considerable quantity of fluid had accumulated in the pelvis.

In the more chronic cases, such as the third, the treatment should be different. An incision directly on to any inflammatory mass would be the right procedure, and, in the event of pus or other fluid being found, this should be evacuated with the greatest care, to prevent fouling of the general peritoneal cavity. For this reason I should prefer to trust to sponging rather than to flushing for cleansing purposes, as the irrigation may carry infective particles to more distant parts whence they cannot escape again, but may set up fresh mischief. A drain to the bottom of the abscess cavity is then required, and all that can wisely be done has been done. To search for the perforation, with a view to closing it, would be useless and dangerous.

The third case here described is the most successful with which I am acquainted. Since this was written a successful case of suturing has been published by Kriege in the *Berl. klin. Woch.*, December, 1892, but there is every reason to look forward to better results in the future than in the past. It is most important that practitioners should recognise this accident of perforation at once, and that immediate operation should follow. Here hours are of as much importance as days in other conditions; in fact there is hardly any emergency more urgent in surgery.

NERVE INJURIES COMPLICATING FRACTURES OF THE UPPER EXTREMITY, WITH SIX CASES.

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THE subject of nerve injuries complicating fractures is one which receives little notice in any of the standard surgical textbooks. Hamilton, in his large work on fractures, completely ignores it. Weir-Mitchell in his *Injuries of Nerves*, gives a brief account of the subject, in which he remarks that "contusion or laceration of nerves from fracture of bones is most commonly encountered in such accidents as involve the humerus and the bony parts forming the elbow-joint," and he refers to two cases of this nature published by Erichsen in 1871, and to an essay by Ferrol Reuillet (Paris, 1869) on paralyses of the upper extremity connected with fractures of the humerus. He also discusses the question of compression by callus, and cites a case of this kind by Ollier. By far the most complete account of the subject which I have been able to find is given by Bowlby in his *Injuries and Diseases of Nerves*. This author remarks that fracture of the shaft of the humerus is more frequently the cause of nerve lesion than similar accidents in any part of the body. He cites, partly from Continental and partly from English sources, eleven cases of fracture of the humerus complicated with lesions of the musculo-spiral nerve, one with injury of the median and ulnar, and two with injury of the ulnar alone. With regard to fractures of the bones of the forearm, he remarks that "instances of nerve injury in cases of fracture of the bones of the forearm are certainly rare," and he cites two cases of injury of the median and of the ulnar nerves produced respectively by fractures of the radius and of the ulna. The cases cited by him are collected from sources dated from 1871 to 1882. It would thus appear that nerve injuries of this kind are of considerable rarity.

The following six cases have occurred at the General Hospital, Wolverhampton, during the past two and a-half years, and I cannot help thinking that nerve injuries of this kind are in reality of less rarity than might be supposed from the number of recorded cases. Many such cases are probably not detected, the symptoms being regarded as effects of disuse or confused with the stiffness of joints and muscles which commonly occurs after fractures. Cases, too, in which nerve lesions have been produced by undue pressure of splints are, for obvious reasons, little likely to be recorded.

Of the six cases now recorded, four are fractures of the humerus and two of the bones of the forearm. Of the four fractures of the humerus, three were complicated with para-

lysis of the musculo-spiral, and one with paralysis of the median and ulnar nerves, showing, as in the cases cited by Bowlby, the much greater frequency of lesions of the musculo-spiral. Of the two cases of fracture of the forearm, one was complicated with paralysis of the median, the other with paralysis of the posterior interosseous, a complication of which Bowlby remarks that he has been unable to find any recorded case.

As regards the mode of production of these nerve injuries, they fall into two classes: those in which the nerve is injured simultaneously with the fracture, and those in which it becomes involved at a later period. In the first case the nerve may be injured by the same form of direct violence as causes the fracture, or by the violent displacement of portions of the fractured bone at the time of the accident. The nerve may become involved at a later period in several ways. It may be stretched or slowly compressed through imperfect reduction or subsequent displacement of the fragments; or it may become involved in and compressed by the callus about the site of fracture; or, lastly, nerves in exposed positions may be slowly compressed by splints or other apparatus used to immobilise the fractured limb.

The six cases recorded below include examples of all these different modes of production. Of these, there is only one in which the symptoms can be attributed to injury of the nerve at the time of fracture through violent displacement of the fractured bone. This, however, appears to be the most probable explanation in Case I, in which a compound fracture of the upper part of the shaft of the humerus was complicated with paralysis of the median and ulnar nerves. In this case the symptoms of nerve injury appeared immediately after the accident, the hand being described by the patient as feeling "dead." The fracture was produced by direct violence applied to the outer side of the arm, and the broken ends were probably forced inwards against the nerve trunks on the inner side. The fact that the belly of the biceps muscle was also completely ruptured may, on the other hand, have allowed the whole limb and the nerves with it to be violently stretched.

CASE I.—Compound Fracture of Right Humerus; Paralysis of Median and Ulnar Nerves; Exploratory Operation.—J. C., aged 26, on September 25th, 1891, had his right arm severely crushed by a fall of earth in a coal mine. The humerus was broken in its upper third, and the fracture was rendered compound by two small wounds on the inner side of the arm. The belly of the biceps was completely torn across just above its middle. The following day the patient complained of great numbness in all the fingers, but especially in the middle and index. He was nevertheless able to localise a touch on all the fingers. He said that immediately after the accident the whole hand felt "dead," and remained so till the following morning, when feeling began to return. The wound ran an aseptic course. On October 20th, splints and dressings having been removed, the patient was found to be completely unable to flex the wrist or any of the fingers, and all the muscles on the front of the forearm failed to respond to the strongest faradic current. The voluntary power and electric reactions of the other muscles of the limb were normal. The hand still felt numb, but there was no definite loss of sensation. On November 7th, these symptoms continuing, the median and ulnar nerves were exposed and examined in the middle of the arm, but were not found involved in callus or in any way abnormal in their appearance and relations. On November 18th the patient had recovered slight power of flexing the little and ring fingers (ulnar nerve). On December 1st, contracture of the flexors had set in, and prevented extension of the wrist beyond the straight position. Under treatment by massage and the faradic current, power was rapidly recovered in the muscles supplied by the ulnar nerve, but in those supplied by the median recovery was slow. On January 19th, 1892, the arm presented the typical characters of isolated palsy of the median nerve, with wasting and loss of electric reaction in the affected muscles. On February 4th the flexor carpi radialis was found to contract on faradising the median nerve at the middle of the arm. On February 27th there was slight power of voluntary flexion of the last joint of the thumb. From this time he made a gradual but steady recovery, and when last seen on September 25th, 1892, nearly a year after the accident, he had a strong and useful arm and hand, and was able to oppose and flex the thumb perfectly. There still however remained slight numbness of the last joint of the index finger, and supination of the forearm and extension of the wrist were much limited by contracture of the muscles which had been paralysed.

Examples of nerve paralysis of later onset, due to slow compression by displaced fragments of bone, are probably furnished by the following cases:

CASE II. Separation of Lower Epiphysis of Left Humerus; Paralysis of Musculo-spiral Nerve.—B. H., aged 8 years. The accident, which was caused by a fall on February 18th, 1892, was recognised by the usual signs. After reduction the elbow was immobilised at a right angle by plaster-cast. When this was removed at the end of four weeks, there was much bony thickening about the lower end of the humerus and the elbow was very stiff. There was also complete paralysis of all the muscles supplied by the musculo-spiral below the elbow. These muscles gave no response to faradism, but responded to a smaller minimal galvanic stimulation than the corresponding muscles of the opposite side. No loss of sensa-

tion could be detected. Massage, passive movement, and the galvanic current were employed daily. Recovery of voluntary power began in the supinators on March 9th, and was complete in all the affected muscles on May 2nd, although then and for long afterwards there was no recovery of faradic irritability. Redundant callus having been absorbed, it was found that the displaced fragments had not been perfectly reduced, the lower end of the shaft being in front of and overlapping the lower fragment, forming a prominence at the front of the elbow which stopped flexion at a right angle. Extension was also slightly limited. In other respects the limb was perfectly normal.

CASE III. Separation of Lower Epiphysis of Right Humerus; Paralysis of Musculo-spiral Nerve.—J. B., aged 8 years. The accident was caused by a fall off a gate on September 8th, 1892. This displacement was reduced, and the limb put up on an internal angular splint. On September 10th he was found to have complete paralysis of the extensors of the wrist and fingers and of the supinator longus. No anaesthesia was detected. This case resembled Case II in almost every respect, both in the imperfect reduction of the fragments and in the result. The muscles, which had lost their faradic but preserved their galvanic irritability, were treated daily with one or other form of electric stimulation. Recovery began in the supinator on October 27th, and was complete in all muscles on November 27th, patient having been under treatment nearly three months.

In these cases musculo-spiral palsy followed imperfectly reduced fracture or separation of the lower end of the humerus. The exact time, however, at which the paralysis made its appearance was unfortunately not determined. In one case it was first noted on the fifth day, and in the other not till one month after the accident. It is possible, however, in each case that it was present soon after the accident but was overlooked. The paralysis might be attributed to pressure of callus involving the nerve. In both cases it is true there was much callus thrown out, but that involvement in callus is ever a real cause of nerve paralysis does not appear to me to be very well established.

That nerves may become more or less surrounded by callus was demonstrated by Ollier's case cited by W. Mitchell, and by the following case:

CASE IV. Fracture of Left Humerus; Paralysis of Musculo-spiral Nerve; Operation; No Recovery from Paralysis Two Years later.—G. W., aged 13, sustained a fracture of the left humerus in two places. After the fracture had united it was found that he had wrist-drop. The upper fracture having been in the neighbourhood of the musculo-spiral groove, it was thought that the nerve might be involved in callus. It was accordingly exposed in this situation, and found lying between two ridges of new bone and adherent to the periosteum. It was freed from adhesions. The wound healed readily, but patient was discharged unimproved. When first seen by the writer two years later there was complete paralysis and wasting of all the dorsal muscles of the forearm, except the supinator longus, which acted feebly. There was complete loss of electric irritability, both faradic and galvanic. The triceps was unaffected.

In neither this case nor Ollier's was the nerve shown to be subject to any pressure by the groove of callus in which it lay. "Paralysis," as Bowlby remarks, "is of comparatively rare occurrence when the fractured ends are in close apposition, but is prone to occur when much displacement—and often a disproportionate amount of callus—results from the injury." Unreduced displacement was a marked feature in both Cases II and III, and is probably the most important factor in all cases of so-called callus pressure.

Lastly, in the two following cases, in which paralysis of the posterior interosseous and median nerves respectively followed fractures of the forearm, I can, in the absence of any other probable cause, only attribute to undue pressure from splints. There was, it is true, no direct evidence of this cause, such as is sometimes afforded by sloughs of the skin. In one case, however, the patient was afterwards discovered to have complained of the tightness of the splints when they were first applied. In neither case was there any displacement or faulty union of the fragments. In one case the possibility of involvement of the nerve in callus was disproved by an exploratory operation.

CASE V. Fracture of both Bones of Forearm; Paralysis of Posterior Interosseous Nerve.—A youth, aged 16, fractured his right forearm by a fall on the hand; both bones were broken at the junction of the upper and middle thirds. The fracture was treated in the ordinary way with straight flat splints well padded. When these were removed at the end of four weeks the fracture had united in good position, but he was found to have complete paralysis of the muscles supplied by the posterior interosseous nerve—namely, all the muscles of the back of the forearm except the supinator longus and extensor carpi radialis longior. There was no contracture or limitation of passive movement in the fingers or wrist. The affected muscles responded well to a moderate faradic current. There was no loss of sensation. In answer to inquiries the patient stated that the fingers became numb immediately after the accident, but that feeling returned on the following day. The callus which marked the site of the fracture of the radius was nearly 2 inches below the point at which the posterior interosseous nerve winds round that bone. The paralysed muscles were faradised every day. Voluntary power began to return at the end of a month, and recovery was perfect a fortnight later.

CASE VI. Fracture of Both Bones of Forearm; Paralysis of Median Nerve; Recovery.—J. S., aged 6, was admitted on September 11th, 1891. Six weeks before admission she had broken both bones of the right forearm near the middle by a fall, and had worn the ordinary straight splints for one month. When these were removed she was unable to straighten the fingers, and had a very weak grasp. On admission, the fractured bones were united in good position, but still surrounded by callus, which appeared to involve both bones. All the fingers were flexed, the little and ring fingers more than the middle and index. The wrist was adducted and the metacarpal bone of the thumb close to and on the same plane with the second metacarpal. Pronation and supination were very limited. There was complete inability to flex the last joints of the thumb and index fingers. The muscles in the forearm and hand supplied by the median nerve did not respond to a strong faradic current. Those, however, which are supplied by the ulnar nerve, namely, the flexor carpi ulnaris, the inner half of the flexor profundus digitorum, and the interossei and adductor pollicis responded readily to the faradic current, and had unimpaired voluntary power. The electric reaction and voluntary power of the extensor muscles of the wrist and fingers were also unimpaired, but their range of movement was much limited by the contracture of the flexor muscles, both paralysed and unparalysed. There was no loss of sensation so far as could be ascertained from a not very intelligent child. There was no scar or sign of pressure from the splints. On November 11th, three months after the date of the fracture, in spite of passive movement, massage, and the regular use of the faradic current, there was no sign of return of power in the paralysed muscles, although contracture was rather less. The median nerve was therefore exposed in the middle of the forearm at the site of fracture, but was found to present no abnormal appearance, nor was it compressed by callus or in any other way. It was freed from its bed, hooked up, and slightly stretched; the wound was then closed. The electric treatment and rubbing were resumed, and improvement gradually took place. On January 14th, 1892, the contracture was much less, the grasp much stronger, and the last joint of the index could be freely flexed and extended voluntarily. No response to faradism could be obtained from any of the paralysed muscles until January 24th, a considerable time after the first return of voluntary power. On March 16th, 1892, the functions of the hand were completely restored. The patient was able to write well, and perform all movements. It only differed from the normal in the inability to completely straighten the little and ring fingers, in the flexors of which, although never paralysed, contracture was from the first the most marked.

The naked eye appearance of the injured nerves was examined in three cases by an exploratory operation undertaken with a view to remove any existing cause of pressure. In none of the cases did the nerve present the slightest sign of present or past lesion; in none was there found any existing cause of pressure.

The diagnosis seldom presents any difficulty. I do not doubt, however, that cases of this kind are at times overlooked, nerve lesions not being thought of, and paralysis and contracture of muscles being confused with the general weakness and stiffness which are so often left for a considerable time after the fracture has united. This applies more particularly to lesions of the median and ulnar nerves. Paralysis of the musculo-spiral nerve produces the characteristic and familiar wrist-drop, which is little likely to be overlooked. There are two signs which should always make the surgeon suspect damage to nerve trunks in cases of fracture of the upper limb. One is that the patient makes more than usual complaint of numbness of the fingers during the first two or three days. The other is an excessive amount of stiffness of the elbow, wrist, and fingers found when the splints are removed. Disturbance of sensation is almost always transient, but is seldom absent during the first week. Sensation is blunted, but seldom quite abolished; sensations of numbness, tingling, etc., often persist for a considerable time. In affections of the median nerve the patient complains mostly of the tips of the index and middle fingers, less of the thumb. In affection of the musculo-spiral nerve the numbness is referred to the back of the hand and forearm, but in these cases complaint is less often made, and the alteration of sensation is more transient.

Contracture both of the paralysed and of the unopposed muscles sets in early in the case of the median nerve from the fourth to the eighth week. In musculo-spiral palsy due to fracture of the humerus, contracture either of the paralysed or of the unopposed muscles does not occur. Median palsy is, therefore, that which, owing to contracture, is most liable to be confused with stiffness due to prolonged immobilisation. The position of the hand, however, in this case is very characteristic. When the nerve is implicated in the upper arm the patient is quite unable to supinate the hand beyond the mid position to which it is carried by the biceps and supinator longus; the wrist cannot be extended beyond the straight position; the metacarpal bone of the thumb is drawn back into the same plane as those of the fingers; and there is total inability to flex the last two joints of the index and middle fingers. The proximal phalanx can still be flexed by the

action of the interossei and lumbricales. At a later time the wrist becomes considerably adducted by the unopposed action of the flexor carpi ulnaris, and the metacarpal bone of the thumb becomes approximated to that of the index finger by the similar action of the adductor pollicis. The attitude of the hand therefore closely resembles that which may be produced by faradising the normal ulnar nerve in the middle of the arm. In the case given below, in which the median nerve was compressed in the forearm, the most marked feature of the hand, in addition to those just described, was the strong flexion of the little and ring fingers due to the action of the unopposed half of the flexor profundus digitorum supplied by the ulnar nerve, and therefore unparalysed. It is worthy of note that in this case contracture of this unparalysed half of the muscle was both more severe and more permanent than in the paralysed muscles supplied by the median. It is this liability of contracture (organic shortening) to affect both paralysed and unparalysed muscles which makes the determination of the exact cause of the attitude assumed by the limb in lesions of peripheral nerve trunks so difficult to determine.

If any doubt as to the existence of nerve lesion remain after the examination of the voluntary power, sensation, and attitude of the limb it can generally be set at rest by testing the electric excitability of the muscles and nerves to the faradic and galvanic currents. In doing this, one or two facts should be borne in mind. In the first place, when the limb has only recently been taken out of splints or plaster, the skin is usually so dry and non-conductive that the reactions cannot be accurately tested until the limb has been thoroughly washed and rubbed for several days in succession. Secondly, mere disuse of a limb from immobilisation produces such a diminution of faradic excitability of all the muscles that often for several days no reaction can be obtained from a strong current. Hence diminution or loss of faradic irritability cannot be relied on as a proof of nerve lesion unless it is confined to a group of muscles supplied by a particular nerve. If loss of faradic irritability is found, some alteration, quantitative or qualitative, or both, will be found in the reaction to galvanism. In all the cases which have come under my notice, except one, faradic irritability has been lost; galvanic irritability, on the other hand, was retained, and in some cases increased together with the usual qualitative alteration. In only one was there total loss of both kinds of electric excitability (Case rv).

The prognosis is a point of considerable importance. It is on the whole extremely favourable. Only one of the six cases now recorded failed to recover (Case rv). If galvanic irritability is not lost at the end of a month from the time of injury, a favourable result may always be expected under proper treatment. The time varied from three to twelve months. It was more rapid in children than in adults.

The treatment consists in passive movement, friction, and electrical stimulation of the affected muscles and nerves. As a rule, no attempt should be made to deal with the nerve injury until the fracture is soundly united—that is, from four to eight weeks after the injury. Adhesions and contracture should then be dealt with, an anæsthetic being used if necessary. The whole limb should then be treated with systematic rubbing and with electricity. Whether for this purpose the interrupted or the constant current should be used is a subject of dispute. At present it is generally recommended to use the constant current, to which the muscles still respond. It is certain, however, that the beneficial effects of electricity do not entirely depend on its producing a muscular contraction. The efficiency of faradism, even after the muscles have ceased to respond to it, is indisputable. Duchenne, to whom we owe the use of electricity in muscular paralysis, produced his remarkable cures entirely with the faradic current. One of my own cases was also successfully treated by faradism alone. The use of the latter has several advantages over the galvanic current; the battery is of simpler construction, less liable to get out of order, and requires much less care and skill in its application than the constant current. This allows the application to be entrusted to a nurse or patient's friend—a point of some practical importance when it has to be continued for some months. Finally, the nerve may often be faradised above the seat of lesion, and the muscles may in this way be got to respond long before volitional impulses

are able to pass. If desired, the faradic current may be applied daily by a nurse or friend, and the galvanic once or twice a week by the surgeon himself.

The question of operation will naturally arise in many of these cases. No operation should be advised, unless there is reason to believe there still exists some pressure or traction on the nerve which can be relieved. I believe that the number of cases in which such a condition exists is small. Of the three cases in which an exploratory operation was done no sign of still existing pressure was discovered in any: in one it is true the nerve lay in a groove of callus, but there was no evidence that it was compressed by it. If, however, there is any condition such as marked displacement of bony fragments, or any other cause which seems remediable by operation, no hesitation need be had in undertaking it and in at least ascertaining the actual state of the nerve.

For permission to publish these six cases I have to thank the honorary surgeons of the Wolverhampton General Hospital.

THE COMPOSITION OF THE FETAL URINE SECRETED IN UTERO.

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My purpose in this communication is to publish a new observation which is, I think, important, in that it provides the missing link of the chain of evidence that the foetal urine is one possible and probable source of the amniotic fluid. Numerous analyses have demonstrated the presence of urea in the liquor amnii, the amount varying in different cases, but always increasing as gestation advances, and proportional to the size and weight of the foetus.¹

The presence of urea has been explained in three ways: (1) By transudation from the maternal structures; (2) by excretion from the foetal kidneys and skin; and (3) from both these sources. Very few observations on the urine from the foetal bladder have been made. Urine obtained from two sources, however, has been examined: (1) That obtained from the bladder of the dead-born child; (2) that obtained by catheterisation from the bladder of the live-born child. Analyses of these urines have demonstrated the presence of urea in each series, but in one case only has a quantitative estimate been made, by Gusserow-Wislicenus,² the amount found being stated as 6.06 per cent.; probably, however, this is a printer's error, as has been suggested by Krukenberg;³ for von Ziemssen, in his *Cyclopædia*, says: "On the other hand, when fluids have been abstained from up to a point when really unendurable thirst has been sustained, I have never found that more than 6.1 per cent. of urea was contained in the urine. The twenty-four hours' urine of a strong, well-nourished adult, himself no great consumer of fluid, contains an average quantity of 2 or 3 per cent. of urea."⁴

The results of analysis of the urine obtained from both these sources are, however, vitiated: (1) In the first series the urine was obtained *post mortem*, and had presumably, therefore, undergone *post-mortem* changes; these analyses must therefore be excluded in discussing phenomena of life. (2) In the second series the analyses are useless for our present purpose because the children had breathed before the urine was obtained.

We have, therefore, no single analysis of healthy foetal urine—that is, of urine from the bladder of a healthy child before it has breathed; in other words, the chain of evidence that the foetal kidneys are one source of the liquor amnii breaks down at this one point; there is no evidence that the urinary secretion of the healthy living foetus contains urea.

¹ Prochownick, Beiträge zur Lehre vom Fruchtwasser, Arch. f. Gyn., Band xi, 1877.

² Zum Lehre vom Stoffwechsel des Fötus, Arch. f. Gyn., Band iii, 1872.

³ Kritische und experimentelle Untersuchungen über die Herkunft des Fruchtwasser, Arch. f. Gyn., Band xxii, 1884.

⁴ Cyclop. of the Practice of Medicine, translated by A. H. Buck, 1877, vol. xv, p. 27.