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LOCAL ANÆSTHESIA

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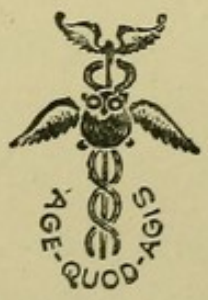
ILLUSTRATED



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PREFACE

THE study of local anæsthesia has made such great progress recently, and has led to so great an improvement and perfecting of methods, that it seems desirable that it should be still more widely employed by medical practitioners than has hitherto been the case. Only in the last year or two has it begun to figure at all frequently as an item of any importance in the clinical curriculum, a change which will be, I think, of material advantage to the present generation of students.

The chief aim of this book is to enable those who have no opportunity to gain acquaintance with the various methods by observing them in actual practice, to perfect themselves in technique by proceeding gradually from the simpler to the more difficult tasks. In the second place, I have endeavoured to describe, in accordance with the present state of our knowledge and for the benefit of specialists, the best methods of dealing with those more difficult tasks.

Comparatively little space has been given to expositions of theory. These are, however, so

important for a right understanding of the subject that due consideration should always be given to them, especially as, owing to the very rapid development of our subject, many divergences of opinion have arisen. I have avoided detailed references to the literature, but have everywhere named the more important authorities.

As regards technique, I have throughout endeavoured to put before my readers what I have found by experience to be the simplest and most practical methods. Where new and as yet unproved methods are cited, the fact is always made clear in the text.

I have to render cordial thanks to Privatdozent Dr. Haike and to Dr. Fehr, Surgeon to the Virchow Hospital; to the former for assistance in the preparation of the section on aural and nasal operations, and to the latter for similar help in dealing with operations on the eye.

THE AUTHOR.

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LOCAL ANÆSTHESIA

CHAPTER I

HISTORICAL SURVEY

The endeavour to render operations painless by inducing local anæsthesia is almost as old as medicine itself. From the most ancient times physicians have, in addition to their attempts to carry out operations painlessly by some method of dulling the sensorium, endeavoured also by some locally acting agent to secure anæsthesia of the actual site of operation.

The different ways in which this end was sought to be attained may here be briefly reviewed.

Leaving out of account the experiments mentioned by ancient writers, with crocodile fat, dried and powdered crocodile skin, friction with vinegar and stone of Memphis, and so on, we may regard as the earliest scientific method—

1. *The Production of Anæsthesia by Compression of Nerves.*—In very early times, and later among the Arabs, the method of nerve compression by liga-

turing the extremities was practised with a view to the production of local anæsthesia. Since then the method has been again and again "re-discovered," only to be again abandoned on account of its imperfections. At the beginning of the nineteenth century it was, according to Desault, in frequent use. Quite recently the method has been once more "discovered" by Kofmann. While, however, the earlier authorities regarded the nerve compression brought about by ligaturing the extremities as the anæsthesia-producing agent, Kofmann held that the anæsthesia was caused by the bloodless condition of the limb due to the ligature. Braun's experiments have proved finally that ligature owes such power as it possesses to diminish pain solely to the compression of nerves caused by it.

2. *Cold* as an anæsthetic agent was first employed in the sixteenth century by Marcus Aurelius Severinus, who simply placed pieces of ice upon the part to be anæsthetized. Much later the anæsthetic action of cold was again learnt in the Napoleonic campaigns in Russia (*Larrey*), when, as for instance after the Battle of Eylau, it was found that limbs benumbed by cold could be amputated without pain. After this Hunter, and later (1849) Arnott, employed freezing mixtures for the production of local anæsthesia. A few years later, again, sulphuric ether was employed by Rochet,

the method at first adopted being to allow the ether to drop slowly upon the skin and evaporate. It was not, however, until 1866 that Richardson furnished, in his well-known and still widely used ether spray apparatus, a really practical means for the utilization of the volatile properties of ether.

The substances which have since that time been introduced as substitutes for ether, to be applied by means of the spray apparatus, such as brom-ethyl, ethylene chloride, etc., have not all succeeded in securing any wide adoption. The introduction of *ethyl chloride* constituted the first notable advance, inasmuch as its applicability was independent of the surrounding temperature. At all ordinary room temperatures the chloride of ethyl is gaseous, and can only be kept in the liquid state under pressure. The time required to freeze the skin is, by the use of ethyl chloride, notably diminished.

The newer substances of still lower boiling-point than ethyl chloride (*methyl chloride*, *anæsthyl*, *metethyl*, *koryl*, etc.) have not been much used, the danger of injury to the tissues increasing with the rapidity of action of the evaporating agent.

Equally little practical success has attended attempts to employ ethyl chloride or ether to act upon deep structures such as nerve-trunks (*Rossbach*, *Scheller*, *von Hacker*).

3. As regards other purely physical methods, it may be stated, merely as a matter of historical interest, that in the 'fifties of the last century the electric current was warmly extolled as a local anæsthetic agent, and that the claims made for it proved to be quite unjustified. It is possible that results of practical utility may eventually be attained by the use of rhythmic intermittent currents (the so-called Le Duc's currents). Repeated experiments by the author have had negative results. At the same time, the fact that with these currents one can obtain at any rate a diminution of sensibility, *e.g.*, in the finger (one electrode on the median nerve and the other around the base of the finger), shows that the prospect of some further practical advance in this direction is not to be summarily dismissed.

Other physical conditions—osmotic differences, drying or infiltration of tissues, etc.—play, as we shall see, a certain rôle as auxiliaries in the production of local anæsthesia.

4. Finally, attempts to produce local anæsthesia by chemical means can also be traced back to ancient times. In this connection the impetus to investigation has almost always been given by the idea that substances which produce a general deadening of sensibility must, if applied to some special part, exert there also a sedative influence.

Thus the Egyptians, the Greeks, and, later, the Romans employed the poppy, Indian hemp, henbane, mandrake-root, and mandragora, as local anæsthetics. The same conception governed the practice of the Middle Ages. Plasters and poultices containing the substances named were applied to the site of operation by medieval physicians, while the ancients generally employed sponges soaked in the juice of the selected plant. As late as the middle of the nineteenth century Bouisson stated that he could produce anæsthesia of a toe by applying opium compresses.

When the general anæsthetic properties of ether and chloroform were discovered, these substances also came into use for the production of local anæsthesia. Richardson and Aran believed that local anæsthesia, as well as general narcosis, depended on abstraction of water. Later, again, Türck and Scheff employed local applications of chloroform, solutions of morphine salts, etc., for the anæsthetization, for instance, of the laryngeal mucous membrane. All these experiments were quite without practical result. The ever new recommendations, however, of substances and methods show how great is the power of suggestion in the whole matter. The recommendations are, of course, made for the most part in good faith, but the optimism of operators and variations in the degree of sensibility to pain in their patients

have been very fruitful sources of fallacy in these experiments.

Again, after the discovery of the method of hypodermic injection by Wood in 1853, the local anæsthetic power of morphia and chloroform was tested by this method, in the latter case with the result that the pain of the injection often greatly exceeded that of the operation itself.

Of other sedative substances and methods which have been experimented with and recommended, mention may be made of hydrocyanic acid (*Simpson*), carbonic acid externally applied (*Percival*, 1772), and saponin hypodermically injected (*Pelikan*).

The question of the production of local insensibility to pain acquired an altogether greater practical importance with the commencement of our knowledge of the local anæsthetic properties of cocain. Leaves of the coca-plant were brought to Germany by Scherzer from South America, where their partly stimulating and tonic and partly sedative effects had long been known. In several German laboratories investigations were made with a view to the discovery of the true active principle of the plant. At first it was thought that this had been discovered in a body to which the name *erythroxylin* was given. Later, however, the claims of this body were entirely thrust aside in favour of those of a substance dis-

covered in Woehler's laboratory by Niemann and Lossen in 1860, and named by them *cocain*.

Twenty years elapsed before the knowledge of the anæsthetic properties of the substance spread sufficiently widely in the medical profession to lead to the resolve to test its applicability to operative surgery. Its results in ophthalmic operations were first reported on in 1884 by Koller, and soon after this followed its use as a locally-applied anæsthetic in operations on the nose and larynx.

In 1885 the first monographs on the use of cocain hypodermically in surgical operations appeared almost simultaneously in Germany, the United States, and Austria (*Landerer*, *Corning*, *Woelfler*). The most important of these papers is that of Corning, which establishes two significant facts: (1) The heightened effect of cocain in tissues emptied of blood, and the consequent possibility of obtaining satisfactory results by the injection of very dilute solutions; (2) the possibility of interrupting conduction in sensory nerves by cocain injections, an observation which formed the foundation of the method of *conduction-anæsthesia*, later to become so fruitful in good results.

In general, the method adopted in these early times of cocain anæsthesia was to inject certain quantities of 1 to 5 per cent. solutions in the

neighbourhood of the site of operation and to wait for their diffusion.

It was the French surgeon, Reclus, who was the first—in the late eighties of last century—to make any extended use of cocain injections for the production of local anæsthesia. He employed at first 5 per cent., later 1 per cent. and ½ per cent. solutions, and performed with their aid a very large number of operations on the genito-urinary organs and the anus. We cannot, in the light of our present knowledge, assent when he describes his methods as free from risk. His maximal dose of 0·2 gramme (3·08 grains) injected in 1 per cent. solution is undoubtedly much too large—so dangerous, indeed, in my opinion, that one is almost forced to conclude that the preparations employed by him were different from those used nowadays.

The credit of devising a technique satisfying the first demand one is entitled to make of any method for producing local anæsthesia—namely, that it shall be safe and thus freely utilizable—belongs undoubtedly to the Berlin surgeon, Schleich. For a long time past a Schleich-Reclus "infiltration anæsthesia" has been spoken of. It is certain, however, that the method to which Schleich gave that name, with its production of a local œdema and its small dose of cocain, differs in principle from any that preceded it. The

method of rendering the skin itself insensitive by injecting in such a manner as to form wheals (*Quaddel*) was described by Roberts before Reclus or Schleich wrote on the subject.

Schleich's discovery was greeted with much scepticism when first demonstrated before the Surgical Congress in 1892. The method gradually made its way, however, and was for some years almost the sole method in general use. In spite of the improvements in technique made since that time, it will probably never be abandoned altogether, but will be employed from time to time in specially suitable cases.

Side by side with this method of *terminal anæsthesia*, in which the sensory nerve-endings in the area of operation itself are acted upon by anæsthetic solutions, another method has been evolved which has gradually surpassed it in importance, a method which, following Braun, we name *regional* or *conduction anæsthesia*. In this method the actual site of operation is left uninterfered with, but the conduction of sensory impulses therefrom is interrupted by injections into the neighbourhood of the nerve-trunks supplying it. The originator of this method is the American, Corning, who, in 1887, by means of injections around the *N. cutaneus antebrachii*, produced an anæsthesia of the cutaneous area supplied by that nerve. The method remained of little importance in prac-

tice until 1890, when Oberst and Pernice, who were unacquainted with Corning's experiments, rendered a finger anæsthetic by ligaturing the base and injecting the neighbourhood of the nerve-trunks in which ran the finger's sensory fibres.

A further step forward was Hackenbruch's *circular analgesia*. In this method injections of anæsthetic solutions are made all round the site of operation, the conduction of the sensory impulses therefrom being thus entirely interrupted. Hackenbruch employed a solution, consisting of equal parts of $\frac{1}{2}$ per cent. solutions of cocain and eucain.

In Oberst's method the injections are made *perineurally*, and the solutions reach the nerves themselves by diffusion. Krogius has suggested *endoneural* injections, but the method has as yet little practical importance. The perineural method, on the other hand, has been widely developed. Hall applied it to the infra-orbital nerve, Hallstedt to the inferior alveolar, and Manz to the larger nerve-trunks in the hand and foot. It is to Braun, however, who in his textbook of local anæsthesia, published in 1905, gives detailed descriptions of technique applicable to every region of the body, that credit is chiefly due for the development of the method. Braun's later work has been chiefly devoted to a confutation of Schleich's views, according to which physical

factors—osmotic tension, œdema, pressure—play the chief part in producing anæsthesia, the anæsthetic itself having only a secondary rôle. We have to thank Braun, also, for another notable advance—the introduction of preparations from the suprarenal gland, which, injected with the anæsthetic, lessen the risk of poisoning and at the same time increase the local effect.

Important progress has been made during the last few years in another direction. Experimental chemistry has furnished us with substitutes for the poisonous cocain, which, while considerably less toxic than that substance, are not markedly less effective as anæsthetics. Among these novocain has, in consequence of its combining high anæsthetic efficiency with low toxic power, come very rapidly into general use, and is employed now by the majority of surgeons. So far, indeed, has this displacement of cocain by less toxic substitutes advanced that Bier was justified in saying at the Surgical Congress of 1909 that, except for operations on the mucous membranes and the eye, cocain ought no longer to be used. Another advance we owe to chemical industry is the synthetic production, a few years ago, of the bodies to which suprarenal preparations owe their efficacy.

The latest development to which we would draw attention, as it opens up a new field for local

anæsthesia, is the introduction of Bier's *venous anæsthesia*, in which $\frac{1}{2}$ per cent. solution of novocain is injected into a vein between two Esmarch's tourniquets applied to the arm or leg. An anæsthesia is produced in this way which is fully sufficient for the performance of major operations, such as resections or amputations, between the two ligatures, or at any point peripheral to them.

CHAPTER II

PHYSICAL PRINCIPLES

If we inject some ordinary tap-water underneath the human epidermis into the cutis (endermal injection), a whitish weal is produced, somewhat resembling that caused by the sting of an insect; at the same time fairly acute pain is felt, and this is followed later by an anæsthetic condition limited to the area of the weal. This, too, gradually passes away.

The cause of the pain and of the subsequent anæsthesia is as follows:

If we have in a vessel two solutions of the same salt, but of different concentrations, whether separated by a permeable membrane or not, an exchange of molecules will take place between the two: molecules of the salt will pass from the more concentrated to the more dilute solution, while molecules of water pass simultaneously in the opposite direction. This exchange proceeds, if both solutions are of the same salt, until the solution is of the same concentration throughout. Before diffusion there is a condition of so-called

"osmotic tension" between the two solutions. The more concentrated solution is said to be "hypertonic" the more dilute "hypotonic." After diffusion we have an "isotonic" condition, in which the solution presents the same molecular concentration throughout. If the salts in the two solutions are not identical, then, for each concentration of the one solution, a certain definite concentration of the other is required to bring about the isotonic condition, in which no exchange of molecules, whether of salts or of solvent, takes place. The simplest method for estimating osmotic tension is the determination of the freezing-point of the solution dealt with. Isotonic solutions have the same freezing-point; in hyperosmotic (hypertonic) solutions the freezing-point is lower, in hyposmotic (hypotonic) solutions it is higher.

If, now, we apply the foregoing to our chosen example, we have, after injection of water into the cutis, an exchange of molecules, for the reason that the lymph or blood flowing through the tissues has a relatively high saline content, and is therefore hypertonic to water, so that saline particles pass from the blood and lymph to the injected water, and, on the other hand, water diffuses itself through the tissues, producing a sodden or soaked condition (*Quellung*). This soaking of the tissues is the cause of the phenomena we observe. It irritates the sensory nerve-

endings, thus causing pain (*Quellungsschmerz*), which is followed by a condition of anæsthesia (*Quellungsanästhesie, Braun*). Injection of concentrated solutions, in consequence of the abstraction of water it brings about, also causes, though in a slightly different way, pain with subsequent anæsthesia.

The anæsthesia, preceded by pain, which is caused by injections of water is named, after Liebreich, "anæsthesia dolorosa." It is not a suitable method for producing local anæsthesia in actual practice, for the reason that the injection of substances markedly hypotonic to the tissue fluids, apart from the pain it produces, actually injures the tissues, as is proved by the frequent occurrence of necrosis after injections of water (*Braun*). If common salt is added to the water injected, it is found that both the pain and the subsequent anæsthesia diminish as the concentration of the solution increases, and a point is finally reached at which the salt solution (0·9 per cent., or "physiological" salt solution) causes neither pain nor anæsthesia. The freezing-point of the tissue fluids is, at this point, the same as that of the salt solution. If we now carry the concentration of the salt solution further, the phenomena of pain and subsequent anæsthesia are again elicited. They are, however, to be ascribed now, not to the soaking of the tissues, but, on the contrary, to

their being drained of fluid (*Braun*). We have, then, in physiological salt solution, a combination which neither causes pain when injected, nor injures the tissues, and constitutes, therefore, an ideal vehicle for anæsthetizing substances.

The absence of either "soakage" or "drainage" anæsthesia is of little importance in view of the pain-deadening power of the substances we employ as local anæsthetics.

We require of the anæsthetic itself, no less than of the vehicle in which it is dissolved, that its injection shall be free from pain, and shall not cause injury to the tissues. Braun and Heinze have tested a large number of substances by Schleich's method, and have found very few which meet our requirements fully in these respects. Those which do so, and are therefore suitable for use as local anæsthetics, exert their anæsthetic powers, when injected endermally, in very dilute solutions.

The method of testing an anæsthetic by injecting it so as to form weals is, however, only valid if the object for which we wish to employ the substance tested is the production of anæsthesia of the skin or mucous membrane. Other laws come into operation where diffusion through several tissues is in question, as, for instance, when a mucous membrane is rendered insensitive by external application of the anæsthetic.

Thus tropacocain, which is quite useless for the production of infiltration anæsthesia, is used by many ophthalmologists for subconjunctival instillation.

The laws of diffusion apply, of course, as fully to endermal as to hypodermic injection. Of special importance here is the fact that concentrated solutions, after injection, continue to take up water from, and give up their salts to, the tissues, until a condition of osmotic equilibrium obtains. We can thus, by injecting a concentrated solution of an anæsthetic merely into the neighbourhood of an organ such as a nerve, secure, by means of the diffusion process set up, the gradual passage of the anæsthetic into the nerve itself.

CHAPTER III

LOCAL ANÆSTHETICS

THOUGH, as we have stated above, cocain itself is no longer widely used, it, nevertheless, as the first of modern local anæsthetics, and the one from which nearly all those in common use to-day may be said to have been derived, deserves special and prior mention and consideration.

Cocain, an alkaloid obtained from the leaves of the coca-plant, was first isolated by Niemann and Lossen in Wohler's laboratory. Later it was produced synthetically. Commercial hydrochlorate of cocain of the present day is a white powder freely soluble in water and alcohol. It is odourless, but has a bitter taste. The nature of the local action of cocain has been a subject of prolonged controversy. It was formerly held that it acted by virtue of its power to produce anæmia, as it is known to cause contraction of the smaller blood-vessels and capillaries. This anæmia certainly plays a part in cocain anæsthesia, which we shall consider later ; the actual anæsthetic effect, however, depends on a purely chemical action, on an

affinity between the drug and the protoplasm of the tissues, which gives rise to a chemical combination, of whose exact composition we are at present ignorant. That the anæmia is not the efficient cause of the anæsthesia is proved by the following facts :

1. Cocain has been found to produce its anæsthetic effect even when the blood in the vessels has been replaced by salt solution.

2. There is a whole series of preparations which are efficient producers of local anæsthesia, but do not cause simultaneous anæmia—*e.g.*, eucain.

The aqueous solutions of cocain which were in general use until the introduction of the modern substitutes are all strongly hyposmotic or hypotonic. Their freezing-point varies, according to Braun, from 0·02° (0·1 per cent. solution) to 0·115° C. (1 per cent. solution), the freezing-point of human blood being about 0·55° C. Their injection, nevertheless, causes no "infiltration pain" (*Quellungsschmerz*), as this is overborne by the essential anæsthetic effect of the drug.

Different kinds of protoplasm have different degrees of chemical affinity for cocain; what chiefly concerns us is the high degree of affinity in the case of the sensory nerves. Thus, according to Braun, a 0·005 per cent. solution of cocain injected so as to produce a weal is sufficient to deaden for a short time the sensory nerve-endings within the

weal. By this property of acting in very dilute solutions cocain and its derivatives are clearly distinguished from a whole series of other substances which act as anæsthetics when injected, but all belong more or less to the group of *anæsthetica dolorosa*, and, being consequently of no practical value, need not be enumerated here.

It is important to remember that tactile and pressure sensations are diminished by cocain later and in less degree than sensations of pain. Thus it often happens that patients in whom sensibility to pain has been entirely removed at the site of operation will be conscious of the pressure of the surgeon's knife, or of the drawing apart of the edges of the wound, and this may lead in nervous and excitable patients to failure, or comparative failure, if sufficient time be not allowed for the anæsthetic to produce its full effect on sensation.

The senses of smell and taste are also inhibited by cocain, but here, too, later than sensations of pain.

The motor nerves are much less affected—so little, in fact, that the effect of cocain upon them is as a rule practically negligible. It is only in the so-called *venous anæsthesia* that motor paralysis serves to announce the commencement of anæsthesia. The greatest sensitiveness to the action of cocain is, however, exhibited by the central nervous system. If, over and above the cocain

remaining and acting at the site of injection, any considerable quantity of the drug should make its way into the general circulation, symptoms referable to the brain and spinal cord will be the first to manifest themselves, cardiac symptoms being the next in order of appearance.

Cocain-poisoning was, not so very long ago, a factor of considerable importance in local anæsthesia, and though, fortunately, it now rarely comes under our notice, some consideration of its symptoms and prophylaxis will help towards a clear understanding of the whole subject of local anæsthesia; such consideration is called for, also, in view of the fact that cocain is still freely used both by ophthalmologists and dental surgeons.

In acute cocain-poisoning (with which alone we have here to do) the patient is seized, almost immediately after the injection, with giddiness, which in severe cases passes on to a condition of syncope; palpitation is generally present; the face is pale, the pulse small and rapid; as a rule the patient feels anxious and oppressed, with a sensation of tightness across the chest. The whole symptom complex may be referred in part to contraction of the cerebral bloodvessels, in part to a specific action on the cerebral cortex.

In the milder cases the patient recovers after a few seconds or minutes; in the more severe the dominating feature is a condition of excitement

resembling in some respects that due to alcoholic intoxication. In fatal cases death due to paralysis of the respiratory centre is ushered in by convulsions and coma. In severe cases which do not end fatally the patient exhibits extreme excitement, and talks volubly like a slightly drunken man. There is generally marked anxiety, with dryness of the throat and tingling or numbness in the extremities; the pupils are dilated and fixed. In most non-fatal cases recovery is rapid; occasionally, however, a condition of debility supervenes which lasts for a considerable time.

Of the very first importance in connection with the causation of cocain-poisoning is the fact, established clinically by Schleich, and experimentally by Maurel, that *a given dose of cocain which, injected in concentrated solution, will give rise to severe toxic symptoms, may be quite well borne if given in a dilute solution.* The maximum dose of cocain is often given as 0·05 gramme (0·77 grain). Such a statement is entirely futile. I can inject twice that dose in a 0·1 per cent. solution without risk, whereas a fraction thereof in a 5 per cent. solution may produce most alarming symptoms of poisoning, or even cause death. It requires a very short time to produce cocain-poisoning when cocain, in solutions over and above a certain concentration, reaches the blood-stream.

The explanation of this fact put forward by

Schleich is that around the small ischæmic œdematous area, where the small quantity of concentrated solution lies deposited, a collateral hyperæmia, with increase of blood-pressure, is established, which, by causing pressure from without, forces the cocain into the lymph channels, whereas, where a larger deposit of more dilute solution is in question, this action from without is exerted more gradually, so that absorption is delayed. Simple suction by the lymph-stream is a factor which may, in Schleich's opinion, be neglected.

We cannot agree with this explanation of Schleich's, for we find that the rule holds also for injections which are not made according to Schleich's method, and in which œdema and ischæmia of the tissues cannot play any part. Further, it holds also in the case of applications to a mucous membrane, where it is, of course, beyond question that no pressure is exerted on the cocain solution. The following seems to us a far simpler explanation :

Let us assume that we have in a cubic centimetre of a 1 per cent. solution 100 molecules of cocain, then in a cubic centimetre of a 10 per cent. solution we shall have 1,000 molecules. Now, if we inject these two cubic centimetres under the skin of two separate individuals, a fluid deposit of the same size will be formed in each case. In

the first case the 100 molecules will readily find 100 molecules of protoplasm with which to combine, thus remaining anchored, so to speak, at the site of injection. The 1,000 molecules, however, will not find molecules of protoplasm to combine with and fix them all, and the surplus, say 500, will pass quickly into the blood-stream, and so reach the central nervous system and give rise to symptoms of acute poisoning.

Such being the conditions which determine the the supervention of cocain-poisoning, it is possible to infer from them what objects we have to aim at in order to obviate the danger—

1. *We must endeavour to delay the absorption of cocain into the blood-stream.*

2. *We must use solutions as dilute as possible.*

The first point will be dealt with in the next chapter ; as regards the second it has been found that a 1 per cent. solution is the strongest that should be injected subcutaneously, and this only when special means, which we shall discuss later, are adopted with a view to delaying absorption ; and I cannot help suspecting that Reclus, who states that he has performed several thousand operations with use of 1 per cent. solutions, without a death, must have used preparations of cocain weaker than those at present at our disposal, or that his sterilizing precautions must in some way have weakened the action of his injections.

According to Braun, the largest quantity of a 1·0 per cent. solution, with suprarenin, which can be regarded as safe is 5 c.c., whereas of a 0·1 per cent. solution 100 c.c., or double the maximal dose of cocain in the more concentrated solution, can be injected without risk.

Dosage becomes a matter of great difficulty in applications to the oral and nasal mucous membranes. Here, in order to get anæsthesia, one must paint with 10 to 20 per cent. solutions. In this method it is quite impossible to say how much is absorbed. It is important that the solution should be applied, not to a large area of mucous membrane at once, but to small areas, if necessary, in succession. With all precautions, however, as I have learnt from repeated experiences, it is impossible to avoid cocain-poisoning altogether and with certainty in this method, though I have not seen any really severe cases. The best precautionary measure would be to avoid cocain altogether, and use only its substitute preparations (*alypin*, *novocain*); it must be admitted, however, that a considerable number of authors consider cocain to be superior to its substitutes as an anæsthetic for mucous membrane.

In the case of hollow organs (such as the bladder or the interior of a joint), where we can give the drug sufficient time to produce its

effect, satisfactory results are obtained with quite dilute solutions (0·1 and 0·2 per cent.).

It ought not to be necessary to insist that cocain should not be injected into young children. Nevertheless, even infants in arms have been successfully cocainized.

Special care is necessary with cocain in the case of anæmic and cachectic patients, as such patients often exhibit marked intolerance of the drug.

In the treatment of acute cocain-poisoning the first indication is to place the patient in a horizontal position, with the head somewhat lowered. The face should be sprinkled with cold water, and all windows should be opened. If amyl-nitrite is at hand, a few drops should be administered by inhalation. Though, according to Dastra, it is not theoretically an antagonist to cocain, it, nevertheless, often acts exceedingly well in practice. In women all constricting garments should, of course, be loosened.

In severe cases caffeine or camphor should be given hypodermically, the body should be vigorously rubbed or flicked with wet towels; should the breathing begin to fail, artificial respiration must be resorted to.

The sterilization of cocain must be carried out with great care, as the drug is readily decomposed by heat, with loss of anæsthetic power. Above all things, it is important that the solutions employed

should be made immediately before use. The simplest method of sterilization is to raise the solution once to the boiling-point. Cocain will bear this without undergoing decomposition. Prolonged boiling causes decomposition of the active substance. According to Braun, cocain in powder or tablet form may be heated to 80° C. for an hour on each of three successive days, and then dissolved in sterile salt solution.

Chemists have for a long time endeavoured to provide substitutes for cocain, which, while little, if at all, less powerful as anæsthetics, shall be without its toxic properties. Of the substances with which chemical industry has furnished us up to now some are chemically closely allied to cocain (*tropacocain*, *eucain*, *novocain*), while a series of others belong to the orthoform group (*orthoform*, *nirvanin*). Only a few of these bodies have established themselves in practice. We will deal here with the more important of them.

Tropacocain is much used in spinal anæsthesia, of which we shall not treat here, as it is not, strictly speaking, a form of local anæsthesia. It has also proved useful in 2 to 3 per cent. solutions in ophthalmology. When injected subcutaneously, however, it is of use only for operations of very short duration, as its anæsthetic effect quickly passes off. It does not, like cocain, cause anæmia, nor has it been found to cause injury to the

tissues. According to Braun, up to 0·2 gramme of the substance may be given in 1 per cent. solution. No by-effects have been observed from injections of solutions of that strength. Sterilization is most conveniently carried out by boiling the solution for five minutes. Addition of suprarenal preparations does not increase the effect of tropacocain.

Eucain β, which was at one time widely used, has now almost disappeared from practice. Its property of causing hyperæmia and the impossibility of combining it with suprarenal preparations, have stood in the way of its extended use. Its use is now practically confined to ophthalmologists, many of whom still recommend it for subconjunctival injections. To the two hitherto recorded cases of poisoning I am able to add a third. A solution of 1 in 30 was injected into the slightly ulcerated bladder of an elderly man. The most severe collapse followed immediately, complete pulselessness and cessation of respiration. The condition seemed desperate, but artificial respiration, with injections of camphor and caffein, brought the patient round in about ten minutes.

Alypin, a glycerin derivative (*monochlorhydrate of benzoyl*), is now used by many ophthalmologists in place of cocain. The drug acts on the eye in about the same strength of dose as cocain, but is

less poisonous. The lethal dose is about double that of cocain. Alypin differs from cocain in causing dilatation instead of constriction of blood-vessels. It does not, like cocain, cause mydriasis nor paralysis of accommodation. It may be combined with suprarenal preparations. It is, further, less harmful to the cornea than cocain. It may be sterilized by boiling for five to ten minutes. Solutions of 2 per cent. strength are generally used for conjunctival instillation. In rhino-laryngology, also, the drug has many advocates. It is here painted on the mucous membrane in 10 to 25 per cent. solution.

Alypin shares with novocain the preference of a good many surgeons. Apart from Schleich, who uses it as a substitute for dilute solutions of cocain, Schloffer, for instance, has carried out with it a series of strumectomies. For infiltration 0·5 to 2 per cent. solutions are employed. So far as I am acquainted with the literature of the subject, no mishaps have been reported from its use.

Stovain, on account of its irritating properties, is not suitable as a local anæsthetic.

A substance which has rapidly won for itself, in the estimation of general surgeons at any rate, the first place as a local anæsthetic is *novocain* (*Meister*, *Lucius*, and *Bruning*), which during the last few years has assumed a position of commanding importance in surgery, so that, in most

of the great surgical cliniques, it is now exclusively employed for anæsthetic injections.

Novocain (*monochlorhydrate of para-amido-benzoyldiethylamidoethanol*) is a white, crystalline powder, which can be heated to 120° C. without decomposing, and is readily soluble in water and alcohol.

Pharmacological tests and clinical experience alike have shown that the drug does not act as an irritant even in concentrated solutions. Its toxicity is only about one-seventh of that of cocain. So far as I am aware, no case of novocain-poisoning has yet been recorded in practice. Occasionally injections of large doses have been followed by slight faintness and pallor; these, however, have been quite transient. Half a gramme (7·7 grains) of the drug may be injected in 1 per cent. solution without risk. I have injected as much as 80 c.c. of such a solution—*i.e.*, 0·8 gramme, or 12·3 grains, of the drug, without any untoward symptom.

It has been stated that novocain is quite as powerful an anæsthetic as cocain. This is, however, not quite correct. In Oberst's method we have found that its action is weaker, the anæsthetic efficiency of its solutions being about as 1 : 2 when compared with solutions of cocain of equal strength. The non-poisonous character of the drug, however, admits of our employing

double the maximum dose of cocain. Solutions of novocain may be boiled for ten minutes without losing strength.

Novocain does not, like cocain, cause local anæmia; where this effect is desired, therefore, suprarenal preparations must be added to the solutions. While eucain β loses in anæsthetic power through the addition of adrenalin, novocain, on the contrary, has its efficiency heightened. Novocain is also very suitable in 10 to 20 per cent. solutions as an anæsthetic for mucous membrane. It has here, however, to compete with alypin, which is also widely used, while cocain also has, in this connection, many advocates. An advantage attributed by many writers to novocain is that there is much less pain after its employment than is the case with cocain. I do not think, however, that there is, in this respect, any very great difference between the two drugs, the intensity of the after-pain depending much more on the quantity and concentration of the added suprarenal preparation.

When the various factors are taken into consideration, there is no doubt that the introduction of novocain represents a notable advance, as, indeed, the very rapid extension of its employment sufficiently proves.

Finally, mention must be made of the anæsthetics which act by production of cold. These

played formerly quite an important part. They have now, however, been relegated to a very subordinate position, and are employed only for trifling operations. Anæsthesia from cold is a terminal anæsthesia, the organs acted upon being the sensory nerve-endings.

Sulphuric ether, which was at one time very widely used, has now been almost entirely displaced by more powerfully acting substances. It was sprayed on to the skin or mucous membrane by means of Richardson's ether spray (Fig. 1). The apparatus consists of a bottle filled with ether and fitted with a perforated cork, through which passes a tube, one end of which is covered by the ether in the bottle, while the other is drawn out to a fine point. By means of the well-known rubber bulb arrangement air is forced into the bottle, the increase of pressure forcing the ether along the tube until it emerges at the fine exit from the nozzle in a jet of minutely-divided spray, which is directed on to the skin or mucous membrane. The degree of cold produced by evaporation of the ether reaches about $-15°$ C. The ether—anæsthetic ether free from water must be used—is sprayed on to the

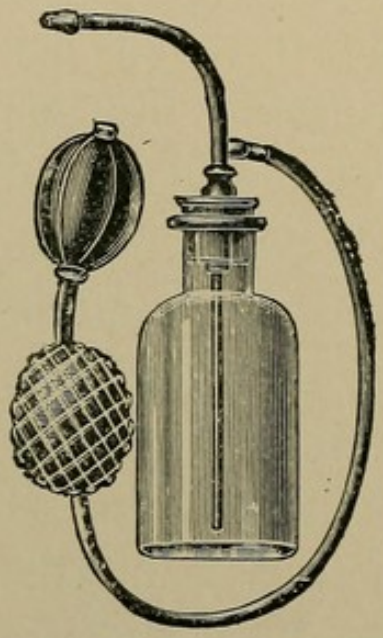

Fig. 1.

skin from a short distance. After a few minutes the skin becomes white and frozen. Until this change occurs the anæsthesia is not complete. If the blanching is delayed, a slight mechanical irritation such as a prick with the point of a knife is often sufficient to bring the skin or mucous membrane quickly into a frozen condition. The ether spray is useless in a very warm room, as under such condition the necessary degree of cold cannot be attained. The more vascular the tissue, the more difficult it is to bring it to the freezing-point. Formerly the extremities were frequently rendered bloodless by the ordinary surgical methods before applying the spray. Before the onset of the anæsthesia pain is often felt, slight if the skin be healthy, but often severe if it be inflamed. The thawing of the frozen parts is always accompanied by a condition of hyperæsthesia.

The drawbacks associated with ether, the slow irregular onset of the anæsthesia and its slight intensity, have led to the adoption of other substances with a lower boiling-point, whose spray, therefore, produces a greater degree of cold by evaporation. The most useful of these substances is ethyl chloride or chlorethyl, C_2H_5Cl. This compound boils at 11° C., thus at about the ordinary room temperature. It is supplied in glass tubes containing 15, 30, 50, or 100 c.c.

The tubes are generally fitted with an automatic tap (*b*, *Fig.* 2), which enables one to close or open at will a fine opening at one end of the tube, so that by holding the opening downwards a fine jet of the fluid can be obtained. It is very necessary—and this point is often neglected—to remove fats from the skin by benzine or ether before applying the chlorethyl; otherwise one must

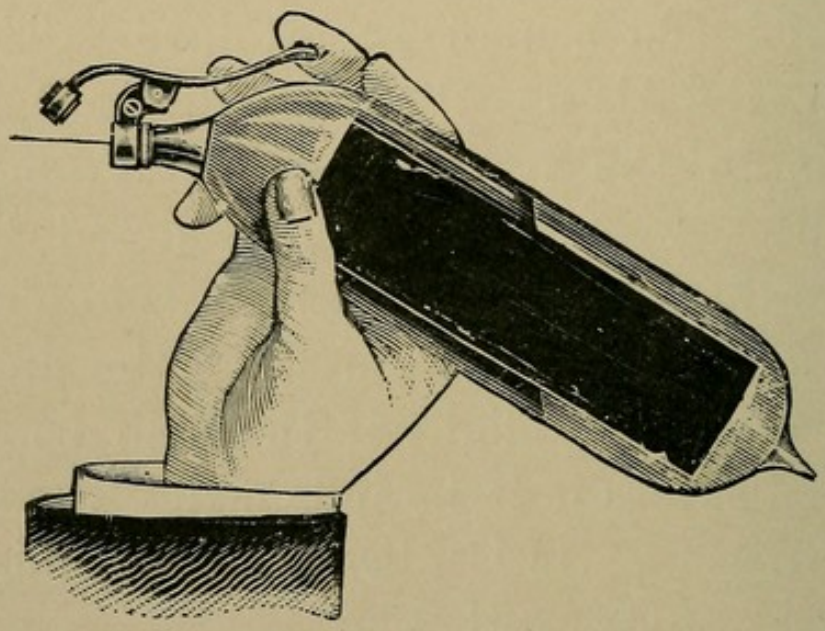

Fig. 2.

often wait a long time for the onset of anæsthesia. The tube must not be held too near the part to be treated, but must deliver its jet from a distance of about 30 centimetres (1 *foot*), so that evaporation may have already begun when it reaches the skin or mucous membrane. The buccal mucous membrane is often difficult to freeze on account of the passage over it of the warmed

breath. For tooth extraction Kuehnen has introduced a special bifurcated attachment by which both aspects of the gum may be simultaneously sprayed in a manner similar to that in use with ether. The tissues must, of course, only be sprayed until blanching appears; otherwise permanent injury may be done.

It has been stated that with ethyl chloride it is not safe to render the part bloodless, as is frequently done with ether, as the effect produced is likely to be too powerful. I hardly think there is any real danger of the kind, but as the application of a tourniquet is uncomfortable and has little effect in intensifying the anæsthesia, there seems no advantage in its use.

The pain which often comes on before the onset of anæsthesia is more severe than with ether, in consequence of the more rapid freezing. It is especially marked if the tissues be inflamed.

With ether, again, a deeper effect can be produced than with ethyl chloride. Nevertheless, I cannot advocate, with Braun, a return to a more extended use of the ether spray, and I think few who have had much experience of the annoyance and loss of time inseparable from the method will prefer it to the more convenient ethyl chloride, in spite of the fact that the latter possesses also some disadvantages.

Of substances possessing a still lower boiling-

point than ethyl chloride I have practical experience only of anæstol (*Speyer* and *Karger*). This is a mixture of chlorethyl and chlormethyl, the latter of which boils at −23° C. It acts rather more rapidly than chlorethyl. I have seen no injury to tissue from its use, though I have applied it for some minutes in attempts to remove an angioma.

For the production of still more intense effects of cold, such as can be produced by the use of methyl chloride, or of liquefied or solidified carbonic acid, there is, for purposes of local anæsthesia, no necessity. The danger of injury to the tissues, too—gangrene of the skin has been observed after the use of methyl chloride—must be held to contra-indicate the use of these substances in practice.

CHAPTER IV

ADJUVANTS IN LOCAL ANÆSTHESIA

These all have one thing in common: they act upon the circulation in such a manner that the blood-stream is slowed at the point where the local anæsthetic is required to produce its effect. By this slowing of the blood, and consequentially of the lymph-stream, the absorption of the anæsthetic is delayed, and the danger of general poisoning therewith lessened. Another consequence of this delaying of absorption is that the anæsthetic is allowed to remain longer about the site of injection, where it may form combinations with the protoplasm of the tissues, and thus develop to the full its anæsthetic effect. This effect of a slowing of the blood-stream may be demonstrated experimentally as follows: a certain quantity of an aqueous solution of eosin is injected endermically into one arm and a similar quantity into the other after application of a tourniquet. It is then seen that on the ligatured side a very much larger quantity of the colouring matter remains and becomes diffused about the

site of injection than is the case on the unligatured, on which a far larger quantity of the eosin has obviously been taken up into the general blood-stream (*Braun*).

This delay of absorption, with its converse intensification of local action, involves in its turn a certain danger. By the slowing of the blood-stream at the site of injection the vitality of the tissues is diminished, and too prolonged and too intense action of the anæsthetic on the protoplasm within its reach may lead to injury to the tissues; one must aim, therefore, at such a balancing of effects that the anæsthesia may be as complete as possible without involving any harmful toxic action on the tissues.

1. Cold.

Cold has not won a position of any great importance as an adjuvant in the production of local anæsthesia. Brief mention, however, may be made of methods of application which have had a certain vogue.

(*a*) Tubes of cocain-chlorethyl are now sold containing solutions of cocain in ethyl chloride of different concentrations (1 to 5 per cent.). When this preparation is applied to mucous membrane, sensibility is abolished temporarily, and returns only with the thawing of the frozen parts. Then,

after a time, there supervenes an intense cocain anæsthesia, which is of considerable duration. The same result may be brought about by painting the surface with cocain solution and then applying the ethyl chloride jet. The nature of the action is as above explained. Absorption is slowed, or even abolished, in the cooled parts, and the local action of the cocain thereby intensified, and the risk of general poisoning diminished.

The introduction of the suprarenal preparations, to be dealt with later, has rendered this method of applying anæsthetics more and more superfluous. In tooth extraction, for which the method was especially advocated, it enables us to anæsthetize merely the mucous membrane, not the sensory nerves supplying the tooth.

(*b*) Schleich has recommended the injection of powerfully cooled solutions, again with a view to the slowing of absorption and the intensification of local action. Others (*Braun*), when, for some reason, they do not wish to make use of suprarenal preparations, frequently apply the ether spray in order to heighten the local effect of an anæsthetic injection. I have never found any such proceeding necessary. Schleich, too, seems but seldom to have recourse to it.

2. Methods for rendering the Parts Bloodless.

(*a*) *Ligature.*

This method, to whose importance attention was first drawn by Corning, also acts by stoppage of the circulation and consequent inhibition of absorption and intensification of local anæsthetic action. Klapp has proved this experimentally. He injected solutions of milk-sugar under the skin of the arm. The sugar was rapidly absorbed and excreted in the urine. The application of a tourniquet caused a marked slowing of absorption. It was formerly thought that rendering a part bloodless had in itself an anæsthetic effect. Braun has shown, however, that anæsthesia follows the application of a constricting band only if the band is applied very tightly so that the nerve-trunks are compressed. The anæsthesia brought about in this manner depends, therefore, directly on the tightness of the constriction and the position of the nerve-trunks at the point where the constricting band is applied. It is quite uncertain, and therefore of no practical significance.

In operations on the fingers and toes the emptying of the parts of blood has been widely adopted as an auxiliary to the so-called *Oberst's Anæsthesia.* At the present time, however, the

use of suprarenal preparations is generally preferred. Bloodless methods cannot, however, be dispensed with altogether. If the bandage is carefully and not too tightly applied to the forearm—a tight constriction is not at all necessary—the method has few, if any, drawbacks. It is specially applicable when the site of operation is at the base of the finger, or at a still more central point, where an anæsthetic condition is not so easily attained as in the finger itself, and when we wish to avoid using the larger dose of suprarenal extract which is here generally necessary.

The use of constriction to render the affected parts bloodless is again playing an important part since the introduction of Bier's method of *venous anæsthesia*. As we have stated, in this method a section of the limb having been rendered bloodless and included between two constricting bandages, a $\frac{1}{2}$ per cent. novocain solution is injected into one of its veins. Bier has shown that fluids pass through the venous wall with extraordinary facility. The solution, therefore, injected under pressure into the vein rapidly permeates all the tissues within its reach.

(*b*) *Infiltration* (*Schleich*).

In Schleich's view chemical factors play only a secondary part in his method of "œdematizing" the site of operation. Their function is to counter-

act the pain due to the injection; the chief part is played by the 2 per cent. salt solution, and anæmia and pressure act as auxiliaries.

The action of the 2 per cent. salt solution will be considered in the next chapter. Anæmia plays a certain part if the method is correctly carried out—that is to say, with production of a marked degree of œdema. It acts in the manner described at the commencement of this chapter, enabling us to make use of dilute solutions and heightening the local effect of the anæsthetic by causing a slowing of absorption.

(*c*) *Suprarenal Preparations.*

These have of late years gained a position of steadily-increasing importance in the practice of local anæsthesia. After attention had been drawn by Pellacini to certain pharmacological properties of suprarenal extract, a series of investigators (*Türk*, *Abel*, *Takamine*, *Aldrich*, *Oliver*, *Schäfer*) worked at the isolation of its active principle with ultimate success. A number of different preparations were now put on the market in correspondence with the different methods of manufacture employed; suprarenin (*Höchst*), epirenan (*Byk*), paranephrin (*Merck*), adrenalin (*Parke, Davis*) and others. These have all approximately the same constitution. Following the suggestion of Braun, to whom we owe the introduction of the

suprarenal preparations into the practice of local anæsthesia, we shall hereafter include them under the general name *suprarenin.*

Suprarenin is a white powder which dissolves freely in water, but combines with the oxygen of the air as it does so, and takes on a reddish or brownish tint. On the other hand, it dissolves freely also in dilute hydrochloric acid without undergoing any change. It is therefore generally sold in the form of a solution of suprarenin hydrochloride (1 in 1,000). In speaking in the ensuing pages of suprarenin solution generally, we must be understood, unless otherwise stated, to refer to the 1 in 1,000 solution. Solutions in boric acid are less frequently used. Höchst's preparation contains an added 6 per cent. of thymol. The solutions are readily decomposed by heat. On standing, also, they soon undergo change and take on a reddish tint. Solutions in this condition should on no account be used. Apart from the fact that solutions which are no longer clear show a diminished efficiency as anæsthetics, poisonous substances are formed in solutions which have been kept for any length of time, and these may give rise to unpleasant symptoms (*vomiting, after-pain,* etc.). One fatal case, even, has been recorded. A positive result of the ferric chloride reaction—an emerald-green coloration on adding ferric chloride to an acid solution; changing

to red on addition of ammonia—is not at all reliable. The rubber corks with which the bottles are fitted in which suprarenal preparations are generally sent out are very inimical to the keeping powers of the solutions. If after opening the bottle—only bottles containing a very small quantity of the solution should be employed—a cork be substituted for the rubber stopper, the solution will remain in good condition for a very much longer period.

The instability of suprarenal preparations, the impossibility of sterilizing them with certainty, and, not least, their inconstant action, have led to attempts to prepare them by synthesis. In this field Stolz, the chemist to the Höchst Works, has succeeded in synthesizing several substances whose injection calls forth the same effects—increase of blood-pressure and peripheral vaso-construction—as does that of suprarenin. In their quantitative action, however, they differ among themselves materially.

Arterenin (or *arterenol*) Braun found to resemble suprarenin in its action. Others, however, describe it as quantitatively inferior to that substance. It has disappeared from practice.

Homorenon is described by the Höchst firm as being fifty times less poisonous than suprarenin. As, however, one must employ 5 per cent. solutions instead of those of 1 in 1,000 strength, the gain from

the lower degree of toxicity is very problematical. Further, according to Hoffmann, the activity of the preparation is lost by sterilization. It, like the former preparation, has failed to gain a place in practice.

The preparation which has won the largest degree of recognition is *suprareninum synthe-ticum*, which has been tested by various observers, and according to Braun and Hoffmann is a little more powerful in action than the substance obtained from the organ itself. It is, like the two foregoing preparations, a white crystalline powder, which is unaltered by exposure to air, dissolves in water acidulated with hydrochloric acid, and gives the ferric chloride reaction described above. It must be kept in a dark place, but will then remain unchanged for a considerable time. As a general rule a light rose colour develops in the solution, but only after it has been kept for some time. The solution can be sterilized by a brief boiling immediately before use. Repeated sterilization is not advisable, and, if only small bottles are used containing small quantities of the solution, hardly necessary. If making one's own solution of commercial suprarenin hydrochloride, great care must be taken that there is no free alkali in the glass in which the solution is boiled, as all the suprarenin preparations are very sensitive to the action of free alkali. To avoid this risk it is a good plan

to use the small bottles supplied by the manufacturers. The toxicity of synthetic suprarenin is somewhat less than that of the preparation made from the gland itself.

Judging from my own experience, the action of synthetic suprarenin is slightly weaker than that of its predecessors. The dose given by Hoffmann—viz., 2 minims to 10 c.c. of a 1 per cent. novocain solution—was frequently hardly sufficient to cause any marked anæmia. The dose I have generally employed for infiltration anæsthesia has been from 2 to 4 minims to 10 c.c. of the solution. That the ideal of an absolutely pure preparation has not been reached by this substance we may gather from the introduction by the Höchst firm of a new preparation, *Synthetic L. Suprarenin*, which turns the polarized ray to the left. This preparation is more stable and more constant in its action than the first synthetic suprarenin, which has now been withdrawn from commerce. Experience with this new suprarenin—clinical experience is the best criterion—is not at present extensive. So far as it goes, the preparation would seem to be of about equal activity with the earlier synthetic suprarenin.

The whole suprarenin question is not yet fully cleared up. Different authors, for instance, differ widely from each other on the question of dosage. Further experience is required to decide whether our present dosage of synthetic suprarenin is not

too high, and also whether some further attempt ought not to be made to separate the toxic from the useful elements. The maximal dose given by Braun, $\frac{1}{2}$ c.c. = 8·5 minims of the 1 in 1,000 solution, is, however, a very small one, and though perhaps as a rule sufficient, some slightly greater latitude as to dose may, I think, safely be allowed. No fixed scheme of dosage can, as a matter of fact, be laid down. In parts well supplied with blood more suprarenin must be used than in parts more poorly supplied. The presence of a considerable quantity of subcutaneous fat calls frequently for a free addition of suprarenin as an adjuvant to the anæsthetic. In small operations, too, in which not more than 5 to 10 c.c. of the anæsthetic solution are employed, we may safely add 1 or 2 drops more of the solution of suprarenin than in the case of larger operations where the dosage of anæsthetic already approaches the maximum.

In general, the dosage of synthetic suprarenin may be put at 1 *to* 4 *drops to* 10 *c.c. of anæsthetic solution in "infiltration" and "circular" anæsthesia*, 1 *to* 2 *drops per c.c. for the interruption of conduction in the larger nerve trunks.*

To pass to the effects of suprarenin preparations on the organism, the most prominent is an increase of blood-pressure, which comes on even after a minimal dose. The cause of this increase of blood-pressure is a direct action of the drug on the heart-

muscle and on unstriped muscle throughout the body, especially on that of the medium sized and smaller bloodvessels.

The rules governing the local action and absorption of suprarenin are the same as in the case of cocain. Suprarenin, like the latter, combines locally with the tissue protoplasm, and consequently, if given in concentrated solution, yields up its surplus to the blood-stream more readily than if more dilute solutions are employed.

Suprarenal preparations injected in large doses into the blood-stream have a powerfully poisonous action on the organism. While small injections cause an increase of blood-pressure which gradually passes away, with larger doses there follows, after a transient rise, a fall of blood-pressure, which in severe cases may lead to pulmonary œdema, convulsions, paralytic phenomena, and death. Braun has studied the early stages of suprarenin-poisoning on himself. After subcutaneous injection of rather more than 0·5 c.c. of 1 in 1,000 solution he was seized with palpitation and a feeling of oppression; the same quantity injected in 10 c.c. of salt solution caused no toxic symptoms. Of course, in intravenous injection a very much smaller quantity suffices to cause symptoms of general poisoning than is the case with parenchymatous injections. The prophylaxis of general suprarenin-poisoning may be summed up as follows:

Give small doses in dilute solution. The maximal dose of 0·5 c.c. given by Braun is quite sufficient in the case of cocain anæsthesia. Even as an addition to novocain solutions, which, in my experience, require somewhat larger additions than cocain, in view of the absence of any anæmia-producing action in novocain, this dose will generally be found sufficient. The maximal dose of 10 c.c. of 1 in 1,000 solution, given by Müller, must be regarded as, in the majority of cases, too large.

The way in which suprarenin acts as an auxiliary in local anæsthesia will be plain from what we have said above. The contraction of the arterial musculature gives rise to a vaso-constriction at the seat of injection, and thus produces a condition of local anæmia, with slowing of the local circulation and consequent delay in absorption, the general result being an increase of local anæsthetic action and diminution of general absorption, with its attendant risk of poisoning. The duration of the anæsthesia is also increased by the addition of suprarenin.

Suprarenal preparations have in themselves no anæsthetic action. Concentrated solutions empty the parts so completely of blood that not a drop issues even from the larger vessels. With correct application and dosage the parts become practically empty of blood; from the larger vessels

there will be slight oozing, but no spurting of blood. This action of suprarenin is of assistance also in the conduction-anæsthesia which will be dealt with later on, for though here the suprarenin does not, as a rule, act directly upon the vessels in the operation area, nevertheless, the vessels passing to that area contract under its influence sufficiently to diminish materially, or even to inhibit, the blood-supply to the part.

We have seen above that suprarenin combines with the tissue protoplasm. The combination is a somewhat transitory one; at the same time, it is important to remember that when we use a mixture of a local anæsthetic with suprarenin we are injecting two substances, each of which has its own local poisonous action. The greatest caution is therefore called for. Injuries to tissue through the use of suprarenin have been pretty frequently observed, and several cases of gangrene have been reported in patients, the subjects of arterial sclerosis (*Neugebauer*). I myself, when the use of suprarenin was in its infancy, have seen cutaneous gangrene of the finger develop in a patient, a professional colleague. It would seem, however, that with our present dosage we are fairly safe from such mishaps.

Schleich, on account of this risk of injury to tissues, rejects suprarenal preparations altogether. In this attitude, however, he is likely to stand

alone. Almost every method has its dangers and its victims at first. Only gradually, as experience accumulates, do we learn to avoid the dangers. It is worth noting, too, that in Schleich's method the addition of suprarenin may probably be dispensed with, as the œdema it produces causes a sufficient degree of anæmia.

The second danger associated with suprarenin, that of secondary hæmorrhage, can now be avoided with some certainty. Large doses of suprarenin lead, after the initial vaso-constriction has passed off, to a loss of vascular tone with vaso-dilatation; if dilute solutions are employed, this loss of tone does not occur, or occurs only in so slight a degree that it is not of practical significance.

The galvanic current as an auxiliary in local anæsthesia is at present merely of scientific, not of practical, interest. Wagner and Hertzog apply to the skin, which is generally impermeable to aqueous solutions, an anode soaked in cocain solution, and by this means bring about a local anæsthesia. The method, however, though it has been given some trial also in dentistry, has not gained any real footing in practice.

CHAPTER V

METHODS OF LOCAL ANÆSTHESIA AND THEIR APPLICATION

1. Anæsthesia produced by Cold.

This method is, or at any rate should be, of but occasional application. With highly sensitive patients it is often advisable to render slight punctures painless by means of the ethyl chloride jet. This is especially the case if needles of large calibre have to be used, as in saline infusion. Broadly speaking, it is considerations rather of convenience than of necessity that determine the employment of the method. Small boils, quite superficial whitlows, visible splinters, etc., are suitable for operation under this method. It should, however, be definitely discarded in any case of more extensive inflammation. Especially is it to be avoided in any extensive phlegmon of the fingers or hand. In the out-patient department of any large hospital it is a very common thing to see cases of phlegmon burrowing deeply along the sheaths of the tendons or elsewhere in which, a day or two before, an incision has been

made under ethyl chloride anæsthesia. In such cases the operator cannot possibly have determined which tissues were affected, still less how far the suppurative process spread. The operation must be quickly finished on account of the transitory nature of the anæsthesia—if any sufficient degree of the latter be attained at all—and the part bound up under pressure—this generally causing severe pain—on account of the free bleeding which supervenes on the thawing of the frozen parts. It is the same with large boils or carbuncles. Here, in the first place, if the inflammation is severe, the application of the jet is itself painful, as also the process of thawing; while, in the second place, the incision itself, however quickly made, often causes very severe pain, because, though the tissues through which the actual incision is made are insensitive, it is impossible so to make the incision as to avoid pressure on the excessively sensitive nerves throughout the whole inflamed area. I have often seen surgeons express astonishment at a patient's cry of pain, because they knew they had cut through frozen tissues only; and I have even heard them ascribe the patient's protest to prejudice against local anæsthesia.

The fact that major operations—resection of scapula, ovariotomy, etc.—have been carried out under anæsthesia from cold is of merely historical

interest. The attempt has likewise been made to render large nerve-trunks insensitive by the application of cold. The pain, however, which here precedes the onset of anæsthesia is so exceedingly severe as to surpass in most cases that of the operation itself.

In tooth extraction the method is only appropriate when the tooth is quite loose and free from pulpitis, so that all that is required is to render painless prehension of the tooth by the forceps. A small operation which is quite satisfactorily carried out under ethyl chloride anæsthesia is removal of ingrowing toe-nail and excision of the bed of the nail. It is essential, however, in this operation that one should, before operating, see the tissues frozen white underneath the whole nail. If the operation is then quickly performed, it can be completed without any pain at all.

2. Anæsthesia of Mucous and Serous Surfaces.

As was stated in the first chapter, cocain was first applied as an anæsthetic to the conjunctiva. The anæsthesia is here a terminal one, and does not generally extend beyond the mucosa. Small doses are here generally sufficient, as the anæsthetic does not flow away, but may remain in the conjunctival sac, exerting its action on the mucosa for a considerable time.

In the case of many mucous membranes (*e.g.*, pharynx), the impossibility of accurate dosage has constituted a difficulty of some moment. As, in consequence of the limited degree to which diffusion can take place through the uninjured mucous membrane, very concentrated solutions (10 per cent. to 20 per cent. cocain solutions) have to be used, overdosage is difficult to avoid with certainty, and cases of cocain-poisoning, fortunately, as a rule, slight, have been fairly numerous. In these cases the use of the substitute preparations is especially to be desired, and in many surgical cliniques they have practically displaced cocain. The use of suprarenal preparations admits, further, of the employment of more dilute solutions than could be used formerly. The concentration is, of course, dependent on the time that can be allowed to the solution to produce its effect, and in the method of external application to a mucous membrane by swabbing this is, of course, especially brief. Thus, for anæsthetizing the pharynx the solution must be about forty times as strong as for the bladder.

An anæsthetic is often required to render painless the injection of an irritant solution (iodine, phenol) into a serous cavity, such as a joint or a hydrocele sac. The site of puncture is first "infiltrated" with 0·5 per cent. novocain solution, to which suprarenin has been added, and the

same solution is then, after the removal of the fluid present, injected into the cavity until the latter is tightly filled. In ten minutes complete anæsthesia will be established, and not only may drugs be injected, but contractures may be corrected so long as they are merely reflex, and not due to serious structural changes in the joint.

3. Schleich's Infiltration Anæsthesia.

In this method the operation area is infiltrated with a dilute anæsthetic solution in such a manner as to cause a marked œdema of the tissues, so that the subcutaneous cellular tissue, for instance, appears swollen and glassy. The skin in the neighbourhood of the coming incision is first infiltrated, and immediately afterwards the subcutaneous cellular tissue, then, gradually, deeper and deeper layers of the subjacent tissues. As the discoverer of this method, Schleich is entitled to the credit of having been the first to devise a really safe method of local anæsthesia, as it admits of the use of very dilute solutions of anæsthetic drugs. His discovery was novel in principle, and it is quite incorrect to speak of a Reclus-Schleich method of anæsthesia. Reclus adopted subsequently much of Schleich's technique; he worked, however, with 1 per cent. solutions of cocain, and was therefore able to

inject only very small quantities of the solutions, forming small deposits, so to speak, of concentrated cocain solution, which gradually diffused themselves into the surrounding tissues, and only then produced any widespread effect. Schleich first anæsthetized the skin by forming endermal weals, and then œdematized the subcutaneous cellular tissue. Only after incision of these tissues, now insensitive, were the deeper layers infiltrated, step by step, with large quantities of solution.

At first Schleich employed three solutions of cocain, a 0·2 per cent. (I.), a 0·1 per cent. (II.), and a 0·01 per cent. (III.). In each the cocain was dissolved in 0·2 per cent. salt solution; a small quantity of morphine was also added. Recently Schleich has substituted alypin for a portion of the cocain—in his view the two anæsthetics, when mixed, "heighten each other's potency"—so that the solutions he employs at present have the following formulæ:

Solution I.	Solution II.	Solution III.
0·1 cocain.	0·05 cocain.	0·01 cocain.
0·1 alypin.	0·05 alypin.	0·01 alypin.
0·1 sodium chloride.	0·2 sodium chloride.	0·2 sodium chloride.
100·0 aq. dest.	100·0 aq. dest.	100·0 aq. dest.

It would seem that Schleich no longer adds morphine to his solutions; we need not, therefore, discuss the significance of such addition

Schleich believes that in the 0·2 per cent. solution of common salt he has found a fluid which, possessing a concentration intermediate between that of physiological salt solution and pure water, can, like the former, be injected without causing pain, and, like the latter, when injected, causes anæsthesia. This 0·2 per cent. salt solution must then be regarded as, in itself, an anæsthetic, and this is the essentially novel feature in his method. A second factor of importance in the method is the artificially-produced œdema and consequent (1) ischæmia and (2) compression of sensory nerve-endings. Another factor working in the same direction is the difference in temperature between the blood and the solution, which is injected at the ordinary room temperature, or is even cooled before injection with a view to increasing the difference. The method is therefore, in the main, one depending on physical principles, the cocain itself fulfilling, in Schleich's opinion, quite a secondary rôle, its main function being to deaden the pain caused by the actual infiltration, and especially to over-compensate for the hyperæsthetic condition of inflamed tissues. If the operative procedures are carried out on absolutely healthy (uninflamed) tissues, they may be carried out quite satisfactorily with 0·2 per cent. salt solution alone, without any anæsthetic drug.

The whole theoretical basis of Schleich's teach-

ing has been vigorously attacked by Braun, who challenges especially Schleich's views as to the part played in local anæsthesia by the 0·2 per cent. salt solution. We have seen above that a 0·2 per cent. solution does actually cause anæsthesia (*Quellungsanästhesie*) when injected. This anæsthesia, however, is preceded by pain, due to the injection ; and though this pain is less severe than when pure water is injected, so also is the intensity and duration of the anæsthesia less than in the case of water. While, then, Braun freely admits that a slight, transient anæsthesia may be produced by injection of a 0·2 per cent. salt solution, he maintains that the effect of a 0·1 per cent. solution of cocain, such as is contained in the most frequently used No. II. solution of Schleich, so enormously surpasses this "physical" anæsthesia as to deprive the latter almost entirely of significance. Another question is whether it is desirable to choose 0·2 per cent. salt solution as our fluid basis. It has been shown that distilled water acts, when injected, as a powerful tissue irritant. On the other hand, physiological salt solution is, as we know, entirely unirritating. We must, then, admit the strength of Braun's position when he contends for physiological salt solution as the ideal vehicle for anæsthetic solutions. If, then, a method can be devised in which physiological salt solution constitutes the vehicle, it

must certainly be preferred *a priori.* Schleich states, indeed, that he has performed a large number of operations under his method, and has never seen any injury to tissue from it. No surgeon, however, finds all his operation wounds heal by first intention. Who can say, in many cases, whether some slightly unsatisfactory condition about a wound is to be ascribed to the catgut, to some failure in asepsis, or perhaps to the local anæsthesia? Thus Bier, for instance, one of the earliest advocates of Schleich's method, speaks of his fear that it may cause injury to tissues (Surgical Congress, 1909). Hocher, also, in his latest teaching on operative surgery, expresses the same misgiving. Probably in this, as in other methods to be discussed later, certainty in this respect will only be arrived at by combining the experience of many great hospital cliniques. We may see a long series of laparotomies heal without complications, and yet not be justified in deducing therefrom the complete harmlessness of our methods in all cases. It is certain, however, that novocain is far less dangerous to tissues than cocain, and we may regard it as probable that in novocain we have approached a full and satisfactory solution of the problem in this regard.

The second point on which Schleich lays stress appears to us of greater significance than his opponents admit. The ischæmia caused by the

artificially-produced œdema is, if his method is correctly carried out, a very pronounced one. It is, in my opinion, a powerful auxiliary, and fulfils almost the same function as suprarenin. Where the œdema is very marked, pressure on sensory nerves may also come into play as an auxiliary. Difference of temperature—increased by cooling the anæsthetic solution before injection—also tends to heighten anæsthetic effect.

Where Schleich's method is correctly carried out, the order of importance of the different factors is probably represented with sufficient accuracy as follows :

Anæsthetic (chief agent).
Ischæmia of tissues (chief auxiliary).
Soaking of tissues.
Pressure on nerve-endings.
Difference of temperature.

Much of Schleich's theory, then, cannot be upheld at the present day. At the same time, it is not, in my opinion, correct to ascribe to the physical factors in Schleich's method an entirely subordinate rôle. They act as powerful auxiliaries to the anæsthetic itself, always, of course, assuming that the method is carried out strictly according to Schleich's directions.

It is quite another question whether Schleich's method is to be regarded as the method of election

at the present day. A disadvantage quite distinct from any we have considered above is the impossibility of distinguishing the tissues. In many operations, especially in infected tissues, this may be of little moment; in others, however, especially where an exact differentiation between healthy and diseased tissues is of the essence of the operation, it adds enormously to the surgeon's difficulties. A further disadvantage lies in the fact that in many operations the anæsthesia is not established before the first incision is made, but it is necessary during the course of the operation to infiltrate the deeper layers, and often to wait some time for anæsthesia to develop. The operator's loss of time is not the only evil here, for, as every surgeon knows, it is of the first importance, in the interest of asepsis, that operations shall be performed quickly, and, if possible, without interruption of any kind. In small operations this is not of so great moment; in the larger operative procedures, however, the certainty of maintaining asepsis undoubtedly diminishes as the duration of the operation increases.

Finally, especially in the deeper regions, it is impossible to count with certainty on Schleich's dilute solutions for the efficient anæsthetization of the larger nerve-trunks. This is of special importance in operations for ligature of bloodvessels, so that Schleich himself advises that in these

operations the nerve-trunks running with the arteries shall be previously dabbed with 1 in 20 carbolic acid. This is troublesome, and requires time.

All this does not in any way diminish the great merit of Schleich's work. No investigator reaches at a bound the limit of the attainable in his line of discovery. As, however, we have to-day, as we shall see in the following sections, methods which are free from the disadvantages presented by Schleich's, the latter will only be employed when these other methods are for some reason inapplicable.

4. "Conduction" Anæsthesia.

This method, whose foundations were laid by Corning, has, during the last few years, acquired rapidly growing importance from the work of Hackenbruch and Braun. By the term "conduction" anæsthesia we understand a method in which a given area of operation is rendered insensitive by anæsthetizing the sensory nerve-trunks passing from it, thus by interruption of sensory nerve-tracts.

Two forms of conduction anæsthesia may be distinguished: (1) that caused by perineural injection, in which the anæsthetic is injected into the neighbourhood of the nerve to be dealt with, and reaches the nerve by diffusion; and (2) that caused

by injection into the nerve itself (endoneural). The latter is now hardly used, and we may confine our attention to the former.

Of considerable importance here is the anatomical fact that the smallest and finest branchings of the peripheral nerves possess only a very thin sheath, and that this increases in thickness as one passes along the nerve in a central direction, in proportion to the increase in calibre of the nerve itself. The thinner the sheath the more readily can anæsthetic solutions penetrate it to reach the nerve, interrupting the passage along the latter of sensory impulses. An important principle follows from the foregoing, namely, that it is more difficult to interrupt conduction in the larger nerve-trunks than in their peripheral branches. Whenever it is possible, therefore, to render insensitive the area of a projected operation by anæsthetizing the smaller nerve-trunks, this simpler method is adopted, and the larger nerves may be left out of account.

The most frequently used method of this kind is the so-called "circular anæsthesia" of Hackenbruch. Here the tissues surrounding the site of operation are thoroughly infiltrated with an anæsthetic solution, and the conduction of afferent impulses thus cut off in all the sensory nerves supplying the area.

Schleich's method of dealing with inflamed areas (*e.g.*, *furuncles*) is, in my opinion, in spite of

Schleich's expression of the contrary view, merely a form of conduction anæsthesia. He begins by infiltrating the healthy tissues round the inflamed focus, and slowly, with intervals sometimes of minutes, continues the infiltration into the inflamed parts. This is nothing more nor less than conduction anæsthesia, and the latter part of the procedure, the infiltration of the inflamed area, could quite safely be omitted, as it becomes anæsthetic, and often very rapidly, when the surrounding tissues are efficiently infiltrated.

The new substitutes for cocain, and the introduction of the suprarenin preparations, have enabled us to employ the method of circular anæsthesia much more freely than was formerly the case. A freer range of dosage is now permissible, stronger solutions and larger quantities may be employed than was formerly the case, and thus wider areas and larger nerve-trunks brought under the influence of the local anæsthetic. We inject now without misgiving as much as 50 c.c. of 1 per cent. novocain solution, while the quantity of cocain required to produce about the same effect—viz., 50 c.c. of a 0·5 per cent. solution—is far beyond the limit of safety. Thus, for instance, the performance of an operation on strumous glands under local anæsthesia, which was formerly a difficult and doubtful proceeding, is now simple, and as a rule absolutely safe.

Where *circular anæsthesia* is applicable, we must endeavour to interrupt conduction in the larger nerve-trunks by perineural injection. In the case of some nerves this method is both simple and sure (*e.g.*, nerves of the fingers); in others (*nervus alveolaris inferior*), it is not simple, but when the technique is mastered, it is fairly sure. In others, again, as, for instance, the nerves of the forearm, it is not to be relied on, and is beginning to be replaced by other methods. The best-known method of conduction anæsthesia by perineural injection is that bearing Oberst's name. It is used in operations on the fingers and toes. After injection, which is carried out in the manner described below, the base of the digit is found to become anæsthetic first, the anæsthesia then gradually spreading towards the periphery. This fact might easily lead the unskilled observer to infer that the anæsthetic slowly diffuses in the bloodless member towards the periphery, and that the whole process is a centrifugal one. We know, however, that conduction of sensory impulses is much more readily interrupted in the finer than in the larger nerve-trunks. Thus the skin of the digital periphery, which contains the terminal ramification of the nerve-trunks which at the base of the finger are of substantial calibre, is the last to become anæsthetic, while the skin at the base is supplied by fine nerve-trunks running, at the point of in-

jection, side by side with the main trunks, and these lose their sensitiveness to pain very soon after the injection. Diffusion, as a matter of fact, plays but a small part in the development of this form of anæsthesia, as can be seen by noticing the whitening of the skin in a direction from centre to periphery, when a somewhat larger dose of suprarenin than usual is added to the anæsthetic.

Ligature of the digit at the base is no longer necessary in Oberst's method. The finger can be anæsthetized with certainty by a 2 per cent. novocain solution + suprarenin.

Endoneural injection is, as we have stated above, hardly employed at the present day. Formerly a certain number of major operations, especially amputations, were performed under it, the larger nerve-trunks being first exposed under Schleich's infiltration anæsthesia, and then directly injected with concentrated cocain solutions. This complicated method is now practically abandoned. Even before the introduction of Bier's *venous anæsthesia*, most surgeons chose in preference to it either general or spinal anæsthesia.

In operations on inguinal hernias, a method introduced by Cushing has been frequently employed, in which endoneural injections are administered after exposure of the nerves of the inguinal region. This is now superseded by another method, in which the whole quantity of anæsthetic

solution is injected before the commencement of the operation, and the operator is thus enabled to work quickly and surely.

It is beyond question that the method of conduction anæsthesia possesses very real advantages over Schleich's method. As the chief of these I should place the possibility, especially in major aseptic operations, of carrying out the operation quickly and without anxiety about the anæsthetic, and, further, the completeness of the anæsthesia, and the fact that the parts operated on retain their normal anatomical conditions, and the operator is thus enabled to distinguish clearly the boundary lines of the different tissues. Another advantage is the lessened risk of injury to the tissues. There are, however, whole classes of operations to which the method of conduction anæsthesia is not applicable, and in which Schleich's method, generally somewhat modified, still holds its ground.

5. Venous Anæsthesia.

This latest advance in methods of local anæsthesia was first described by Bier before the Surgical Congress of 1908.

While, as we have seen, it is difficult to anæsthetize the larger nerve-trunks by perineural injections, owing to the thickness of their connective-tissue covering, Bier succeeded, by inject-

ing anæsthetic solutions under pressure into the veins of a limb between two tourniquets, in securing the penetration of the solution into all the tissues of the involved area, including the protective sheath of the nerves, and this rapidly and with a completeness unknown under any previous method.

Bier was able to demonstrate this experimentally on amputated limbs by injecting an indigo-carmine solution into the veins. Careful examination shortly after the injection showed that the tissues were traversed in every direction by blue tinted capillaries, even the bone marrow sharing in the general blue coloration. (Doubt was thrown at first on Schleich's statement that the bone marrow could be infiltrated by injecting the periosteum. The possibility, however, of infiltrating the medulla by way of venous injection proves the correctness of his observation.) In the living subject the section of the limb enclosed between the two tourniquets becomes anæsthetic almost immediately after the injection of the solution ($\frac{1}{2}$ per cent. novocain solution), under pressure (*direct anæsthesia*). Somewhat later the portion of the limb beyond the distal tourniquet also becomes anæsthetic (*indirect anæsthesia*). There is practically no risk of general poisoning in venous anæsthesia. The only untoward symptom observed by Bier has been nausea, which he has

seen once in a child of seven and once in a woman of sixty after removal of the tourniquets.

The doses employed: 60 to 100 c.c. of ½ per cent. novocain solution—are by no means large. Of chief importance, however, is the certainty that the novocain, being distributed to every part and tissue of the affected area, will enter into combination with the tissue protoplasm, and thus lose its power of causing general poisoning.

Bier adopts special precautions only when he administers large doses to children. The precautions he adopts are as follows:

1. After removal of the tourniquet it is reapplied for a time and then finally removed. This insures the passage of the drug in two portions into the general circulation, with an interval of time between.

2. The cannula, which is furnished with a stop-tap, is left in the vein until the operation is finished and it is time to apply the sutures. Warm physiological salt solution is then injected, so as to wash out any excess of the anæsthetic.

How far there exist risks of injury to tissue which might contra-indicate the use of venous anæsthesia, only prolonged experience can show. In amputations for diabetic or senile gangrene Bier has several times observed abnormalities in the behaviour of the wounds which might possibly be ascribed to the anæsthetic. He therefore

advises against the use of the method in such cases.

In one patient, a woman, motor paralysis of the hand followed an operation under venous anæsthesia. The paralysis disappeared in the course of four weeks. Bier considered that the paralysis was of the same nature as that sometimes seen after administration of a general anæsthetic. The latter, however, only appears when the arm and shoulder have been kept during the operation in an abnormal position, such as would not occur or be maintained during venous anæsthesia.

Air-bubbles have several times been seen in the veins. No symptoms of embolism, however, have followed their appearance.

Out of 134 operations, Bier has had 115 good, 14 satisfactory results, and 5 failures. With increasing sureness of technique failures will gradually come to be avoided altogether.

The *direct* anæsthesia, that, namely, affecting the section of the limb between the two tourniquets, comes on immediately in the smaller and medium sized nerves. The saturation of the larger nerve-trunks requires some minutes (up to five minutes in the larger limbs). The more complete is the removal of blood from the parts involved the quicker is the development of anæsthesia. Irregularities in these respects are, however, observed occasionally.

The rapidity with which *indirect* anæsthesia —that affecting parts peripheral to the distal tourniquet—comes on varies very much. The onset may be almost immediate, or there may be a delay of as much as twenty minutes. Simultaneously with the development of indirect anæsthesia there is noticed a weakness of the muscles, which is soon followed by complete paralysis. This motor paralysis is a sign that the indirect anæsthesia is complete, and that the operation may therefore be begun.

The deeper parts are, according to Bier, more rapidly involved in the anæsthesia than the more superficial.

The so-called *indirect* anæsthesia is a conduction anæsthesia, determined by an interruption of conduction in the larger nerve-trunks. It spreads from the centre (distal tourniquet) to the periphery.

Bier has abandoned the addition of suprarenin preparations. While in some cases they had some effect in deepening and prolonging anæsthesia, in others they failed completely.* Petrow also has only occasionally noticed any prolongation of anæsthesia from the addition of suprarenin.

The chief drawback to venous anæsthesia is its rapid disappearance (two to seven minutes) after removal of the tourniquets. This makes the arrest

* The uncertain effects of the earlier suprarenin preparations may have been a factor here.

of hæmorrhage a difficult process and its painlessness not sufficiently certain. We may hope, however, to succeed before long, perhaps with the aid of suprarenin preparations, in overcoming this difficulty.

In any case venous anæsthesia represents certainly an important step forward in the practice of local anæsthesia. On the one hand, certain operations which could only be carried out imperfectly and with difficulty under conduction anæsthesia (*e.g.*, operations on the hand after perineural injections round the nerves of the forearm), can now be performed safely and surely under venous anæsthesia; while, on the other, the larger operations on the extremities—amputations, resections, etc.—have lost some of the dangers involved in general or spinal anæsthesia. Whether and to what extent special contra-indications will manifest themselves it is impossible now to say. It is probable that wider experience will show the necessity of using the method but sparingly where septic processes are present or the nutrition of the affected part is already interfered with.

As a further disadvantage must be mentioned the somewhat complicated technique of venous anæsthesia.

Arterial Anæsthesia.

For the sake of completeness mention may be made of some experiments of Goyanes and Oppel, who have brought about an arterial anæsthesia in animals by injecting cocain into the arteries. Oppel, for instance, found that he could inject eight to ten times as much cocain into the aorta as into the vena cava inferior, and deduces from this fact, fallaciously in my opinion, the superiority of arterial anæsthesia. The cocain is, he thinks, neutralized in the arterio-capillary area. Goyanes has twice employed this form of anæsthesia in the human subject. It is hardly probable that these experiments will lead to results of much importance. Though the introduction of an anæsthetic into the arteries is in itself quite feasible, the situation of the arteries is such as to necessitate for that purpose a somewhat complicated preliminary operation, and it is for this reason unlikely that the method can compete seriously with the relatively simple method of venous anæsthesia.

CHAPTER VI

GENERAL TECHNIQUE

Preliminary Remarks.

In general, local anæsthesia should only be employed in cases where it is possible to attain complete local insensibility to pain. This rule should only be departed from in cases of absolute necessity, that is to say, when general anæsthesia involves so great a risk to the patient's life as to forbid its employment. Everyone must expect failures at the commencement. The surgeon should candidly ascribe such failures to his own faulty technique or the imperfection of our methods, and should not seek forcibly to persuade his patient and himself that the former felt no pain. There are, of course, patients whose anticipation and fear of pain is such that they cry out and betray extreme excitement throughout an operation, and yet confess afterwards that they felt nothing; for such patients local anæsthesia is unsuitable, and a general anæsthetic should be employed; for the terror they endure during the whole procedure must involve hardly less suffering than the

actual pain of an operation. One must not be fanatical in one's advocacy of local anæsthesia. If it is not discredited by being used in unsuitable cases or by faulty technique, it will gradually gain in popularity, and cases such as that cited above will become rarer when patients can come to their surgeon for an operation with the absolute certainty of the operation being painless. Even to-day patients frequently come to us with the request that they may be operated on under local anæsthesia, and not be rendered insensible by a general anæsthetic.

Suggestions for a "combined anæsthesia," that is, for the auxiliary employment of a general anæsthetic during certain specially painful parts of the operative procedure, are, in my opinion, not to be commended. Here, again, exception may be made in respect of cases in which for special reasons narcosis must, as far as possible, be avoided. In such cases a brief ether or chloroform narcosis may be used in reinforcement of local anæsthetic methods, as for instance in a laparotomy, when at one stage traction must be made on the mesentery. Otherwise, one should allow the patient the assurance of an absolutely painless operation, and should avoid exaggerating the dangers of general anæsthesia.

In passing to the consideration of general technique we would lay down at the outset, as a

foundation principle, that it should be as simple as possible. We purposely avoid descriptions alike of complicated injection apparatus and of complicated anæsthetic solutions. The object aimed at is to describe methods in such a manner that they may be applied as readily by the practical country doctor, as in a large surgical clinique furnished with every modern auxiliary and appliance.

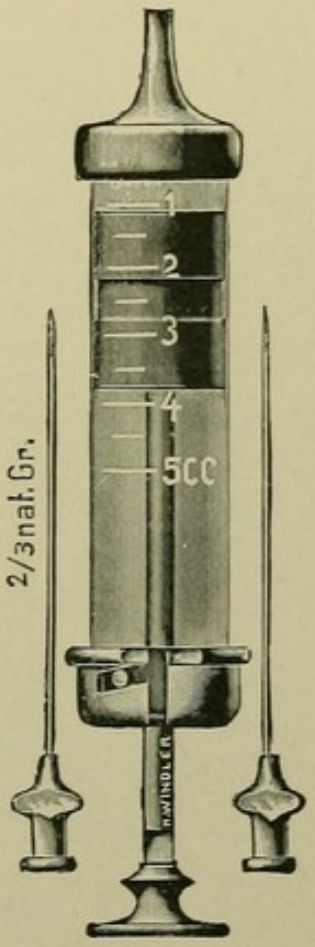

Fig. 3.

The syringe I have found by prolonged trial to be most satisfactory is a glass syringe with a metal piston, which can be completely withdrawn from the glass cylinder.* The syringe is boiled each time before use, either in water, physiological salt solution, or soda solution. In the latter case it must be washed through before use with sterilized water or salt solution, as soda irritates the tissues and lessens the effect of anæsthetic drugs, and especially of suprarenin preparations. Before boiling, the syringe must be taken apart. The cylinder must not, of course, be plunged suddenly into boiling water, as this would involve great risk of breakage. From the moment boiling commences the parts should be left in the boiling water for five minutes. On withdrawal from the water the

* The so-called "Record" syringe.

metal cylinder must first be cooled, otherwise it will be found impossible to introduce it into the cylinder. For those who only occasionally employ local anæsthesia syringes of 2 and 10 c.c. capacity are the most generally useful. Those who use it frequently should be supplied with syringes of 1, 2, 5, and 10 c.c. capacity.

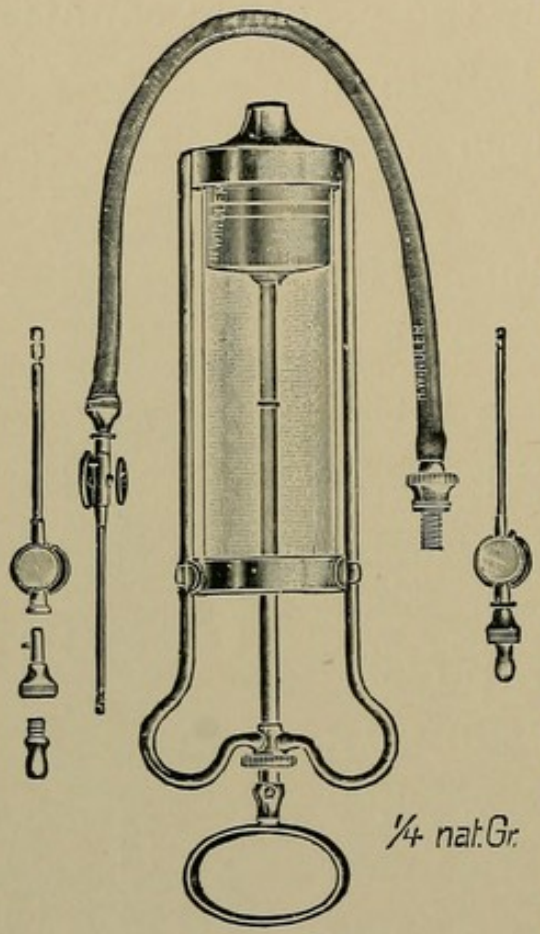

Fig. 4.

A supply of needles of various lengths and calibres should be at hand, including, perhaps, a few curved ones, though I have so far not found it necessary to employ the latter. The best are platino-iridium needles, which, though more costly than steel ones, are more durable, do not rust, and can be made red-hot without injury. It is, of course, a great advantage in practice that all his needles should fit every size of syringe used by the surgeon.

After use all parts must be well dried and the needles washed through with absolute alcohol. It is advisable also to wash through the nozzle of the syringe in a similar manner in order to remove water completely. The needles should have a wire

passed through their barrel before being put away. It is advisable to smear the metal parts of the syringe with a drop of paraffin to prevent rust.

For his method of venous anæsthesia Bier employs a syringe of about 100 c.c. capacity (Fig. 4). It, too, has a metal piston working in a glass cylinder. A thick-walled rubber tube can be fitted by a screw attachment to the nozzle of the syringe, the other end of the tube being connected with the injection cannula by a bayonet fastening. The whole apparatus is thus very readily put together and taken apart again. The injection cannula is fitted with a tap, which prevents leakage of solution. The cannulas employed are as thin walled as possible. Near their termination are two circular grooves to facilitate the process of tying into the vein. The syringe must be boiled only in physiological salt solution, not in alkaline solutions, otherwise the rules given above for the use and management of injection syringes apply here also.

As regards solutions, it is advisable for any surgeon who operates much under local anæsthesia to have a supply of both 1 per cent. and 2 per cent. solutions of novocain in physiological salt solution always at hand.

The physiological salt solution is sterilized in $\frac{1}{2}$ or 1 litre flasks, preferably in a water-bath, the flasks themselves having been previously sterilized by boiling. The flasks are best closed by an

india-rubber cork or a wad of sterile muslin. The novocain solution is kept in ordinary medicine bottles in quantities of 100 grammes, or, in the case of 2 per cent. solutions, of 50 grammes. Bottles and stoppers must be sterilized. The novocain solution is shaken up in the bottle, and the sterile physiological salt solution is added gradually ; the whole requires then only a short boiling in a water-bath. Before use, if one is not certain that the solution is still sterile, it should be heated to 100° C. in a water-bath for five minutes, or the required quantity can be raised to boiling-point in a sterile test-tube. The amount required for use is then poured into a sterilized graduated glass cylinder of about 50 c.c. capacity, and from this into a sterilized glass dish (all, of course, boiled in soda-free solutions). Suprarenin is added immediately before the solution is to be used. It is kept only in small bottles holding 5 c.c. Suprarenin solutions that are not absolutely clear should on no account be used. It is advisable also to reject any bottles that have been kept for any considerable time since opening. After the first use the rubber stopper should be replaced by an ordinary cork. In the case of major aseptic operations it is better to take the solution from a previously unopened bottle.

Those who make only occasional use of local anæsthesia will find Braun's novocain suprarenin

tablets suitable and useful. They are simply dissolved before use in a given quantity of sterile physiological salt solution. Any of the solution that may remain over after use should be thrown away; it should on no account be used again. I personally prefer to add the suprarenin immediately before the operation, as I have several times observed a rose tint to develop on dissolving the tablets in warm water.

Two tablets are manufactured:

Tablet A.

Novocain, 0·125 gramme; suprarenin, 0·00016 gramme. This tablet dissolved in 50 c.c. gives 50 c.c. of a 0·25 per cent. novocain solution + 5 drops of suprarenin (Solution I.).

Twenty-five c.c. gives 25 c.c. of a 0·5 per cent. novocain solution + 5 drops of suprarenin (Solution II.).

Tablet B.

Novocain, 0·1 gramme; suprarenin, 0·00045. This tablet dissolved in 10 c.c. gives 10 c.c. of a 1 per cent. novocain solution + 10 minims of suprarenin (Solution III.).

Five c.c. gives 5 c.c. of a 2 per cent. novocain solution + 10 minims of suprarenin (Solution IV.).

Solutions II. and IV. can be obtained ready prepared in small bottles or ampullæ, and Solutions I. and III. can be prepared by simple dilution with an equal volume of physiological salt solution. It is still a disputed point whether or no the tablets are sterile. Until just recently it has been impossible to boil their solutions, as the suprarenin they contain is not the synthetic form. Lately, in view of the fact that the ready decomposibility of the suprarenin is due to the presence of traces of alkali (in the glass vessels?), Braun has recommended that officinal dilute hydrochloric acid be added to the physiological salt used for dissolving the tablets, in the proportion of 1 minim to the litre. The solution can then safely be boiled before use.

To dentists who employ almost always the same strength of solution, ampullæ containing 1 c.c. of 2 per cent. novocain solution + 1 minim of suprarenin may be recommended as useful and convenient.

The 1 per cent. solution of novocain is the one I generally employ in minor surgery. The 2 per cent. solution is only used for interrupting conduction in nerve-trunks of some size, especially in operations on the teeth and fingers. In all operations in which more than 50 c.c. of the solution has to be injected I use the 0·5 per cent. instead of the 1 per cent. solution. If more than 100 c.c. is

required, I make the additional infiltration with 0·25 per cent. solution. Of suprarenin—I always use the 1 in 1,000 solution of *Suprareninum L. Syntheticum*—I add, in most operations, 1 to 4 minims to each 10 c.c. of the anæsthetic solution, fixing the maximum quantity of suprarenin to be injected at from 15 to 20 minims. Only where large nerve-trunks have to be anæsthetized do I add a larger percentage of suprarenin to 2 per cent. anæsthetic solutions—*e.g.*, from 1 to 2 minims to each cubic centimetre. As only small quantities of solution are here employed, this larger percentage of suprarenin may be added without misgiving.

When, in the following pages, nothing is said about the dosage of suprarenin, the rules already laid down on the matter must be taken as applying. Those more practised in local anæsthesia will not, however, follow them too rigidly, but will suit the dose to the individual case in accordance with the amount of blood in the tissues, the nutritional condition of the latter, and so on.

If the method of Schleich is carried out rigidly and the tissues so thoroughly infiltrated in layers that they appear to have undergone a simultaneous soakage, it is advisable either to omit the addition of suprarenin altogether, or to add only small doses (1 minim to 10 c.c. as a maximum), as the anæmia caused by the artificial œdema acts as an auxiliary to the anæsthetic. In small operations

one may use 0·5 per cent. novocain solution with confidence. For larger operations 0·25 per cent. solution should be employed.

It is, however, often advisable to modify slightly Schleich's technique, and avoid producing a maximum degree of œdema, though the tissues should always be freely permeated by the injected solu tion. In small operations we then employ 1 per cent., and in larger 0·5 per cent., solutions, with or without the addition of the dose of suprarenin given above. It is not then necessary to dab the larger nerve-branches specially with phenol solution ; the concentrated novocain solution will soon render them anæsthetic, though a certain time must always be allowed for this effect to develop. We shall also, when the infiltration method has to be employed, infiltrate as many of the tissue layers as possible before the operation, wait for a time, and then carry out the operative procedures, if possible, without a break. A thorough infiltration of the subcutaneous cellular tissue renders superfluous any special infiltration of the skin itself.

In conduction anæsthesia, also, it is often advisable to infiltrate the tissues pretty thoroughly with anæsthetic solution. This, however, does not apply in the case of anæsthetization of the larger nerve-trunks by concentrated (2 per cent.) solutions. While in Schleich's method the operation is commenced immediately after the infiltra-

tion of the tissues, in conduction anæsthesia, on the other hand, some considerable time must often be allowed to elapse between the completion of the infiltration and the commencement of the operation, it being essential to success in this method to wait a sufficient time to allow of the development of a completely anæsthetic condition. Many a failure is to be attributed to the impatience of the operator. There need be no fear of letting the right moment pass, for the anæsthesia produced with the aid of suprarenin lasts a considerable time. No general rule can be laid down as to the time that must be allowed after the injection. This depends on the calibre of the nerve-trunks involved, the strength of the solution used, and other factors. Often, especially in small operations on the face or head, complete anæsthesia becomes established almost immediately after the injection. After injection in the neighbourhood of the inferior alveolar nerve it is often necessary to wait half an hour for the onset of anæsthesia. It is, for reasons already given, especially important to avoid, if possible, injecting into inflamed tissues. Occasional exceptions to this rule will be considered later.

As regards the technique of the actual injection, the risk, though a slight one, of injecting into a vein must be kept in mind. It is a good

plan to move the needle backwards and forwards continually during the injection. The syringe may be withdrawn from the needle after the puncture is made, and the operator may thus assure himself that no blood passes out through the needle.

Technique of Bier's Venous Anæsthesia.

The solution is injected into a vein lying in a section of a limb, which is cut off from the general blood-stream by two tourniquets. The tourniquets may, for example, be applied above and below the elbow-joint, and the injection be made into the vena basilica at the level of the joint.

The part of the limb between the tourniquets must be rendered as bloodless as possible. As a rule the blood is expelled from the limb by an Esmarch bandage, applied up to the level of the central tourniquet. If, owing to the presence of an infectious process, this is not possible, the peripheral tourniquet is applied above the infected area, and the blood then expelled from the level of the peripheral to that of the central tourniquet. The central tourniquet is applied a little above the area of operation, and is not bound more tightly round the limb than is necessary. The pressure of the tourniquet is not as a rule

unpleasantly felt after the injection. We have, however, known patients to complain of the pressure throughout the operation. It is advisable, therefore, to inject at a point as near as possible to the upper (central) tourniquet; the vein may also be exposed before the tourniquets are applied. The tourniquets are kept in phenol solution after aseptic operations, otherwise they are sterilized by boiling.

The exposure of the vein is carried out under infiltration anæsthesia with the same 0·5 per cent. solution that is used for the injection. If the search for the vein is carried out before the parts have been rendered bloodless, it is advisable to add a little suprarenin to the solution. The subcutaneous cellular tissue must also in this case be thoroughly infiltrated. If the vein is sought for under bloodless conditions, its position, rendered plain by obstructing the venous flow, must be marked before the tourniquet is applied. A diagonal incision is made through the skin. In obese subjects the vein is often concealed by masses of fatty tissue. When the vein is exposed, a silk thread is passed round it by means of a Deschamps' needle, and the vein thoroughly exposed and freed for a distance of about 2 centimetres. If there is much scar formation, the vein must, in view of the possibility of obliteration, be sought for well above the scar. In the leg the

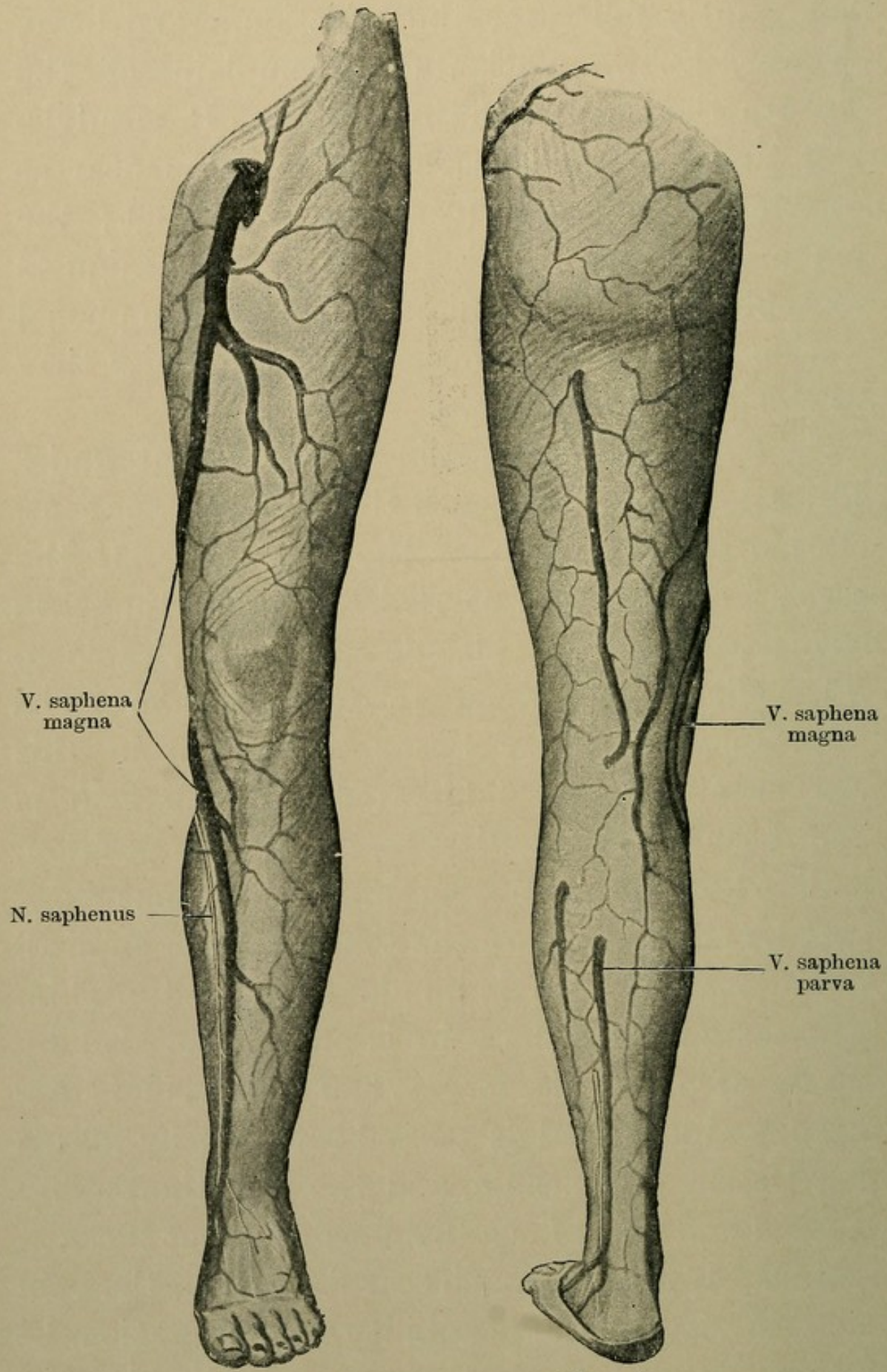

FIG. 5. FIG. 6.

COURSE OF THE VEINS IN THE LOWER EXTREMITY.

great saphenous vein is the one most frequently injected in practice (Figs. 5 and 6). Its course is depicted in the figure. It arises from the middle of the venous network on the dorsum of the foot, and then passes in front of the inner malleolus to the inner side of the leg, where it is accompanied by the saphenous nerve. It then runs along the inner side of the knee-joint, passing behind the inner condyle of the femur, after which it again comes forward, coursing along the inner and anterior surface of the thigh to the saphenous opening, where it ends in the femoral vein.

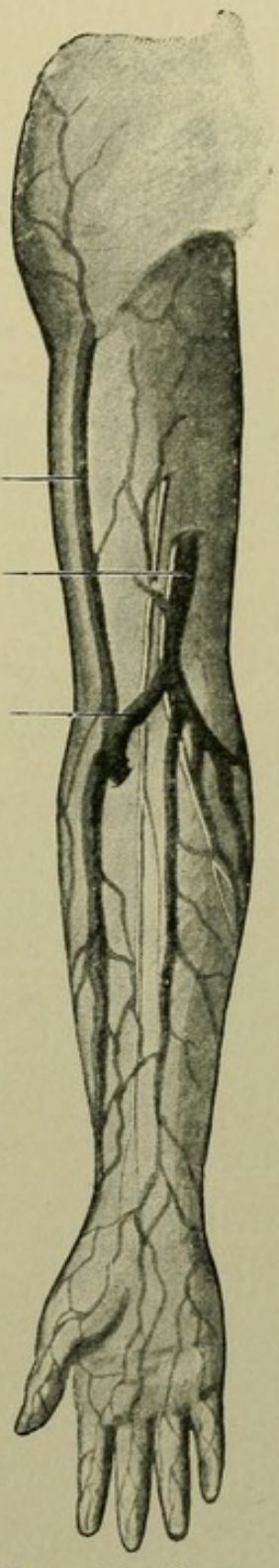

FIG. 7.—COURSE OF THE VEINS IN THE ARM.

In the arm (Fig. 7) the veins used as a rule for injection are the cephalic and basilic veins in the lower half of the arm. The portion of the cephalic vein with which we are concerned lies, according to Bier, in front of the *sulcus bicipitalis lateralis*, on the outer side of the biceps. The basilic vein lies in the *sulcus bicipitalis internus;* the accompanying *nervus cutaneus*

antebrachii must be kept in mind. The median vein (*vide* Fig. 7) is, according to Bier, not well adapted for direct anæsthesia, especially for operations on the elbow-joint. While the deeper parts are quite insensitive, there is always, just peripheral to the central tourniquet, a cutaneous area which is not anæsthetic, and this area is larger the more peripheral the site of injection (Figs. 8 and 9). The injection must therefore be made as close up as possible to the central tourniquet. For indirect anæsthesia (*vide* pp. 69, 72) the median vein is quite suitable.

To return to the technique, the vein having been exposed and a ligature passed round it, it is drawn up by means of the ligature into the upper angle of the wound. A second ligature, peripheral to the first, is then passed round the vein, into which an incision is made with a fine pair of scissors between the two ligatures. The needle or cannula is now passed carefully into and along the vein in a peripheral direction—injection in a central direction has occasionally been followed by symptoms of poisoning—and the peripheral ligature is tied round the vein and cannula, the latter being then withdrawn until the ligature, which is drawn somewhat tight, slips into its groove (*vide* p. 79 and Fig. 4). The ligature is then securely tied, and its security tested by gently drawing the cannula backwards.

The 0·5 per cent. solution at blood-heat is then injected (maximum quantity 100 c.c.), the vein being held sightly tense during the injection. Many patients find the inflow of the solution,

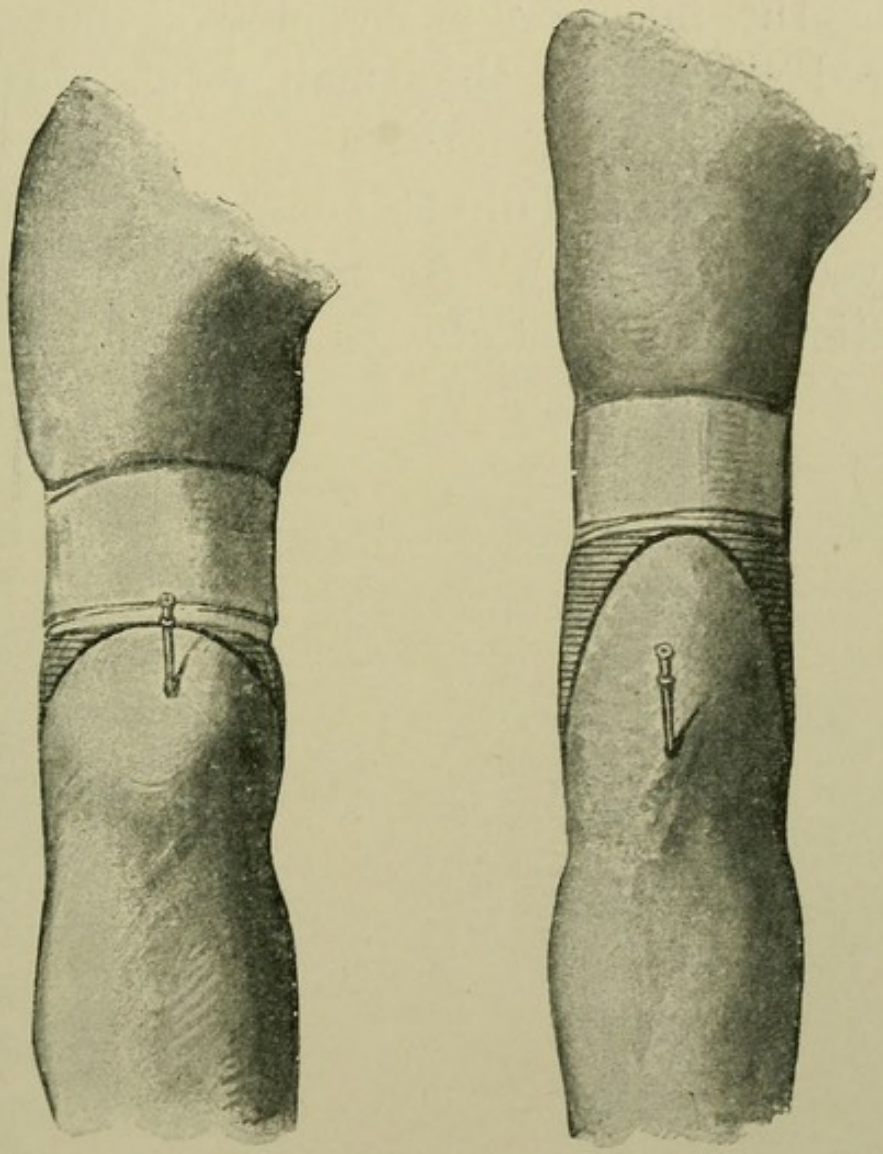

FIG. 8. FIG. 9.

EXTENT OF VENOUS ANÆSTHESIA ACCORDING TO SITE OF INJECTION.

which causes a swelling of the affected section of limb proportional to the amount injected, somewhat unpleasant.

Bier has on two occasions found, when operat-

ing on the forearm, that the valves of the veins have acted as an obstruction. In both cases he was able finally, by the exercise of considerable pressure, to overcome the resistance.

After the injection is completed, the vein is ligatured above and the small wound attended to at once.

As a general rule direct anæsthesia should be employed (*vide infra*). According to Bier 80 c.c. of solution will almost always be found sufficient.

CHAPTER VII

METHODS FOR ANÆSTHETIZING THE SKIN AND THE DIFFERENT TISSUES — PROCEDURE IN CERTAIN DISEASED CONDITIONS — CIRCULAR ANALGESIA

THE skin is an organ extraordinarily sensitive to pain, the most sensitive, in fact, of the whole body. In the degree of this cutaneous sensibility to pain, however, different parts of the body differ from each other very widely. The least sensitive cutaneous areas are probably those of the back and the abdomen, the most sensitive those of the nose and ear, and the flexor surface of the fingers and hands. In these respects, also, however, there are wide differences between individuals.

The skin may be rendered insensitive either by terminal or by conduction anæsthesia—that is to say, by anæsthetizing either the sensory "end-organs" in the skin, or the terminal sensory nerve-tracts which convey sensory impulses from those end-organs.

In the first method, usually given Schleich's name of "wheal anæsthesia" (*Quaddelanästhesie*),

the solution is injected endermally by means of a fine hollow needle. In making the puncture a fold of skin should be pinched up where this is possible, and the needle inserted parallel to the cutaneous surface. A white insensitive wheal is then seen to form immediately after the solution is injected. The needle must be kept in the skin itself, and must not be allowed to pass into the subcutaneous cellular tissue. Often, if the skin is elastic and not too thin, the needle may be pushed forward endermally, so as to anæsthetize an area of skin of considerable length. As a rule one must be satisfied with making as large a wheal as possible, and then making another puncture within the area, but near the edge, of the first wheal, which is now anæsthetic (*vide* Fig. 10). The first puncture may be rendered painless by the use of ethyl chloride. If, however, a fine

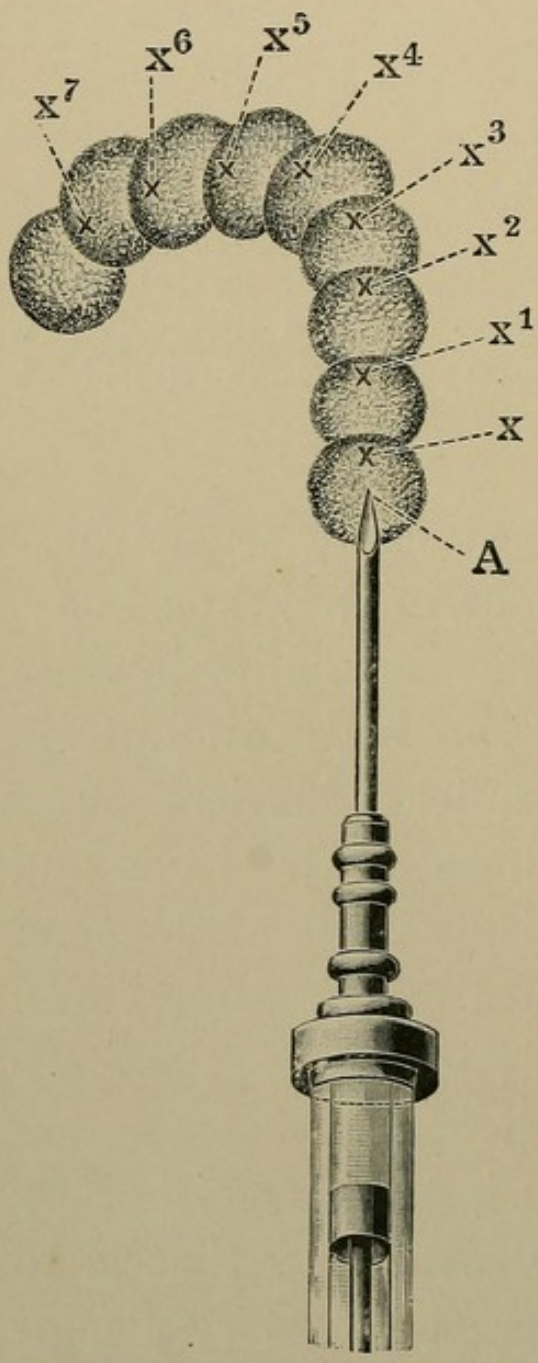

Fig. 10.—Wheal Anæsthesia (Schleich).

needle is used, the pain of the puncture is very slight. A 0·25 per cent. novocain solution, with a small dose of suprarenin added, is quite sufficient for longer operations. In minor operations requiring stronger (0·5 or 1 per cent.) solutions, however, small areas of skin can be safely anæsthetized with these solutions. A larger dosage of suprarenin is not, in my opinion, advisable in this form of anæsthesia. As the pressure-œdema helps to intensify the anæsthesia, small doses of suprarenin (at most 1 minim to each 10 c.c. of solution) are sufficient to increase the duration and intensity of the anæsthesia without risk of injury to the tissues.

The area infiltrated in the above manner is but a narrow one, and the anæsthesia does not extend much beyond the borders of the wheals themselves ; it is important, therefore, that in suturing at the end of the operation the stitches should be inserted within the zone of infiltration.

Nowadays the skin is generally anæsthetized by conduction anæsthesia from the subcutaneous cellular tissue. This does not, like the skin, possess sensory end-organs, but only terminal sensory nerve-tracts, for the skin or organs situated immediately beneath it (glands), and, *e.g.*, in the head, also sensory fibres, which penetrate the fasciæ towards the deeper parts and supply the periosteum.

In this method the subcutaneous cellular tissue is infiltrated from two opposite points, chosen with reference to the position and extent of the area to be anæsthetized, generally with 0·5 or 1 per cent. novocain solution and suprarenin, and an anæsthesia of the overlying skin area then develops. The rapidity of its onset is dependent on various circumstances. Thus where, as in the scalp, the injection causes a bulging outward of the skin, anæsthesia comes on quickly, often immediately. Where, on the other hand, the subcutaneous cellular tissue is very rich in fat, as in the gluteal region, considerable quantities of concentrated solutions, large additions of suprarenin, and a long period of waiting, are often required before a condition of anæsthesia can be attained. In many operations it is preferable to inject the subcutaneous cellular tissue, not underneath, but around the line of incision, so that the surgeon will be able afterwards to operate in tissues in a normal condition.

The foregoing rules apply also to the anæsthetization of the subcutaneous cellular tissue itself.

Anæsthesia of mucous membranes is brought about either by "painting" the mucous surface with the anæsthetic solution, or by conduction anæsthesia, as just described in the case of the skin. In the latter case the first incision may be rendered painless by the previous application of 10 per

cent. phenol solution (Schleich's), or of 10 per cent. novocain solution.

It is important not to employ too dilute solutions. As above stated, the 1 per cent. solution of novocain is the best for all minor operations. This solution very soon interrupts conduction of sensory impulses, even in the larger nerve-branches which traverse the subcutaneous cellular tissue, so that prolonged waiting is unnecessary.

Let us take a concrete example, for instance, the excision of a lupous focus in the face. The conduction of sensory impulses from the diseased area is to be thoroughly interrupted without infiltrating the area itself. In the first place the subcutaneous cellular tissue in the neighbourhood of the focus must be infiltrated from two, or, if the diseased area be a large one, from four, injection points a few centimetres outside the operation area, with 1 per cent. novocain solution + suprarenin. This will interrupt the conduction of sensory impulses in most of the nerve channels supplying the area. It is a good plan to render the injection points insensitive by the method of "wheal" anæsthesia, so that the subsequent injection with a larger needle may be painless. In many cases the injections above described suffice. Often, however, the affected area is also supplied with sensory nerves which reach it from the deeper parts. Besides this, nerve-trunks often traverse the subcutaneous

cellular tissues for considerable distances, and these will be of notable calibre at the points of injection. In order to interrupt conduction in these also it is necessary to infiltrate the subcutaneous cellular tissue immediately underneath as well as that surrounding the diseased focus. We have then the most commonly employed form of local anæsthesia, the so-called *circular analgesia* of Hackenbruck—*i.e.*, the disconnection of an area of operation by circular interruption of all sensory nerve-channels supplying the area. The method is applicable to the great majority of diseased conditions necessitating operations on the skin or subcutaneous cellular tissues, furuncles, tumours, foreign bodies, lymphadenitis, etc. The peripheral parts of the area are the first to become anæsthetic, the nerves supplying the central portions being "caught," so to speak, by the anæsthetic at a greater distance from their terminations, and being, therefore, of larger calibre than those supplying the periphery. Diffusion phenomena also play a part in the matter, as is often made plain by the spread of a whitish tint from the periphery towards the centre.

Difficulties may arise in cases where nerves of considerable calibre pass direct from the deeper tissues to the diseased organ. Thus it is often difficult to render completely painless an operation for the extirpation of inflamed inguinal glands.

The boundary of the possible area of circular analgesia is here placed where the inflamed area and the underlying tissues join, so that it is impossible to inject beneath the focus and thus completely interrupt the sensory conduction. An exception is formed where subcutaneous nerves pass through the fascia to the deeper tissues and supply periosteum and bone—*e.g.*, on the scalp. Otherwise we must in these cases either anæsthetize the larger nerve-trunks where we can reach them, or—as, for instance, in an extirpation of inguinal glands, where the mass is in intimate connection with the underlying tissues—we must, after subcutaneous injection, proceed to infiltrate successively with a large amount of anæsthetic solution the tissues through which the surgeon will have to make his incisions. Often, when it is not essential to render insensitive the whole diseased area—as, for instance, in a parulis which is "pointing"—we merely infiltrate by Schleich's method the line of incision. We can generally do this painlessly in spite of our rule against infiltrating inflamed tissues, as the existing œdema has lowered the sensibility of the parts, and, secondarily, inflamed skin is often less sensitive than that attacked by a primary inflammation. No wheal is formed in this case, but the solution diffuses itself through the relaxed tissues, and must be injected in considerable quantity. Where, then, we have an

area of œdematous and only secondarily affected skin overlying inflamed parts, it is often possible to infiltrate those parts painlessly without previous injection of surrounding sound tissues. The matter is still more simple in the case of a small incision or puncture of an abscess, if the skin and other covering tissues are quite sound. It is only necessary to inject continuously, as the needle is passed on through the overlying tissues, in order to render the whole path of the puncturing instrument anæsthetic. All the more important is it, however, in inflammations of the skin itself, such as boils and carbuncles, to avoid infiltrating inflamed parts until they have been rendered anæsthetic. This is only likely to present difficulty when the inflammation extends into the deeper-lying parts, as, for instance, in the case of a large cervical carbuncle. In such a case we must, following Schleich's practice, infiltrate the tissues step by step, starting in sound tissues, and only after the onset of anæsthesia (which is quite rapid if 1 per cent. novocain solution is employed) continue the injection till the whole diseased focus has been surrounded. Otherwise, when several layers of tissue have to be infiltrated, the rule of infiltrating the deeper layers first, holds good.

The foregoing applies, of course, also to superficial tumours. Malignant tumours, however, should not be operated upon under local anæs-

thesia, in the absence of a clear demarcation between the cancerous and the healthy tissues. If the cancerous growth has attacked the surrounding parts, and especially if the neighbouring glands are involved, operating under local anæsthesia cannot be too strongly deprecated. General anæsthesia is here avoided at a heavy cost, radical removal of the tumour and of its metastases in the neighbouring glands being impossible without it. In the case of innocent tumours intimately attached to the underlying tissues the method above described, as applicable to the extirpation of inguinal glands, may be recommended. First free injection around the diseased glands, the dissecting out being continued under Schleich's infiltration method. It is particularly important to secure complete anæsthesia when operating for the removal of foreign bodies. Every surgeon of experience in this matter knows how frequently unpleasant surprises are experienced. It is often necessary, especially when the foreign body is situated deeply in the substance of a muscle, to bring Schleich's infiltration method to one's aid.

As regards other tissues of the body, it should be noted that tendons are insensitive, while the tough, connective tissue surrounding them and their sheaths has, on the contrary, a high degree of sensibility to pain. Muscle fasciæ, or aponeuroses, are also in most parts sensitive. As a

rule, therefore, it is sufficient, in order to render tendons and fasciæ anæsthetic, to infiltrate the surrounding connective tissue. Local anæsthesia is not suitable for operations on tendons involved in cicatricial tissue, unless a pure conduction anæsthesia can be employed.

Muscles behave in much the same way as the subcutaneous cellular tissue. Broadly speaking, their substance is insensitive to pain. They are, however, traversed in many parts by sensory nerves, interference with which causes pain. Small scars, or sclerosed centres in muscle, are particularly sensitive. Muscles should be freely infiltrated, and usually, following Schleich's practice, with not too dilute solutions. Schleich himself has often used 0·5 per cent. cocain solutions. It is necessary to wait a few minutes for the full development of anæsthesia.

Divergent views prevail as to the sensibility of the periosteum. The truth of the matter would appear to be that in some regions the periosteum has no sensibility, while in others it is, on the contrary, extraordinarily sensitive to pain.

The bones are as a rule supplied with sensory nerves from the periosteum. If the periosteum be elevated from the bone, the outer uncovered surface of the latter is insensitive. The medulla of bone, however, exhibits, according to Schleich, sensibility to pain. Thus it has been repeatedly observed

that in amputations carried out under local anæsthesia the whole operation is painless, except the sawing through of the bone. This is probably to be explained by the fact that nerves traverse the substance of bones for considerable distances, and as the periosteum is, in practice, only elevated for a short distance, the medulla, at the given point, contains sensory nerves, which have passed from the periosteum to the bone at points central to the line of amputation. Anæsthetization of bone and periosteum is brought about with the most facility where we are able to induce anæsthesia by interruption of conduction in superficially situated nerve-trunks, as, for instance, in the fingers, the scalp, or the lower jaw (*nervus alveolaris inferior*). In flat bones injections must be made around the affected area at as deep a level as possible (*e.g.*, focus in sternum). Finally, in the case of many hollow bones—as, for instance, in resection of ribs—we must inject all round the whole area of bone which we wish to anæsthetize. If this is done thoroughly, it is sufficient if the needle be passed down close to the periosteum, and it is not necessary to proceed to an actual subperiosteal infiltration. As stated above, the deeper layers are always injected first, and then the subcutaneous tissues.

For cartilage and perichondrium the same rules apply as for bone and periosteum, both as regards

sensibility to pain and the best methods of producing anæsthesia.

As regards articular capsules, ligaments, and synovial membranes, though the opposite opinion has been expressed, Braun's view is undoubtedly correct, that these possess a somewhat high degree of sensibility, which, as is the case also with all the tissues we have considered, is very much increased in inflammatory conditions. In major operations on the larger articulations, as also in many operations on the large tubular bones of the extremities, venous anæsthesia is likely soon to displace other methods. In simple puncture of a joint the same procedure is adopted as for the puncture of abscesses. If an irritant substance has to be injected into a joint, the latter is first freely injected with 0·5 per cent. novocain solution + suprarenin. After the lapse of a period of five to ten minutes the joint is entirely insensitive. The anæsthesia can be tested by moving the trocar, which has been left *in situ*, backwards and forwards, and when found to be complete the medicament should be injected at once.

CHAPTER VIII

OPERATIONS ON THE HEAD

1. Operations on the Scalp and Forehead.

As already stated, the scalp is a specially favourable region for the application of local anæsthesia, inasmuch as the nerves, running for considerable distances under and parallel to the skin, ultimately, after passing through the fascia to the deeper tissues, innervate the bones of the skull and their periosteum, so that it is easier here than in most other regions of the body to bring about an anæsthesia of bone by subcutaneous injections. The usually small development of fat in this region is also favourable to the attainment of an anæsthesia on which one can rely.

A glance at Fig. 11 shows the course of the nerves, and makes it clear that near the points of exit of the nerves it is possible, without circular injection, and merely by subcutaneous injection of a strip at right angles to the course of the nerve, to bring about anæsthesia of a given area. This cannot, however, be recommended as a general

practice, in view of the existence of occasional irregularities in the course of the nerves. The method is most to be depended on when applied to the frontal region. In general, however, circular injection alone gives certainty of the

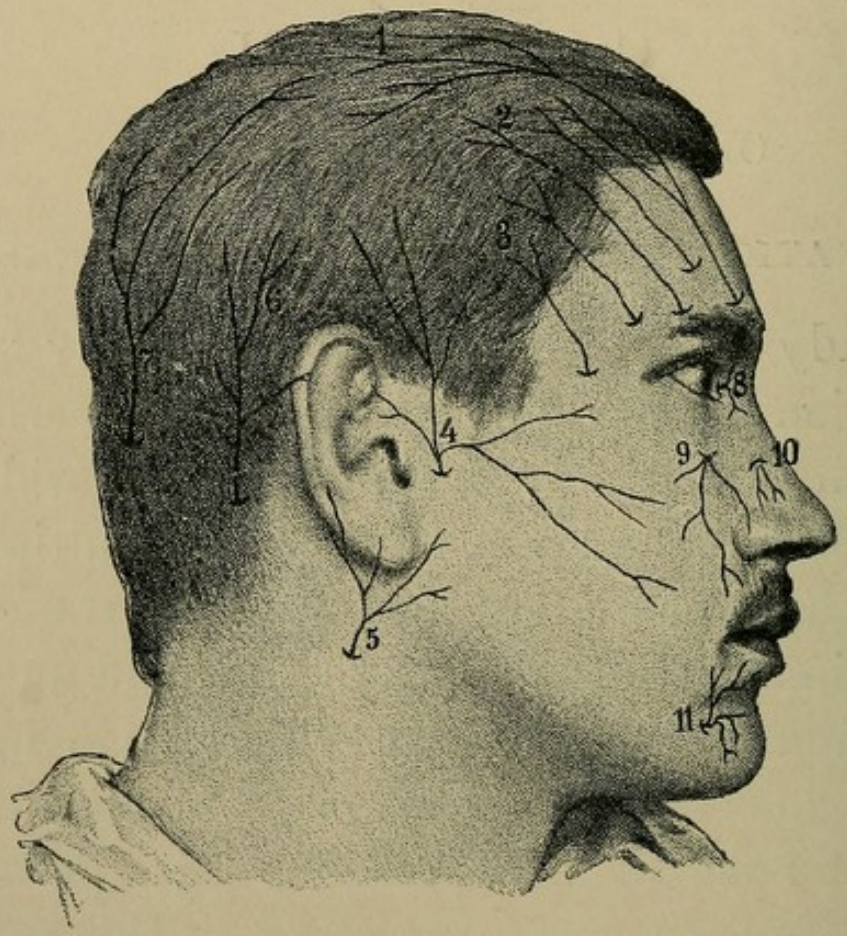

FIG. 11.—COURSE OF THE SENSORY NERVES OF THE FACE (BRAUN).

1, N. frontalis; 2, N. supraorbitalis; 3, N. zygomat. temporalis (Trigem. II.); 4, N. auriculo-temporalis (Trigem. III.); 5, N. auricularis magnus; 6, N. occipitalis minor; 7, N. occipitalis major; 8, N. supra- and infra-trochlearis; 9, N. infraorbitalis; 10, R. nasalis ext. N. ethmoidalis; 11, N. mentalis.

attainment of a complete anæsthesia. It is, however, not as a rule necessary on the scalp or forehead—in view of the general course and distribution of the nerves above described—to pass the injecting needle beneath the affected area, it

being generally sufficient to make one's injections around the area of operation in the form of a circle or rhombus. The necessary first treatment of head injuries, even of those involving severe injury to bone, can be carried out under this method most satisfactorily. The parts surrounding the injury are dry-shaved, the skin near the wound is painted with tincture of iodine, the anæsthetic solution is injected, and the area of operation is then further prepared by cleansing with ether or benzine. If the dura mater is met with in the course of the operation, no harm is done, as the injections will have rendered it insensitive by interrupting conduction in its sensory nerves. My experience in a good many operations entirely bears out Braun's statements in this regard. Cases have been recorded, however, by other observers in which the dura retained its sensibility. The surface of the brain, however, seems to be quite insensitive, the fact having been established by numerous recorded observations on the living subject. Trephining operations, therefore, especially where there is no large amount of muscular tissue beneath the galea, are specially suitable for local anæsthesia. Suprarenin is here of great utility. In the proportion of 1 minim of synthetic suprarenin to 10 c.c. of solution it causes a sufficient degree of anæmia, and renders superfluous Heidenhain's method of

ligation. Where, in view of the large area of the field of operation, very large quantities of solution have to be employed, the suprarenin may be given in still more dilute proportion. It has also been recommended in operations under general anæsthesia that, instead of ligation, a dilute suprarenin solution should be injected with a view to the prevention of hæmorrhage. I have obtained a thoroughly satisfactory local anæmia after injection of 1 minim of suprarenin to 20 c.c. of solution. Heidenhain's method, however, must be regarded as that which involves least risk of doing harm. To what extent local anæsthesia will secure adoption in larger operations on the skull the future alone can decide. It is, however, not everyone who can bring himself to let his skull be chiselled open while he is fully conscious. One of my patients told me that, though he suffered no pain, the sensations of hammering and boring were so horrible that he would much prefer to be put under chloroform. Such points must be borne in mind, in the absence of some very compelling ground for avoiding general anæsthesia, and the boon of unconsciousness should not be denied such patients.

The foregoing applies only to those parts of the head in which the periosteum lies immediately under the galea, so that other tissues are not in question. If the operation is to be performed on a

region nearer the face, a careful circular injection must be carried out. Where muscles are situated between the skin and the bone (*e.g.*, *maxilla temporalis*), these also must be carefully infiltrated. If two dilute solutions are not employed, which is seldom necessary here, where large quantities of solution are hardly ever required, a reliable anæsthesia can be attained in any part without paying too close attention to the exact points of exit of the superficial nerves.

In trephining the frontal sinus, injections are made, first deeply and then subcutaneously, around the point where the trephine is to be applied. The trephining can readily be made painless. The mucous membrane of the sinus, however, is supplied by the ethmoidal nerve, which passes from the orbit. As an interruption of conduction in this nerve is hardly practicable, necessary manipulations of the mucous membrane must be rendered painless by the application to it of a concentrated solution — 10 per cent. novocain solution + suprarenin. The method is not very satisfactory, and where it is necessary to go beyond the mucous membrane the case is quite unsuitable for local anæsthesia.

2. Operations on the Face.

The rules already laid down for anæsthetizing the skin and subcutaneous cellular tissue will as a rule be found sufficient in the case of operations on the soft parts of the face, such as incisions of furuncles, removal of tumours, plastic operations, etc. If 1 per cent. novocain solution is employed, it is hardly necessary to pay minute attention to the points of exit of the nerves through the fascia, though, should such a point come within the area of operation, a somewhat more copious infiltration may be made in its neighbourhood. Large quantities of solution are not generally required, so a few extra cubic centimetres may be used in this manner without misgiving. The dose of suprarenin need not be large for operations in this region. From 1 to 2 minims of synthetic suprarenin to each 10 c.c. of solution, according to the amount of fat in the subcutaneous cellular tissue, is generally sufficient. In a large number of operations injection around and underneath the affected area will suffice. Of the treatment suitable in extensive superficial morbid processes, a concrete example has been given above in the description of the methods to be applied in a case of lupus of the cheek. Should the focus be attached to the subjacent tissus—*e.g.*, should it be adherent to the surface of the superior or inferior

maxilla—the circular injection of the subcutaneous tissue must be preceded by a similar injection of the deeper layers immediately above the periosteum. Here, however, should the area of operation include a point of exit of one of the nerves, it will be necessary, after the incision of the skin, to inject a small quantity of solution into the larger divisions of the nerve.

In operations on the eyelids it is sufficient, in the case of either eyelid, to infiltrate along the line of the corresponding bony border of the orbit.

3. Operations on the Ear.*

With regard to the distribution of sensory nerves to the ear, the following points should be borne in mind :

The pinna and external auditory meatus are supplied—

1. By the auriculo-temporal nerve.
2. By the auricular branch of the vagus.
3. By the great auricular nerve.

The nerves, for the most part, pass to the meatus from in front and from below (*vide* Fig. 11).

In operations on the pinna it is generally suffi-

* Privat-docent, Dr. Haike kindly assisted me in the preparation of this section, as also of that dealing with operations on the nasal and oral cavities.

cient to interrupt, by a subcutaneous infiltration, the conduction of sensory impulses from the part to be dealt with. Very small quantities of solution suffice here, as the skin rises immediately in a wheal-like manner after even a small injection.

If the whole pinna is to be anæsthetized, all that is necessary is to infiltrate subcutaneously in a circle immediately around it with 1 per cent. novocain-suprarenin solution. As a final precaution, it is advisable to inject deeply an extra 2 or 3 c.c. where the larger branches pass to the ear—that is to say, behind the lobe of the ear and in front of the mastoid process.

For operations on the external auditory meatus reliance is often placed on the application of a plug of cotton-wool saturated with a solution containing—

	Parts.
Ac. carbol. liq.	5
Cocainæ hydrochlor.	2
Menthol	2
Sp. vini. rect.	10

The most frequently required operation in this region—the incision of boils—is certainly rendered less painful by this application, but is by no means painless. For operation on the bony walls of the meatus the method is, of course, quite useless. The method advocated by Eichen and Braun for operations on the meatus will probably gradually secure

wider adoption. Its aim is to anæsthetize, by interruption of conduction, the nerves above described as supplying the external meatus.

Solution of novocain (1 per cent.) + suprarenin is first freely injected behind the lobe of the ear in the depression in front of the mastoid process, the needle being passed deeply in along the lower border of the auditory meatus; a second injection is made in a rather more anterior position, and the neighbourhood of the anterior wall of the meatus is thus infiltrated with the same solution. After five minutes the anæsthesia is as a rule complete.

Difficulties occasionally arise, as, for instance, in furuncles, when the inflammation has spread posteriorly to the adjacent parts. In view of the extreme sensitiveness of the parts, it is necessary to proceed slowly from the healthy to the diseased, injecting gradually more and more deeply.

The membrana tympani is partly supplied by the nerves above mentioned; in part, however, as is also the case with the middle ear, it is supplied by sensory fibres from the glosso-pharyngeal and vagus nerves, in whose case, of course, an interruption of conduction is out of the question.

By instillation of the above-mentioned phenol-cocain solution the sensibility of the membrana tympani can be considerably diminished. A pledget of cotton-wool soaked in the solution should

also be pressed against the point involved until the latter becomes whitish. The carbolic acid renders the epidermis more permeable by the anæsthetic solution. As, however, the solutions diffuse only very imperfectly through the epithelium of the membrana, the results are not altogether satisfactory.

Two methods have been introduced recently :

Tiefenthal takes 4 minims of 20 per cent. cocain solution + 1 minim of suprarenin, allows this quantity to act upon the membrana tympani for fifteen minutes, and then injects 2 to 4 minims of cocain-adrenalin solution (5 to 10 per cent.) through the drum at its lower part into the middle ear.

Rupprecht kneads a piece of alypin about the size of a bean with 2 minims of suprarenin, covers the upper half of the drum with the mixture, and leaves it to act for fifteen or twenty minutes. According to Rupprecht, the osmotic difference between the mixture in contact with the drum and the lymph of the middle ear facilitates diffusion through the somewhat impermeable tympanic epithelium.

Both authors, however, admit that their methods do not give a thoroughly trustworthy anæsthesia.

It must be remembered that often, when the ear-drum is near the point of perforation, the amount of pain caused by attacking it is minimal ;

this may perhaps explain the wide differences in the recorded results.

Strenuous attempts have been made to arrive at more satisfactory results by other methods.

Neumann, in particular, has pointed out new lines on which to attempt the anæsthetization of the membrana tympani and of the organs of the middle ear.

Otologists are not in agreement as to the value of these methods: they, however, certainly point out a way by which we can bring about a very thorough deadening of sensibility of the interior of the middle ear.

Neumann discovered that an anæsthetic injected into the upper wall of the auditory meatus in such a manner as to raise it from its bed finds its way between the two layers of the membrana tympani, and thus brings about anæsthesia of the drum and of the middle ear (Fig. 12).

A 2 per cent. novocain solution is employed with 3 minims of added suprarenin to each 5 c.c. of solution. The heating of the solution to 45° C., which Neumann recommends, is not necessary. The needle is inserted from $\frac{1}{2}$ to 1 centimetre in front of the junction between the cartilaginous and the bony portions of the meatus. The line of junction can be recognized by a fold formed when the pinna is raised or lowered, also by the glistening of the bony portion. The needle is passed

upwards and inwards in a slanting direction, thus between the bone and the upper cutaneous wall of the meatus. The anæsthesia is fully established in about ten minutes. That of the drum is complete, that of the middle ear-organs, though not quite complete, is nearly so.

For operations on the membrana tympani,

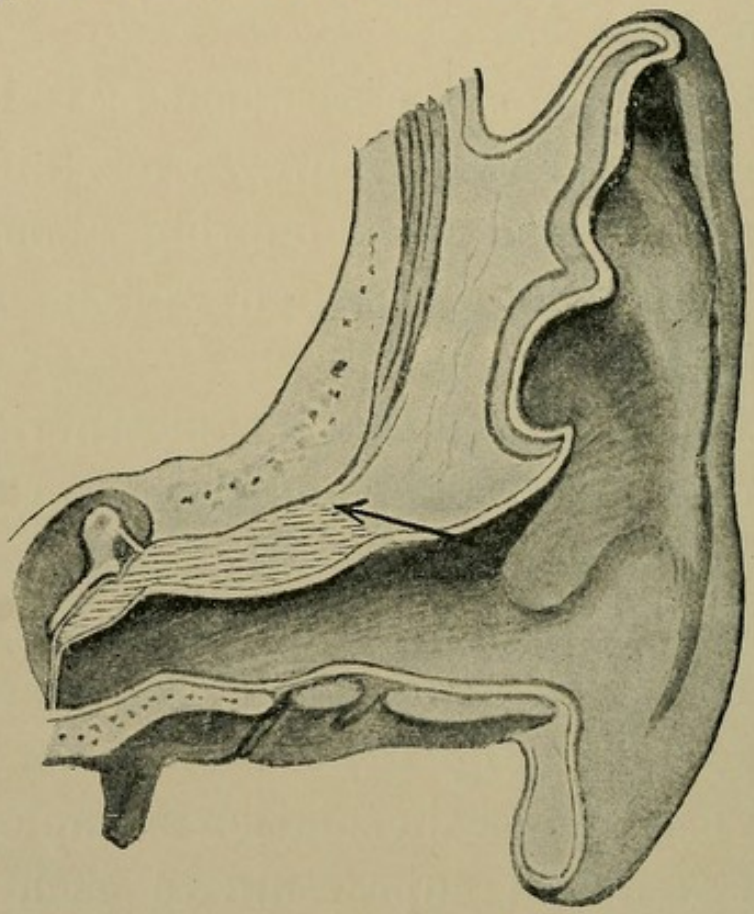

Fig. 12.—Anæsthetization of the Membrana Tympani and Middle Ear (Neumann).

especially paracentesis, the method has not gained wide adoption, as there is a general agreement that the pain of the injection is no less severe than that of the paracentesis itself.

On the other hand, the method, though perhaps not yet fully perfected, appears to point

to the right way in which to bring about anæsthesia for operative procedures on the middle ear, which often require considerable time to carry out. Where the tympanic cavity is to be attacked by way of the auditory meatus the method is as a rule sufficient in itself.

If a trephining of the mastoid process is to be combined with the "radical" operation, the method must be reinforced by the simple and sure method of anæsthetization of the bone from without.

The mode of procedure follows from what has been said above. It is only necessary to surround the mastoid process with a deep, and a superficial infiltration with 1 per cent. novocain-suprarenin solution, and the bone can be trephined painlessly in from ten to fifteen minutes. The deep infiltration should be, as far as possible, subperiosteal. The above-described method of anæsthetizing by way of the meatus then comes into use for the deeper parts. The performance of this operation under Schleich's anæsthesia alone—that is, after a gradually progressive infiltration carried deep into the bone, as has been practised by some surgeons—has, in my opinion, this serious drawback—viz., that in a region so rich in lymph channels infectious material may very readily be carried by the infiltration to the deeper parts.

In operations on the peripheral portions of the nose we can either employ a circular infiltration, for which, owing to the tenseness of the tissues, only small quantities of solution are required, with little or no added suprarenin. For the removal of small tumours this is the most practical method. For plastic operations, where the area of operation is to be treated as gently as possible, conduction anæsthesia is to be preferred. It must be borne in mind that the nasal branch of the ethnoidal nerve issues at the junction between the bony cartilaginous portions of the nose, also that the alæ nasi and the septum receive sensory twigs from the upper lip. In order to anæsthetize the whole lower end of the nose, its lower border must be infiltrated first deeply, then subcutaneously, the upper lip being elevated for the latter infiltration; afterwards, starting from the ridge of the nose, injections are made outwards and downwards, in a slanting direction, until the former injection points are met with. The deeper parts also (cartilage) are thus rendered anæsthetic. If it is desired to anæsthetize the whole organ, the second infiltration must be carried out from the root of the nose along its lateral borders, and it will be necessary, in view of the nasal branch of the ethnoidal nerve, to inject specially a narrow strip at the junction of bone and cartilage (Braun).

Operations on the Nasal and Buccal Cavities.

I have already stated that for producing anæsthesia of mucous membranes cocain has not yet been altogether ousted by other anæsthetics. In two respects, indeed, its replacement by other substances is not so urgently called for here as in the method of anæsthesia by infiltration. In the first place, the question of sterilization is here of subordinate importance, while, in the second, it is less necessary here to insist on entire freedom from tissue-irritant qualities in the drug employed than is the case with subcutaneous injections. There remains, however, the risk of poisoning, which, in spite of improvement since the introduction of suprarenin, is, in my opinion, a somewhat serious one, though cases of severe poisoning are but rare. Those who still, at the present day, employ cocain for anæsthetizing mucous membrane, give as their reason that for this particular purpose none of the newer preparations equal cocain in respect of the completeness of the anæsthesia produced. A number of other authors, however, state, in opposition to this view, that here also they have had excellent results with the newer anæsthetics, particularly with novocain and alypin.

Both of these are used, like cocain, in 10 to 20

per cent. solution. The dose of suprarenin must be fairly strong, about 5 minims per cubic centimetre.* The application is made with a brush (pharynx), or by placing *in situ* pledgets of cotton-wool soaked in the solution and changing them frequently. Care must be taken that none of the solution passes down the œsophagus, and to this end too free a soaking of the cotton-wool should be avoided. The shrinkage of mucous membrane caused by the action of suprarenin is in many cases of great importance as an aid both to diagnosis and to the carrying out of operative procedures.

The anæsthesia brought about in this manner is limited to the mucous membrane. If operations on bone are to be undertaken (septum resections, etc.), infiltration must take the place of external applications. In septum resections the surgeon injects on both sides of the septum beneath its covering mucous membrane with 1 per cent. novocain solution with a small addition of suprarenin, and proceeds gradually from before backwards.

Attempts have quite recently been made (*Rupprecht*) to devise a satisfactory local anæsthetic technique for two minor operations of great

* Haike has several times observed, after the use of suprarenal preparations, a nasal discharge, very troublesome to the patient, and lasting several days.

importance to the practical surgeon — for the extirpation of tonsils and the removal of adenoid vegetations.

Many surgeons deny the necessity of any local anæsthesia for these two operations, and object, on account of the expenditure of time, to a preparation for operation whose duration seems out of all proportion to the short time necessary for the actual operative procedure. At the same time, the efforts being made in the matter deserve attention. If the public should come to realize that it is possible to perform these operations painlessly, under local anæsthesia, many patients will certainly express a wish that it shall be done in their case. At present, however, the methods are by no means perfected, for "painful" or "slightly painful" are words still frequently occurring in reports of cases. Many patients, too, and especially young children, are unsuitable subjects for any method of the kind.

In the operation for the removal of adenoid vegetations it is of the first importance to anæsthetize thoroughly the very sensitive appendage to the choana. In particularly sensitive patients, with a view to rendering the mirror examination also painless, about 1 c.c. of cocain-suprarenin solution should be first cautiously applied to the interior of the nose as a spray. After waiting from eight to fifteen minutes from the onset of anæsthesia pledgets of cotton-wool soaked in

10 per cent. alypin-suprarenin solution are introduced by means of sounds or applicators into the nostrils, while the patient lies down with head thrown back. A sound is left for a time in each nostril with its pledget in contact with the appendage to the choana. After a few minutes the sounds are changed for fresh ones, the process being repeated three or four times, so that the whole procedure lasts about ten or twelve minutes. The surgeon waits a few minutes, and then carries out his operative procedures within the ensuing ten minutes.

In operations on the tonsils the method applied is particularly suitable for the recently practised total enucleation of those organs. It consists in injecting (with a Record syringe, carrying a special attachment) 2 per cent. novocain solution into the tonsils, after Schleich's method. Before the injection the tonsils may be painted with 10 per cent. alypin solution. The solution is injected into the tonsil around, and as near as possible to, its base. Special importance is to be attached to the due infiltration of the upper pole of the tonsil (exit of nerve); the infiltration of the lower pole also is advisable, with a view to the prevention of hæmorrhage.

After the infiltration it is necessary to wait eight or ten minutes.

In operations on the lachrymal sac it is

advisable to inject around the whole area of operation; it is generally sufficient, in addition, to inject at the inner canthus (N. intratrochlearis); this cannot, however, always be fully relied on, as sensory branches often reach this region from a mesial direction.

Operations on the Eye.*

While, as we have seen, the anæsthetization of mucous membranes by external application presents certain difficulties, the ocular conjunctiva is an exceedingly favourable field for the employment of local anæsthesia. Apart from the property possessed by the conjunctiva of readily taking up watery fluids by diffusion, we can secure here a more prolonged action of the drug than we can with mucous membranes, by the simple plan of holding the lower lid a little away from the eye and making the patient look downwards, so that the eye is bathed in the solution, filling the lower conjunctival sac. As a consequence we can secure satisfactory results with far less concentrated solutions of the anæsthetic drug; this is desirable also, because too concentrated solutions might easily be harmful to the corneal epithelium. The majority of ophthalmolo-

* My thanks are due to Dr. Fehr for assistance in the preparation of this section.

gists have remained faithful to cocain, though recently a number have also employed holocain, alypin, tropacocain, and novocain. For subcutaneous and subconjunctival injection tropacocain must be entirely rejected, on account of its powerfully irritant effects; novocain takes first place, and the otherwise almost abandoned eucain also renders good service.

Alypin, in contrast to cocain, causes vaso-dilatation, and in many cases gives rise to a condition of general irritability which is unpleasant to the patient.

With reference to one important question, that of injury to the corneal epithelium, there is, at present, no general agreement of authorities. Many regard alypin as in this respect the most satisfactory anæsthetic; others, on the contrary, maintain that with the usual precautions (covering the eye), and in solutions of the usual strength, cocain is the least harmful drug. The principal ground on which cocain has been, in other directions abandoned—its toxicity—hardly comes into consideration here, on account of the small quantities employed. The one drawback of cocain is its pupil-contracting, or myotic action. Where this would interfere with the operation, as in many iridectomies, those ophthalmic surgeons who generally employ cocain have recourse to some other drug.

Local anæsthesia is of special importance in operations on the eye, not only because general anæsthesia must in these cases be very deep owing to the late abolition of the palpebral reflex, but also because it is often desirable during the operation to let the patient carry out certain ocular movements. Vomiting, too, during or after the anæsthesia, imperils asepsis, and, in the case of incised operation wounds, involves danger of opening of the wound with all its consequences (prolapse of iris and vitreous). Even if general asæsthesia has to be resorted to, local anæsthesia is called in as an auxiliary. Fortunately, too, in the great majority of cases, a thoroughly satisfactory anæsthesia can be attained.

For removal of foreign bodies from the cornea 2 per cent. cocain solution is employed, by instillation into the conjunctival sac. From two to six drops are required. The same concentration and dosage are employed for the extirpation of chalazia, for the painful instillation of medicaments, for cauterization of the cornea, and for other operations on the cornea and conjunctiva. The use of salves and oily solutions before operations is to be avoided, as they may smear over the site of operation. The anæsthesia generally comes on very quickly. The addition of suprarenin is not necessary.

Anæsthetization of the iris is usually effected

by subconjunctival instillation, and requires free use of solution and prolonged application. Two to 5 per cent. solutions are employed, and the surgeon must be prepared to find the anæsthesia incomplete, and to meet with evidences of slight pain when the iris is interfered with. It has been suggested that the anæsthesia should be made more complete by circular subconjunctival injection. Most operators, however, refrain from this, as the resulting chemosis complicates the operation. The plan recommended by Haab, too, of introducing crystals of cocain into the anterior chamber, should only be employed in exceptional cases.

Where a sufficient degree of anæsthesia cannot be attained, as in cases of marked ocular hyperæmia, general anæsthesia must be resorted to.

Many ophthalmologists employ in all intra-ocular operations a combination of cocain and suprarenin, others, however, only in hyperæmic conditions, or when, owing to alterations in the blood-vessels, hæmorrhages are to be feared. The best proportion is 5 minims of suprarenin to each 5 c.c. of cocain solution.

For puncture of the sclerotic, suture of wounds of the bulb, and magnet operations, instillation into the conjunctival sac is generally sufficient.

Many also perform strabismus operations under simple instillation anæsthesia. Two minims of a

2 to 5 per cent. solution of cocain are instilled. The subconjunctival injection of a 2 per cent. cocain-suprarenin solution at the point where the tendon is to be divided is very serviceable in these cases.

Even for the most severe of all ophthalmic operations, enucleation of the bulb, local anæsthesia is, in many cases, sufficient, and this is particularly fortunate, as enucleation is often necessitated by morbid conditions of the eye, depending on disease of the blood-vessels, which render it desirable to avoid general anæsthesia. Some (*Bostely*) have performed enucleations painlessly under instillation anæsthesia. In cases of suppurating panophthalmitis, in which it is impossible to secure anæsthesia by injections, and in which general anæsthesia is to be avoided, one must be content with instillation, though by this method it is impossible to attain complete anæsthesia with any approach to certainty.

Many and varied trials have been made of Schleich's method in enucleation operations. It has, however, been made plain by them that his dilute solutions do not suffice to produce complete anæsthesia.

With the novocain-suprarenin solution employed to-day the anæsthetization presents, as a rule, no difficulties. After instillation of a few drops into the conjunctival sac about $\frac{1}{4}$ c.c. is injected sub-

conjunctivally above, below, and at each side as far as the equator of the bulb, a fold of conjunctiva being pinched up each time for the purpose. From $\frac{1}{2}$ to 1 c.c. is then injected into the orbit, the cannula being passed into the bulb as far as possible in a nasal direction.

Many operators use 2 per cent. eucain solution, others again employ 2 per cent. novocain or alypin solutions with suprarenin.

Anæsthesia of the lips is very easily produced. In place of a circular we have here of course a semicircular or wedge-shaped line of injection points, the lip forming the base of the triangle. If anæsthesia of the whole lip is required, deep (submucous) injections must follow the subcutaneous ones. Even when the area of operation extends upwards from the upper lip, or downwards from the lower, even to the lower border of the inferior maxilla, a semicircular or wedge-shaped injection will be found quite sufficient. If, however, no deep injection is carried out, special attention must be given to the points of exit of the nerves mentioned above. A 1 per cent. novocain solution answers every purpose.

With reference to operations on the upper and lower maxillæ, as well as on the teeth, a few preliminary remarks must be made :

The infraorbital nerve (Fig. 13), the most important nerve supplying the upper jaw, passes from the pterygo-palatine fossa in a bony canal, from which it emerges through the infraorbital foramen. This last occupies a fairly constant position a little more than half a centimetre below the orbital border. The infraorbital nerve gives off:

1. Before its entrance into the bony canal and after its exit therefrom: Branches for mucous membrane, periosteum, and the anterior wall of the upper jaw.

2. Before it enters the canal: Branches which enter the bone at the tuber maxillæ behind the appendage to the zygomatic process of the upper jaw (this can easily be felt from the mouth), and the last two of which often supply the first molars. These branches are often joined by others, which are given off directly from the main stem of the second ramus of the trigeminus.

3. In the bony canal: Branches for all the teeth of the upper jaw, including the first molars.

The branches enumerated under the foregoing three heads constitute together the superior dental plexus which gives the rami alveolares, anterior, median and posterior. The branches mentioned in Sections 2 and 3 are generally connected with each other by an anastomosis (*Moral*).

Further, of importance to us as supplying the periosteum and the gums on their lingual side are (Fig. 13):

1. The *N. palatinus ant.*, which issues from the bone by the greater palatine foramen at the level of the third molar.

2. The *N. nasopalatinus*, which leaves the bone by way of the foramen incisivum.

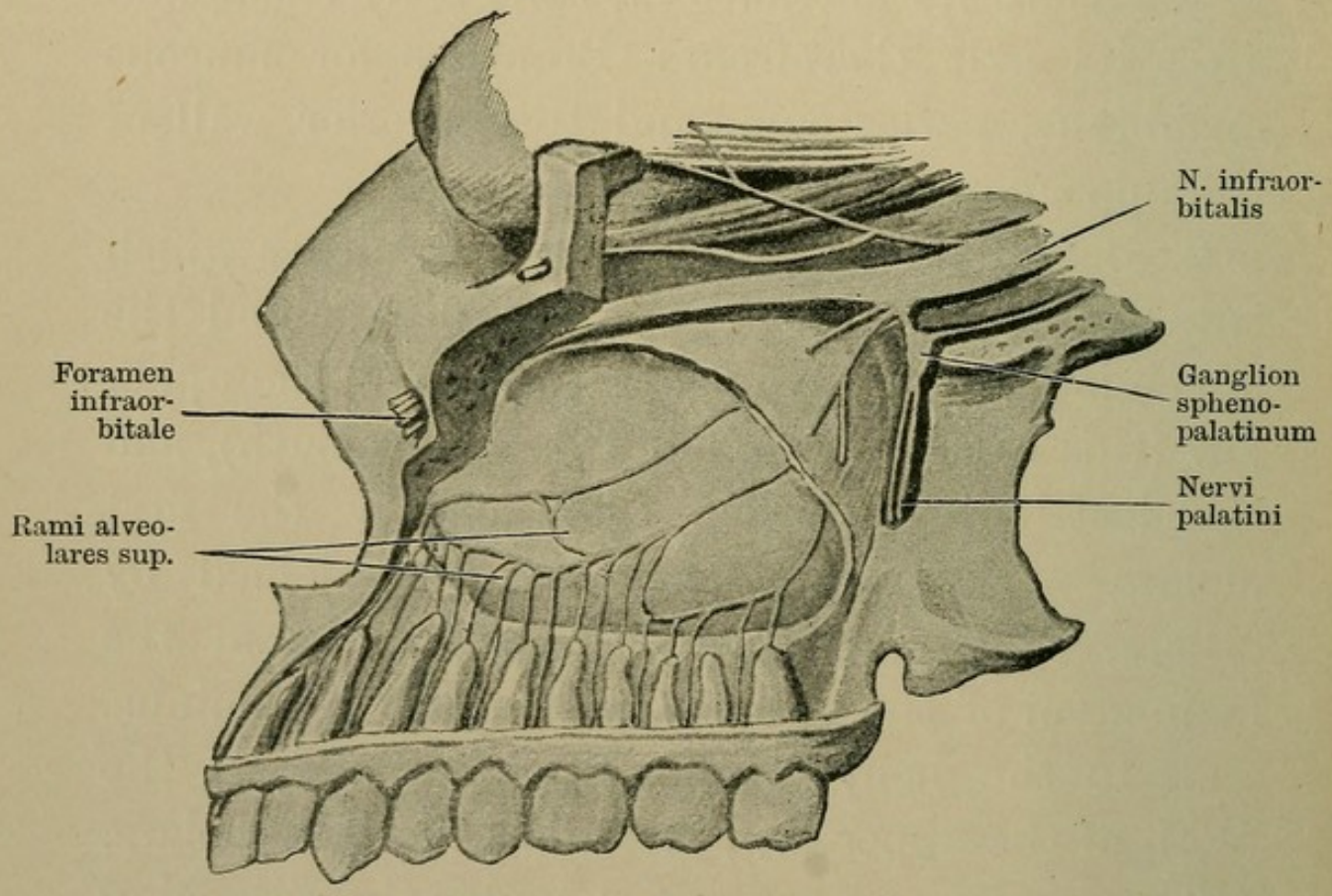

FIG. 13.—NERVES SUPPLYING THE UPPER JAW.

These nerves are connected by an anastomosis (*Bünte*). Of great importance in regard to local anæsthesia is the fact that the nerve fibres which pass to the dental roots from the dental plexus lie close against the anterior and lateral

wall of the upper maxilla, which is here exceedingly thin.

As regards anæsthetization of the superior maxilla, we have seen that for small foci on the anterior surface circular anæsthesia by deep injections is quite sufficient. If the focus is situated close to or above the point of exit of the supra-orbital nerve, it is advisable to infiltrate this point with especial thoroughness. Attempts to anæsthetize the whole upper maxilla by injections into the pterygo-palatine fossa (*Matas*) have led to no practically useful results, and, in view of the fact stated above, that the second ramus of the trigeminus often shares directly in the innervation, they can hardly be regarded as very promising.

Local anæsthesia is of very great practical importance in regard to dental surgery, especially for extractions. It is true that in many cases, especially when the tooth is quite loose, the extraction may be rendered painless, or, at any rate, less painful by ethyl chloride. The method, however, is very imperfect, and is steadily giving place to more recent ones. As need hardly be said, it is necessary, when ethyl chloride is employed, to operate very quickly, and the pain following the operation is often very severe. Ethyl chloride is useful, however, for the incision of small periosteal abscesses,

which are completely frozen and then quickly incised.

For the great majority of dental operations conduction anæsthesia is the most suitable method. We have seen that between the terminal stem of the *N. dentalis* and the periosteum covering the anterior bony surface of the upper maxilla there lies a very thin bony lamella. That an anæsthetic solution, injected submucously or subperiosteally, can be forced directly through the bone into the neighbourhood of the nerve is, I think, placed beyond doubt by experience with Bier's method of "venous" anæsthesia. Thus Schleich's procedure has been to infiltrate (to the point of œdema) with his dilute (0·1 per cent.) cocain solution the gum and periosteum in the neighbourhood of the dental alveolus, carrying the infiltration to a level above the entry of the nerve into the tooth, and then to use the ethyl chloride spray as an auxiliary. This method is now generally abandoned in dental practice, for experience has shown that it is not necessary to bring pressure to one's aid in order to ensure that the solution shall pass through the bone and reach the nerve, but that it is, on the contrary, sufficient to inject a "deposit" of a concentrated solution just over the bone, the solution then reaching the nerve by diffusion. It is true that we always inject under pressure on the lingual side, where the mucous membrane is pretty

closely attached to the periosteum. Even here, however, it is not to be assumed that pressure plays any important part in bringing about the anæsthesia, for, in the first place, only a small quantity of solution is injected, and, in the second, diffusion through the bone is not here in question, as our object is to affect merely the branches of the palatine nerves running between the mucous membrane and the periosteum. These nerves, however, have nothing to do with the innervation of the dental pulp. Experience has fully proved the applicability in this connection of anæsthesia by interruption of conduction. It is only necessary to employ concentrated solutions and fairly large additions of suprarenin. Drug absorption, however, appears to take place in very marked degree in the neighbourhood of the teeth, and with the use of cocain and suprarenin, symptoms of poisoning, fortunately, as a rule, of a quite transitory character, have been observed in a large number of cases. Since the introduction of novocain such toxic symptoms have, according to many observers, ceased to appear.

For dental extractions to-day 2 per cent. novocain solution + 1 minim of suprarenin to each cubic centimetre is generally employed. For difficult extractions a slightly larger dose of suprarenin is taken (3 to 4 minims per 2 c.c.). For operations on dentine, resection of fangs, and other operations

hardly coming within our purview, a 1 per cent. novocain-suprarenin solution is generally employed. According to the great majority of observers this mixture of novocain and suprarenin causes no injury to the tissues. As, however, extraction of teeth is always accompanied by more or less damage to tissues, sometimes even by œdema, it is not yet possible to speak decidedly on the point. A still larger volume of experience will be necessary before we can decide whether the free dosage of suprarenin here requisite is, in reality, quite harmless to the tissues. In order to make the injection itself painless to very sensitive patients, a pledget of cotton-wool soaked in 20 per cent. novocain solution may be kept applied to the mucous membrane for ten to fifteen minutes previously.

In order to render painless the extraction of an upper tooth, we elevate the lip and inject 0·5 to 1·5 c.c. of 2 per cent. novocain-suprarenin solution on the labial side of the tooth, passing the needle horizontally deep into the space between mucous membrane and periosteum over the affected tooth, at the level of the fold where the labial or buccal mucous membrane passes over to that of the gums. For the two last molars, however, whose nerves course over the bone above the tuber maxillæ, we inject the solution behind the easily felt zygomatic process in a more vertical direction.

We always inject from within outwards, so that the solution leaves the needle at a point above, and somewhat lateral to, the tooth to be anæsthetized. For injection on the lingual side but little solution is required, 0·25 to 0·5 c.c., so that for the extraction of one or two teeth hardly more than 0·2 c.c. of solution is required in all. The solution is injected deeply into the gum on the lingual side of the tooth. Fairly strong pressure is needed, as the mucous membrane and periosteum are closely connected. Infiltration of the point of exit of the palatine nerves is only necessary where a number of teeth are to be extracted. If it is desired to "catch" the *N. palatinus* anterior at a central point, it will be necessary to inject also at the foramen incisivum of the *N. nasopalatinus*, as the two nerves are connected by a loop. The point of exit of the *N. palatinus anterior* lies opposite the last molar tooth, and about 1 centimetre mesial to it, that of the *N. nasopalatinus* in the middle line, $\frac{1}{2}$ to 1 centimetre behind the central incisor teeth. The period of waiting required is about five minutes. After ten minutes one may be sure that the effect will be fully developed if the injection has succeeded at all.

For operations on the hard palate it is sufficient to bear in mind the above-mentioned points of exit. A 1 per cent. solution generally suffices, as also for operations on the soft palate, which is either

infiltrated diffusely or cut off from its sensory nerves by a semicircular injection along the border between soft and hard palates.

There remains to be considered the method of producing anæsthesia for the operation of opening the antrum of Highmore. This can almost always be successfully performed under local anæsthesia. If the antrum is to be opened through an alveolus the procedure is exactly the same as for an extraction, except that the anterior surface should be somewhat more freely injected. Trephining the antrum, by way of the anterior surface of the maxilla, is also free from difficulty as regards local anæsthesia.

Free submucous infiltration is made, with 1 per cent. novocain-suprarenin solution, of the whole of the anterior surface in the neighbourhood of the selected site of operation. In addition, the needle is passed as high as possible in order to leave a few cubic centimetres of solution about the point of exit of the infra-orbital nerve. After waiting five minutes the trephining can then be carried out quite painlessly.

By this latter method the mucous membrane is anæsthetized over the greater portion of the facial wall of the antrum. If, however, the mesial wall here is to be interfered with, the mucous membrane must, after the opening has

been made, be painted with 20 per cent. novocain solution.

For the opening of Highmore's antrum from the lower nasal passage, injection into the muco-periosteal covering of that region is sufficient. If the opening is to be made from the border of the pyriform aperture, deep injections from the mouth, pushed to the extent of elevation of the periosteum, will produce a sufficient anæsthesia; the cutting of the bone is, however, generally found hard to bear owing to the vibration caused by the trephine.

The nerve supply of the lower maxilla is as follows (Fig. 14):

1. The *N. alveolaris inferior* supplies the periosteum and pulp of all the teeth, as also the gums and alveolar periosteum on their labial side.

2. The *N. lingualis* supplies the lingual side of gums and alveolar periosteum.

The *N. alveolaris inferior* enters the lower jaw-bone on its medial side at the so-called lingula. Before it enters the bone it runs for a space along the inner surface of the latter about $1\frac{1}{2}$ centimetres behind the *N. lingualis*. During its course within the bone the *N. alveolaris inf.* gives off branches for the dental roots (*Plexus dentalis inferior*) and the gums. One branch, the *N. mentalis*, emerges from the bone about opposite

the first bicuspid—the point of exit is not very constant—and takes part in the innervation of the labial gums. In the middle line there are numerous anastomoses between the nerves.

As regards the anæsthetization of the teeth of the lower jaw, the general principles laid down above in connection with the upper jaw apply here *mutatis mutandis*.

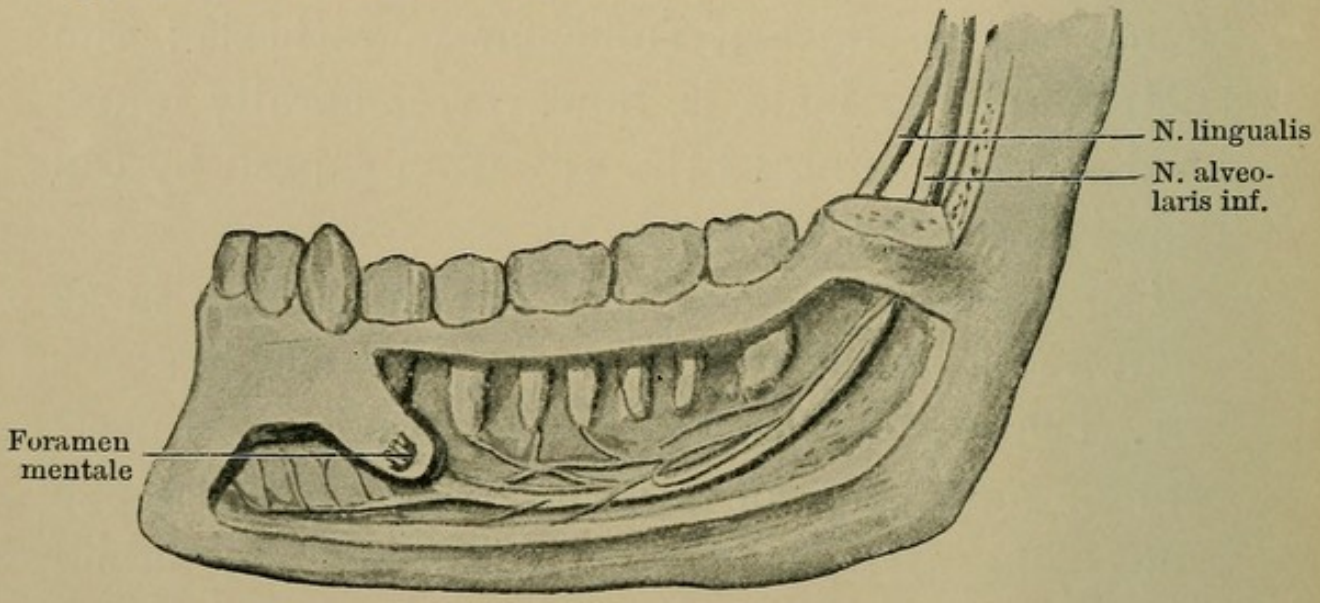

Fig. 14.—Nerves of the Lower Jaw.

Many dentists employ for all the lower teeth, at any rate for all single extractions, the method of sub-gingival injection above described. The majority, however, while adopting this method for the mesial teeth, including the canines or even the first bicuspids, employ the method of anæsthesia by interruption of conduction in the *N. alveolaris inf.* for the lateral teeth. Others, again, combine both methods.

Interruption of conduction in the inferior

alveolar nerve, and in the lingual nerve, after Halsted's method, is not an easy matter for the beginner in local anæsthesia, and gives good results only to those of wider experience. The technique has been elaborated chiefly by Hübner and Braun: the mouth being open, the sharp anterior border of the coronoid process of the lower jaw is felt behind, and slightly lateral to, the third molar tooth, a little internal to this again is another bony ridge, the *linea obliqua* (*interna*). Close to this, and about one centimetre above the masticatory surface of the molars, lies the lingual nerve immediately beneath the mucous membrane. Passing now backwards in a direction parallel to the upper surface of the molar teeth, and keeping close to the bone, one comes upon the inferior alveolar nerve about $1\frac{1}{2}$ centimetres behind the lingual, and just before its entry into the bone.

The solution generally used for injection here is a 2 per cent. novocain solution + 1 to 2 minims of suprarenin per cubic centimetre. The index finger is passed into the mouth over the last molar tooth, until the extremity of the nail, the surface of which looks towards the middle line, meets the linea obliqua. The needle is then inserted about 1 centimetre above the last molar (not too far in a mesial direction) until the bone is felt; it is then withdrawn slightly, and about

·25 c.c. injected for the *N. lingualis.* For the *N. alveolaris inf.* the needle is pushed on backwards for a distance of 1½ centimetres, always keeping close to the bone and maintaining a direction parallel to the molar masticating surface. During the passage of the needle the remainder of the solution is injected, thus about 1 c.c. in all. (Fig. 15.)

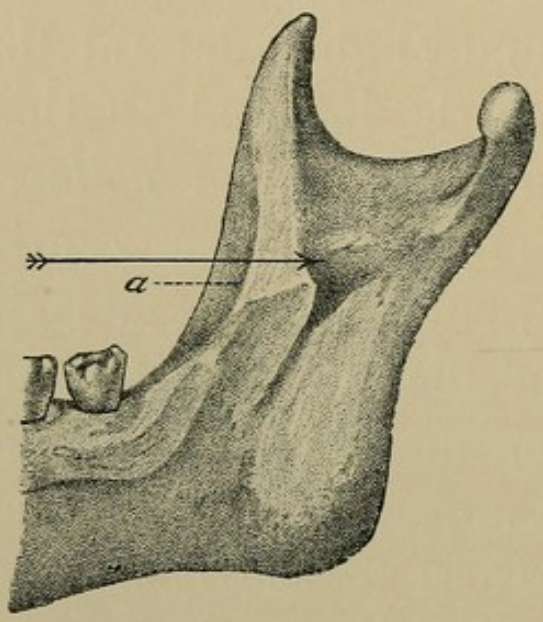

FIG. 15.—ANÆSTHETIZATION OF THE INFERIOR ALVEOLAR NERVE (BRAUN).
a. Bony ridge.

After about 5 minutes anæsthesia comes on in the region supplied by the lingual nerve. For the inferior alveolar nerve it is necessary to wait 20 minutes or, to be safer, half an hour. Failures are by no means unknown even to practised operators. With a view to their avoidance, Bünte has recommended that, in view of an anastomosis which is frequently present, some solution shall be injected at the point of exit of the *N. mentalis* (below the first or second bicuspid). It may be further pointed out that the point of entry of the *N. alveolaris inferior* into the bone is at a lower level in children and the aged than in young adults.

In carrying out the sub-gingival method of

anæsthetizing the teeth of the lower jaw, it should be remembered that the bone is thicker and denser on its labial side than that of the upper jaw, therefore the dose of solution injected must not be too small. The technique of injection is the same as already described for the upper teeth, except that on the lingual side the injection must be made at the fold, where the mucous membrane of the gums joins that of the floor of the mouth. It is also important that the solution should be injected a little behind the affected tooth. The method is not quite certain for the lower molars, though the results are often perfectly satisfactory.

As regards other operations in the region of the lower jaw, the most important, from a practical point of view, is the incision of a parulis. Here, where we have to do generally with large inflammatory swellings closely connected with the deeper tissues, circular anæsthesia is not generally found to give the results desired. If, as is most frequently the case, we have merely to open an abscess, Schleich's infiltration method is the most suitable. As has been stated, it is generally possible to infiltrate painlessly the stretched, and only secondarily involved, skin. No wheal is formed, but merely a diffuse œdema. If the infiltration is carried step by step into the deeper tissues, the abscess can generally be

incised painlessly, and the wound then somewhat enlarged. If it is necessary to deal with the bone itself, which in these abscesses is seldom the case, it is safer to anæsthetize the inferior alveolar nerve by the method we have described, and, in addition, to inject the whole area of operation. As a rule, however, general anæsthesia is to be preferred in these cases, especially as a certain amount of immobility of the jaw often prevents injection of the nerve.

For operations on quite superficial morbid foci affecting the lower maxilla, the method of circular analgesia with a special injection at the point of exit of the *N. mentalis* will be found to answer every purpose.

It is easy also to produce a satisfactory anæsthesia for operations on the middle ne, as, for instance, suture of a broken maxilla. A fairly long needle is inserted at the chin and a free infiltration, subcutaneous, submucous, and, so far as possible, subperiosteal, is carried out, both before and behind the bone, with 1 per cent. novocain solution. A finger inserted into the mouth feels and controls the needle through the labial or lingual mucous membrane. One needle puncture is generally sufficient in view of the free movability of the skin. If a tooth has to be extracted, the neighbourhood of its alveolus must be specially freely infiltrated; free sub-

cutaneous infiltration is then carried out on either side of the line of incision, the lips being of course also infiltrated if necessary. It is not necessary to infiltrate specially about the mental foramen.

If the area of operation is more laterally situated conduction is first interrupted in the inferior alveolar and lingual nerves in the manner already described, the soft parts involved being then anæsthetized by circular infiltration. In suture of the horizontal ramus of the lower maxilla this interruption of conduction is, according to Braun, not necessary. From points about 2 centimetres on either side of the point of fracture he infiltrates the anterior and posterior surfaces of the bone, and also the subcutaneous and submucous cellular tissues, as described above for operations on the middle line. After exposure of the fractured ends he injects a little concentrated solution into the lateral opening of the bony canal for the nerve.

Of other operations about the lower jaw mention need only be made of extirpation of glands from the submaxillary region, which, unless the glands are adherent to the subjacent tissues, can be carried out quite painlessly under circular analgesia (using preferably 1 per cent. novocain solution).

The same applies to operations on the cheek and the floor of the mouth.

As regards operations on the tongue—it is

only for the anterior half of the organ that local anæsthesia comes into question at all—the method of circular analgesia is quite effective. Braun first anæsthetizes the tip of the tongue by submucous infiltration, and passes a strong retaining thread through it. It is not possible to produce with certainty anæsthesia of any part of the tongue by interruption of conduction in the larger nerve trunks.

No attempt should be made to operate on large carcinomata of the tongue under local anæsthesia, as in these cases the glands are almost always involved, and a complete and radical removal is necessary.

CHAPTER IX

OPERATIONS ON THE CERVICAL REGION

Although the internal organs of the cervical region are in chief part supplied by three nerves (*auricularis magnus*, *cutaneus colli*, and *supra-clavicularis*), which are fairly easily reached at the point where they emerge at the posterior border of the sternocleido-mastoid, the anæsthetization of these nerve-trunks has not, in consequence, apparently, of the numerous anastomoses between these and other nerves in the neighbourhood, established itself as a practical method. For the most important operations in this region, extirpation of cervical glands and strumectomies, the method of circular analgesia is exclusively employed.

In the extirpation of cervical glands, however, local anæsthesia is but of limited application, and must not be employed save where the glands are fairly superficial, and are easily separable from their surroundings. For the removal of small glands a free infiltration is made of 1 per cent. novocain solution, a 0·5 per cent. solution

being employed if the area of operation is more extensive. In those cases, however, where a long chain of larger and smaller glands extends into the deeper tissues along the large bloodvessels general anæsthesia must be resorted to in preference; otherwise one will frequently be placed in the embarrassing position of having to continue under general an operation begun under local anæsthesia. For the simple incision of lymphadenitic abscesses the rules above laid down with reference to parulis hold good.

The matter is more complicated, however, if it is desired to scrape out an abscess cavity which extends deeply and is adherent to the subjacent parts, so that it is impossible to inject all round it. In such a case we must adopt Schleich's method, and, as the incision is deepened, infiltrate step by step the deeper layers, always proceeding from the healthy towards the diseased tissues. This rule should be strictly adhered to. On the other hand, in removing an aseptic cystic tumour which is connected with the deeper tissues, so that the method of primary circular anæsthesia is impracticable, the deeper layers may be infiltrated directly from the operation wound. At the same time the beginner, at any rate, should realize that in all these conditions it is inadvisable to form too wide a conception of the indications for local anæsthesia.

Local anæsthesia has very rapidly advanced in the favour of surgeons for the removal of a bronchocele. Formerly the greater part of the operation could be carried out painlessly; as soon, however, as it came to the actual dislocation of the thyroid gland, the methods then in use failed as a rule. As methods have been perfected it has become possible to secure that this part of the operation also shall be performed painlessly in the majority of cases. There is still a good deal of difference of opinion with regard to the proportion of cases in which local anæsthesia is indicated. Many operators always remove the thyroid gland, even in cases of retrosternal extension, under local anæsthesia; it must be admitted, however, that in the more difficult cases of thyroid excision the anæsthesia is by no means completely to be relied on, especially during the luxation of the gland. The solution generally employed is a 0·5 per cent. novocain-suprarenin solution. As regards the dosage of suprarenin, marked differences of opinion prevail. Bier, for instance, adds 1 minim and Hackenbruch 4 minims (both non-synthetic suprarenin) to each 10 c.c. of solution. I have found the addition of 1 to 2 minims of synthetic suprarenin per 10 c.c. answer every purpose.

In small bronchoceles, for which not more than 50 or 60 c.c. of solution are required, it is, in my opinion, quite suitable to employ a 1 per cent.

novocain solution. Of the 0·5 per cent. solution we may inject without misgiving 100 c.c. or more. Some surgeons use alypin (0·5 to 1 per cent. solution) + suprarenin, and also report good results.

The technique of circular injection in these cases is very simple. It is best to inject at four points (which may be first rendered anæsthetic by the cutaneous wheal method), first at the border of the sterno-mastoid deep into the connective tissue surrounding the bronchocele, in the direction followed by the great bloodvessels, and then above and below as deeply as possible beneath the fascia. A complete surrounding injection of the deeper tissues is often impossible; it is, however, sufficient to pass the needle as far as possible under the tumour. The injection of the deeper tissues must follow the circular subcutaneous injection. Finally, the neighbourhood of the isthmus is injected. To guard against injecting into a vein the needle should be withdrawn after making the puncture, so as to satisfy oneself that no blood issues. As an additional precaution, the needle may be kept constantly moving during the injection. After the injection is completed, sufficient time (at least ten to fifteen minutes) must be allowed for anæsthesia to develop. The anæsthesia will last long enough unless the operator is abnormally slow. Morphine is administered beforehand to excitable patients by many surgeons. Hacken-

bruch gives two doses of tincture of opium, the first an hour and the second half an hour before the operation, and maintains that, in this way, the vomiting often observed during the operation when morphine has been injected is avoided. In my opinion, however, better results are obtained without the use of narcotics.

Among other operations on the cervical region tracheotomy can be performed satisfactorily under circular anæsthesia. The needle is inserted on either side, a centimetre or two from the middle of the line of incision, and a 0·5 or 1 per cent. novocain + suprarenin solution is infiltrated into the surrounding tissues, with special thoroughness into the deeper tissues at the sides of the trachea and around the lower part of the larynx, finishing with a subcutaneous infiltration.

For the anæsthetization of the laryngeal mucous membrane it is generally sufficient to apply a 20 per cent. novocain solution to which 3 minims of suprarenin per cubic centimetre have been added. About 3 c.c. of this solution in all are employed, in separate applications, at intervals of three to four minutes. Alypin in 20 to 25 per cent. solution is also employed in these cases by a number of surgeons ; others, again, hold to cocain, maintaining that it is the most reliable anæsthetic for this mucous membrane. As, however, 20 per cent. solutions are generally necessary, the need

for some method other than that of external application to the membrane has been strongly felt. Frey has anæsthetized the laryngeal mucous membrane by interruption of conduction in the nerve which supplies it, the superior laryngeal.

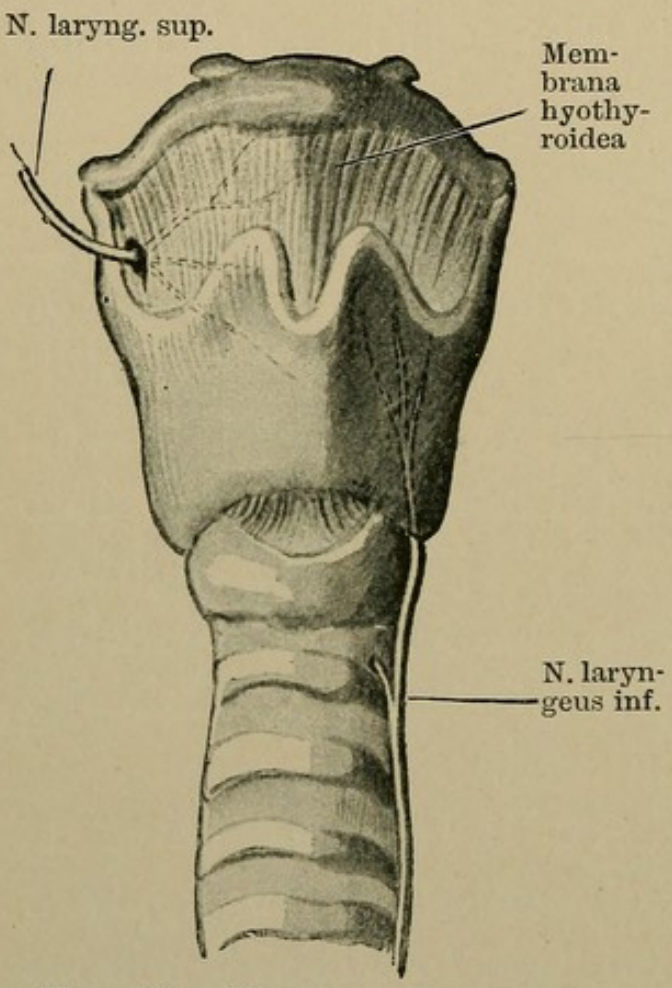

FIG. 16.—NERVES OF THE LARYNX.

This nerve supplies the mucous membrane, from the epiglottis to the vocal cords, with sensory fibres. Below, the glottis fibres of the inferior laryngeal nerve also take part in the innervation, so that here the anæsthesia is no longer reliable. The superior laryngeal nerve passes through the hyothyroid membrane into the larynx, and can be reached at the point at which this passage takes place (Fig. 16). About 1 c.c. of a 2 per cent. novocain-suprarenin solution is injected on either side, the operator selecting a point midway between the greater cornu of the hyoid bone and the upper border of the thyroid cartilage, and, in strong adults, about 3 centi-

metres from the middle line. The needle is passed horizontally and slightly towards the middle line. The patient is told not to swallow during the injection, as this causes a change in the relative positions of the parts. The solution is ejected at the point where the nerve enters the membrane—some surgeons pass the needle through the membrane and then inject. The anæsthesia reaches its height in from ten to fifteen minutes, and lasts in usable degree for about twenty minutes. It may, however, last much longer, even in some cases from one to two hours. It is, of course, necessary to add to the injection a local application to the fauces in order to cut off the faucial reflex.

Recently (*Bier*) many major operations on the larynx—in particular, extirpation—have been carried out under local anæsthesia. For this, interruption of conduction in the superior laryngeal is not sufficient. It is necessary, in addition, to inject around the whole larynx with 0·5 per cent. novocain-suprarenin solution. Two cutaneous wheals on either side of the larynx are generally sufficient, so far as the skin is concerned. The deeper parts on either side of the larynx and trachea are freely infiltrated, and a circular subcutaneous infiltration is added. If the technique for anæsthesia of the superior laryngeal is correctly carried out, the local application to the mucous

membrane, which formerly accompanied the circular injection, will be found hardly necessary.

Circular anæsthesia is quite reliable for the incision of boils or carbuncles at the back of the neck In view of the rich blood-supply in this region, the dose of suprarenin should not be too small. In very large carbuncles it is often not an easy matter to ensure complete painlessness if the latter is to include, as is, of course, to be desired, the injection itself. As the inflammation here extends far into the deeper tissues, it is often necessary to inject subcutaneously into the healthy area all round the carbuncle (preferably with 1 per cent. solution), and then, after allowing a short time for the diffusion of the solution, to proceed to infiltrate gradually the deeper parts. In order to ensure complete anæsthesia it is necessary to inject freely beneath the inflamed area, for, in the first place, fairly large sensory branches pass outwards through the fascia ; and, secondly, the pressure of the knife in making the incision causes a compression of the deeper parts which, if the anæsthesia be incomplete, gives rise to severe pain.

CHAPTER X

OPERATIONS ON THE THORAX

Operations on innocent mammary tumours are particularly suitable for local anæsthesia. The ordinary surrounding injection, with, if the tumour is extensive, an infiltration of the retro-mammary tissue, is sufficient in all cases.

For malignant tumours of the breast, on the other hand, local anæsthesia must be entirely discarded, since, even if the removal of the mamma itself were possible, the radical extirpation of the axillary glands could not be carried out painlessly under any local anæsthetic method.

Operations for suppurative mastitis are quite feasible under local anæsthesia, especially if one confines oneself to small incisions and then employs Bier's suction apparatus. In circumscribed suppurations one can, of course, inject all round the diseased focus. In the more severe cases, however, it is best to have recourse to Schleich's infiltration method. The stretched and only secondarily inflamed skin as a general rule admits, as is the case with gumboils, of the

injection being carried out painlessly. It is necessary here, however, to operate with great caution and to avoid interference with the deeper parts of the inflamed area. For manipulations of the latter kind, especially for dilatation of the abscess with the finger or with forceps, local anæsthesia is only effective if injections are made all round and beneath the area of operation.

In puncture of the pleura, infiltration of the subcutaneous and deeper tissues will enable the small operation to be carried out quite painlessly.

Of operations on the bony thorax, the one most commonly performed under local anæsthesia is the resection of ribs for the evacuation of an empyema. We have seen in a previous chapter that it is not always necessary to inject beneath the periosteum in order to render the bone anæsthetic by interruption of conduction, but that it is often sufficient to inject freely into the deeper tissues adjoining the periosteum. Two points therefore are marked, one below and one above the middle of the chosen line of incision, and from these 1 per cent. novocain-suprarenin solution is injected all round the section of bone to be removed so that it is, so far as is practicable, bathed in the solution. We inject first at the lateral then at the mesial border beneath the rib, then in the deeper tissue-layers above it. It is advisable also to bathe the rib in anæsthetic solution at the middle of the line of

incision ; so that we have here no pure conduction anæsthesia. The whole operation area is then subcutaneously injected. A dose of 50 to 60 c.c. of solution is usually sufficient. Should it not prove so the injection should be completed with 0·5 per cent. solution.

If it is wished to proceed by Schleich's method the subcutaneous cellular tissue and musculature are first infiltrated, then the anterior and posterior borders of the rib, so far as possible subperiosteally. The rib is then resected and the pleura infiltrated separately.

What has been said with reference to the ribs applies also to their cartilages. I have, for instance, carried out entirely painlessly by this method a *Freund's* operation (resection of the first to the fourth costal cartilages). The anæsthetization of the first rib presents some difficulty in these cases. It must be freely bathed in 1 per cent. solution. Here, in view of the near neighbourhood of large bloodvessels, special care must be taken to keep the syringe always in movement during the infiltration.

Anæsthetization for operations on the clavicle is, on the contrary, a very simple matter, for which there is no necessity to add to the rules laid down in the foregoing.

Carious foci in the ribs or sternum can also be operated on successfully under circular anæsthesia,

provided that the extent of the diseased area, and so of the possible field of operation, is accurately known beforehand. It is then only necessary to be sure that the deeper tissues are sufficiently infiltrated. Even when the disease is found to extend farther than was expected it is often possible, with a stout needle, to infiltrate the bone marrow freely from the opening made into the medullary cavity, and so again attain an anæsthetic condition.

CHAPTER XI

OPERATIONS ON THE EXTREMITIES

We are here in a region in which our knowledge is at the present time very largely in a state of flux. Bier's 'venous' anæsthesia has won quite new prospects for local anæsthesia, and we may confidently expect that before long we shall succeed in changing the "encouraging results" and "failures," which are to-day reported, into complete successes. For major operations on the extremities, especially for amputations and resections, local anæsthesia has not as yet, in spite of isolated successes, become really popular; in the lower extremity, spinal anæsthesia has offered a substitute. It is, however, worth endeavouring to supersede this method, which is by no means free from danger, by local anæsthesia, where it can be applied. Wherever possible we shall prefer our older methods to that of venous anæsthesia, if only for their greater convenience.

Among operations on the shoulder and axillary region those on glandular abscesses offer the most frequent occasion for the employ-

ment of local anæsthesia. What has been said above as regards the cervical region applies here also. Foci which are adherent to the subjacent tissues are difficult to anæthetize, unless a superficial incision is all that is required. Only in the case of secondarily inflamed skin should one begin by infiltrating a diseased tissue. In other cases it is necessary, following Schleich's practice, to proceed gradually from the healthy to the diseased tissues.

I have several times operated on subdeltoid bursæ under local anæsthesia. As these are generally connected with the shoulder joint, or at any rate lie very close to it, it is as a rule only possible to infiltrate the deeper tissues after incision through the more superficial layers.

Crile has performed an exarticulation of the shoulder by the aid of endoneural injection into the brachial plexus, which he exposed at the posterior border of the sternocleido-mastoid. He injected into each nerve enough solution to produce a slight bulging. The operation was painless, except as regards the skin incision.

I mention the method, because, in exceptional cases, if general anæsthesia is contraindicated, it may be worth considering as a last resort. It should hardly be employed as a method of election.

Most operations on the superficial tissues of the upper arm, elbow, and forearm can be performed

under local anæsthesia. It is employed very frequently for operations on the olecranon bursa. As the posterior border of the bursa is firmly adherent to the bone, it is necessary to infiltrate the deeper tissues thoroughly in order to interrupt conduction in all nerves entering the periosteum.

If it is desired to anæsthetize large areas of skin, *e.g.* for the removal of skin grafts (*Thiersch's* method), the following procedure advocated by Braun may be adopted :

As the nerves of the upper arm, in part at any rate, only pass through the fascia immediately before their terminal ramification, a simple injection around the area of operation is not, in the case, at least, of the more extensive areas, sufficient. The operator therefore marks on the outer aspect of the arm eight or ten injection points about $2\frac{1}{2}$ centimetres distant from each other, and from these infiltrates the subcutaneous cellular tissue backwards and forwards in slanting lines. The solution is then distributed by gentle massage movements. A 0·5 per cent. novocain solution with a small addition of suprarenin is the most suitable, and is to be preferred to the cooling by ether spray recommended by Braun. If more than 100 c.c. of solution are required, the further infiltration, if the operator hesitates to use more of this solution, should be made with one of ·25 per cent. strength.

Schleich's method of endermal infiltration appears quite unsuited for this operation, apart altogether from its complexity, as it is here especially necessary to avoid any treatment likely to injure the tissues.

The anatomical distribution of the nerves above described is to be borne in mind also in the case of other operations, especially those on tumours of considerable size. Where the area of operation is extensive it is always necessary to inject beneath as well as around it. In the forearm, it is true, most of the nerves run subcutaneously for considerable distances; the only exit of a larger nerve through the fascia being that of the superficial radial nerve. For the majority of operations, therefore, an oblique, circular, or semicircular injection will suffice. Variations in the course of the nerve are, however, sufficiently frequent to indicate the method of injecting beneath as well as around the operation area as the one to be generally employed.

Of major operations, amputation of the forearm especially has been frequently performed under Schleich's infiltration anæsthesia. Each layer of tissues must here be separately infiltrated. In view of the large quantity of solution required, it is best to employ a ·25 per cent. novocain solution. Nerve-trunks must be treated with special thoroughness. After division of all soft parts, a

very free subperiosteal infiltration is necessary. Schleich has performed amputations of the forearm and leg under this method.

In general, however, this method may, in such operations, be replaced by Bier's venous anæsthesia, which is applicable to operative procedures up to the junction between the lower and middle thirds of the upper arm. In practice it would find most frequent and suitable application in resections of the elbow and in operations on large osteomyelitic foci. Anæsthesia comes on sooner in the arm than in the leg, on account of the smaller calibre of the former. The indirect anæsthesia also generally comes on in a few minutes. Fifty c.c. of solution will always suffice. The anatomical relations of the veins and the method of finding them are described above (p. 89, Figs. 5-9). Direct anæsthesia is indicated for elbow resections and operations on the arm. For operations on the forearm Bier prefers the indirect anæsthesia on account of the difficulty sometimes observed in carrying out the injection owing to the presence of the valves in the veins.

For successful anæsthetization of the fingers and hands, it is of the greatest importance in the first place to understand the course of the sensory nerves supplying the fingers. In practice the chief point to bear in mind is that two pairs of nerves, a radial and an ulnar,

a dorsal and a volar nerve, run fairly close to the bone (*vide* Fig. 17). On this fact is founded the so-called Oberst's method of interruption of conduction in the nerve-trunks at the base of the fingers, which, with Corning's experiments, constitutes the foundation for the whole theory and method of anæsthesia by interruption of conduction. Oberst used an elastic ring, slipped over the finger as a tourniquet. Later, a thin rubber band was wound round the base of the

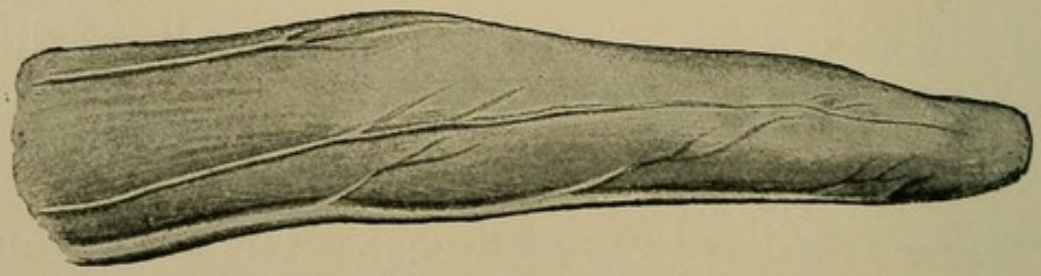

FIG. 17.—COURSE OF NERVES SUPPLYING THE FINGERS.

finger, the ends being crossed over the back of the hand, carried round the wrist, and either tied in a knot or held together by forceps.

The use of suprarenin preparations in operations on the fingers has rendered these methods of cutting off the blood-stream more or less unnecessary. It is, however, advisable, especially in operations on the base of the fingers or at a still more central point, to slow down the blood-stream considerably. In such operations, therefore, we apply (not tightly, so that little or no pain is caused) a rubber band round the lower third of

the forearm, and then inject 1 per cent. novocain solution, either without or with only a very small addition of suprarenin. If, on the other hand, no constricting band is applied at all, it is advisable to use 2 per cent. novocain solution + suprarenin (1 to 2 minims per c.c.).

In operations on the palm of the hand, 1 per cent. novocain solution is employed. It is not necessary in finger operations to inject always at the base of the finger. The only essential point is that the injection be made in healthy tissues. Thus, in operations about the nail we may inject at the level of the last phalangeal joint, and only a small quantity of solution need be used. If the area of operation be quite peripheral, 1 per cent. solution will be found effective without tourniquet, in view of the minimal calibre of the nerve-branches in the affected area.

The following technique of injection has given me satisfactory results (*vide* Fig. 18): At the base of the finger and a little to each side of the middle line of the dorsum an injection point is marked (ethyl chloride or wheal anæsthesia). From these points the injection is made. Say we commence at the radial point. The needle is introduced and passed a little way towards the volar surface, $\frac{1}{2}$ c.c. of solution being injected in the neighbourhood of the dorsal radial nerves. The needle is then pushed on fairly close to the

bone, and another ½ c.c. injected in the neighbourhood of the volar nerves. The same proceeding is carried out on the ulnar side. Anæsthesia comes on from five to ten minutes after the injection. Any operation, either on the soft parts or on the bones, can then be painlessly carried out. The operation must not be begun until the finger-tip is quite insensitive. In small superficial foci, especially on the dorsal surface, it is often sufficient to infiltrate a strip on the central side of the operation area. One must always, however, reckon with irregularities of the nerve-supply, or anastomoses, so that it is generally advisable, in order to feel quite safe, to inject a little solution around the affected area. It is not generally necessary to inject beneath it.

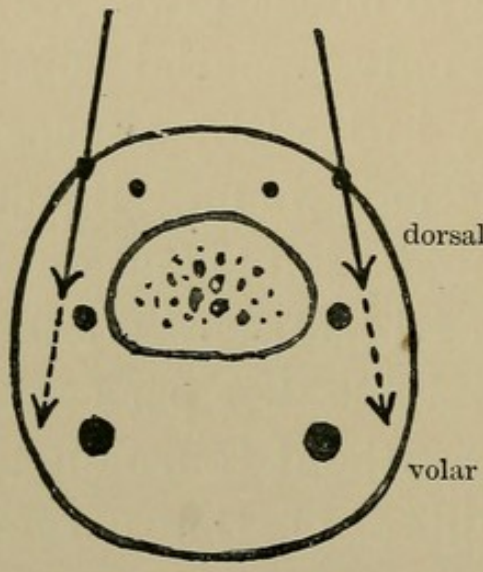

FIG. 18.—INJECTION OF THE FINGER.

In operations on the base of the fingers and up to the metacarpo-phalangeal joint the injection is carried out on either side of the metacarpal bone (*mutatis mutandis*), as described above for the peripheral portion of the digit, care being taken that the injection is made at a sufficient distance from the diseased area. In these cases, however, rather more than 2 c.c. of solution must be

employed. In view also of lateral anastomoses, supplementary subcutaneous injections must be made at the sides with more dilute (1 per cent.) solution.

As regards operations on the hand, it is important to bear in mind the point of exit of the median nerve at the ulnar border of the ball of the thumb.

In operations about this region this point must be freely infiltrated. In general there are so many anastomoses among the nerves of the hand, both lateral and also between dorsal and volar nerves, that nothing can be done by interruption of conduction in single nerve-trunks.

On the dorsum of the hand the anæsthetization of any superficial operation area presents no difficulty. If the affected area be small, injection around it is sufficient; if larger, it will be necessary to inject beneath it also. Of course, if the operation be at the periphery, the form of the injection must be semicircular or wedge-shaped, instead of circular, and with the base toward the periphery.

Operations on the periphery of the palm give favourable opportunity for anæsthesia by semicircular injection. Novocain solution (1 per cent.) and suprarenin should always be employed. It is often advisable, especially if the operative procedure is somewhat complicated, to apply a rubber band, not too tightly, round the forearm. Up to about the middle of the palm (reckoning from

the periphery), operations on the deeper tissues (tenotomy) may also be performed in this manner. Where possible, the injection points should, in view of the sensitiveness of the skin of the palm, be in the interdigital spaces. In the central half of the palm only superficial foci should be attacked by the simple method of injection around and beneath the affected area.

Dupuytren's contracture may be operated on in this way if a thorough injection is made beneath the parts to be removed. The thumb and the ball of the thumb may also be cut off from their sensory supply by this method, a free and deep injection being made at the ulnar border of the thenar eminence.

Braun has recommended for larger operations on the hand a method of interruption of conduction in the three main nerve-trunks—ulnar, radial, and median—above the wrist. The technique is not altogether simple, nor are the results, in my experience, quite certain. The method (Fig. 19) will, perhaps, in the future be superseded by Bier's venous method.

The procedure is as follows: Two per cent. novocain solution is employed + 1 minim of suprarenin per cubic centimetre. Of this solution 1 c.c. is required for each nerve.

Injection for the median nerve: Above the wrist, at the ulnar side of the *M. palmaris longus.*

The needle is passed beneath the muscle and pushed onwards for a distance of about $1\frac{1}{2}$ centimetres.

For the ulnar nerve: Three finger-breadths above the wrist, between the ulna and the tendon of the *M. flexor carpi ulnaris*, the needle to be passed under the tendon and inserted altogether about 2 centimetres. A circular injection (1 or ·5 per

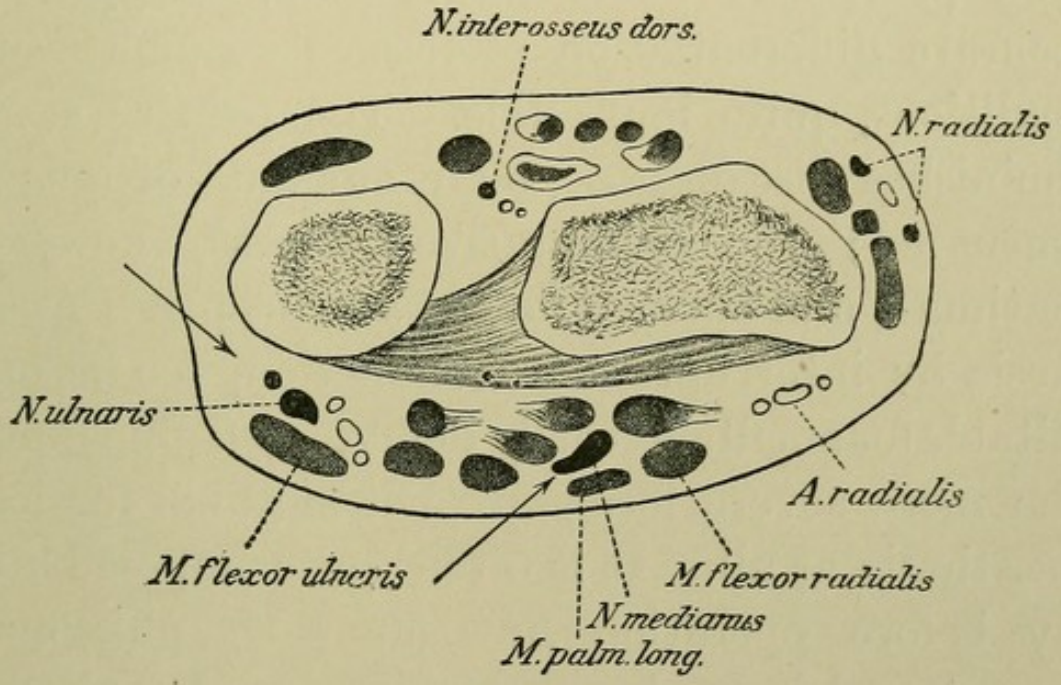

Fig. 19.—Anæsthesia of the Whole Hand by Interruption of Conduction (after Braun).

cent. solution) round the forearm immediately above or below the capitulum ulnæ should supplement the foregoing, and this suffices for the radial nerve. For the region supplied by the median especially the method is not very trustworthy.

Finally, a few words may be said in connection with phlegmonous conditions, especially phlegmon of the sheaths of the tendons.

In the first place, the surgeon cannot be too strongly warned against the use of ethyl chloride, except in the case of quite small cutaneous or subcutaneous foci. Those who have much to do with the treatment of phlegmonous processes see, far too often, cases of suppuration in the sheaths of tendons in which a small superficial incision has been previously made under cold, though any accurate differentiation of tissues is, under such conditions, quite impossible. The pain ceases or diminishes because a small amount of pus is evacuated; the suppurative process, however, continues, and spreads deeper and deeper. Anæsthesia by interruption of conduction, too, is only suitable for small and easily demarcated phlegmons. The more severe forms are not suitable for local anæsthesia at all. It is often quite impossible to say before operation how far such phlegmons extend, and it is always to be remembered that, apart from the obviously inflamed lymphatics of the arm or forearm, there are often microscopic bacterial infiltrations, in the neighbourhood of the phlegmonous focus, which involve serious risk of spreading infection by an injection made in apparently sound tissues. Thus, I once saw a fairly extensive necrosis of the subcutaneous fatty tissue follow injection around and incision of a so-called interdigital phlegmon—a complication which, though it was fortunately recovered from

without bad effects, caused an inconvenient delay in recovery. As I have never, with this exception, seen any occurrence of the kind, I feel justified in assuming that infectious material was disseminated by the injection among apparently healthy tissues. In the palm, especially, morbid processes affecting the deeper tissues are, in consequence of the tightness of the skin in this region, but very little apparent on the surface. To what extent Bier's venous anæsthesia will supply us here with a thoroughly safe substitute it is at present impossible to say. In Bier's paper the question whether lymphangitic cords along the arm are to be regarded as contra-indicating his method is not alluded to. Even, however, if no superficial inflamed lymphatics are visible, there is always a possibility that the deeper lymph channels may be full of infectious micro-organisms. Whether this does or does not constitute a danger only further experience will show.

As regards the lower extremity the older methods of local anæsthesia do not suffice for any but quite superficial operations on the thigh. For Thiersch's skin-grafting the same rules apply as in the upper arm. It is, however, advisable to note the amount of fatty tissue, and if the layer of fat be well marked, to infiltrate very freely, a point, indeed, to which attention should be paid in all operations on this region.

Operations on the femoral and inguinal glands are only suitable for local anæsthesia when the affected glands are easily separable from the subjacent tissues. Even then free injection around and especially underneath the area of operation with 1 per cent. novocain-suprarenin solution is necessary in order to secure trustworthy anæsthesia. As regards incision of glandular abscesses, what has been stated above concerning parulis and abscesses in cervical glands applies here also. Where the glandular tumour has been adherent to the subjacent tissues I have seldom attained a thoroughly successful anæsthesia, even when, after a superficial injection, a free infiltration after Schleich's method has been carried out during the operation.

For the extirpation of a portion of the saphenous vein the procedure is similar to that given for producing anæsthesia of bone—injection around and beneath the vein after the latter has been made clearly visible by obstruction to the flow of blood within it.

With the help of venous anæsthesia surgeons have now succeeded in carrying out painlessly major operations on the thigh—indeed, anæsthesia of the whole lower half of the thigh has been produced. Bier has carried out three necrotomies in this way. He, however, regards it as doubtful whether the present technique will prove definitely

effective, as the anæsthesia on the outer side of the thigh, where operations of this kind have, for the most part, to be performed, is the latest and most uncertain in its onset, because the solution is injected on the inner side.

Of operations on the neighbourhood of the knee-joint, those on the bursa patellæ offer the most frequent opportunities for the employment of local anæsthesia. Just as in the case of the bursa olecrani, it is possible here to bring about a reliable anæsthesia by injecting with 1 or ·5 per cent. novocain solution + suprarenin, provided an injection is first made as deeply as possible around the bone and followed by a circular subcutaneous injection. Removal of loose bodies from the joint has frequently been performed successfully after injection around the selected site of incision, and subsequently very free infiltration of the deeper parts. I am, of course, speaking only of bodies easily to be felt externally. If one is not sure of reaching the loose body by the first incision, it is suggested by Braun as preferable that the joint shall be filled with ·25 per cent. solution, and a period of ten to twenty minutes be allowed for it to act.

Similarly, in other small operations on the knee-joint (injection of irritant fluids, incision in cases of suppuration, with a view to drainage), the synovial membrane must first be rendered insensitive by

injection of an anæsthetic solution, preferably ·25 to ·5 per cent. novocain solution + 2 minims of suprarenin per 10 c.c. An incision can then be made painlessly, either under circular anæsthesia or under Schleich's infiltration method. Of major operations, Bier has performed several resections of the knee-joint under direct venous anæsthesia. The upper band must not be applied too close to the joint.

In the leg, apart from operations on superficial foci, all operations on the anterior surface of the tibia may be carried out satisfactorily under circular anæsthesia, as above described.

Amputations of the leg have been performed by Schleich and Reclus under infiltration anæsthesia.

Tenotomy of the tendo Achillis can be peformed painlessly after injection around and beneath the tendon.

Braun suggests the following procedure for producing anæsthesia of the whole foot :

Infiltration of the subcutaneous cellular tissue all round the limb above the ankle with ·5 per cent. novocain solution. The same solution is injected beneath the fascia at the anterior surface of the tibia, in the space between the tibia and fibula and behind the tendo Achillis ; finally, 4 c.c. of 2 per cent. solution are employed to interrupt conduction in the tibial nerve. Just above the ankle-joint, where the inner malleolus is at its

thickest, the needle is inserted 1 centimetre internally to the mesial border of the Achilles tendon, and passed straight forward until it meets the bone. It is then slightly withdrawn, and the injection made. Whether or not the method is to be depended on only further experience can show.

For major operations on the leg and foot Bier uses indirect instead of direct venous anæsthesia in all cases where he wishes not to be limited in regard to the extent of the operation area, also when the site of operation is covered with cicatrices, as, under the latter conditions, the vein is difficult to find, and the anæsthesia is apt to be incomplete. The operator must wait till motor paralysis sets in—*i.e.*, generally about fifteen minutes. Of course, all other operations on the leg and foot can also be carried out under indirect anæsthesia.

Direct venous anæsthesia has the advantage that the operation can be begun almost at once. The saphenous vein is easily found anywhere in the leg (*vide* Figs. 5 and 6). In operations on the foot Bier recommends that a rubber bandage shall be applied to the most peripheral parts. If long incisions are necessary, the operation may be carried out partly under direct and partly under indirect anæsthesia. The central tourniquet should be applied just above the knee, the peripheral a little above the middle of the leg. After

indirect anæsthesia has set in the peripheral tourniquet is removed.

What has been said above concerning the upper extremity holds good also for small operations on the foot and toes (small phlegmons, exarticulations, etc.). Here, as there, a tourniquet may be applied to the lower third of the leg in order to deepen the anæsthesia.

The operation for ingrowing toe-nail can, as already stated, be performed satisfactorily under ethyl chloride spray, if the nail be thoroughly frozen and the operation quickly carried out.

For operations in the neighbourhood of the first metacarpo-phalangeal articulation the middle of the metacarpal bone is freely bathed in 1 per cent. novocain solution, the needle being entered at the dorsum. The next step is to infiltrate the tissues bordering the bone on its outer side, carrying the infiltration up to the interdigital fold between the first and second toes. Anæsthesia is more easily and more surely produced in the dorsum of the foot than in the sole.

CHAPTER XII

ABDOMINAL OPERATIONS

The degree of sensibility to pain possessed by the abdominal organs has been a much disputed point. It might, indeed, be supposed that the large number of operations which have been carried out under anæsthesia produced by infiltration of the abdominal wall must by now have thoroughly cleared up the matter. That this is by no means the case we may ascribe to the fact that the abdominal organs exhibit an extraordinary variability in this respect. Thus, apart from the fact that there are unusually marked differences between individuals, the age of the patient, the pathological condition of the organs, and the temperature, are important factors, and may help to explain the wide differences between the views put forward by different observers. According to Lennander, to whom we owe the most detailed investigations of the matter that have yet been made, all parts supplied by the sympathetic are insensitive, sensibility to pain being a function confined to the cerebro-spinal nerves. According

to Ritter, sensibility to pain is associated with the bloodvessels. His experiments on dogs (which have, of course, less inferential value than observations on the human subject) revealed, in all the organs of the abdominal cavity, a sensibility to pain whose intensity depended on the richness of the part in bloodvessels.

The facts of chief practical importance may be here briefly stated:

1. The parietal peritoneum is certainly sensitive to pain, and often the mesentery.

2. The stomach, intestine, omentum, liver, renal parenchyma, and fundus uteri, are insensitive.

3. Inflammatory processes generally heighten insensibility, and this is specially the case in the parietal peritoneum.

4. In the old, sensibility is generally diminished.

5. Reduction of temperature lowers sensibility.

6. There are marked individual differences in sensibility, of which we can at present give no explanation.

In regard to the question whether any given operation is one for which it is suitable to employ local anæsthesia, the following points deserve attention.

It may be laid down as a fundamental principle, that only such operations should be performed under local anæsthesia as can be carried out painlessly to the end. I do not consider it good

practice to make a routine use, as Schleich does, of the combined method—*i.e.*, the employment of general anæsthesia for the more painful parts of an operation which is otherwise carried out under local anæsthesia. The patient has, in the present state of the technique of anæsthesia, the right to be operated on painlessly, and the risks of general anæsthesia, which are really not great when all is taken into consideration, should not be unduly exaggerated. There are, of course, exceptional cases in which the patient's condition is such that no unnecessary drop of chloroform or ether must be used. Often, however, even in such patients a rapid narcosis in the course of the operation requires as much of the anæsthetic as would suffice for the whole operation had chloroform or ether been employed with care and skill throughout. One may, of course, be forced by unforeseen emergencies to call general anæsthesia to one's aid. Thus in case of incarcerated hernia in which we are anxious, on account of pronounced cardiac weakness, to operate under local anæsthesia, the existence of tough adhesions may oblige us to continue the operation under narcosis. So, too, in gastrostomy, which is often performed under local anæsthesia, the stomach may be so contracted that the necessary pull upon it will cause pain. In such case, very frequently, before deciding to continue under general anæsthesia,

the surgeon makes trial once, or perhaps several times, whether he cannot get through without chloroform, and so causes the patient, who has probably received an emphatic promise of a painless operation, unnecessary suffering.

Such *contretemps* should be avoided, if possible, and unless it is absolutely necessary to avoid general anæsthesia, doubtful operations of the kind should be performed throughout under ether or chloroform. The combination of local anæsthesia with morphine-scopolamine narcosis should also be unhesitatingly rejected. I have seen a number of cases in which serious sequelæ manifested themselves, and the number of surgeons who have definitely abandoned the method increases steadily.

It follows, from what has been said, that it is only a comparatively small proportion of abdominal operations that we can perform under local anæsthesia, those, namely, in which, after the abdominal incision, the further operative procedures are confined to certain presenting organs (intestine, omentum) and no dragging or pulling manipulations of any kind are required. In some individuals, it is true, especially some old patients, it is possible to carry out manipulations in the abdominal cavity freely, and, without any special precautions, to pull on the mesentery, and so on. Such cases are, however, exceptional. It is more

usual to find that the mere insertion of a compress between the parietal peritoneum and the intestinal coils is painful, and that any vigorous traction on the sides of the wound with retractors is generally (probably because of the dragging on the parietal peritoneum caused thereby) found by the patient extremely unpleasant.

Schleich infiltrates the abdominal organs, as he does other tissues, to the point of œdema. Those who hold, as most surgeons do, that in abdominal surgery the organs must be handled as gently as possible, can hardly approve of this procedure. One can, of course, infiltrate the pedicle of an ovarian tumour, or the line of incision in a gall-bladder which is to be opened, but operations on the ovaries or the gall-bladder involve other manipulations, such as the drawing forward of the ovarian tumour and the indispensable sounding of the gall-ducts, which are painful, and in which infiltration is of little use.

Infiltration of the wall of the stomach for the purpose of a gastrostomy involves, in my opinion, risk of injury to the tissues infiltrated, and this is altogether apart from the facts that the stomach is itself insensitive, that only the act of dragging on it is painful, and that against this pain local anæsthesia leaves us powerless.

Local anæsthesia, then, in abdominal operations, can do little more than render painless the in-

cision in the abdominal wall. The method now usually employed is a modified form of Schleich's infiltration anæsthesia—that is to say, an infiltration of the parts with somewhat concentrated solutions, which, however, is not carried to the point of causing a maximum degree of œdema, and is, if possible, completed before the beginning of the operation.

This method is often combined with circular anæsthesia of particular regions. If only a small incision is required, and the abdominal wall is thin, we may employ 1 per cent. novocain solution +1 to 2 minims of suprarenin per 10 c.c. For larger incisions ·5 or ·25 per cent. solution is employed, according to the quantity required for the infiltration. The method is most successful in very thin subjects, in whom, in the case of a median incision, the whole infiltration may be completed before the commencement of the operation. The operator first infiltrates subcutaneously to a distance of a centimetre or two from the chosen line of incision, and follows this up with a free subfascial infiltration. In about ten minutes one can count on complete anæsthesia. Only when more room is required for the suture is it necessary, after division of the fascia, to proceed to a further infiltration, on both sides of the incision of the præperitoneal tissue. The same procedure may be adopted away from the median line in

thin subjects, if the region of operation is one in which the muscles and fasciæ are very thin, as, for example, in the formation of an artificial anus, and often also in gastrostomy.

The larger the quantity of fat in the abdominal wall, the more difficult is the anæsthetization, at any rate in patients whose abdominal wall is at all tense. It is then often necessary to anæsthetize the skin itself by the wheal method over the selected line of incision. Then, after infiltration of the subcutaneous cellular tissue, the incision may be carried down to the fascia. The injecting needle—a right-angled one is not absolutely necessary—is then passed under the fascia and the præperitoneal tissue infiltrated, the infiltration being continued farther after division of the fascia.

If large nerves are met with in the area of operation, the solutions employed must not be too dilute (1 per cent. novocain solution). If the incision be a small one, the infiltration may be carried out to the end without change of solution. Here, too, in thin subjects, the whole or the greater part of the infiltration may be carried out before the operation is begun—*e.g.*, in an incision at the outer border of the rectus, in which special attention must be paid to the obliquely-running branches of the intercostal nerves, or in a slanting incision such as is made in cases of perityphlitis, when the ilio-hypogastric and ilio-inguinal nerves

are found running in the deeper muscular layers between the internal oblique and transverse muscles.

In individuals, however, with a larger deposit of fat, an infiltration of the separate layers step by step is required.

I will give here the technique for an incision in the flank, as described by Braun, merely substituting novocain solution for that of cocain.

Wheal anæsthesia of the skin along the line of incision, using ·25 per cent. novocain solution with suprarenin. Infiltration of the subcutaneous cellular tissue in the form of a Hackenbruch's rhombus. Division of the soft parts down to the fascia. Infiltration of and beneath the external oblique muscle in the line of incision. A short period of waiting. Division of the muscle and its fascia, followed by injection of about 3 c.c. of 1 per cent. solution in a line along the lateral border of the divided external oblique (drawn outwards for the purpose), into the muscular tissue of the internal oblique and transversus as far in a lateral direction as possible. A few minutes waiting. Division of both muscles in a direction parallel to the course of the fibres. Infiltration of the now exposed præperitoneal tissue with ·25 per cent. solution over a wider area around the line of operation. Division of the peritoneum in a diagonal direction.

The whole infiltration may be carried out quite well with ·5 per cent. solution, only remembering to infiltrate specially freely the internal oblique and transversus muscles in which the nerves run.

I have endeavoured to give above, in outline, the points necessary for a decision of the question whether local anæsthesia shall be employed or not. Individual peculiarities must, of course, not be left out of consideration in the matter.

Of morbid processes in this region we may mention as specially suitable for operation under local anæsthesia extra-peritoneal abscesses—*e.g.*, large encapsuled perityphilitic abscesses, if so far softened that only a simple incision is required, also cystic tumours which merely require opening (hydatid cysts). Formation of an artificial anus and gastrostomy are also suitable for local anæsthesia in many cases. The latter operation, however, cannot be performed painlessly if there is much contraction of the organ, and this is not infrequently the case.

Other simple laparotomies which do not involve manipulations in the abdominal cavity may also be performed under local anæsthesia.

Operations for appendicitis are, in some clinics, frequently performed under local anæsthesia; whether always painlessly I should not like to say. It is impossible to say beforehand, with the least

approach to certainty, whether or not adhesions, generally involving the parietal peritoneum, are present. Where they exist local anæsthesia is illusory.

But even in the absence of adhesions, the simple fact that the cæcum is often fairly closely attached to the posterior abdominal wall, and that, in consequence, a slight pull is required to bring the appendix into the wound, may be sufficient in many cases to preclude all chance of the operation being performed under local anæsthesia without severe pain.

Hernia Operations.

It is necessary to distinguish between herniotomy for strangulated hernia and the so-called radical operation. The first offers generally a very favourable field for the employment of local anæsthesia. The reason for this is not very clear. We must not attach any great significance in this matter to the mental attitude of the patient, who is, of course, grateful for the prospect of relief from his suffering, for in the case of pains in other regions of the body, far surpassing in intensity those proceeding from a strangulated hernia, we meet with no such psychic analgesia during the operation. The diminution of sensibility to pain noticed in strangulated herniæ must be almost

entirely attributable to a disturbance of nutrition in the nerves which pass through the constricting ring to the hernial sac, which disturbance is to be attributed partly to compression of the nerves at the point of constriction, and partly to a blood stasis affecting the whole strangulated area. Where the strangulation has existed for some time, and especially in old persons, it is often only necessary to anæsthetize for the skin incision in order to be able to perform the whole operation painlessly. The shorter the duration of the strangulation has been, the less can we count on the presence of this condition of diminished sensibility. Where the lowering of sensibility is marked, it often affects the parts surrounding the constricting ring to such an extent that it is possible, in addition to the herniotomy, to perform painlessly a radical operation, and this with only a slight injection, though, in the absence of strangulation, it is not an easy matter to perform a radical operation under local anæsthesia on, say, an inguinal hernia.

The hernial contents in a strangulated hernia cannot be directly anæsthetized; the breaking down of adhesions, however, between the hernial sac and its contents is rendered painless by anæsthetization of the sac. Dragging and pulling the organs within the sac causes pain. The larger the hernia the sooner will the operator

find himself compelled to have recourse to such manipulations.

In umbilical hernias the distribution of the nerves involved—converging radially from all sides upon the umbilicus—is a very simple one. The circular method is, therefore, generally the best to employ here, the solution (·25 to 1 per cent. novocain-suprarenin solution) being injected all round the umbilical ring, first under the fascia, and then in the subcutaneous cellular tissue.

In large irreducible hernias with fatty abdominal walls the method is often insufficient. Here, after a surrounding subcutaneous injection, the hernia must be opened by a curved incision over its greatest circumference with the aid of Schleich's skin-wheal anæsthesia, using the fingers as a director. The sac must then be more widely spread, and the præperitoneal tissue surrounding the neck of the hernial sac freely infiltrated from the wound.

Local anæsthesia is, however, only of limited applicability to operations on umbilical hernias. We have seen that it is far easier to carry out a hernia operation under local anæsthesia if the hernia be strangulated. Even in strangulated cases, however, patients with tense abdominal walls often prove unsuitable subjects for local anæsthesia. If the parts are much stretched in suturing, local anæsthesia is often ineffective.

The best subjects are women with lax abdominal walls.

Often, too, a very large hernia, or very strong adhesions, render a case unsuitable for local anæsthesia. It must not be understood that it always fails in such cases, but rather that it cannot be regarded as an absolutely certain method, and should therefore only be employed when very strongly indicated. Finally, local anæsthesia must be employed with great caution in patients with a large deposit of fat in the abdominal wall. Here it is not so much any failure in the anæsthesia that is to be feared as the tendency of adipose tissue to necrosis, for even the most unirritating injection involves some injury to tissue, if only a minimal one.

What has been said above concerning umbilical hernias applies also to hernia of the linea alba.

In inguinal hernias the conditions are much more complicated, seeing that in the neighbourhood of the inguinal canal there are various nerve-trunks of considerable size crossing each other in different directions.

The figure given on the next page shows the distribution of the separate nerves. The internal inguinal ring, in whose neighbourhood the surgeon is bound to work in performing a radical operation, which is nowadays almost always super-

added to a herniotomy, is so situated, as the figure shows, that conduction must be interrupted in all the nerves in order to render it and its neighbourhood anæsthetic.

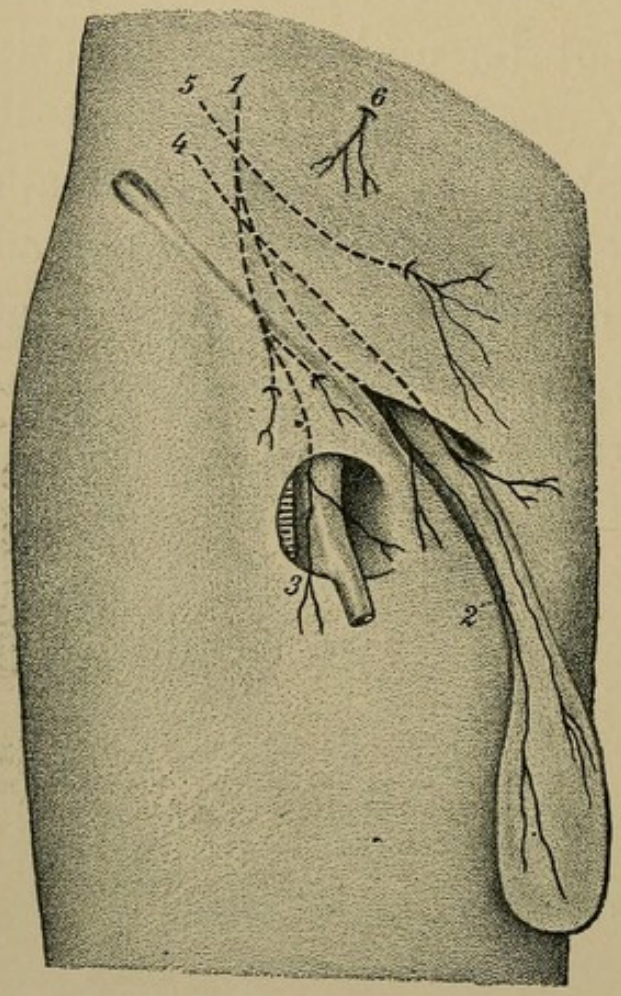

FIG. 20.—DISTRIBUTION OF NERVES IN THE INGUINAL OR CRURAL REGIONS (AFTER BRAUN).

1. N. genito-femoralis. 2. N. spermaticus externus. 3. N. lumbo-inguinalis. 4. N. ilio-inguinalis. 5. N. ilio-hypogastricus. 6. Rami cutanei ant. N. intercostalis xii.

As a rule anæsthesia is most easily attained in cases where the inguinal hernia is strangulated. The operator first injects deeply around the neck of the hernial sac with ·5 or 1 per cent. novocain solution. The subcutaneous tissue is then infiltrated along the selected line of incision, the skin having been previously anæsthetized by the wheal method if the abdominal wall is very fatty. The tissues are then divided down to the aponeurosis of the external oblique muscle, the incision being extended sufficiently to expose the neighbourhood of the external inguinal ring. The needle is

then inserted through the aponeurosis a little above the constricting ring and solution is injected, at first in a direction parallel to and immediately above Poupart's ligament, then at a point somewhat above and external to the first, where the internal oblique and transversus muscles pass. This will anæsthetize the hernial sac sufficiently to allow of its being opened. If it is preferred not to open the sac until the neighbourhood of the external ring is completely exposed, it is necessary either to wait or to divide under continuous infiltration, first the aponeurosis at the external inguinal ring, and then the constricting ring itself. There follow now replacement of the contents of the sac, further infiltration of the whole præperitoneal tissue, ligature of the hernial sac, and radical operation.

For the radical operation on free hernias—I have experience only of Bassini's method—Cushing's method of endoneural injection of the separate nerve-trunks was formerly often employed. On account of its troublesomeness, however, it never became really popular.

Meanwhile, in consequence of our ability to employ nowadays more concentrated anæsthetic solutions without any risk, a method has been successfully devised which has been already adopted by a number of surgeons (*Braun, Nast-Kolb, etc.*), and which may be regarded as, to a

certain extent, a successful outcome of the many endeavours that have been made to render inguinal hernias operable under local anæsthesia. Its simplicity, too, will probably materially contribute to secure its adoption in practice.

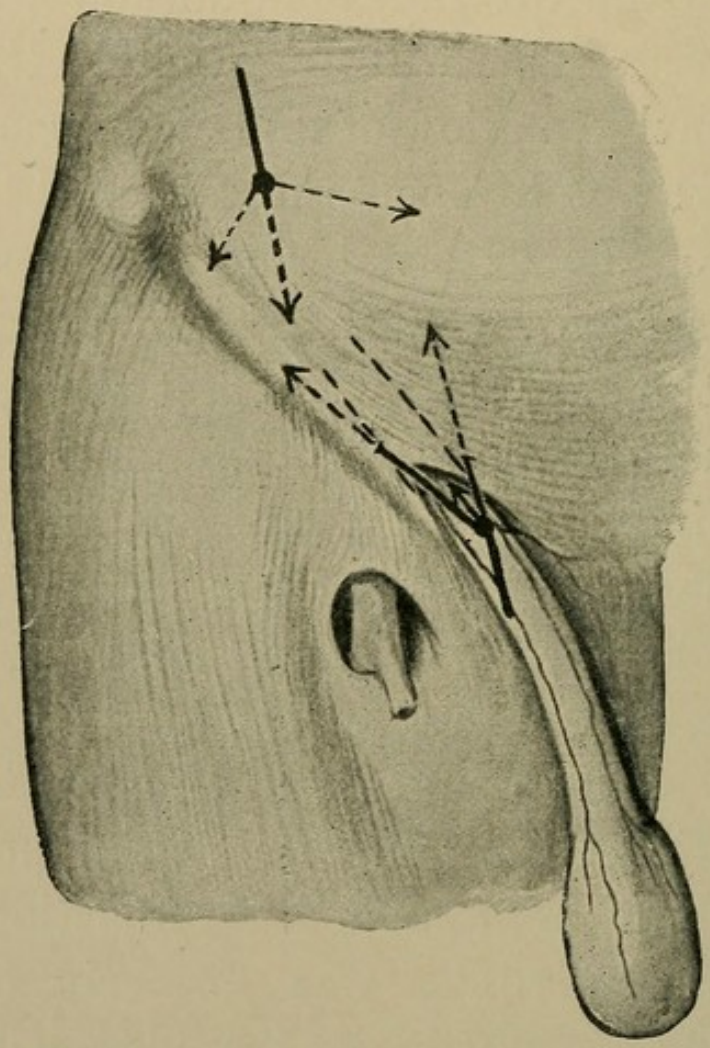

FIG. 21.—METHOD OF ANÆSTHETIZATION FOR THE RADICAL OPERATION ON AN INGUINAL HERNIA.

The needle is first inserted (after formation of a cutaneous wheal) 1 centimetre above the end of the selected line of incision, and the subcutaneous tissue underneath and around that line is infiltrated with ·5 per cent. novocain-supra-

renin solution. From the same point of injection the fascia is penetrated, and the needle passed through the whole thickness of the abdominal wall, infiltrating the deeper tissues, first in a median direction, then laterally towards Poupart's ligament. The injecting needle is now inserted a little below the external inguinal ring (again after formation of a cutaneous wheal), the spermatic cord is raised and injected, then, while the needle is either passed on through the external inguinal canal or made to penetrate the aponeurosis a little above the external inguinal ring, the operator injects, both in a median and a lateral direction from the spermatic cord, the deeper tissues of the abdominal wall. After waiting a certain time, the operation may be begun. From 30 to 50 c.c. of solution are usually employed. It is always advisable to infiltrate very freely.

In subjects with very fatty abdominal walls the method is not a very sure one. Unless there is some special ground for avoiding a general anæsthetic, operators who are not thoroughly practised in local anæsthetic methods had better forego the attempt to operate under local anæsthesia in these cases. If local anæsthesia is to be employed, the separate layers must be infiltrated step by step after Schleich's method, some waiting time being allowed after each successive step of the process, and special attention being paid to the præ-

peritoneal tissue. The method cannot be regarded as a perfect one, and though, as a rule, when carried out correctly, it enables the surgeon to operate painlessly, vigorous dragging on the spermatic cord, which cannot in some cases be avoided, is not always quite painless to the patient.* What has been said as regards Bassini's radical operation applies also to the Alexander-Adams operation in women.

In herniotomy for strangulated femoral hernia the method of circular injection is effective. The injection is made, first subcutaneously, then into the deeper parts, special care being given to the injection of the præperitoneal tissue at the neck of the hernial sac. Exposure and ligature of the sac can then be carried out painlessly, provided there be not too great a development of fat.

If a radical operation is to supplement the herniotomy, the parts to be fixed in contact, and again *especially the præperitoneal tissue*, must be freely infiltrated. The infiltration can only be carried out after complete exposure of the fascia, owing to the presence of the large femoral blood-vessels in this region.

* The method failed in a case of congenital hernia in an adult. The failure will appear explicable on a study of the anatomical conditions present in such cases.

CHAPTER XIII

OPERATIONS ON THE ANAL REGION AND GENITO-URINARY TRACT

The mucous membrane of the urethra possesses a fairly high degree of sensibility to pain, which is, however, more marked in the posterior than in the anterior portion of the urethral tube. The vesical mucosa is, in normal conditions, very slightly sensitive, but when inflamed may exhibit a high degree of sensibility.

For anæsthetizing the human male urethra, with a view, for instance, to the carrying out of a difficult catheterization or of a cystoscopy, we have found the following method effective: With an ordinary gonorrhœal syringe of about 5 c.c. capacity, 30 to 50 c.c. of 2 per cent. novocain solution (the addition of suprarenin is not absolutely necessary) are slowly injected into the urethra, and their escape prevented by placing round the base of the glans a rubber ring or a piece of bandage. A certain amount of the solution usually finds its way into the bladder.

The greater part, however, remains in the distended urethra.

In ten minutes the solution may be allowed to flow away, and the catheter or cystoscope can then almost always be introduced without causing pain.

If a stricture is present, suprarenin is freely added to the solution, and as much of the latter as the urethra will hold is injected. It is left to act for at least fifteen minutes in order that the suprarenin may exert its full detumefying effect on the mucous membrane. It will then generally be found possible to pass a fine catheter. In the subsequent dilatation the same procedure is adopted; the results, however, as regards anæsthesia are not so certain.

According to Reclus, internal urethrotomy can be painlessly performed after injection into the urethra of 1 per cent. cocain solution. This solution would now be replaced by 2 per cent. novocain-suprarenin solution.

In external urethrotomy the urethra must first be anæsthetized in the manner above described, after which the operator must inject all round the operation area, special care being given to the injection of the deeper parts.

It is seldom necessary to anæsthetize the female urethra. Occasionally I have removed small growths from the neighbourhood of the meatus

urinarius under circular anæsthesia. If the whole urethral mucous membrane is to be rendered insensitive, it is only necessary to dip a pledget of cotton-wool wrapped round a thin rod of some kind in 2 per cent. novocain solution, and place it in the urethra for a few minutes.

The vesical mucous membrane can also be rendered insensitive without much difficulty. The bladder is filled, according to its capacity, with or without previous anæsthetization of the urethra, with ·25 to ·5 per cent. novocain-suprarenin solution, which is then left to act for at least twenty minutes.

If the vesical capacity is very small, Braun advises that the operator should cautiously allow the solution to flow in under slight pressure from any irrigator. The vesical spasm then gradually gives way, so that the bladder, after twenty or thirty minutes, has generally regained its full normal capacity. The suprapubic operation should not be attempted under local anæsthesia save in thin patients with very lax abdominal walls, in whom no stretching of the muscles is necessary. The vesical mucous membrane must first be anæsthetized, and the site of the abdominal incision then infiltrated in the ordinary way after Schleich's method.

Of operations on the penis, that for phimosis is one of the most favourable of all operative

procedures for the employment of local anæsthesia.

If Roser's operation is to be performed, the whole line of incision should be freely infiltrated between the inner and outer surfaces of the prepuce with 1 per cent. novocain solution. Further infiltration should be made during the process of incision; special attention must be paid to the injection at the fold between the glans and the inner præputial surface, if the so-called lobule of Roser is to be formed. If the infiltration be sufficiently free, complete anæsthesia is always attained.

If, as is now more often the case, circumcision is to be performed, this can always, so far as my experience goes, be carried out successfully under circular anæsthesia. The surgeon injects freely from one or two points all round the organ at the level of the sulcus coronarius, using for the purpose 1 per cent. novocain-suprarenin solution; then, after retraction of the prepuce, he infiltrates specially the very sensitive frenulum. If the prepuce cannot be sufficiently retracted, it must be slightly incised after full infiltration of the site of incision. If, then, sufficient time (about ten minutes) is allowed, the operation can generally be painlessly performed. Before commencing to operate the surgeon should ascertain by means of a surgical forceps whether the inner præputial surface, which is much more sensitive and more

difficult to anæsthetize than the outer, is also thoroughly insensitive.

In the operation for paraphimosis the most practical method is to infiltrate freely, after Schleich's method, the selected line of incision. If the deeper layers are also injected, further infiltration during the operation is not necessary. If a supplementary circumcision is determined on, the surgeon may, as recommended by Braun, inject round the organ immediately on the proximal side of the constricting ring, and then round the line between the latter and the glans under the retracted præputial mucous membrane.

Reclus has performed amputations of the penis under infiltration anæsthesia. The operation should present no difficulties for local anæsthesia if the penis be infiltrated in its whole circumference with 1 per cent. novocain solution, either on the proximal side of the line of amputation, or at the line itself.

Superficial operations on the scrotum may be performed under simple circular anæsthesia.

Puncture of a hydrocele may be made painless by Schleich's infiltration of the site of puncture. During the infiltration, as during the puncture itself, the skin of the scrotum is drawn tightly back. If an irritant fluid (tincture of iodine) is to be injected, the cavity must be filled, after the hydrocele fluid has drained away, with ·25 per

cent. novocain solution, and the trocar left *in situ*. The solution must be left to act for about fifteen minutes, and then allowed to flow away. The irritant fluid can then be injected without pain.

For larger scrotal operations, such as operations for hydrocele or castrations, anæsthesia by interruption of conduction is the best method to employ. Novocain solution (1 per cent.) with suprarenin should be employed. If a greater quantity of solution than usual is required, the additional quantity should be in ·5 per cent. strength.

The spermatic cord is first seized as high as possible between finger and thumb, pressed against the tightened skin, and injected with several cubic centimetres of solution. Its surroundings are then freely injected. This injection renders the testicle and its coverings insensitive in about ten minutes. If the operation is merely on a hydrocele, a free infiltration around the spermatic cord will suffice, the scrotal incision being then made painless by the circular method, or by subcutaneous injection beneath the line of incision.

In castration the whole connective tissue of the scrotum must be infiltrated in a plane perpendicular to the spermatic, and at as high a level as possible. Owing to the great laxity of the skin, two points of injection generally suffice, one for the injection into the spermatic cord, and another

at the posterior surface of the scrotum at the root of the cord. The anæsthetization of these middle parts often presents difficulties owing to the great laxness of the tissues, which enables them to take up a large quantity of solution. A free infiltration here with ·5 per cent. solution is advisable. If after fifteen minutes this region is not completely anæsthetic, the skin must be anæsthetized by the wheal method. The procedure is completed by an infiltration of the raphe between the two testicles. If the technique is carefully and correctly carried out, the surgeon can count on a painless operation.

Operations of every kind on the female external genital organs—*e.g*, suture of ruptured perineum, incision of suppurating glands of Bartholini, cauterization of tumours, etc.—can be performed satisfactorily under local anæsthesia. Colporrhaphy also can be very successfully performed under circular submucous injection, only, however, in persons in whom distension of the vaginal orifice by the speculum is borne without pain. Many multiparæ suffer no pain, either from the introduction or manipulation of specula, or from traction on the uterus with forceps.

In such women operations on the not very sensitive portio vaginalis of the cervix can be carried out after circular injection of a few cubic centimetres of an anæsthetic solution. Vagina fixations

have also been frequently performed lately under local anæsthesia.

Operations on the rectum constitute one of the most important fields for local anæsthesia. Bier is quite right when he pronounces it a mistaken practice to employ general anæsthesia for the minor surgery of the anal region unless it is for

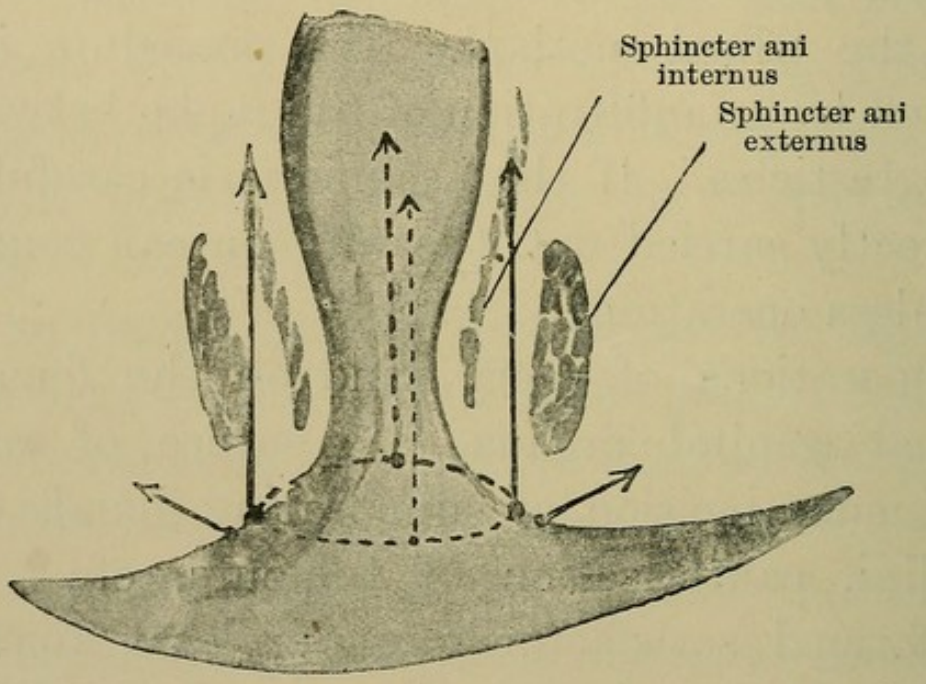

FIG. 22.—ANÆSTHETIZATION OF THE ANAL REGION.

some reason specially indicated. Local anæsthesia gives excellent results in operations for fissure and for hæmorrhoids, and in dilatation of the sphincter ani. I use the following method, described by Braun, for the anæsthetization of the whole anal region, and find it always effective (see Fig. 22).

Four injection points are marked round the anus, each about 1 centimetre from the anal

border. An index-finger is then passed into the rectum ; with care this may almost always be done without causing pain. If in the given case the parts are too sensitive to admit of this, it is possible, after some practice, to dispense with the introduction of the finger. The needle is then introduced at the four injection points in succession and passed along the inner aspect of the external sphincter, infiltrating as it goes (1 or ·5 per cent. novocain solution), until the finger in the rectum feels the submucous swelling caused by the injection. Finally, a subcutaneous injection is made around the anus. As a rule, after five to seven minutes it is found possible to dilate the sphincter without pain, and when this is so any operative procedure about the anal region may be embarked on without misgiving.

Most cases of anal fistula are suitable for operation under local anæsthesia, particularly if the fistula be internal to the sphincter. Braun's failure to get good results in operations on periproctitic abscesses is to be attributed to his use of too dilute (·25 per cent.) solutions. I always employ 1 per cent. novocain-suprarenin solution, and include the fistulous sinus or the abscess in the area of injection. Owing to the lax condition of the tissues in the anal region, which enables them to absorb considerable quantities of fluid, large doses

are often required. I have, however, never seen any untoward effects.

It need hardly be said that major operations, such as the removal of carcinomata, are, in this region, not suitable for local anæsthesia.

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