A CLINICAL LECTURE

ON

SECONDARY SUTURE OF THE BRACHIAL PLEXUS.

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GENTLEMEN,—The case which I propose to bring before you to-day presents several points of interest. It is an admirable example of the result of complete rupture of the brachial plexus, and it is also, I believe, the first case in which suture of that plexus has been effected long after the original injury. To the various minor details which it illustrates I shall refer after describing the symptoms presented.

At the end of August, 1895, a girl, then aged 16, was caught by some machinery in a mill in which she was working, but the exact nature and mechanism of her injuries could not be ascertained, there being apparently no witnesses, while the girl herself was unconscious, and remained so for about an hour. She was treated for ten weeks in hospital, and was then discharged as incurable. She came under my care in the Manchester Royal Infirmary on March 21st, 1896, seven months after the accident, and she then presented the following condition:

The whole of the left upper limb was absolutely paralysed, flail-like, and much wasted. Of the intrinsic muscles of the limb none were capable of any response to voluntary, faradic, or galvanic stimulation. The condition of the extrinsic muscles and of those about the shoulder-joint requires a rather more detailed description. The deltoid, pectoralis major, latissimus dorsi, and teres major were totally paralysed and wasted; the trapezius presented slight wasting, but was not paralysed; the serratus magnus could be seen and felt to contract upon voluntary or electrical stimulation, and the scapula was readily moved thereby; contractions of the subclavius could also be felt through the wasted pectoralis major; the fulness of the scapular fossæ indicated that there was no marked wasting of the supraspinati and infraspinati and their voluntary contractions were thought to be felt through the trapezius. The pectoralis minor, subscapularis, rhomboids, and levator anguli scapulæ could not be defined, but the mobility of the scapula was little if at all interfered with, while rotation of the humerus was impossible, so that the rhomboids and levator anguli were probably unaffected, while the subscapularis was probably paralysed. The pupils were equal in size, and reacted well to alteration of light; the palpebral apertures were equal on both sides. The diaphragm was unaffected.

Anæsthesia was absolute in the hand and forearm, as well as in the anterior and posterior aspects of the upper arm, but it presented no sharp boundary. On the outer aspect of the limb sensation extended over the deltoid muscle to about 3 inches below the level of the clavicle and of the spine of the scapula; on the inner side a band of sensation extended from the axilla to within an inch of the internal condyle of the humerus. Although no sharp definitions were possible it was thus clear that sensation was retained in the distribution of the cervical plexus above and over the deltoid, and in that of the branches of the second or second and third dorsal nerves on the inner aspect of the arm, but that there was complete anæsthesia of the region supplied by the brachial plexus proper.

In addition to the wasting of the limb there was an indication of vasomotor and trophic changes in its coldness (temperature records were not made) and in the "glossy skin" of the hand. The joints appeared to be perfectly normal, and the whole limb was flaccid and occupied the position of gravitation. Beyond the confines of the brachial plexus the nervous system was perfectly normal.

It is not my intention to-day to discuss the general question of injuries of the brachial plexus. The above case is sufficiently typical of the class and could not be confused with any other injury. The most common diagnostic error is the mistaking of a hysterical monoplegia for an injury of the plexus; but in the present case the absence of any other hysterical manifestations, such as hemianæsthesia or affections of the field of vision and colour sense, taken together with the completeness and unaltering character of the sym-

ptoms and the limitation of anæsthesia in accord with the distribution of the nerve roots, render such error impossible.

More important is the question of the precise localisation and nature of the injury, and upon these points we can speak with considerable precision. The anæsthesia was that of a lesion of the entire plexus, the area of lost sensation involving the distribution of all its roots. So far as the sensory symptoms alone are concerned, the roots of the plexus might have been torn away from the spinal cord, or the injury might have been inflicted at any lower level down to the general breaking up of the plexus into its various branches. On the other hand, the completeness and persistency of the anæsthesia, which remained absolute at the end of seven months, are sufficient evidence of the serious nature of the injury, and could only result from a complete rupture or from a contusion which had produced local injury and subsequent degeneration, at least as serious as that following upon complete rupture. Section of the plexus was eliminated by the absence of any external injury, and the injury was clearly not associated with fracture of the clavicle or other bone. Thus, then, we have established a rupture or contusion of the plexus of maximum intensity, but of doubtful localisation.

The motor symptoms enable us to take a further step, and to define the localisation of our injury. The roots of the brachial plexus pass between the anterior and middle scalene muscles, and at or close to the outer border of the latter the two upper roots unite together, as do also the two lower roots, thus yielding three great cords. Close to the junction of the two upper roots arise the nerve to the subclavius and the suprascapular nerve, which supplies the supraspinatus and infraspinatus. Above this point the roots give off no sensory branches but supply motor branches to the scaleni, the longus colli, the rhomboids, the serratus magnus, and the dilator iridis and muscle of Müller. Below the origin of the suprascapular nerve is a region from which no branches arise until the plexus begins to break up into its ultimate branches of distribution.

The muscles supplied from the plexus and its roots are in our case divisible into three groups, namely, those which are shown not to be paralysed, those which are equally proved to be paralysed, and those whose condition was doubtful. In the first group we have the dilator iridis, muscle of Müller, serratus magnus, subclavius, supraspinatus, and infraspinatus. In the second we have the latissimus dorsi, teres major, pectoralis major, and all the intrinsic muscles of the upper limb. In the third group we have the scaleni, longus colli, rhomboids, subscapularis, and pectoralis minor. If we assume that the scaleni, longus colli, and rhomboids were intact while the subscapularis and pectoralis minor were paralysed, we have a perfect clinical picture of an injury situated in the body of the plexus, but beyond the outer border of the scalenus medius and the junction of the roots into three cords; above this level we have all the branches intact, below it all are paralysed.

To sum up: We have here an injury of the brachial plexus situated in an accessible region of the neck, external to the scalenus medius; the motor fibres above that level are intact, those below it are paralysed; the sensory fibres all arise below it, and are all paralysed. The plexus has been torn across or hopelessly contused in the region named, but its roots have not been torn away from the spinal cord. On these grounds a plastic operation was regarded as possible.

The operation of secondary suture was performed on April 13th, 1896, or seven and a half months after the injury. A long incision was made in the posterior triangle of the neck parallel to and just in front of the anterior border of the trapezius, commencing opposite the level of the hyoid bone, and extending across the clavicle between the origins of the deltoid and great pectoral muscles, and thence for 2 inches further on to the chest. The clavicle was divided at the point indicated and a hole drilled in each end of the bone, through which were passed strong ligatures allowing of thorough retraction. The lax soft tissues of the neck were readily dissected away and the great cervical vessels held inwards by retractors. The outer borders of the scaleni were now well defined; the omo-hyoid muscle was drawn downwards and inwards; the subclavian vessels, fully exposed, did not interfere with the operation. Immediately outside of the scalene muscles the brachial plexus was represented by an

irregular cicatricial mass, which, when artificially dissected from its vaguely-defined surroundings, formed a dense cord about 2 inches in length and $\frac{3}{4}$ inch in diameter. On dissecting this upwards the five main roots of the brachial plexus could readily be defined, each entering the cicatricial mass. They were thick and bulbous as far back as they could be traced, and the junction of the fifth and sixth cervical and of the eighth cervical and first dorsal respectively could not be clearly differentiated from the general mass. The nerve to the rhomboid muscles and the suprascapular nerve were distinguished as they left the upper part of the cicatrix; no other branches were sought for or recognised. Immediately below the level of origin of these two nerves the cicatrix was somewhat artificially separated into three cords, each of which was secured by a few fine silk sutures to which the needles were left in attachment. The cicatrix was then cut away from them below these sutures with sharp scissors. Peripherally, and at a distance of about 2 inches from the last incision, the peripheral ends of the nerves could also be defined; they were freed from their general adhesions and cut cleanly away below the main cicatricial mass. By means of the holes drilled in it the ends of the resected clavicle were now secured to one another and tension thus removed from the shoulder. The sutures passed through the central nerve ends were now carried through the peripheral ends, when it was found possible to approximate the cut surfaces without tension. No precise differentiation of the peripheral ends was possible, as they contained a good deal of cicatricial tissue; they were—to some extent artificially—separable into five cords; to the upper proximal end were attached the two higher peripheral trunks, to the lower proximal end the two lower peripheral trunks, and to the middle proximal end the remaining or middle peripheral cord. The cicatrix removed in the operation was carefully examined for me by Dr. Craven Moore, whose report thereon is detailed at the end of this lecture.

Wound healing was by primary union, and was uneventful. On the fourth day after the operation there ensued a violent arthropathy of the elbow; the joint became greatly swollen, hot to the touch, and of a dusky-red colour, oedema extending throughout the forearm and the lower part of the arm; this condition was unassociated with pain or with rise of general temperature; it gradually subsided in the course of two or three weeks, and left no fixation of the joint. The patient remained under observation in the Manchester Infirmary and the Cheshire Convalescent Hospital for four months, during which period there was no sign of recovery of function. From that time I did not see her until recently—namely, on February 22nd, 1900.

I now learn that in October, 1896, the girl returned to work in the mill, her left arm being still completely paralysed. About a month later, or, as nearly as she can remember, in the beginning of November, 1896, she "began to move her arm a little," six months and a-half having then elapsed since the date of the operation. She can give no information at all as to the order in which the functions have been restored; all that can be ascertained is that there has been a gradual improvement up to the present time. She has carried out no accessory treatment, and has entirely neglected to use warmth, friction, or movement; she is utterly apathetic and indifferent about the matter, and simply says that she "gets along very well as it is." To this carelessness must probably be attributed the want of a much better result than is now to be described.

On February 22nd, 1900, or nearly four years after the operation, the limb is still much wasted, and the hand is not used for any of the practical duties of life, but the forearm is employed for carrying articles which can be thrown over it, and the upper arm is also used for carrying by apposition to the chest. The patient has occasional subjective sensations of heat and cold, and at rare intervals pain about the point of the shoulder. There is sensation throughout the entire limb, but localisation of touch is defective. In the hand sensation is least developed, and there is only a general impression of contact with localisation within the limits of each finger, and, roughly, of the area of the hand which has been touched; a warm and cold test tube are not distinguishable. In the forearm the tactile impressions are clearer, but contact is liable to be localised as far as about two inches from the

point actually touched; as a rule the touch is localised a little higher than the point at which it is actually made; heat and cold are here readily distinguished. In the upper arm sensation is blunt, but by no means seriously defective; no boundaries can be defined between the areas of varying sensibility, and the different grades of comparative anaesthesia shade very gradually one into another. The tactile sense bears no relation to root areas, but appears to be determined solely by proximity to the shoulder. The sensation of pain is appreciable throughout the limb.

As regards muscular power, it is only possible to define the gross movements of the limb, individual muscles can be felt to contract only in the case of a few of the more prominent masses. Abduction of the shoulder is slight, but can be performed, and the deltoid can be felt to harden; adduction is more powerful, and the arm is used for carrying light articles pressed against the chest; the contractions of the pectoralis major are well defined; advancement and retraction of the arm are effected within a short range, and with little power; no rotation of the shoulder can be elicited; the shoulder-joint itself is capable of tolerably free passive movement; but abduction is not quite complete. At the elbow-joint flexion is fairly powerful, and the forearm is habitually carried at a right angle, clothes, etc., being carried lying thereon; the contractions of the biceps are readily seen and felt; extension of the elbow is very feeble, nor can contractions of the triceps be detected; the elbow-joint presents no abnormality. The wrist can also be flexed with considerable power; the power of extension is insufficient to support the weight of the outstretched hand; pronation and supination are indicated only by the slightest movements. The fingers are semiflexed at all their joints, and stiff but not ankylosed; their flexion is capable of slight voluntary increase and decrease, so that the extensors and flexors of the fingers present some activity. Adduction and abduction of both the thumb and the little finger are manifested, but only very slightly so. In brief, almost all the movements of the limb are recognisable, but all except flexion of the elbow and wrist and abduction and adduction of the arm are very feeble. There is no confusion of movement; within its limited range the movement asked for is correctly performed in every case. Muscular sense and localisation are perfectly normal. The skin of the wasted fingers is somewhat glossy, but not more so than would be explicable by its disuse. No acute "trophic" lesions have presented themselves since the operation, and a few slight injuries which have been received in the anaesthetic area healed normally.

The above case presents several points of interest to which I wish now to call your attention.

In the first place, I bring it before you now because it is not improbable that we shall shortly see in England a good many similar cases resulting from the present war. The soldier lying prone under fire is obviously peculiarly liable to be struck in the region of the neck and shoulder, and bullet wounds of the brachial plexus inflicted from above the clavicle may reasonably be expected. Possibly some at least of these will be sent home as incurable, and may be greatly benefited by secondary suture.

Secondly, I believe no operation similar to the above has as yet been recorded. Primary suture of the brachial plexus or of parts of it has been resorted to upon several occasions, generally in association with open wounds or with injuries of the clavicle in which the broken ends of the bone have required resection, but I can find no recorded example of deliberate secondary suture of this important collection of nerves.

Thirdly, the question may fairly be asked, Was operation really called for in this case? The uselessness of the limb was obvious; but was there no chance of recovery without operation? The question thus becomes, At how late a period may complete motor and sensory paralysis resulting from injury of the brachial plexus first show signs of recovery? Upon this point I can obtain no precise information. Personally I have seen many injuries of the brachial plexus, but in none have the symptoms remained absolute for seven and a-half months, after which time recovery has commenced; nor can I find any such case in medical literature. In all in which function has been at all restored there have been

indications of its restoration at some earlier date. Our own case confirms this view, as it is beyond question that the severance of nerve fibres was complete at the time of the operation, but in spite of this there were indications of recovery six and a-half months later. The original injury could not have caused a more complete severance of nerve fibres, and the want of all recovery after seven and a-half months therefore suggests some absolute bar to regeneration. The development of changes in the elbow-joint within a few days of the resection of the cicatrix appears to indicate *prima facie* that the operation sacrificed at least some nerve fibres which were previously intact, but such evidence must be received with caution; we are still too ignorant of the significance of "trophic lesions" and the importance of vasomotor changes in their production to assert or to deny that these changes were not evoked by the general disturbance of a severe wound in the neighbourhood of the subclavian vessels, or by traumatic injury of the elbow during anaesthesia, or during subsequent bandaging of the limb. The cicatrix which was removed presented no clear evidence of having been directly traversed by untorn or regenerated nerve fibres, in continuity between the peripheral and distal ends.

A further difficulty which was raised before operation was the impossibility of attaching the torn cords correctly to their proper peripheral ends, and it was suggested that the spinal nuclei might on regeneration be attached to muscles other than those for which they were intended, and that hopelessly confused movements might thus result. In my opinion this is a matter of little moment. When we perform secondary, or even primary, suture of a single motor nerve, it is unimaginable that the central axis cylinders grow into peripheral tubes, with which they were formerly connected, and that each eventually leads from its spinal cell to the muscle plate originally associated therewith. Hopeless anatomical confusion must occur in all cases, but there is no evidence of any ultimate physiological difficulty. In the case of the brachial plexus there is no new factor to disturb our results; it is a mere accident that the various fibres lie in five bundles instead of in one; the confusion can hardly be greater than in ordinary cases. In the case with which we are dealing to-day there is no evidence whatever of difficulty in moving the muscle which it is desired to move, and there is no ataxia. Sensory localisation is unquestionably imperfect, but such confusion is common after nerve injuries: in our case it differs only in degree, and not in kind, from that which is generally observed, and there is no indication of gross confusion, such as persistent mistaking of one part of the limb for another distant part.

Lastly, we have to inquire how far the operation was justified by results, and what hope is offered to us by it in similar cases. That the plexus is capable of repair after complete resection and secondary suture is clearly proved. The extent of recovery is disappointing, but its promise for other cases is less unsatisfactory than appears at first sight. Both sensation and motion have been partially restored in the whole upper limb, and even the small muscles of the hand have acquired some power. So much having been gained, there can hardly be a doubt that much more might have been gained by the aid of systematic massage, and by a little effort on the patient's part; the very fact that the flexors of the elbow and wrist and the adductors of the shoulder, which are the only muscles she has attempted to use, have improved much more than have other groups is an indication in this direction.

Even at this date slow improvement is in progress, and between two examinations which I made at an interval of seventeen days there was distinct improvement both in the sensation of the hand and in the mobility of the fingers, the interval having been devoted to education of the limb. On the experience thus gained there can be no doubt that old injuries of the brachial plexus located within an accessible region should be submitted to operation rather than condemned as hopeless—a position which has even led to amputation for the removal of a useless encumbrance. It is only in those cases in which the plexus is torn away from the cord that operation is impossible, and a careful examination on the lines indicated in an earlier part of this lecture will readily distinguish such cases.

ADDENDUM.

REPORT ON CICATRIX REMOVED FROM THE BRACHIAL PLEXUS.
By F. CRAVEN MOORE, M.D., Pathologist to the Manchester Royal Infirmary.

The specimen, which had been preserved in alcohol for some time, apparently consisted of a number of nerve trunks imbedded in dense fibrous tissue. The continuity of the nerve trunks could be traced towards one end of the specimen and then it was lost in a mass of fibrous tissue. Sections cut parallel to the long axis of the specimen and stained with borax carmine, and according to the method of Van Giessen, showed the following appearances.

A number of large nerve trunks, separated from each other by dense white fibrous tissue, could be traced from one end of the section to within 2 cm. of the other end, where they abruptly terminated in a mass of fibrous tissue; beyond this, short pieces of nerve trunks were present in the extreme opposite end of the specimen. The nerve fibres composing these trunks were degenerated, the great majority consisting merely of neurilemma sheaths containing large numbers of nuclei; here and there, however, a nerve fibre appeared to have escaped, and showed a well-defined axis cylinder. The tissue between the individual nerve trunks differed from the normal in its greater density, and obviously indicated the occurrence of inflammatory changes, culminating in the formation of dense cicatricial tissue. The mass of tissue which interrupted the continuity of the nerve trunks was of a similar nature. It consisted of white fibrils closely arranged, with but few cells and few vessels. A few nerve fibres could be seen in the midst of this cicatrix; they possessed well-defined axis cylinders and nuclei; the neurilemma sheaths were less well defined. Their course was very irregular, curving round in various directions, and not apparently passing directly from the nerve trunks at one end to those at the other. The exact meaning of these fibres it is somewhat difficult to estimate. They might represent either regenerated nerve fibres or fibres which had escaped destruction. The apparently adult constitution of the fibres is somewhat against the former hypothesis, but is discounted by the fact that more than seven months had been allowed for regeneration between the time of injury and the date of removal of the cicatrix. In consideration of their curiously irregular course, and of the difficulty in imagining how, if persisting nerve fibres, they had escaped destruction during the inflammatory changes which led to the extensive cicatrization present, it is probable that they must be regarded as evidences of regeneration.

CLINICAL NOTE ON A CASE OF FRACTURE
OF THE CARPAL SCAPHOID.

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(SEE SPECIAL PLATE.)

THE signal aid which we now so frequently derive from *x-ray* photography, in the diagnosis of osseous lesions especially, is in no instance better illustrated than in its application to some of the forms of carpal injury. In their recognition it must, I think, be regarded as one of the most obvious examples of its practical value. Previously to the discovery of this latest development of photographic art no surgeon, however skilful a diagnostician he might be, could with any accuracy form a true estimate of many of these injuries. The case is different now, however, and it is no exaggeration to say that they can, as a rule, be recognised and differentiated as easily as any of the ordinary fractures or dislocations the surgeon has to deal with.

I feel confident this favourable estimate of the practical value of Roentgen-ray photography will be accepted by most persons interested in surgical diagnosis, especially in reference to the obscurer injuries which occur at or in the immediate vicinity of joints.

This opinion, however, cannot be said to be of universal acceptance, as witness the published views, among others, of Professor Stimson in his well-known and excellent work on fractures. He observes: "While the *x-rays* have been of interest and value in showing details of certain fractures, especially at the wrist, elbow, and ankle—yet it cannot fairly be said that they have yielded much information and practical value which could not be obtained by palpation. Probably their usefulness will be increased by improvements in methods and apparatus, but at present the information which they give needs to be sifted with great care from among many misleading appearances."

Such views as these will not, I venture to think, be endorsed by most surgeons, even by those of comparatively limited experience.

As a rule, the assistance derived from Roentgen photography will ever be gratefully remembered by surgeons, not only in the recognition of carpal and radio-carpal injuries, but also in many of the obscurer lesions—fractures, dislocations, or a combination of both—which occur at the elbow or ankle-joints. For example, it is hard to understand how by