position. The orthopaedic surgeon has the advantage that he waits until the risk of recurring sepsis is practically absent, but he labours under the disadvantage that scars and contractures have occurred as the result of the original sepsis, which make it difficult to get the bones into correct position.

The treatment of stiff joints, again, presents a whole series of problems. In civil practice after a sprain or injury of a joint a few adhesions often occur which interfere with its free action, and, moreover, any movement which stretches these adhesions causes pain. The treatment as a rule is simple—forced manipulation to break down the little fibrous bands of adhesions. This class of case very rarely occurs in military surgery—so rarely that I would almost say a surgeon without considerable experience of manipulative methods, when he is tempted to move a stiff joint after gunshot injuries, had better pause, reflect, and refrain. I emphasize this because I have seen so many cases in which joints have been forcibly moved with disastrous results. As an illustration, let us very briefly consider a series of hypothetical cases, types of which occur over and over again as varieties of stiff knee.

1. First assume that a small fragment of metal has penetrated the front of the knee-joint, tearing the capsule and aponeurosis, but has been removed and the wound has healed without suppuration. The movement of the joint later is limited by pain, localized to near the wound and a definite stop to movement. The knee is flexed under an anaesthetic and one or two definite snaps are felt and all is well. This is a simple case of a few fibrous bands about the capsule which were stopping movements.

2. Next we will take a similar injury followed by effusion and a brief mild suppuration in the joint, relieved by cleansing and very temporary drainage. The movement of the knee is limited on attempting movement under anaesthesia; no great resistance is felt, but there is a soft tearing sensation. The experienced surgeon stops at once. He is not breaking one or two bands but is tearing a diffuse soft fibrosis extending all through the joint, and the result of his assault will be the formation of a more dense fibrosis. By waiting until the pathological changes are ended, movement may be restored in gentle stages of persuasively conducted alternate attack and rest.

3. In another case a piece of shell has torn the quadriceps above the patella and the muscle is firmly fixed down to the bone. If the surgeon attempts to flex the knee forcibly, he runs a big risk of fracturing the patella; but if he puts the limb on a back splint, so as to relax the quadriceps completely so that there is no strain on the scar, and massages the scar, it may loosen in a few weeks and become merely a fibrous intersection in the muscle, and then movement of the knee may be commenced.

4. There has been a septic fracture of the femur, and the quadriceps, especially the vasti, have become infiltrated first with toxic fluids and later by a matted fibrous tissue. Any attempt to stretch that by force is doomed to failure and will probably lead to a fracture of the patella. The best way of attacking such a case is to apply a splint which will allow of gradual flexion in stages. It may take two or three months to restore a range of movement of 45 degrees. With that range of movement the patient can walk with a little knee action and not merely with a stiff leg. After that, by use and help, he will gradually get more and more movement in the knee as the fibrous tissue in the muscle becomes absorbed.

There are other types of extra-articular obstruction which require operative attack. This is especially the case in the elbow and knee. The obstruction is usually found in a thickened capsule very much shortened, or in muscular adhesions. The extended elbow may require the free exposure of the capsule and its division, with perhaps a plastic elongation of the triceps. By similar methods the knee may be approached. The elbow or knee is then kept for a fortnight flexed. One rule must be strictly adhered to: If a stiff joint has to be moved under an anaesthetic, the bones above and below the joint must be protected. *This is especially called for where a fracture has existed.*

I have spoken of the reconstructive function of an orthopaedic surgeon, and to make this attitude clear we will take a hypothetical case.

A case is presented with an ankylosed shoulder, elbow, and wrist, with the potentialities of movement confined to the thumb and two adjoining fingers. The shoulder is adducted, the elbow extended, the wrist palmar-flexed, the muscles ischaemic. The question arises, Can any use be made of this apparently useless limb, or should it be amputated? On inquiry, the surgeon finds that the patient can shrug his shoulder—the scapular muscles are acting. The first procedure is to develop power in the thumb and two fingers, then to ankylose the wrist in dorsiflexion, and the elbow at the angle best suited to the patient. An osteotomy is next planned, in order to get the arm abducted. In a few weeks the scapula

carries the humerus through a long range of movement, and the patient has secured a limb much more useful than the best of artificial arms.

Time will not allow me to touch upon the interesting problems of scars, transplantation of bones and tendons, pseudarthroses, and many other allied themes. Enough has been said, however, to lay bare the orthopaedic mind. It strives for function rather than for form, but is more content if it can secure excellence in both; it is conservative and constructive, but it desires to take the most direct road to function—be it by knife, by hand, or suasion.

I cannot conclude without paying the highest tribute to the loyalty and enthusiasm of my American and British staffs all over the country. If I sometimes try to direct their thoughts, I hope I shall never hamper them in their endeavour to solve the fascinating problems that surround them. Finally, I wish to express my deep gratitude to my professional brethren everywhere, who have neither by word nor deed done aught but encourage me in my work and lessen my labours. Without their help and confidence and kindness I should, indeed, be powerless.

ON THE SEPARATE SUTURE OF NERVES IN NERVE TRUNKS.

By J. N. LANGLEY, Sc.D., F.R.S.,

PROFESSOR OF PHYSIOLOGY, CAMBRIDGE.

THERE are a considerable number of factors which determine the degree of recovery from the effects of nerve severance. One of these factors is the accuracy of apposition of the central and peripheral ends of the severed nerve fibres. In man, all the nerve trunks consist of bundles of nerve fibres; each bundle has its own perineurial sheath, and is surrounded by epineurial connective tissue. The relative position of the nerve bundles alters gradually in their course in the nerve trunk. It is in the highest degree improbable that an exact apposition of corresponding bundles can be made even in a freshly cut nerve, and if a piece has been excised it is certain that exact apposition never occurs. Further, microscopic examination shows that after suture the nerve fibres growing out from the central end of any one bundle usually take a devious course, and run to several peripheral bundles.

In all cases, then, in regeneration after nerve suture, the connexion of the central nervous system with the peripheral tissues will differ to a greater or less extent from the normal connexion. The new arrangement caused by nerve fibres growing out of their course is spoken of as the distortion of the nerve pattern. The nerve pattern is distorted both on its efferent and on its afferent side. On the efferent side the central nerve cells which formerly in a limb controlled solely, say, a flexor muscle, may after regeneration control flexor, extensor, adductor, abductor or rotator muscles in varying proportion. On the afferent side cutaneous fibres normally giving rise to the different sensations of cold, heat, touch, etc., will run to muscle and tendon, and muscle and tendon afferent fibres will run to the skin. The straying of nerve fibres into others having a different function may possibly to some extent be lessened by the central fibres growing more readily into fibres of their own class than into fibres of a different class, but experiment shows that such selective direction of growth, if it occurs, is not sufficient to prevent nerve fibre of any one function growing into the peripheral end of a nerve fibre of any other function. Some readjustment of the processes in the central nervous system must, then, take place in order that reflex and voluntary movements may occur in a properly co-ordinated manner. The readjustment takes place fairly rapidly in the case of simpler movements, such as flexion and extension of the limb,¹ but finer movements are only gradually recovered and the sensory adjustment appears to take a still longer time.

In regeneration after nerve suture there is not only distortion of the nerve pattern, but a varying degree of loss of innervation. Besides the nerve fibres which grow into the connective tissue surrounding the nerve bundles of the trunk and surrounding the trunk itself, a more or less considerable number grow from efferent fibres into afferent fibres, and from afferent fibres into efferent. These can make no functional connexion with the nerve

endings to which they are diverted. The loss will tend to a decrease of muscle innervation and to a reduction in the delicacy of sensation. It may to some extent be compensated for by an increase in the number of nerve fibres in consequence of their division at the central end.

There is one other abnormality which occurs in regeneration. It was shown by Anderson and myself, by Kilvington, and by Osborne and Kilvington,² that if, after nerve regeneration, the nerve be cut above the point of union, and the central end of a peripheral branch stimulated, contraction may be obtained in the muscles innervated by other branches. This is due to the single fibres of the central end dividing into two or more fibres which pass to different peripheral nerves. Such reflected actions occurring in branching axis cylinders I have called axon reflexes. Axon reflexes may be produced not only from muscle nerve to muscle nerve, but also from cutaneous nerve to muscle nerve. In a recent case in a cat³ I obtained lively contraction both in the tibialis anticus and peroneus longus on stimulating the central end of the cutaneous branch of the musculo-cutaneous nerve, the peroneal nerve being cut above the point of suture. The effect of the division of the fibres, with divergence of the branches, will vary according to the nature of the fibres, and the nerve endings, if any, which they make. Thus, when a muscle nerve fibre divides and makes new nerve endings in different muscles, a nervous impulse passing down it will cause contraction in both muscles; and when an afferent fibre capable of giving rise to sensation divides and makes new nerve endings in different regions, we must suppose that a stimulation of either region will give rise to a sensation referred to both.

All the modifications of the original connexion of the nerve fibres spoken of above may be grouped together under the head of disturbance of nerve pattern.

From the facts given above we may conclude that any procedure which reduces disturbance of nerve pattern will make recovery more complete, and will shorten the time taken in attaining that degree of recovery which is possible in the circumstances. It must be noticed that the time at which voluntary movements are first made is to a large extent independent of disturbance of nerve pattern. The first voluntary movement occurs a short time after the nerve fibres of any muscle nerve make new nerve endings in any muscle. Although exact apposition of the nerve bundles in a nerve trunk never occurs in nerve suture, some motor nerve fibres always have an opportunity of growing into other motor nerve fibres. Now it is obvious that if each peripheral nerve ran a separate course in the nerve trunk, and these were sutured separately, the distortion of nerve pattern would be much diminished. It has, however, long been known that in the larger nerve trunks the bundles exchange nerve fibres and form a plexus, which may be spoken of as the internal nerve plexus.* It would seem, then, that in the larger nerve trunks no separation of the nerves for different muscles and for different cutaneous areas is possible. But, on the other hand, some observers have mapped out the nerve bundles of the trunk of the sciatic into anterior tibial, musculo-cutaneous, posterior tibial, gastrocnemius, and other nerve bundles. If this were so, there would be a possibility of suturing the nerves separately in the sciatic.

In view of the facts and deductions I have given above, an investigation was undertaken by Dr. Hashimoto and myself upon the connexion of the peripheral nerves with the internal plexus of the sciatic in various animals. The results have been published in the *Journal of Physiology*.⁴ As regards the possibility of separate suture in man, they were as follows:

The only peripheral nerves which have more than a short isolated course in the sciatic from the great trochanter to the popliteal space are the nerves to the hamstring muscles (with the nerve to the adductor magnus), the nerve to the short head of the biceps, the lateral cutaneous and external saphenous nerves, the nerve to the outer head of the gastrocnemius, and that to the inner head and soleus. All the others soon after joining the sciatic become connected with the internal nerve plexus and are mixed with nerve fibres of varied peripheral dis-

tribution. All the nerves mentioned above run for part of their course in the loose outer sheath of the sciatic before they enter the dense inner sheath. They may be regarded in this part of their course as being attached to the sciatic rather than as forming an integral part of it. When a nerve has penetrated the dense inner sheath it merely forms one of the many nerve bundles of the trunk; the cutaneous nerves and the gastrocnemius nerves can still be recognized by their relation to other bundles, but, naturally, to do so requires previous dissection on *post-mortem* specimens.

The most accessible nerves are the cutaneous nerves. They run, as mentioned by Compton,⁵ on the posterior surface of the sciatic. The lateral cutaneous nerve runs an isolated course nearly the whole length of the sciatic, but in its upper part it penetrates the thick epineurial sheath of the peroneal division of the sciatic. It is known that there is considerable variation in the relative number of nerve fibres which the external saphena receives from the tibial and peroneal divisions of the sciatic. In the cases dissected by Dr. Hashimoto and myself, the peroneal contingent arose from the mid region of the sciatic, and the tibial contingent from the lower third. Probably when the tibial contingent is larger, the additional portion, like the peroneal contingent, arises from the mid-sciatic region. The practical point is that the greater part of the cutaneous nerves given off by the sciatic to the leg can be isolated and separately sutured in a considerable length of the sciatic trunk.

The nerves to the inner and outer head of the gastrocnemius, as is known, run as separate nerves in the popliteal space and join the sciatic either separately or as a single nerve. The two nerves, or the conjoined nerve, have an isolated course in the sciatic for about one and a half inches.

The hamstring group of nerves and the nerve to the short head of the biceps run a long isolated course in the outer loose sheath of the sciatic, and in *post-mortem* specimens can be readily isolated. The latter, however, dips to the anterior surface of the peroneal division of the sciatic, and is in consequence not readily accessible in life. The hamstring nerves are embedded in a good deal of connective tissue, and a satisfactory union of their ends, whether they are left in position or sutured separately, is difficult.

As I have said, all the nerves so far mentioned are recognizable on simple inspection in more or less of their course in the nerve trunk. There are others in which the epineurium must be cut open in order to distinguish them. The posterior tibial nerve below its main muscle branches consists of two sets of nerve bundles, the bundles of each set having little or no connexion with those of the other. One consists almost entirely of the external plantar nerve and the other of the internal plantar. In the peroneal nerve there is a relatively short portion in which the anterior tibial nerve, the nervus peroneus longus (with which may be the n. peroneus brevis), and the cutaneous part of the musculo-cutaneous nerve are separate and fairly easily recognizable within the epineurial sheath. The musculo-cutaneous nerve consists of separate muscular and cutaneous portions.

Most of the muscle nerves arise close together from the internal nerve plexus, and run a variable but short distance in the trunk. They occupy definite positions in relation to one another. In the comparatively rare cases of clean severance and immediate operation, it is not outside possibility to distinguish the respective central and peripheral ends of one or more of the muscle nerves, and to suture them separately. The most promising region for this is the lower part of the peroneal nerve. Lastly, there are the peroneal and tibial divisions of the sciatic; between these there is so much connective tissue that it is a question whether in man nerve fibres spread out from one division to the other, and in most regions the separation of the trunks would interfere greatly with the blood supply to the central end. On the other hand, the relative position of the two divisions changes in their course, so that if much is excised, more or less of one division will be brought opposite the other.

All isolation of nerves causes some interference with blood supply in the isolated portions; this is of little importance when the nerves run in the outer loose epineurial sheath, but, if the inner dense sheath has to be

* A figure of the plexus of the median nerve was given by Monro in 1783 (*Observations on the Structure and Functions of the Nervous System*, Tab. xviii, Edin.). This reference I owe to Professor Thane.

opened, it may delay degeneration in proportion to the density of the sheath. It would probably be advantageous to cut away as much as possible of the epineurium. A few experiments on the sciatic of any large animal would determine whether the interference with the blood supply is serious or not.

There are, no doubt, cases similar to those mentioned above in the nerve trunks supplying the arm. The only one dissected by Dr. Hashimoto and myself was the musculo-spiral (radial); in this the muscle division and the cutaneous division ran for a considerable distance isolated from one another, a fact which suggests that in cases of severance of the musculo-spiral the epineurium should be cut open and the two parts sutured separately.

REFERENCES.

¹ Kennedy, *Phil. Trans. Roy. Soc.*, B, 194, p. 127, 1901; B, 205, p. 27, 1914, and references there given. Osborne and Kilvington, *Brain*, 33, p. 289, 1911. ² Langley and Anderson, *Journ. of Physiol.*, 51, p. 372, 1904. Kilvington, *BRITISH MEDICAL JOURNAL*, September 16th, 1905. Osborne and Kilvington, *Journ. of Physiol.*, 37, p. 1, 1908; 38, pp. 268 and 276, 1909. ³ Langley, *Journ. of Physiol.*, 51, p. 388, 1917. ⁴ Langley and Hashimoto, *ibid.*, 51, p. 320, 1917. ⁵ Compton, *Journ. of Anat.*, 51, p. 103, 1917.

ANTENATAL SYPHILIS: SUGGESTED ACTION OF THE CHORIONIC FERMENTS.*

BY

AMAND J. ROUTH, M.D., F.R.C.P.,

CONSULTING OBSTETRIC PHYSICIAN TO CHARING CROSS HOSPITAL.

CONGENITAL SYPHILIS.

AFTER alluding to the discoveries of the *Spirochaeta pallida* by Schaudinn, the Wassermann reaction, and to the treatment by salvarsan, which can destroy the spirochaete without injuring the human tissues, Dr. Routh dwelt upon the serious nature of congenital syphilis as compared with primary infection, a positive reaction in a congenital syphilitic child hardly ever, according to Mr. Charles Gibbs, becoming negative under treatment. He alluded to cases of congenital syphilis transmitted to the third generation, as related by Dr. F. W. Mott, Mr. C. Gibbs, and Mr. J. E. R. McDonagh. He believed that not only is paternal infection of the ovum by the seminal fluid possible but that it is not infrequent, the mother becoming infected (1) either previously or at fertilization if she has a genital abrasion or erosion of the cervix, or (2) indirectly during the pregnancy via the embryo (conceptional syphilis), or (3) she is infected by spirochaetes in a granule stage, the mature organism being developed only after pregnancy.

More usually, he said, the embryo is infected by the already infected mother, either by the ovum being already infected, or by infection whilst embedded in the uterine mucosa, or by transplacental infection.

Sometimes there is a "mixed transmission" of infection from both parents. With very early abortions within two or three weeks of fertilization, following paternal infection of the ovum, it is possible that the woman may escape infection, owing to the absence of any true fetal circulation.

There is evidence (1) that infection can take place by the seminal fluid (F. W. Mott, etc.) even when the father has a negative Wassermann reaction, and (2) that the spirochaete has been found in the ovum in syphilitic women (Levaditi, Ball, and others). Dr. Mott has proved that syphilis is most contagious in its earliest stages, becoming less virulent each succeeding year owing to formation of maternal antibodies, the usual sequences of pregnancies being abortions, stillbirths, diseased children dying at birth or in early infancy, and children showing no signs of disease till puberty.

Dr. Routh believed that 25 per cent. of stillbirths and abortions in urban centres were probably due to syphilis, that if only 20 per cent. were caused by that disease in urban and rural centres in England and Wales, about 27,000 deaths would occur annually during the antenatal period and the first fourteen days after birth from that cause. The mortality of illegitimate children, both *in utero* and after birth, from syphilis was at least twice as heavy. The next most frequent causes of antenatal and natal deaths were toxæmia, *ante-partum* haemorrhage,

and dystocia. Macerated fetuses are, he said, now known to contain spirochaetes in over 80 per cent., though the mature organism is rarely found in abortions before the fourteenth week (Weber).

Many cases, both mothers and offspring, show no clinical evidence of syphilis till some weeks after the childbirth.

The Wassermann Reaction.

The Wassermann reaction, when first discovered, was expected to be positive when the individual was syphilitic and negative when uninfected or cured. Anomalies, however, have appeared and require explanation. Allusion was made to cases of syphilis during pregnancy with unexpected reactions, such as the negative reaction of some women when gravid with a syphilitic child, and for some time afterwards, and the negative reaction of some syphilitic children at birth, becoming positive a few weeks afterwards when the mature spirochaetes developed.

It is recognized, and has been especially stated by Mr. McDonagh, that pregnancy in some way or other often prevents the development of the mature spirochaete and that the disease is in these cases practically arrested in both mother and child during pregnancy. This, Dr. Routh believed, occurred more particularly in cases of paternal infection of the embryo. McDonagh even says that "repeated pregnancies have undoubtedly resulted in a spontaneous cure of the disease."

Some children may show no evidences of syphilis till they get tabes or general paralysis at puberty, whilst some mothers of these children may show no symptoms till after the menopause, or escape apparently altogether. The Wassermann reaction in these long latent periods has not been adequately observed.

All these cases require some other explanations than those usually given. The original words of Colles's law are true, though the numerous and varied explanations are often faulty.

Biology of Spirochaeta pallida.

Dr. Routh then reviewed the life-history of the spirochaete, giving extracts from Dr. Mott's article, in which O'Farrel, A. Balfour, and Noguchi are quoted, tending to show that under the action of salvarsan, etc., as well as spontaneously, the mature spirochaetal spiral becomes broken up transversely into granules, and that in a suitable environment these granules are capable of development into the mature organism after a short or long period of biological activity.

Noguchi had proved that after such granules have been transferred to a passive culture medium "spiral forms again sprout out." Dr. Mott has said:

The researches of Leishman on the spirochaete of tick fever suggest the possibility of an intracellular phase of the spiral organism, and its existence in the form of infective chromidian granules. Moreover, in support of this hypothesis I may mention that Neisser, in his experimental investigations on apes, has observed that the tissues of infected animals in which no spirochaetes were demonstrable, could nevertheless be used effectually for inoculation. The spirochaete may be one form of the syphilitic organism, but there may be other minute stages analogous to the spores of bacilli.

Infection by the granules can apparently occur during pregnancy, and if the granules are kept quiescent it is probable that the infected individual (mother or child) would give a negative Wassermann reaction after the birth so long as mature spirochaetes were absent.

If congenital syphilis is to be checked before the embryo is destroyed it must be dealt with locally at its source, and from the very first days after fertilization and infection. It seemed obvious that the embryonic tissues could not during the first few hours or days produce antibodies which could destroy spirochaetes.

Suggested Action of Chorionic Ferments upon Spirochaetes.

The great changes which occur in the maternal tissues, and especially in the ductless glands, Dr. Routh said, are only gradually produced, and are, therefore, not available in the early weeks to deal with spirochaetal infection. There are, however, locally present very powerful chorionic ferments produced by the syncytial cells of the fetal chorionic villi. These ferments are present in the early days of pregnancy at the point of interdigitation of the fetal and maternal portions of the placenta, and therefore

* Abstract of valedictory presidential address to the Harveian Society of London, January 10th, 1918.