minutes push the hydrocele gently up towards the groin, when it will be found to bulge the skin along the incision line. Incise the skin and cut through the subcutaneous tissue, etc., till the bluish semi-translucent tunica vaginalis appears. Push the hydrocele firmly up and puncture it, when the fluid will escape in a jet and may be collected in a vessel held near the wound. When the sac is empty, seize the cut edges and pull on them, when it will be found easy to dissect the tunica from its coverings, and pull it with the testis out of the wound. Cut away the parietal layer close to its reflection, tie all bleeding points and return the testis to the scrotum. It is of great importance to tie every bleeding or oozing point in this operation; effective pressure cannot be applied to the scrotum, and a troublesome hæmatoma is apt to form if any bleeding takes place after the operation. The whole operation can be carried out quite painlessly. The testis must, of course, be handled gently and all tearing and pulling avoided, but with these precautions excellent results may be obtained. If a scrotal incision be made no infiltration of the inguinal region is required, but special attention must be directed to the region of

the cord at the upper end of the scrotum. Cushing has shown that the ilio-inguinal and genito-crural nerves innervate the testis, tunica vaginalis, and cord, but not the scrotal skin. If they are reached by the injection, no pain will be felt in doing the operation while handling the deeper parts. In dealing with very large hydroceles it is difficult to distribute the available amount of solution over the whole hydrocele, but if special attention be directed to the cord and upper part, and an inguinal or small scrotal incision made, no pain will be felt.

Case XXX.—A. N., *æt.* 26 years, suffering from a left-sided hydrocele, the size of a goose's egg. The hydrocele had been present for two years, its first appearance dating from a trauma received in a bicycle accident. 20 drachms of cocaine-adrenalin solution = $1\frac{1}{4}$ grains of cocaine, were injected along the line of the inguinal incision, round the upper end of the hydrocele, the cord, and over the hydrocele. In ten minutes the hydrocele was exposed and found to be multilocular, one large and two small pouches being found. The testis itself was covered with a network of soft fibrous material, probably organised lymph. The parietal tunica vaginalis was all cut away, bleeding points tied, and the cut edges stitched to the adjacent tissues with catgut. The wound was closed without drainage. After-pain came on several hours after operation and was fairly severe, lasting through the night following the operation. Next day it was found that the scrotum had slipped from under the bandage and that there was a good deal of effusion into it. This quickly disappeared with elevation of the scrotum and proper bandaging, and the wound healed without suppuration. The patient was heard of six months after operation, and

remained entirely free from any sign of recurrence at that time.

Case XXXI.—J. M., *æt.* 74 years. Patient had a right-sided hydrocele, the size of an orange, which had been tapped eleven times within the last two years, and he was anxious to get rid of it. 12 drachms of cocaine-adrenalin solution were injected as in the last case, an inguinal incision being again made. In ten minutes the hydrocele was gently pushed up by an assistant and made to bulge the line of incision in the groin. It was then exposed, partly freed, opened and emptied of fluid, and the whole sac with the testis was then easily delivered out of the wound; the parietal tunica was dissected carefully from its coverings and cut off close to its reflection. One or two stitches were put in to fix the cut edges to the surrounding tissues, and all bleeding points tied. Chromic catgut was used to unite the deeper tissues and also the skin edges. One or two slight twinges of pain were felt when the edge of the cut tunica vaginalis was stitched to the surrounding tissue, otherwise the operation was entirely painless. After-pain came on two hours after operation and lasted five hours, but was not severe. Slight suppuration occurred round one of the deeper chromic gut sutures and delayed healing slightly. The ultimate result was excellent, and no sign of recurrence had appeared eleven months after the operation.

I have operated on three other patients well over seventy years old for hydrocele, all of them more or less unsuitable subjects for general anæsthesia. There is no doubt that the substitution of local for general anæsthesia makes the performance of a radical cure in such cases a comparatively trivial and safe, instead of an unjustifiable, operation.

Cysts of Epididymis—Cysts of Cord.—These may be treated exactly as hydroceles. Infiltrate the line of incision, the cord above the cyst, and the tissue round the cyst. Expose and dissect out the cyst wall.

CASE XXXII.—T. G., *æt.* 57 years. Patient had a cyst of the epididymis, which had been present for two years and was growing slowly and causing slight discomfort. Solution containing 1 grain of cocaine, 1 grain of eucaine, and 12 drops of suprarenin to 3 ounces of sterile saline solution was used. This was injected over and round the cyst in the upper part of the scrotum and into the cord. About 12 drachms were used = ½ grain of cocaine and ½ grain of eucaine. In fifteen minutes a scrotal incision was made and the cyst and tunica vaginalis exposed. A small quantity of fluid was found in the tunica vaginalis, which was opened and its parietal layer partly cut away. The cyst in the globus major was then opened and its wall clipped away. Bleeding points were tied and the wound closed without drainage. The whole operation was quite painless. After-pain was slight. The wound healed by first intention. The cyst fluid contained numerous spermatozoa.

Castration.—Here again an inguinal or scrotal incision may be used. The tissues under the skin incision, the cord itself, and the tissues round the testis and tunica vaginalis must be infiltrated. Special attention must be directed to the cord, which should be exposed where it is to be divided in the first place, and if infiltration has not been successfully carried out from the original punctures the cord with its nerves must be carefully treated, and some minutes given for the solution to act. The cord may then be divided and ligatured, the testis drawn up by the portion of cord left attached

to it and dissected out. Diseased or imperfectly descended testes may be removed by this method.

Case XXXIII.—A. B., *æt.* 17 years, suffering from an imperfectly descended testis on the right side, which came as far as the external abdominal ring but usually lay in the inguinal canal. Patient wished to enter the army and therefore wished the testis removed. The left testis was normally situated. The subcutaneous tissue and tissues round the testis were infiltrated with cocaine-adrenalin solution. In ten minutes an incision was made down to the external oblique, the tissues under the external oblique were then infiltrated and the oblique divided, exposing the cord and testis with tunica round it. The tunica was opened and the testis handled before the cord was thoroughly infiltrated, and a little pain was felt. The cord was then infiltrated more thoroughly and a pause of a few minutes made. Thereafter the cord was clamped, divided, ligatured, and the testis removed without any pain. There was no communication between the tunica and the general peritoneal cavity. The canal was closed with catgut sutures and the wound closed without drainage. No pain was felt except as mentioned above. About 3 ounces of solution = 1½ grains of cocaine, were used, but a quantity of this escaped from the tissues as they were cut. After-pain was slight. The wound healed by first intention.

Varicocele.—No special directions need be given for making injections for the removal of varicocele. From what has already been said it will be obvious that the cord and the subcutaneous tissue only require infiltration.

Case XXXIV.—B. R., *aet.* 15 years, suffering from a large left-sided varicocele. Cocaine-adrenalin solution

was injected under the line of incision in the groin just above the scrotum. The needle was then passed to either side of and into the cord, and solution injected in these situations. In ten minutes the incision was made, the coverings of cord divided, and more solution injected into the cord. The dilated veins were then freed from the rest of the cord for 2 inches, clamped, divided, ligatured, and the two ends tied together in the usual way. A small drain was put in and the wound closed. After-pain was slight and continued for two days. The wound healed by first intention.

Operations in the Ano-rectal Region.

Simple cases of fissure of the anus, hæmorrhoids, and fistula *in ano* may suitably be operated on under local anæsthesia.

Hæmorrhoids: Internal, external, or combined external and internal.—Infiltrate the subcutaneous tissue all round the anal margin to well beyond the area of any external pile present, and infiltrate the submucous tissue all along the anal canal, carrying this submucous infiltration beyond the pile-bearing area. Then pass the needle in the axis of the anal canal into the surrounding sphincter and infiltrate it, the general result being to infiltrate thoroughly the submucous and muscular coats of the lower end of the bowel. By gently stretching the anus and asking the patient to strain, internal piles can be brought into view, grasped by forceps and ligatured, or better, clamped, cut off, and sewn over by Mitchell's method. The sphincter can sometimes be completely stretched without pain after infiltration, but not always, and this need not be

attempted unless it is impossible to bring the piles into view without it. External piles may be cut off in the usual way.

Case XXXV.—Mrs B., *æt.* 43 years, a very stout woman with chronic bronchitis. Patient complained of "bleeding piles." On examination she was found to have several internal and external hæmorrhoids. With patient in the left lateral position, cocaine-adrenalin solution was injected as described above. The pile-bearing area was easily brought into view when the patient strained. Three internal piles were removed and ligatured with silk. Several external piles were cut away. The operation was painless. The patient reported herself in four months as perfectly well and free from trouble.

Fistula in ano.—Simple cases of fistula, where there is little inflammatory thickening and the internal opening is near the anal margin, may be dealt with as follows:—Infiltrate the tissue all round the track, and the tissue between the fistula and the lumen of the bowel completely with cocaine-adrenalin solution. The fistula can, after waiting the usual interval, be slit and scraped with a sharp spoon and swabbed with pure carbolic, without causing the patient any pain.

Case XXXVI.—A. D., male, *æt.* 32 years, with old-standing fistula. Patient had been operated on some months before for fistula, and there were scars round the anus as the result. In one of these was a small round hole, $\frac{1}{2}$ inch in front of the anus, to the left of the middle line. A probe passed in about an inch towards, but not into, the anal canal. At the first operation the patient took chloroform very badly, and it was not thought advisable to give him a general anæsthetic again.

With the patient in the lithotomy position, about

9 drachms of cocaine-adrenalin solution were injected round the fistulous track and between it and the anus. In eight minutes a finger was passed into the rectum and a probe into the fistula; no internal opening was present, but the probe was made to enter the canal where the mucous membrane was thinnest. The fistula was then laid open into the anal canal. The wall, which was hard and fibrous, was vigorously scraped with a spoon and swabbed with pure phenol, and the cavity packed with iodoform gauze. The operation was absolutely painless. Fissures of the anus can be dealt with on similar lines.

It will be noted that *simple* cases of hæmorrhoids, fistula, and fissure are recommended as suitable for operation under local anæsthesia. Cases with much inflammatory thickening, or where the extent of the operation cannot readily be ascertained before beginning to operate, should not be dealt with under local anæsthesia unless, indeed, general anæsthesia is definitely contra-indicated.

The foregoing lists of operations which may be done under local anæsthesia are not meant to be exhaustive; many similar conditions might be named which may be suitably treated with its help. The operations named and the cases briefly referred to, however, will it is hoped show fairly well the possibilities attending the use of infiltration anæsethesia. It will be remarked that in some cases slight pain is noted as having occurred during the operations, that in other cases a hypodermic injection of morphia was given ten or twenty minutes before making the injections of cocaine. That slight pain is and must be occasionally felt is freely admitted, but, on the other hand, if injections are carefully made and suitable cases for local anæsthesia

selected, the pain is never severe, and is indeed so trifling that neither patient nor operator is seriously inconvenienced by it. In many cases—and the number increases as experience in making injections is gained—no pain after the initial prick of the injecting needle is felt at all. A hypodermic injection of morphia may be given with advantage before operation to very nervous or excitable patients; as a general rule it is unnecessary and undesirable.

Operations on Inflamed Tissues under Local Anæsthesia.—It is sometimes maintained that cocaine injections do not produce anæsthesia in inflamed tissues. This is not correct, for cocaine injections, especially when adrenalin is added to the solution, can make inflamed tissues quite insensitive if one or two precautions are taken. In the first place, the solutions used must be isotonic with the tissue fluids, and in the second place, the injection must be begun outside the inflamed area, must be made slowly, and gradually extended to the inflamed tissues. It will be found that it is more difficult to make the solution travel in inflamed than in normal tissues, and that greater force is therefore necessary to expel the solution from the syringe. Injections begun in inflamed areas generally, cause pain, especially when made quickly. If, on the other hand, the injection is begun in healthy tissue, made slowly, and gradually extended to the inflamed tissues, no pain is caused, the patients merely experiencing a feeling of distension in the affected area.

After-pain is apt to be severe in inflamed tissues, which have been anæsthetised with cocaine injections. As a matter of fact, it is rarely worth while to attempt to induce local anæsthesia by direct infiltration in dealing with limited inflammatory or suppurative conditions,

except on the hand, where incisions must be carefully and deliberately made, to avoid damaging unaffected tendon sheaths, and cutting vessels and nerves. On the hand and fingers, some form of regional anæsthesia, to be described in the next chapter, is more satisfactory than direct infiltration. In other parts of the body superficial abscesses or other limited inflammatory conditions which require only a single quick incision, may be treated in most cases under the modified anæsthesia produced by freezing with ethyl chloride, while conditions requiring large or multiple incisions, or careful exploring with fingers or probe, are quite unsuited for local anæsthesia, and should be dealt with under a general anæsthetic.

CHAPTER IV

REGIONAL ANÆSTHESIA—OBERST'S REGIONAL ANÆSTHESIA —BRAUN'S METHODS OF INDUCING REGIONAL ANÆSTHESIA BY PERINEURAL INJECTIONS, ETC.

Regional Anæsthesia.—By injecting cocaine into or immediately round a nerve trunk, a physiological block on the nerve may be produced, with resulting motor and sensory paralysis in the area of its distribution distal to the level of the injection. The resulting anæsthesia is usually termed regional, or conduction anæsthesia (*Leitungsanæsthesie*, Braun). Corning was apparently the first to note that cocaine injected round a nerve paralysed its conducting power. His observations led to no very practical results, and the first practical application of perineural cocaine injections seems to have been made by Oberst[1] of Halle, who found that digits could be rendered completely anæsthetic if cocaine was injected round the nerves supplying them and localised at the site of injection by the application of a tourniquet proximal to the injection level. His method has become known as the Oberst or Corning-Oberst method of producing regional anæsthesia. It is, although limited in its application, one

[1] The description of this method was first published by Pernice, *Deutsche medicinische Wochenschrift*, 1890.

of the most perfect and satisfactory forms of local anæsthesia in use.

Crile,[1] in a long series of experiments on animals and by clinical observations on patients, clearly showed the remarkable effects of direct intraneural cocaine injections. He found that injection of ½ or 1 per cent. solution of cocaine or eucaine entirely blocked sensory or mixed nerves, preventing the transmission of afferent or efferent impulses, with the result that stimuli, producing pain on the one hand and shock on the other, were not conducted as long as the cocaine or eucaine continued to act. The result of his experimental observations encouraged him to use intraneural cocaine injections both for the performance of operations without general anæsthesia altogether and for preventing shock in cases of severe operations when general anæsthesia was also used, his view being that shock is caused by stimuli or impressions conveyed along sensory or mixed nerve trunks, and that these impressions are freely transmitted when a patient is under the influence of general anæsthesia, but not if the nerves supplying the operation area are cocainised before the operation. By cocainising the brachial plexus he was able to amputate at the shoulder joint, by cocainising the sciatic and anterior crural nerves he was able to amputate the leg, and by cocainising the ulnar nerve he was able to operate in the area of its distribution, etc. All these operations were done without inflicting pain, and were not followed by shock, though in some cases the patients were in a very weak condition. He exposed the nerve trunks by infiltrating the overlying tissues with weak cocaine solution and dissecting down

[1] G. W. Crile, *Problems relating to Surgical Operations*, J. B. Lippincott Co., Philadelphia, 1901.

to the nerves, and then injected enough 1 or ½ per cent. cocaine solution directly into the exposed nerves to make a small fusiform swelling on each. Anæsthesia followed almost immediately, and lasted for half an hour or thereby. His results were certainly of great interest as showing that nerves could be completely and almost instantaneously paralysed by intraneural cocaine injections. It is doubtful, however, whether they are really of far-reaching importance. The injection of nerves supplying a whole limb, upper or lower, is a complicated process, especially when it has to be done under local anæsthesia through a wound other than that necessary for the operative treatment of the condition present. That shock may be to some extent prevented by it may be granted, that it may be altogether prevented is doubtful, for the action of the cocaine is brief, and just as wound pain is felt after its effect wears off, so the altered conditions of the circulation and other effects produced by removal of a whole or part of a limb will almost certainly cause a certain degree of shock when the action of the drug is past. In major amputations in the upper limb, his method may have an application in the rare cases where general anæsthesia is absolutely contra-indicated. For major amputations of or through the lower limb, spinal anæsthesia with stovaine, or stovaine-adrenalin, is undoubtedly simpler and more suitable, if it is thought desirable to avoid a general anæsthetic.

Braun[1] has made a number of clinical observations on the perineural injection of cocaine-suprarenin solutions round nerves which can be accurately located from the surface and easily reached by the injecting needle without risk of damaging important vessels. He

[1] H. Braun, *Die Lokalanaesthesie*, Leipzig, 1905.

has found that cocaine in 1 or ½ per cent. solution, with the addition of suprarenin or other adrenal preparation, will completely paralyse a sensory nerve if it can be injected into the connective tissue immediately round it, and time is given for it to diffuse into the nerve. The paralysis lasts generally *for two hours* or longer, and allows of any operation being painlessly performed in the area supplied by the treated nerve and it alone. Braun's results may best be indicated in his own words: "As far as the extremities are concerned, the surest and simplest method of producing anæsthesia for all operations on the hand and foot is to infiltrate completely with weak anæsthetising solutions a layer of tissue bounding the field of operation on the proximal side (as regards its nerve supply). In the forearm and leg the large subfascial nerve trunks, such as the ulnar, musculo-spiral, median, tibial, external popliteal, can be anæsthetised at definite points, on account of their accessible position, by injection of strong solutions immediately round them, whereby after ten to fifteen minutes as a general rule, a block, *i.e.* sensory, motor, and partial vasomotor paralysis, follows in the distribution of the affected nerve. On account of the variable distribution of particular nerves, a satisfactory conduction anæsthesia of practical value is generally only to be obtained by the simultaneous blockage of several nerves. The long cutaneous nerves running in the subcutaneous tissue are much more easily interrupted far from their termination by following Krogius' plan of infiltrating the subcutaneous tissue along a line at right angles to the course of the nerves. For anæsthetising large subfascial nerves, ½ to 1 per cent. cocaine solutions with suprarenin are best, for smaller nerves running in the subcutaneous or subfascial tissues ⅕ per

cent. cocaine-suprarenin solution is most suitable. The best results are got if the absorption of the cocaine-suprarenin solution is still further limited by applying an elastic bandage to the upper arm or thigh, tightly enough to cause a marked venous congestion, while waiting for the cocaine to act, or by holding the limb up vertically. The bandage must of course be removed before the operation is begun, or, if necessary, replaced by one completely arresting the circulation."

Braun's results afford one of the most striking proofs of the increased power of cocaine-adrenal solutions as compared with solutions of cocaine alone. Before the use of adrenal preparations in local anæsthesia many attempts were made to extend the use of perineural cocaine injections beyond the fingers and toes, but the results were disappointing. Only in cases where the circulation in a limb had been completely arrested by tourniquet for a long time could the cocaine action be localised sufficiently to make it concentrate its action on a nerve trunk when injected round it through the skin, and even then success was not invariable, and no practical and easily carried out method of inducing regional anæsthesia beyond the digits was devised.

Not only does the adrenal addition localise the cocaine action sufficiently to enable it to paralyse a nerve as large as the external popliteal or median, but it enormously increases the duration of the resulting anæsthesia. In Crile's experiments direct intraneural cocaine injections only produced anæsthesia for half an hour or a little longer, whereas perineural cocaine-adrenal injections give an anæsthesia of two hours, often indeed much longer.

Braun has succeeded in anæsthetising by subfascial injections the cutaneous branches of the cervical plexus,

the external laryngeal nerve before it passes into the larynx, the median, ulnar, and radial nerves at the wrist, the external popliteal nerve at the knee, the long saphenous nerve just below the knee, the anterior and posterior tibial nerves at the ankle, etc. By subcutaneous injections he has shown the possibility of anæsthetising almost any nerve which can be easily located in the subcutaneous tissue.

Braun's observations are certainly of great interest, and although his methods have not yet been at all widely made use of, it is probable that when further experience has been gained, his method of anæsthetising limited parts of the body by perineural injections will be proved to be of real practical value.

Oberst's Regional Anæsthesia for Fingers and Toes.—By this method any digit can be made absolutely anæsthetic, and any operation on it, from a simple skin incision to an amputation, painlessly carried out. As the result of large experience in its use I have found that the following plan for inducing it is simple and invariably satisfactory. A solution containing

Cocaine, ...	1 grain
Adrenalin chloride (1 in 1000), . . .	8 drops
Solution sodium chloride (·75 per cent.), .	4 drachms

is used, and a syringe fitted with the finest seamless steel tubing needle. The skin at the base of the finger or toe is pinched up from the side to make it taut, and the needle passed into the subcutaneous tissue with a sharp stab, on the dorsal aspect just to one side of the phalanx. It is then pushed on past the phalanx till the point lies near the skin on the palmar aspect, *i.e.* till it lies near the main digital nerve on the corresponding side of the finger. About 10 drops of the

solution are then injected and the needle is slowly withdrawn, another 10 or 12 minims of solution being slowly injected as this is done. In this way a semi-circle of solution is made in the subcutaneous tissue round one half of the finger. This manœuvre is then repeated on the other side of the finger, about 40 minims of solution being used altogether for a finger of average size. For very thick fingers or the great toe, more that 40 minims may be required to complete the circle, while for thin fingers and in children less will suffice.

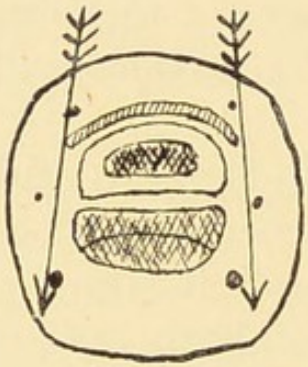

Fig. 3.

The method of making the injections is illustrated in fig. 3, which represents a cross section of the base of a finger with its nerve supply. The arrows indicate the lines taken by the needle. A small rubber tube, the size of a No. 10 catheter, is then loosely applied at the base of the finger, as in fig. 4, proximal to the injection level. In ten minutes—often in a shorter time—the finger or toe is completely anæsthetic, and the congesting band may then be removed. The effect of the injection must be carefully watched. It usually makes a visible bulging, especially on the dorsum where the tissues are lax. If there is no dorsal bulging, and it is, therefore, uncertain whether the ring of solution is complete on the dorsal aspect of the finger, the needle may be passed across the dorsum from one of the punctures before being completely withdrawn, and a few drops of solution injected there. As a matter of fact this is rarely necessary.

Great care must be taken to apply the tourniquet loosely. It is sufficient to cause a marked venous

congestion with it, for that limits absorption and localises the cocaine sufficiently to make it act quickly. If the band is tightly applied it is apt to cause trouble-

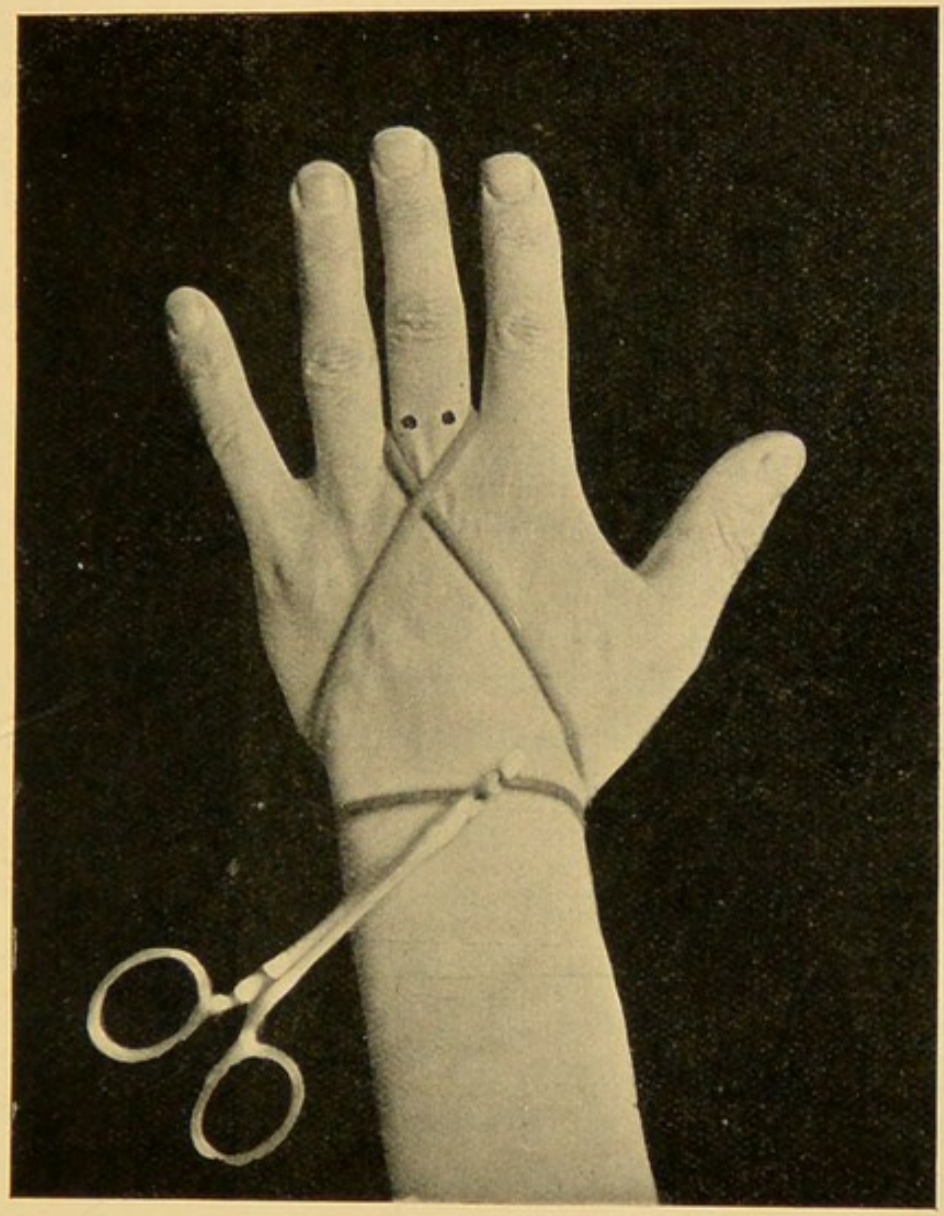

FIG. 4.

some after-pain when the cocaine effect wears off. In many cases I have found that the tourniquet may be dispensed with altogether, but the cocaine takes somewhat longer to act, and therefore when time is short it is advisable to use it. A solution containing eucaine

lactate instead of cocaine acts well when a tourniquet is used, but more slowly when no band is applied.

The first effect of the injection is generally to produce an immediate blanching of the finger due to the compression of the digital vessels; this soon passes off or merges into the more permanent ischæmia due to the action of the adrenalin, which appears in three to five minutes after the injection. This ischæmia lasts as long as an hour or even longer, while the anæsthesia lasts for at least two hours, and often much longer. As it passes off, a burning or tingling sensation is felt in the finger which may last for several hours. If a tourniquet has been tightly applied the burning may be replaced by severe reactionary pain in the finger. If a loosely applied band or none at all has been used, reactionary pain very rarely occurs.

The action of the adrenalin, although strong enough to produce a marked ischæmia, is not strong enough to arrest the circulation in the finger completely, and if troublesome bleeding occurs after incisions are made, the rubber band may be reapplied sufficiently tightly to arrest it, but should not be left on longer than is absolutely necessary. The method may be summarised as follows:—Make a subcutaneous ring of cocaine-adrenalin solution at the base of a finger or toe by injecting from two dorsal punctures. Immediately apply a rubber band to produce a marked venous congestion in the finger. Wait ten minutes, remove the band, and the finger will be found completely anæsthetised. If necessary, reapply the tourniquet tightly enough to completely arrest the circulation after the anæsthesia is complete and the venous congestion has passed off. Several digits may be anæsthetised at the same time by this method. 40 minims of the solution

represents only $\frac{1}{6}$ grain of cocaine in solution slightly weaker than $\frac{1}{2}$ per cent., and as much as 1 grain may be used safely in that concentration. If more than one finger is being treated at a time on the same hand, the congesting band may be applied at the wrist, and should, in that case, be a thin rubber bandage 2–3 inches wide, such as is used in producing passive congestion by Bier's method.

In using Oberst's method it is well to make the patient recline or lie down, so that the hand or foot may be placed comfortably on a suitable table and easily concealed from his view. The peculiar white or bluish white colour which the affected digit takes on is apt to alarm nervous patients, and operative manipulations are much more easily carried out if the hand or foot is resting comfortably on a firm table, with a towel arranged so as to hide what is being done from the patient.

Under the anæsthesia produced in this way all inflammatory or suppurative affections of a finger not extending beyond the base can be as effectively treated as under a general anæsthetic. Free incisions can be made, and the small abscesses in the subcutaneous fat, which are so often met with, thoroughly evacuated, and, if necessary, curetted, to remove necrosing pellets of fat which often line the abscess cavity. Such abscesses often assume a dumb-bell shape, the pus first forming in the subcutaneous fat, then travelling through a tiny opening in the tough cutis, and spreading out again under the surface layers of the epidermis. They often point under the epidermis some distance from the opening in the cutis, and not above the centre of the subcutaneous collection. The common practice of freezing the skin and making a quick incision where

the pus is pointing often fails to open and drain the original abscess cavity thoroughly, and in the after treatment the patient is subjected to painful squeezings of the finger, in order to express the pus through an insufficient opening made in the wrong place. These cases should be treated by carefully clipping away the raised epidermis, inserting a probe through the opening in the cutis to find out the seat and size of the subcutaneous cavity, and the complete opening of this cavity. After-treatment is then much less uncomfortable for the patient, and its period is, in many cases, materially shortened. The treatment of these abscesses may seem a small matter to discuss, but attention to little details of the sort is well worth while, for these abscesses often disable a working man or woman for two or three weeks, and anything which may shorten the treatment or make it easier is important.

The removal of nails, of necrosed phalanges, the opening of tendon sheath whitlows, the removal of warts, of foreign bodies, and all amputations distal to the metacarpo-phalangeal joint, may be carried out under Oberst's anæsthesia with perfect satisfaction. It is often also of great service in treating cases of severe lacerated wounds of one or more fingers, which manual workers so frequently meet with, and where it is essential to thoroughly cleanse the wounded parts, and often necessary to trim edges or amputate parts of fingers.

On the toes Oberst's method is chiefly of use in removing ingrowing toe nails, exostoses, and in operating for hammer-toe by removing the head and part of the shaft of the first phalanx. For all the conditions mentioned a general anæsthetic is never required, the anæsthesia produced by cocaine injections, properly made, being perfect.

Circumcision in lads and adults may also be conveniently done under this form of local anæsthesia if the injections are made in the following way, described by Braun.[1] The prepuce is first drawn forward over the glans so as to stretch the outer and inner layers. The needle is then entered on the dorsal aspect at the level of the coronal sulcus, and a subcutaneous ring made round the penis following the coronal groove accurately all the way round. In this way the nerve supply to both layers of the prepuce is cut off. If the injection is made further back the nerve supply to the inner layer of the prepuce may not be reached and anæsthesia will not be complete. Braun recommends that the prepuce be held taut while the cocaine is acting, *i.e.* for five to ten minutes after the injection. A rubber tube loosely applied near the root of the penis is of advantage in localising and intensifying the cocaine action and causes no discomfort. By using the solution recommended for Oberst's method of 1 grain of cocaine, 8 drops of adrenalin, and 4 drachms of saline solution, injected as described above, a most satisfactory anæsthesia of the prepuce can be obtained, allowing of its complete or partial removal without pain. From $1\frac{1}{2}$ to 2 drachms of solution are usually required for an adult. Care should be taken to ligature all bleeding or oozing points to prevent a hæmatoma forming after the action of the adrenalin wears off. As previously noted, circumcision may also be done under infiltration anæsthesia, but the regional method is preferable, for the prepuce is not rendered œdematous by it, and the amount to be removed can be more accurately gauged and the operation more conveniently done under it than under anæsthesia produced by direct infiltration.

[1] *Loc. supra cit.*

A large number of cases illustrating the use of Oberst's method might be cited, but it is perhaps enough to say, that in a large experience of its use, in all classes of patients, I have never known it to fail, or to produce any bad results, except the occurrence of severe reactionary pain, when the tourniquet has been too tightly applied. I have frequently used it in children, generally using eucaine instead of cocaine, and have found it most useful for them, as well as for adults. After the slight pain caused by prick of the fine sharp needle passes off, most children tolerate the subsequent operation as well as adults. The youngest child I have used Oberst's method on was a little girl aged four, who came to hospital suffering from a neglected whitlow with necrosis of the terminal phalanx of the middle finger. After the injections had been made, she was laid on a table, and her face partly covered with a towel. The suppurating area was opened up, the terminal phalanx excised, and the whole wound thoroughly cleansed, and a dressing applied. On removing the towel from the child's face, it was found that she had gone fast asleep during the operation, a good proof of the efficacy of the anæsthesia!

Braun's Method of Inducing Regional Anæsthesia by Cocaine-Suprarenin Injections.

Numerous attempts were made to extend the use of perineural cocaine injections beyond the fingers and toes, to the hand, and arm, and foot, and leg, after Oberst's method became known, and from time to time successful cases were reported. Hölscher[1] reported in 1899 some cases where he had extended the use of

[1] Hölscher, *Münchener medicinische Wochenschrift*, 1899, No. 8.

regional anæsthesia to the hand and forearm, and Berndt[1] reported a case where he had done a trans-condyloid amputation through the femur by this method. Both writers, however, found that a firmly applied tourniquet was necessary in order to localise the cocaine, and intensify its action, and that it caused great discomfort and often pain, and attempts to extend the use of perineural cocaine injections beyond the digits led to no really satisfactory results till the discovery that adrenalin greatly intensified the local action of cocaine, and to a large extent obviated the need for using a firmly applied tourniquet, was made.

Braun, as noted above, has carefully studied the effects of perineural cocaine-suprarenin injections, and I propose to quote the directions he gives for anæsthetising some of the nerve areas supplied by the main nerves of the forearm and leg. His observations have, I believe, resulted in the development of a really practical method of anæsthetising part or the whole of the hand, but the arrangement of the nerves supplying the foot makes the problem of reaching them all easily and safely with cocaine injections a little complicated, and it is as yet doubtful whether his observations will lead to very practical results in the surgery of the lower limb. If spinal anæsthesia with stovaine proves to be as innocuous as its advocates claim, it will probably be the method of choice for operations unsuitable for infiltration anæsthesia, and where general anæsthesia is undesirable.

Upper Limb.—The median nerve may be treated in the following way. Enter the needle about three fingers' breadth above the pisiform bone, just to the ulnar side of the palmaris longus tendon, avoiding the small veins

[1] Berndt, *Münchener medicinische Wochenschrift*, 1899, No. 27.

which are usually seen at this level. Hold the syringe at right angles to the long axis of the forearm, and push the needle through the deep fascia, under the palmaris tendon, obliquely towards the radius for 1½ c.cm. (⅗ of an inch), so that its point comes to lie about under the tendon of the flexor carpi radialis. While entering and withdrawing the needle, inject 1 c.cm. of 1 per cent., or better, 2 c.cm. of ½ per cent. cocaine solution, with 3 drops of suprarenin 1 in 1000 *under the fascia*. The ulnar nerve may be reached at the same level by entering the needle on the ulnar aspect of the forearm, between the ulna and the tendon of the flexor carpi ulnaris, and pushing it for 1½–2 c.cm. under the tendon, the same quantity of solution as for the median being injected, again only under the deep fascia. There is, according to Braun, no danger of wounding the ulnar vessels if this plan is followed. The nerve may, however, be more easily, and probably more safely reached behind the internal condyle, where it can readily be fixed against the bone by the finger or thumb of the left hand, while the cocaine-suprarenin solution is injected into or round it with the right. All the terminal twigs of the radial nerve can be easily paralysed by injecting a strip of cocaine-suprarenin solution subcutaneously, just above the styloid process of the radius, from immediately outside the radial artery to the middle of the dorsal aspect of the wrist, and 2–3 c.cm. of ½ per cent. cocaine solution with 3–5 drops of suprarenin may be used for this. The palmar cutaneous branches of the median and ulnar nerves may be interrupted by a similar subcutaneous injection across the front of the wrist, or the whole of the subcutaneous nerve twigs passing from the wrist to the hand may be interrupted by infiltrating thor-

oughly the subcutaneous tissue in a ring round the wrist, just below or above the head of the ulna, with cocaine solution of the strength of 1 in 500 with 1 drop of suprarenin to each c.cm. of solution used.

Fig. 5 is from a photograph of a transverse section of the left fore-arm made 1 inch above the most distal skin crease at the wrist. The fore-arm sectioned was

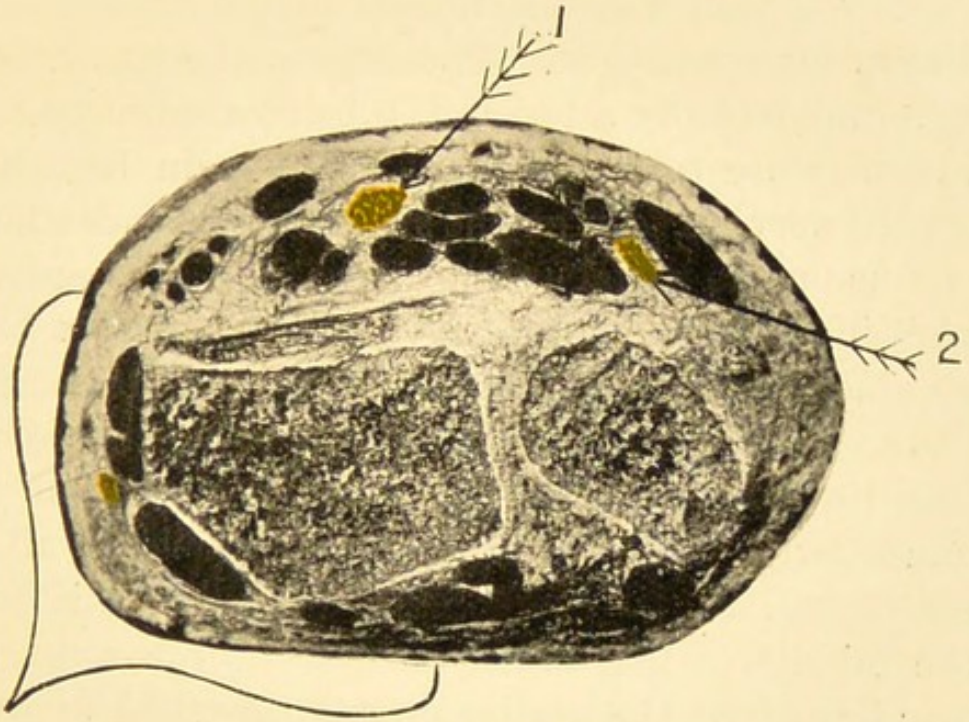

FIG. 5.

that of an adult female subject, and was hardened in formalin before being cut. The section shows the normal relations of the tendons, nerves, and vessels at the level where the perineural cocaine injections may conveniently be made. It will be noted that the median nerve lies between and just on the deep aspect of the flexor carpi radialis and palmaris longus tendons, rather nearer the latter than the former. The arrow 1 indicates the line of puncture recommended by Braun for

reaching it. In a certain number of cases the palmaris tendon is absent or so small that it cannot be easily defined, and in such a case the nerve may be reached with equal certainty by puncturing the skin to the ulnar side of the flexor carpi radialis tendon and pushing the needle for about half an inch obliquely towards the ulna. The ulnar nerve is seen lying behind and to the ulnar side of the artery with its companion veins, and the arrow 2 indicates the line of puncture suggested by Braun for reaching it. Puncture at the elbow, however, is undoubtedly safer and, I believe, more certain, and is therefore to be preferred. The main branch of the radial nerve is seen on the section in the subcutaneous tissue on the radial aspect of the fore-arm, and the bracket indicates the extent of the subcutaneous band of cocaine solution which should be injected to reach it and the smaller branches of the nerve which are not visible in the section. This band also cuts off the terminal twigs of the musculo-cutaneous nerve which reach the ball of the thumb. By extending this band to the middle of the anterior aspect of the wrist the palmar branch of the median may be reached in cases where it comes off high up, but in most cases it is unnecessary to do this, for the deep injection as described cuts it off.

Lower Limb.—At the ankle the posterior tibial nerve may be reached by entering the needle 1 cm. to the inner side of the tendo Achillis, just above the level of the ankle joint, pushing it straight forwards till it strikes the tibia, withdrawing it a little and then injecting 1 or ½ per cent. cocaine-suprarenin solution as for the median or ulnar nerves. There is, according to Braun, little danger of wounding the vessels by this method, but they lie so close to the nerve at this level

that there would certainly appear to be some risk of injecting the cocaine directly into one of the venæ comites or the artery. The anterior tibial nerve may be reached three fingers' breadths above the internal malleolus by entering the needle to the outer side of the tibialis anticus, between it and the extensor longus hallucis, pushing it down to the bone and then, after withdrawing it a little, pushing it under the extensor hallucis tendon and injecting the solution there.

The other nerves reaching the foot, running as they do in the subcutaneous tissue, may all be reached by injecting a ring of 1 in 500 cocaine-suprarenin solution in the subcutaneous tissue just above the malleolus internus.

It sometimes takes twenty to twenty-five minutes before the anæsthesia produced by perineural injections is complete. The effect of the injections may be intensified and hastened if a broad rubber band is applied to the arm, leg, or thigh, to produce venous congestion immediately after injecting. Such a band causes no pain, whereas one applied to completely arrest the circulation is apt to be painful, especially if left on for long. It is always well to apply this congesting band during the time required for the cocaine to take effect. It must, of course, be removed before beginning to operate, and may, when absolutely necessary for operative purposes, be replaced by one completely arresting the circulation.

From the above descriptions it will be seen that Braun has devised methods of anæsthetising the hand and foot, in part or altogether, by means of cocaine-suprarenin injections. Thus the radial half of the hand may be anæsthetised by injecting round the median and radial nerves at the wrist. The ulnar distribution may be anæsthetised by injecting the nerve at the wrist, or

better, at the elbow, behind the internal condyle. The ulnar nerve is so easily felt and located at the elbow that injection can generally be made directly into it, the result being an almost immediate anæsthesia in its distribution. The intraneural injection causes a thrill in the ulnar area in the hand like a strong faradic shock, but is not painful. The whole hand may be anæsthetised by injecting all three nerves in the manner described. Only ½ grain of cocaine or a little more is required for this. The foot may be similarly anæsthetised by injecting the anterior and post-tibial nerves with ½ per cent. cocaine-suprarenal solution, and making a subcutaneous ring all round the leg just above the ankle, of 1 in 500 cocaine-suprarenin solution.

I have had the opportunity of testing Braun's methods on the hand and have found that they give excellent results; the ulnar and median nerves are easily located and reached by cocaine injections and the subcutaneous nerves can be still more easily interrupted at the wrist. For the treatment of suppurative conditions in the palm, or at the level of the metacarpo-phalangeal joints, for metacarpo-phalangeal amputations, for the removal of foreign bodies lodged anywhere in the hand, for the treatment of severe crushes and wounds of the hand and fingers, and, in fact, for any operative treatment of the hand, anæsthesia induced by cocaine injections will in many cases, I believe, come to be the method of choice, for it seems to be safe, simple, and effective, the chief, if not the only, drawback being that perineural cocaine-suprarenin injections take sometimes twenty to twenty-five minutes to act. The following are examples of the use of Braun's methods.

Case XXXVII.—Miss J. I., *æt.* 21 years. While washing clothes, ten days before coming to hospital, the

patient felt something enter the palm of her left hand, and since then had had a sharp jagging pain in the hand when she grasped anything firmly. With the help of the X-rays two pieces of a broken needle were located in the hypothenar eminence, one embedded in the muscles close to the metacarpal bone, the other lying close to the skin. Only one of them could be detected by palpation. 35 drops of a solution containing 1 grain of cocaine, 8 drops of suprarenin, and 4 drachms of saline solution, *i.e.* a solution containing slightly less than ½ per cent. of cocaine, were injected into and round the ulnar nerve behind the internal condyle, the nerve being fixed against the bone by the left thumb while the injection into and round it was made. When the needle entered the nerve, a tingling feeling was felt in the distribution of the ulnar nerve, described by the patient as being like an electric shock. Immediately after the injection a broad rubber band was applied round the upper arm tightly enough to produce a venous congestion, but not to arrest the arterial flow. Twenty minutes later this band was removed and an incision was made on the ulnar side of the hand into the hypothenar eminence, and after dissecting through the muscles one piece of the needle was found lying up against the metacarpal bone. The other piece was found under the skin, superficial to the muscles. The operation took about twenty minutes, as the pieces of needle were difficult to find. When the incision was first made bleeding was free, and the rubber band was reapplied at the wrist to arrest the circulation completely in the hand. The wound was closed without drainage. The whole operation was absolutely painless. The patient said that she felt something going on, and recognised that something was being cut, but the sensation

caused no pain whatever, while the rubber band caused no discomfort. The wound healed by first intention.

Case XXXVIII.—J. H., male, *æt.* 54 years. As the result of a severe tendon sheath whitlow, the little finger of the patient's left hand was left stiff and useless, the tendons having been destroyed. As the finger interfered very much with the patient's work, he wished it removed. In this case the ulnar nerve was exposed behind the internal condyle by infiltrating the overlying tissues with very weak cocaine-adrenalin solution and dissecting down to the nerve. About 20 minims of cocaine-adrenalin solution, of the strength used in the previous case, were injected into the nerve, a very fine needle being used. The elbow wound was then closed. No rubber band was applied. The ulnar area became analgesic almost immediately after the injection, which caused a momentary tingling sensation as usual. The little finger was then disarticulated at the metacarpo-phalangeal joint, no tourniquet being used. No pain whatever was felt during the operation, which was done at 9.30 a.m. At 2 p.m., *i.e.* four and a half hours after the injection, pain was felt in the amputation wound and lasted till 7 p.m. At midnight, slight pain came on at the elbow and lasted for an hour and a half. The elbow wound healed by first intention, the amputation wound after slight suppuration.

Case XXXIX.—Mrs M., *æt.* 40 years. Patient had had part of a needle embedded in the ball of the right thumb for ten weeks, which caused her pain when she used her hand. The needle was located exactly with the help of the X-rays and fluorescent screen. After thorough cleansing of the skin of the wrist 30 minims of cocaine-suprarenin solution, of the strength used in the previous cases, were injected round the median

nerve. The needle was entered immediately to the ulnar side of the palmaris longus tendon, 1 inch above the lowest skin crease at the wrist, and pushed obliquely towards the radius for about ½ an inch. The solution was then injected slowly, the point of the needle being moved about a little during the injection, which was also continued while withdrawing the needle from under the deep fascia. 40 minims of the same solution were then injected in the subcutaneous tissue across the front of the wrist from the radial border to the middle, to catch the palmar cutaneous twigs of the median nerve. Venous congestion was then induced by the rubber band. Half an hour later the congesting band was removed, and replaced by one arresting the circulation at the wrist. The incision was then made into the thenar eminence, and after some searching the piece of needle, ½ an inch long, was found embedded in the flexor brevis pollicis and removed. The operation was absolutely painless. There was no after pain, and the wound healed by first intention.

CASE XL.—A. N., male, *æt.* 43 years. Amputation of the patient's index finger was required for old-standing suppuration destroying the tendons and first phalanx of the finger. 30 drops of cocaine-suprarenin solution were injected round the median nerve as in the previous case. 60–70 drops were then injected in the subcutaneous tissue at the same level, from just outside the radial artery to the middle of the dorsal aspect of the wrist, to catch the branches of the radial nerve. No congesting band was applied. In thirty minutes the index finger was amputated without causing the patient the least pain.

CASE XLI.—Crush of hand with comminuted compound fracture of little finger, severe lacerated wound

of middle finger, etc. Cocainisation of median, ulnar, and radial nerves at wrist. Using the same solution as in previous cases, 35 minims were injected round the median nerve, 70 minims round the branches of the radial nerve, and 35 minims round the ulnar nerve, by entering the needle on the ulnar aspect of the wrist between the tendon of the flexor carpi ulnaris and the bone, and pushing it on for nearly ½ an inch, when the injection was made. No tourniquet was used. Forty minutes later the little finger was amputated through the middle phalanx, the wound of the middle finger cleansed and stitched, and a wound on the dorsum of the hand over the fifth metacarpal bone thoroughly cleansed. The whole operation was painless. The wounds healed without suppuration.

I have, in a number of other cases, anæsthetised the median and radial nerves for amputation of the index finger, always with complete success, and there is no necessity to relate the cases in detail. It will be noted that in the cases related a long interval was always allowed for the cocaine to act, and that in some a congesting band was applied, in others not. As they were test cases it was desirable to give the cocaine full time to act. There was no apparent difference as regards after effects, when the congesting band was used and when it was not used, and although the exact amount by which the waiting after injections may be shortened by it has not yet been determined, it is probably wise to use it in all cases.

The effect of the cocaine-suprarenin solution is sometimes, strictly speaking, to produce analgesia, not complete anæsthesia. During operation the patients feel that something is being done, and can sometimes recognise cutting, stitching, etc., but they say that the

tissues feel dead and that the operation is quite painless. I have not been able to demonstrate a motor paralysis in any of my cases, and this is in accord with the general experience that sensory fibres in a nerve are much more easily affected and paralysed than motor fibres. Owing to the fact that sometimes only analgesia and not complete anæsthesia is produced by the injections, it is well not to ask patients whether they *feel* a pinch or a needle prick before beginning to operate. A better plan is to take a needle and, without allowing the patient to see what is being done, to pass it deeply into the operation area. If any response is made by the patient a question as to whether pain was felt or not may be asked: if no response is made the operation may be begun without any questions being asked at all. The long interval which must be allowed for the injections to act is undoubtedly a drawback if only one patient is being dealt with at a time. In such a case it is well to make the injections before the other preparations for the operation, and then the waiting interval may be spent in making all the other preparations, such as sterilising and arranging instruments, cleansing the skin at the site of operation, arranging sterilised towels, etc. In hospital work the injections may be made and the patient allowed to lie on a couch or table for twenty minutes or longer while other patients are being seen. In this way no time is lost at all, and the induction of anæsthesia is much simpler and less troublesome than when a general anæsthetic has to be given.

In the foregoing pages a short description has been given of what appear to be the most practical of Braun's methods. For a detailed description of these, and of other perhaps less important but interesting

observations which he has made, the reader is referred to his recent book on Local Anæsthesia.

Hackenbruch's Circular Anæsthesia. — Frequent reference is made by writers on local anæsthesia to what is termed "Hackenbruch's circular anæsthesia." By this is meant the plan, apparently first devised or used by Hackenbruch, of infiltrating the tissues round a limited field of operation with cocaine solution so as to cut off its nerve supply, without actually infiltrating the tissues to be cut through directly. This method may be used successfully in dealing with limited superficial conditions, such as ganglia on the back of the wrist or hand, or small prepatellar bursæ, and is sometimes of value in treating limited inflammatory and suppurative conditions, such as large boils, carbuncles, superficial abscesses, etc. The injection may be made in the form of a circle, or a diamond, from two to four separate punctures being usually necessary to complete the figure. On the extremities, where the direction of the nerves in the subcutaneous tissue supplying a given area can be accurately determined, it is often unnecessary to completely encircle the operation field, and a gap in the ring may be left on the distal side, the injection then taking the shape of a horse-shoe or inverted V. Speaking generally, the results of such injections are apt to be uncertain, and this form of regional anæsthesia should only be employed where it is impossible to infiltrate the area of operation directly. On the hand and foot, however, this principle may be used with greater certainty for anæsthetising limited areas; for example, the tissues at the level of the metacarpo-phalangeal joint of a digit. The injection should be made in the shape of a wide open V embracing the affected area, first in the subcutaneous tissue,

and then more deeply in the inter-metacarpal space on each side of the affected digit. In fig. 6 a scheme is indicated for anæsthetising the metacarpo-phalangeal

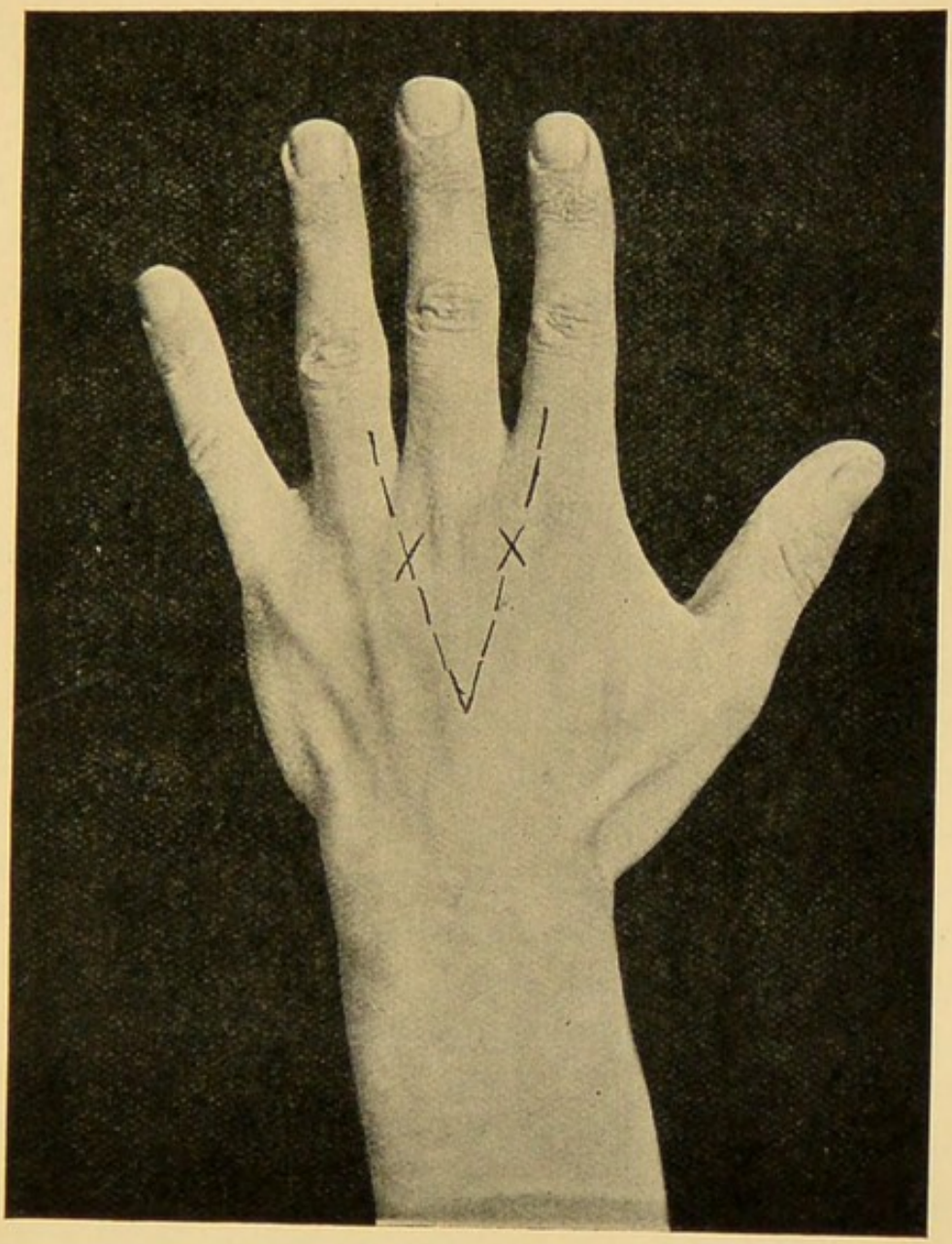

FIG. 6.

region of the middle finger. The dotted line indicates the line of the subcutaneous injections on the dorsum and palm, and at *x x* the needle should be entered deeply on the dorsum and the corresponding interspace infiltrated

by passing the needle nearly to the skin on the palmar aspect of the hand, and injecting solution as the needle travels. The injection must be made in the healthy tissue immediately bounding the diseased area on the proximal side. A solution containing 1 grain of cocaine and 6 drops of adrenalin in 1 ounce of saline solution is suitable for producing regional anæsthesia in this way.

Amputation of Fingers at the Metacarpo-Phalangeal Joint by Combined Regional and Infiltration Anæsthesia.—In a number of cases I have made use of a combination of regional and infiltration anæsthesia for metacarpo-phalangeal amputations by injecting ½ per cent. cocaine-adrenalin solution round the digital nerves in the hand above the level of the joint, and then reinforcing this by infiltrating the tissues to be cut through directly with a weaker solution. The reason for the reinforcement of the perineural injections is that it is not easy to locate the level of the digital nerves in the palm exactly, and hence the result of perineural injections alone is apt to be uncertain, especially where amputation is done for cases of old-standing suppuration which has extended some distance into the palm. On the other hand, infiltration of the operation field alone is difficult, for the injection travels badly in the inflamed or thickened tissues. A combination of the two plans, however, is simple and effective, especially when a congesting band is applied at the wrist. The following cases will illustrate the method of making the injections.

Case XLII.—J. M., male. *æt.* 20 years. Patient had had a suppurative osteomyelitis of the proximal phalanx of the left little finger for six weeks, following a compound fracture. The tendons were destroyed and amputation was advised. The area of inflammation round the wound extended some distance on to the hand. Fifteen

minims of ½ per cent. cocaine-adrenalin solution were injected round each nerve supplying the finger, the injections being made in healthy tissue just proximal to the inflamed area on the hand. ½ per cent. eucaine-adrenalin solution was then used to infiltrate the inflamed tissues at the site of amputation. The injection was begun just outside the inflamed area and gradually extended into it, and caused no pain. 5 drachms of eucaine solution were used altogether. A tourniquet arresting the circulation was then applied at the wrist, and eighteen minutes later the finger was disarticulated at the metacarpo-phalangeal joint without causing the patient any pain whatever. Four hours later after-pain came on and was severe. It lasted through the night following the operation and then subsided.

CASE XLIII.—A. B., male, *æt.* 50 years. The patient was first seen four weeks after the onset of a severe tendon sheath whitlow of the left index finger. After treatment by free incision, drainage, and antiseptic dressing, the acute inflammation subsided, but left a useless finger, without tendons and with stiff joints, and amputation was therefore done. ½ per cent. cocaine-adrenalin solution was injected from the palm and dorsum of the hand round the nerves running to supply the finger, proximal to the inflamed area. 1 in 900 cocaine-adrenalin solution was then used to infiltrate the tissues round the metacarpo-phalangeal joint, the injection being begun as before in healthy tissue. The injection was painless, but, owing to the density of the tissues, was difficult to make. A tourniquet was applied at the wrist. Twenty minutes later the finger was removed without the least pain being felt. Five hours after operation after-pain came on and was severe, lasting through the night following the operation.

CASE XLIV.—R. L., male, *æt.* 19 years. For nine weeks before operation the patient had suffered from a tendon sheath whitlow of the right little finger. The wound healed, but the tendons were destroyed and the finger was in consequence flexed, stiff, and useless, and interfered very much with the patient's work. Amputation was therefore advised. ½ per cent. cocaine-adrenalin solution was injected proximal to the operation line round the digital nerves, and the operation area itself was then infiltrated with 1 in 900 cocaine-adrenalin solution. A tourniquet was applied at the wrist. Ten minutes later the finger was amputated by a racquet incision. No pain whatever was felt. There was no after-pain. The wound healed by first intention.

CASE XLV.—The next case, although not one of metacarpo-phalangeal amputation, illustrates how the operation for hallux valgus with bunion may be done on exactly the same lines.

A. M., female, *æt.* 24 years, with marked hallux valgus on left foot and a suppurating wound over the prominent head of the metatarsal bone. The patient was a domestic servant and was anxious to get back to work quickly, so operation was done before the wound had completely healed. Probably as the result of this the operation wound suppurated, but, apart from this, the operation was successful. ½ per cent. eucaine-adrenalin solution was injected circularly round the metatarsal bone of the great toe 2 inches behind the head. 1 in 900 cocaine-adrenalin solution was then injected all over the metacarpo-phalangeal joint, well on to the dorsum and sole of the foot. 2 drachms of eucaine solution and 1 ounce of cocaine solution, *i.e.* ½ a grain each of eucaine and cocaine, were used. A broad rubber bandage was then applied in a figure of

eight round the foot and ankle to arrest the circulation. Fifteen minutes later the edges of the small wound were excised, and a flap of skin and subcutaneous tissue reflected to expose the head of the metacarpal bone. When this was done a Gigli saw was passed into the joint and the prominent portion of the head of the metacarpal bone removed. The toe was then straightened and the wound closed. Ten hours later after-pain came on and was severe for several hours. A hypodermic injection of morphia was given which relieved it, and it did not return. The wound suppurated, but eventually healed well, and the ultimate result of the operation was good. This or any other operation for hallux valgus can be easily done under local anæsthesia induced by the above method.

The cases related will serve as types of what has been termed combined regional and infiltration anæsthesia. It will be remarked that in three of them severe after-pain was felt. This is to be attributed partly to the fact that a tourniquet arresting the circulation was applied after making the injections in all the cases, and partly to the fact that the infiltrated tissues were either much inflamed at the time of operation or had been inflamed shortly before. Subsequent experience has shown that either no tourniquet at all should be used or only a congesting band, in order to avoid severe after pain.

The above method may be used with complete success on either hand or foot, but where there is much inflammation, with consequent thickening of the tissues and hypersensitiveness of the nerves, it may with advantage be replaced, for the hand at any rate, by perineural injections at the wrist, which are not in my experience followed by severe after-pain.

CHAPTER V

SPINAL ANÆSTHESIA

By injecting stovaine, cocaine, or eucaine, into the spinal subarachnoid space by lumbar puncture, anæsthesia of the areas supplied by the lower dorsal, lumbar, and sacral nerves can be produced. Although not actually the first to inject cocaine in this way, Bier was the first who worked out the method and definitely showed its possibilities as a practical method of anæsthetising the lower extremities. Cocaine was the drug used at first for producing spinal anæsthesia by Bier's method. $\frac{1}{3}$ to $\frac{1}{4}$ of a grain dissolved in 1 c.cm. of distilled water was injected through the third or fourth lumbar interspace into the subarachnoid space. In about ten minutes anæsthesia of the lower extremities followed, and lasted long enough for the performance of almost any operation; amputations, excisions of joints, of the rectum, etc., being done under it. Experience soon showed, however, that the method was by no means free from danger, and that in a majority of cases very disagreeable after effects followed the injection of cocaine into the cerebro-spinal fluid, the chief being severe and persistent headache, neuralgic pains in the back and limbs, sickness, and high fever. A number of deaths following the use of spinal anæsthesia were

reported, and it became evident that spinal anæsthesia induced by cocaine was neither safer nor pleasanter for the patient than general anæsthesia induced by chloroform or ether. Zahradnicky[1] collected 4659 cases in 1902. In 212 of these, anæsthesia was incomplete or entirely absent; in 58, dangerous complications accompanied or followed its use; in 12, death followed its use, eleven times when cocaine was used, once when eucaine was used. These figures show conclusively that spinal anæsthesia with cocaine or eucaine is even more dangerous than general anæsthesia with chloroform, and that there is no justification for its use. Bier himself and the great majority of other surgeons accordingly gave it up, but its use was continued in France, notably by Tuffier, who maintained that it was, when properly carried out, safe and satisfactory. After the introduction of adrenalin, and the discovery of the comparative safety of cocaine-adrenalin injections as compared with injections of cocaine alone, Bier again took up the subject and got much better results than before. Many other surgeons confirmed his results, and spinal anæsthesia, induced by cocaine-adrenalin injections, was shown at any rate to be comparatively safe. Complications during and after its use were, however, by no means abolished by the adrenalin. A certain degree of collapse, uncontrollable tremor in the legs, profuse perspiration, nausea, vomiting, and feelings of great oppression and precordial distress, frequently supervened soon after the injections, and headache, neuralgic pains, and fever were also frequent after effects. These effects were attributed to the specially powerful action of cocaine when brought into direct contact with the central nervous system,

[1] Zahradnicky, *Wiener medicinische Wochenschrift*, 1902, Nos. 44–47.

and to an "aseptic meningitis" following the injections. Many efforts were made to render the method harmless. Eucaine, tropa-cocaine, etc., were used instead of cocaine, cerebro-spinal fluid was used instead of water and saline solution to dissolve the drugs in, but no real improvements resulted. Stovaine, discovered by Fourneau, has however proved to be much more suitable for inducing spinal anæsthesia than any drug hitherto used for the purpose. Although weaker than cocaine, and having therefore to be used in correspondingly larger doses, it produces a complete and satisfactory anæsthesia, said to be rarely attended by complications and rarely followed by disagreeable after effects, and such complications and after effects as do occur are said not to be serious.

Technique.—The method of inducing spinal anæsthesia to be described is that used in Professor Bier's clinique in Bonn and described by Dönitz.[1] No special preparation of the patient is necessary, but it is well to operate at a time when the stomach is empty, in case a general anæsthetic has to be given to supplement an incomplete or transient spinal anæsthesia. Children under fifteen or sixteen are unsuitable subjects for spinal anæsthesia. A fine trocar and cannula with an available length of $3\frac{1}{2}$–4 inches, and a small glass-barrelled syringe graduated in c.c., which fits the end of the cannula accurately, are used for making the injections. After thorough cleansing of the skin in the lumbar region the patient is, if possible, placed in the sitting position, with the head and trunk strongly flexed, in order to open out the lumbar interspaces fully. If unable to sit, the patient must lie on a table, the head and trunk being flexed as before. The iliac crests are then palpated and

[1] Dönitz, *Archiv für klinische Chirurgie*, 1905, Band 77, Heft 4.

a line joining their highest points taken. This line crosses the 4th lumbar spine. The lumbar spines above are then made out, and the injection is made between the 2nd and 3rd or 1st and 2nd spines (probably best between the 2nd and 3rd, for the cord may reach a little below the 1st lumbar body). The trocar and cannula are then entered between two spines, *exactly in the middle line*, the site of puncture being frozen by ethyl chloride in nervous patients. When the skin is pierced, the trocar is withdrawn and the cannula pushed forwards and slightly upwards, exactly in the middle line, till the subarachnoid space is entered and cerebro-spinal fluid escapes. The subarachnoid space may be entered at a distance of 4–10 cm. from the surface. If no cerebro-spinal fluid escapes through the cannula, another puncture at a different level should be made; and if this also fails to tap the subarachnoid space, injection must not be made. In the absence of definite evidence of the needle having entered the subarachnoid space, which is only given by the escape of cerebro-spinal fluid, injection of stovaine will almost certainly fail to produce anæsthesia, and is therefore useless. The fluid should escape freely, in a steady jet, not drop by drop. If it escapes drop by drop the cannula should be moved about a very little, or very slightly moved on or back, to try and get the fluid to flow freely. As soon as this occurs the stovaine should be injected, 1–1½ c.cm. of a 4 per cent. solution, with the addition of a few drops of sterile 1 in 1000 solution of the adrenal active principle, being mixed with the fluid. The injection should be made slowly, and after it is made 1 or 2 c.cm. of cerebro-spinal fluid may be withdrawn into the syringe and reinjected, to avoid leaving any appreciable quantity of stovaine in the cannula or syringe. The

cannula is withdrawn and the puncture sealed with collodion The patient is then laid flat on the table for operations involving the areas of the sacral nerves, *i.e.* the rectum, perineum, prostate, etc.; for operations on the feet and legs the table is slightly tilted, so that the pelvis is raised and the head lowered; and for operations in the inguinal region and lower abdomen the table should be still more tilted. In ten minutes anæsthesia should be complete. It lasts for forty to ninety minutes, sometimes longer. During its development it is important to test where it first appears, for it lasts longest there, and disappears first where it last appears. Dönitz recommends that if it appears first in a nerve area below that of the site of operation—*e.g.* in the feet before the groin, in operating for hernia—the table should be at once further tilted, in the hope that the stovaine may tend to gravitate a little further towards the upper lumbar nerves, and so produce a longer anæsthesia than would follow in the ordinary course of events.

There are certain points in the technique which require comment or explanation. A long hollow needle or cannula without a trocar may be used perfectly well for the injections. The use of a trocar or stylet in the cannula for puncturing the skin alone appears to present no real advantage. The needle and syringe must, of course, be sterilised, and, as in using cocaine and eucaine, they must *not* be sterilised in soda solution, but in plain water or in physiological salt solution. Till recently lumbar puncture was generally done by entering the needle a centimetre to one side of the middle line and guiding it obliquely so that the point lay approximately in the middle line when it pierced the dura mater. It is obviously easier to puncture the dura in or very near

the middle line if the needle is entered in the middle line and pushed straight on. The idea that the needle meets with less resistance and is more easily guided if entered to one side is apparently erroneous, or has had too much importance attached to it. The importance of piercing the dura exactly in the middle line is, according to Dönitz, that by so doing its point enters a small space between the two halves of the cauda equina and lies free in the cerebro-spinal fluid. Hence the fluid readily escapes in a jet, and the injected solution will distribute itself evenly over the nerve roots on both sides. If, on the other hand, the needle pierces the dura a little to one side, it is apt to get entangled among the nerve roots on that side; hence the flow of cerebro-spinal fluid may be partially obstructed by nerve roots impinging on the end of the needle, and the injected stovaine is apt to be distributed chiefly on one side, producing a unilateral or asymmetrical anæsthesia. It will be noted that Dönitz recommends that the injection be made in the first or second lumbar interspace. Many surgeons who make use of spinal anæsthesia make the injection at a lower level. Thus Chaput recommends that the injection be made either immediately above or below the fourth lumbar spine, *i.e.* in the third or fourth interspace. For operations involving the area of distribution of the upper lumbar and lower dorsal nerves, he advises the use of larger doses of stovaine than for operations on the lower lumbar and sacral nerve areas, the maximum dose he uses being 8 centigrammes of stovaine. He uses a 10 per cent. solution of stovaine mixed with sodium chloride in equal proportion, the object of the sodium chloride addition being to prevent or limit a possible precipitation of the stovaine by the alkaline cerebro-spinal fluid. It certainly seems rational

to inject the stovaine in the second interspace when it is necessary to paralyse the upper lumbar nerves, as in operations on the abdomen and groin, for by high injection the solution is brought into more direct contact with all the nerves forming the cauda equina, including the upper ones which leave the spinal canal high up. If by so doing a smaller dose of stovaine is effectual than when injection is made lower down, high puncture seems all the more advisable. On the other hand, if it is only necessary to paralyse the lower lumbar and sacral nerves, injection in the third or fourth interspace will probably be as effectual as in the second. It must be recognised, however, that no certain method of controlling the distribution of the anæsthesia has yet been devised. In some cases it extends much higher than is necessary, involving even the whole trunk, arms, and part of the head, while in others it does not extend high enough. The rule that the bigger the dose the more extensive the area of anæsthesia, is evidently not absolutely, but only approximately, correct. If further experience shows that the plan of tilting the pelvis to a greater or less extent, as recommended by Dönitz, is effectual in localising to some extent the action of the injected stovaine solution, a marked advance will undoubtedly have been made in the technique of spinal anæsthesia. When cocaine-adrenalin solution was used, it was generally considered advisable to lower the patient's pelvis and raise the head, to prevent a rapid diffusion of the cocaine up the spinal canal, with consequent symptoms of faintness, nausea, etc., due to the cocaine coming in contact with the upper part of the cord and medulla. Stovaine appears to be relatively so non-toxic and unirritating that no danger is to be anticipated from the practice of raising the pelvis. This

may possibly be due to the fact that stovaine is said to deposit when mixed with the cerebro-spinal fluid, and so to localise itself chiefly in the immediate neighbourhood of the injection.

The object of moving the needle about slightly if the cerebro-spinal fluid does not flow freely is to get the point, if possible, to enter the small space mentioned and disentangle it from among the nerve roots on one or other side. The importance of using a hollow needle without a stylet for piercing the dura is considerable. The sensory roots lie in a plane posterior to the anterior or motor roots in the spinal canal, and to a certain extent in a compartment of their own, partially shut off from the anterior compartment by the ligamenta denticulata. It is therefore important to know exactly when the needle enters the subarachnoid space, and to make the injections there; for if the needle be pushed on towards the front the injected solution will be distributed more round the motor than the sensory nerve roots, and an imperfect anæsthesia may result. By using a hollow needle, the cerebro-spinal fluid escapes the moment the subarachnoid space is entered, whereas if the stylet is retained till the sensation communicated by piercing the ligamenta subflava is felt, as used to be advised, mistakes may easily be made by the inexperienced, and in cases where this sensation cannot readily be recognised.

It is undoubtedly most convenient to keep the stovaine made up ready for use in little glass flasks which are broken directly before use, and the contents emptied or drawn into the injecting syringe. Such flasks, filled with a slight excess of sterile stovaine solution and epinephran (a reliable adrenal preparation made by Byk, Berlin), enough salt having been added to make

the mixture isotonic with the cerebro-spinal fluid, are prepared by Billon, Paris, who also prepares capsules containing stovaine and sodium chloride without adrenal substance, as used by French surgeons.[1] The addition of adrenal substance is recommended by Bier, as it prolongs the anæsthesia, and its use seems therefore to be undoubtedly advisable.

The maximum dose, according to Dönitz, should not exceed 6 centigrammes of stovaine, *i.e.* 1½ c.cm. of 4 per cent. solution, while French writers state that as much as 8 centigrammes may be safely injected when a high anæsthesia is necessary. The duration of the anæsthesia, as already mentioned, is as a rule forty to ninety minutes, sometimes longer, especially when epinephran or other adrenal preparation is injected along with the stovaine. This allows of the performance of almost any operation in the area of distribution of the affected nerve roots.

Complications during the anæsthesia are not often observed when stovaine is used, but are not unknown. Cases of collapse have been recorded, and the occurrence of nausea and vomiting has also been noted. Motor paralysis frequently occurs along with the sensory paralysis, but passes off before or along with the sensory. Unpleasant after effects similar to those produced by cocaine, but of less intensity, occur in a certain proportion of cases, especially when a large dose has been used. The number of cases in which they occur is difficult to estimate from the records already published, but appears to be 15 to 20 per cent. of all cases. Unilateral or incomplete or total absence of anæsthesia after injections is met with occasionally,

[1] These are to be obtained in this country from Jos. Flack, 16 Water Lane, Great Tower Street, London.

apparently in about 4 per cent. of cases in the practice of those who have most experience in spinal anæsthesia, probably in a larger number in the practice of others. Deaths following spinal anæsthesia induced by stovaine have been reported, but only in a few cases where the condition of the patients was already grave and death from the illness present was only to be expected. No death due to the toxic action of stovaine has, as far as I am aware, been recorded.

Infective meningitis has also been recorded, but only in cases where infective lesions were already present in other parts of the body, such as pneumonia or suppurative peritonitis. With ordinary care, there should be no risk of infecting the spinal meninges in introducing stovaine by lumbar puncture; but it would seem wise to avoid doing so when serious infective lesions are present elsewhere in the body.

The operations which can be done under spinal anæsthesia include all operations on the lower extremities, on the rectum, perineum, scrotum and penis, on the bladder and female genital organs, hernia, appendicitis, etc.—in fact, practically all operations on parts of the body below the umbilicus. In a certain number of cases the anæsthesia extends above the umbilicus, but this is not to be depended on, and operations on the upper abdomen should not be attempted under spinal anæsthesia.

It is not possible yet to estimate the true value of spinal anæsthesia with stovaine in surgical work. That it involves less risk to life than general anæsthesia seems probable, but has not yet been proved. Many thousands of cases must be recorded before a decision on this point can be reached. For major operations where general or spinal anæsthesia is necessary, the

latter is said to be of advantage, because the after effects are, as a rule, much less unpleasant for the patient. Against this must be put the fact that it is undoubtedly unpleasant and often probably harmful for the patient to be conscious while a major operation is being performed, while there is always a risk, although admittedly a remote one, that an infective meningitis may be caused by the lumbar puncture.

For minor operations, which can be done under local anæsthesia, the use of spinal as of general anæsthesia seems unnecessary and therefore unjustifiable. In cases where a general anæsthetic is contra-indicated, as in advanced cardiac disease, etc., in cases where an operator has to work single-handed, and possibly in military surgery and on board ship, spinal anæsthesia seems to possess undoubted advantages. Till, however, it has been definitely shown to be safer than general anæsthesia, its employment as a matter of routine is not to be recommended.

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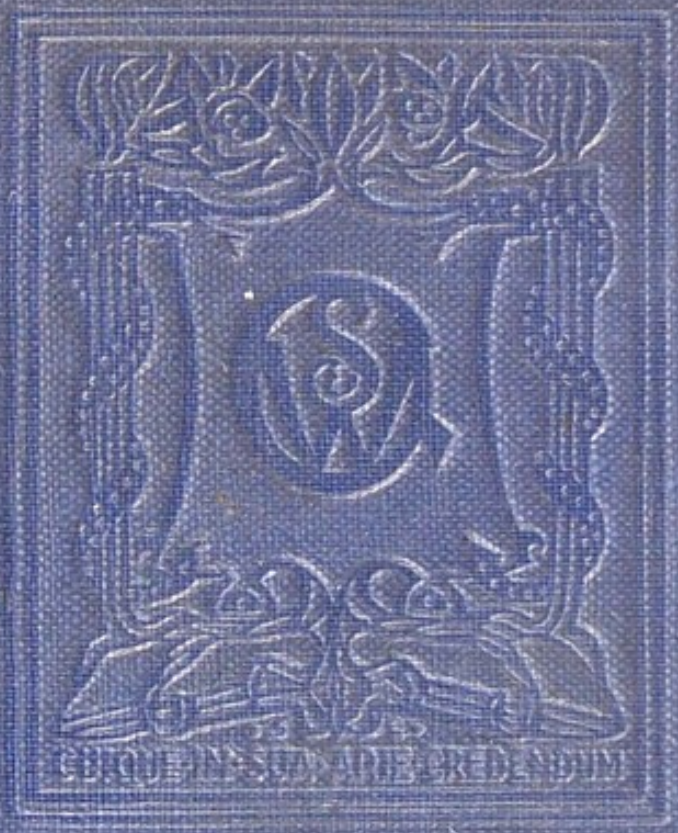
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