The Goulstonian Lectures

ON SPINAL INJURIES OF WARFARE.

DELIVERED BEFORE THE ROYAL COLLEGE OF PHYSICIANS
OF LONDON.

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III. THE SENSORY DISTURBANCES IN SPINAL INJURIES.

In the previous lecture we discussed, as far as time would permit, certain symptoms produced by injuries of the spinal cord, selecting those which were the most important and interesting; in the present lecture the disturbances of sensation, especially those that result from incomplete or unilateral lesions, will be described, and observations that may contribute to our knowledge of the course and grouping of the sensory afferent impulses within the cord will be particularly emphasized.

If you permit me it will be advisable, however, before passing to my own observations, to give a short sketch of the conduction of sensation within the cord as far as it is at present known.

Nearly sixty years ago the first valuable contribution to this subject was made by Brown-Séquard,⁷ who from both clinical and experimental observations concluded that a one-sided lesion of the spinal cord produces motor paralysis, with hyperaesthesia and loss of muscle sense on the same side, and in addition anaesthesia of all other forms of sensibility on the opposite half of the body.

These conclusions have been, however, violently attacked by both physiologists and clinicians, and even Brown-Séquard himself later modified his views, but they have formed the basis of all subsequent contributions, and it has been, in fact, only within recent years that any important additions or modifications have been made to them.

The exact intraspinal course of the various forms of sensation soon began to excite interest. Many workers, following Brown-Séquard and Schiff, held that pain and temperature at least pass upwards through the grey matter, while tactile impressions and those that underlie the sense of position, ascend, according to Schiff, through the dorsal columns. Bechterew's and Bikel's experiments, however, made it probable that impressions of pain are conducted, after decussation, through the white matter of the ventral part of the lateral columns. But it is obvious that neither the grouping nor the course of sensory impulses within the cord could be determined by experiments on animals, and it is not surprising that the most reliable conclusions we have were obtained from clinical observations on suitable cases of injury or disease in man. It is largely to Petré⁸ that we owe the most accurate and comprehensive summary of clinical observations. From the collation of a large number of cases he has concluded that impressions of pain and temperature pass through the opposite lateral column, "muscle sense" through the homolateral dorsal column, while two paths are open to tactile impressions, one through the uncrossed exogenous fibres of the dorsal column, another in the opposite lateral column. A careful and elaborate analysis by Drs. Head and Thompson⁹ of sensory disturbances produced by spinal lesions confirmed these conclusions, and showed that when the appreciation of cutaneous pain is lost, that produced by pressure is also disturbed, that light touch and heavy touch are lost simultaneously, and that the appreciation of all degrees of temperature is abolished together. They also found that the ability to recognize the simultaneous contacts of two compass points depends on impulses conducted through the homolateral dorsal column. The affection of other forms of sensation by spinal lesions has been also investigated. The French school particularly has been interested in the appreciation of the vibrations of a heavy tuning-fork, and Egger,¹⁰ as well as Seiffer and Rydel,¹¹ have shown that disturbance of this is generally associated with loss of the sense of position, and that it consequently depends on the integrity of the dorsal columns. Finally, working with Dr. Head,¹² I found that in unilateral spinal

lesions the appreciation of weight and the recognition of size and shape are frequently lost in the paralysed side, and from this observation, correlated with other facts, we concluded that the impulses that subserve these functions also ascend uncrossed through the dorsal column; we also confirmed earlier observations that the appreciation of vibration passes by this path too.

The nature of our material and especially the fact that we have been able to investigate most of our cases only in that early stage in which certain symptoms may be attributed to shock and other to partial lesions and incomplete blocking of the passage of sensory impulses makes extreme caution necessary in drawing final conclusions on the mode of sensory conduction within the cord, but the disturbances we observed must have an important bearing on this subject. We have been, however, able to keep certain cases under observation as long as ten to twelve weeks after the infliction of the wound.

BROWN-SÉQUARD PARALYSIS.

The description of the sensory changes found in incomplete lesions can be most easily introduced by the history of a typical case of unilateral injury:

CASE IV.

Pte. C., 15417, was wounded on May 12th, 1915, by a rifle bullet, which entered immediately to the right of the fifth cervical spine and made its exit 2 cm. below the right angle of the mouth. His jaw was fractured. He lost all power of movement in both legs and in his right arm at once, and his left arm became weak. He complained of pain in his left shoulder and had retention of urine at first, but this quickly disappeared.

He came under observation three days after the infliction of the wound. An x-ray examination then showed a fracture of the right side of the arch of the fifth cervical vertebra and some damage to the bodies of the fourth and fifth on this side. There was a well-marked palsy of the right cervical sympathetic and his right arm was toneless and completely paralysed. All movements of his left arm were possible, but its

Fig. 6.—Sensory disturbances in Case IV. In this and the succeeding figures the horizontal lines represent tactile anaesthesia, the vertical lines analgesia, and the oblique lines thermo-anaesthesia. Interrupted lines indicate partial loss of the corresponding form of sensation. In Fig. 6 the dotted line on the right arm indicates the limit of anaesthesia to heavy touch.

distal segments were slightly weak. There was practically no movement of the right side of his chest in ordinary respiration or on taking a deep breath, and the rectus abdominis and the diaphragm of this side were weak. The movements of his left lower limb were as full and as strong as normal, but the right was flaccid and powerless. The arm-jerks were absent on both sides, and the knee and ankle jerks on the right, but on the left these reflexes were exaggerated; the right plantar response was extensor and the left was flexor.

He then complained of pins and needles in his right leg and of a sharp stabbing pain in his left shoulder. Examination revealed complete loss of appreciation of painful and thermal stimuli on his left side up to the lower margin of his second rib in front and to his first dorsal spine behind, as well as on the inner border of his arm and hand (Fig. 6). Even the highest

tactile stimuli could be recognized on both legs and on both sides of his trunk, but when a wisp of cotton-wool was drawn over either hairless or hair-clad parts it tickled more, and was "more distinct" on the right than on the analgesic side; when compared with parts above the level of the lesion it was found that this subjective difference was due to non-appreciation of the tickling component in the stimulus on the left side. The extensive sensory disturbances represented on the chart were found on his right upper limb; there was total loss of sensation to pain on the hand and on the radial side of the forearm, loss of appreciation of temperature over a slightly larger area, while cotton-wool and heavy touch could be recognized only on the inner side of the arm; rubbing or scratching, however, produced much discomfort on the area in which sensibility to touch was lost, but that to pain preserved. The sense of position and the appreciation of passive movement were abolished in his right limbs and diminished in his left ulnar fingers, and vibration could not be recognized in his right leg, on this side of his trunk, or below his right elbow. He was also unable to recognize the form of objects placed and moved about in his left hand, but owing to the tactile anaesthesia this could not be then tested in his right hand.

Ten days after the injury his left limbs were almost as strong as normal, and the right reflexes had reappeared, but were feeble; the state of his sensation remained unaltered, except that heavy pin pricks could be occasionally felt on the left side above the level of his fifth rib.

Twenty-four days after the infliction of the wound his general condition had improved and permitted a more complete examination. His right leg was still flaccid and powerless, and his right upper limb was wasted and completely paralysed; the left limbs were now quite strong. He now complained of severe pain in his right leg, especially when it was touched or moved, but there was no local condition to account for this. Apart from his right arm, the lightest tactile stimuli were appreciated as well on one side as on the other; but cotton-wool still appeared smoother and tickled less on the left leg and on this side of his trunk than on the right. Neither pricks nor heavy pressure produced any pain on his left leg or trunk, but strong pricks could be occasionally recognized between the sixth and second rib and in the inner aspect of his left arm. Now pricks and all painful stimuli were "much sorer," and evoked much more reaction than on the right side; in fact, the hyperaesthesia of this side was as pronounced as we have seen it. The appreciation of temperature was still completely lost to the original level. The sense of position was absent in his right limbs and in the three ulnar fingers of the left hand, but vibration could now be recognized in his right leg when the fork was beating strongly. The threshold of discrimination of the compass points was normal on the radial parts of his left arm, but the two points could not be distinguished when 5 cm. apart on the ulnar side of this palm, or on either sole when separated to a distance of 10 cm. (normal threshold 2 to 3 cm.). He was still unable to recognize the form of objects placed in his left hand.

In his right arm the analgesia was now limited to the thumb, index finger, and the lower half of the radial border of his forearm, and the areas of anaesthesia and thermo-anaesthesia had diminished slightly from above downwards.

Fig. 7.

He was transferred to England two months after the infliction of the wound. During the latter half of this time he wasted enormously, and had frequently persistent attacks of vomiting; he regained, however, some power of movement in his right leg, but his right arm remained wasted, flaccid, and powerless. The only noteworthy alterations in the disturbances

of sensation were an ability to recognize strong painful stimuli above the level of the nipple on the left side, though sensibility to pain remained much reduced to its original level, and a further restriction of the anaesthesiae on his right arm, as is illustrated on the chart (Fig. 7); now there was analgesia only on the thumb and the adjacent portion of the hand. The sense of position was still absent in his right limbs and in his left ulnar fingers, and the appreciation of vibration was abolished below his right wrist and diminished in his right leg. The compass points could still not be discriminated when separated to 6 cm. on either sole.

He was admitted to the King George Hospital under the care of Dr. Farquhar Buzzard, to whom I am indebted for the further history of the case. Some secondary change had evidently occurred during the journey, as when he arrived his right leg was again completely paralysed, and the knee-jerk on this side, which had been brisk, had disappeared; the right plantar response was sometimes flexor, though previously it had been constantly extensor. Otherwise his condition remained unchanged till his death on August 10th. A few days before this occurred his right carotid artery had been tied owing to an aneurysm, and an abscess in connexion with his fractured jaw was drained.

On post-mortem examination no obvious deformity of the spinal column was found, but the fourth, fifth, and sixth cervical segments were softened, and contained numerous haemorrhages.

The sensory disturbances in this case may be divided into "remote," or those due to interruption of the sensory conducting tracts in the cord, and "local"—that is, such as are produced by injury of the sensory root fibres as they enter the cord, or at least before the impressions they carry are regrouped within it.

An elaborate analysis is not possible here, but a short discussion chiefly in relation to the current views of intramedullary conduction of sensation will be interesting. It will be based not on this case alone, but on our notes of 45 cases in which the injury was partial and produced the Brown-Séquard syndrome, or some other form of dissociation of sensation.

REMOTE SENSORY DISTURBANCES.

Anaesthesia to pain and temperature is certainly the most common and prominent disturbance of cutaneous sensibility; in incomplete transverse lesions, for instance, it is frequently found that though tactile stimuli can be appreciated, pricking or the application of heat or cold, even of extreme degrees and over a large area, evoke no sensation apart from that of contact. Both are always lost on the side opposite to the lesion when this is unilateral and lies above the first lumbar segment, and more diminished on this side when the injury is bilateral but more severe on the one side. This crossed relation does not occur when the lesion lies below the twelfth dorsal segment. During recovery from bilateral lesions, too, tactile sensibility usually returns before that to painful or thermal stimuli. As a rule both these forms of sensation were lost together, but in some cases only thermal appreciation was disturbed.

We have not yet observed a case with primary isolated affection of either heat or cold, but during recovery sensibility to either may reappear some time before stimulation with the other evokes any sensation. Some dissociation is, however, common at the upper level of the remote sensory loss, but this will be discussed later when the mode of decussation of the sensory paths will be considered. Many cases seen confirm the conclusion put forward by Drs. Head and Thompson, that when pain cannot be excited by cutaneous stimuli it cannot be produced by excessive pressure; we have, however, seen cases in which heavy pressure gave pain in parts which were completely analgesic to pin pricks, but it must be admitted that in some of these at least sensibility to prick returned within a relatively short period. Their further conclusion that sensibility to all degrees of temperature is affected simultaneously may be accepted if it is borne in mind that when the disease is slight the appreciation of moderate stimuli only may be lost; everything is, however, in favour of their view that thermal stimuli of all degrees pass by the same intraspinal paths, but that, as the study of syringomyelia shows, heat and cold are conducted by separate fibres.

Remote tactile anaesthesia was present in only a very few of our cases of unilateral spinal lesion, and then it generally corresponded with the analgesia—that is, it occurred on the side opposite to the injury. Frequently, however, especially when cotton-wool was used as a stimulus over hair-clad parts, there was a marked

subjective difference in the sensations evoked on the two sides, as contacts on the analgesic area "tickled less" or were "smoother" than on the side of the lesion; this might be, on the one hand, attributed to the homolateral hyperaesthesia or unnatural sensitiveness to various stimuli which Brown-Séquard originally described, but when the sensations were compared with those similarly evoked from normal parts it was evident that the tickling element in the sensation was defective on the contralateral side. On the other hand, this difference was not due to a diminution of tactile acuity, as this could not be demonstrated when other stimuli were employed; in a few cases in which von Frey's hairs were used no definite threshold difference between the two sides was found. Further, on stroking the sole, or on applying any other stimulus which naturally tickles, less reaction was evoked on the side opposite to the injury. It appears, therefore, that of the two spinal paths open to tactile impulses only the crossed fibres which are closely associated with those that carry pain are concerned in the conduction of the affective impressions produced by many tactile stimuli. This observation is particularly interesting, as lesions of certain portions of the optic thalami show that at this level the impulses that underlie tickling are closely related to those of pain.

But though crossed tactile anaesthesia was the rule in our cases, in a few there was greater diminution of sensibility to light touch on the side of the lesion, or on the side of the greater motor paralysis; even homolateral anaesthesia with crossed analgesia occurred in one case.

CASE V.

Pte. J., 15863, was wounded by a rifle bullet which entered slightly to the left of the fifth dorsal spine, on March 11th, 1915. He lost power in both legs at once, but was able to move the right again next day.

When seen four days later all movements of his right leg were possible and fairly strong, but the left was absolutely

Fig. 8.

paralysed. The left knee-jerk was much depressed, and extensor responses were obtained from both soles. There was complete analgesia and thermo-anaesthesia on the right leg, and on this side of the trunk to the level of the xiphoid and the seventh dorsal spine, but both painful and thermal stimuli were perfectly appreciated on the left side. On the right tactile sensation was unaffected, but there was total anaesthesia to touch on the left leg, and marked hypoaesthesia as high as the xiphoid (Fig. 8). The recognition of position and of passive movement, as well as of vibration, was abolished in the left leg, but normal in the analgesic limb.

A laminectomy was performed by Lieutenant-Colonel Sargent a few days later; the bullet was found embedded in the left articular process of the sixth dorsal vertebra, and a long, sharp spicule of bone which had been driven by it through the dura mater penetrated, as far as could be made out at the operation, this side of the cord. Very little improvement occurred before he left for England, six weeks after the

infliction of the wound; the analgesia of the left side became, however, incomplete, and there was less anaesthesia on his left leg.

Another interesting form of dissociation of sensation was represented by a case of incomplete injury due to fracture of the left side of the sixth cervical vertebra by a rifle bullet. There was complete paralysis of the left leg and of the trunk muscles on this side, and all the movements of the opposite limb were weak; on the right side there was complete loss of sensibility to touch, pain, and temperature, while on the less paralysed half of the body pricks and other painful stimuli were appreciated normally, and thermal sensation was only slightly diminished, but there was complete anaesthesia to both light and heavy touches. The sense of position and the appreciation of vibration were completely lost on both sides below the level of the second rib.

In such a case we have the converse of the general rule that tactile sensibility suffers less severely than sensation to pain.

One interesting question that rises from these observations is the mode of decussation of the sensory fibres of the second order which convey impressions of touch, pain, and temperature, and the obliquity with which they cross to the opposite side of the cord. In cases in which the lesion was unilateral the upper limit of the remote anaesthesia to these different forms of sensation varied, and as a rule the upper border of the contralateral loss did not correspond to the segmental level of the injury. If such observations were sufficiently numerous it would be obviously possible to determine the number of segments necessary for the complete decussation of each set of fibres of specific sensory function. To obtain unequivocal results, however, it would be necessary to consider only cases in which the lesion interrupted these fibres after their decussation is completed and in which their interruption is total; unfortunately such cases are rare.

In the mid-dorsal region the crossing of pain and thermal impulses apparently occurs quickly, and is probably complete about one segment above the entry of the dorsal roots that carry them to the cord. Thermal impressions probably cross here less rapidly than those of pain, and as touch, if it is affected, is generally lost to the slightly lower level the fibres of the second order that convey it probably require two segments for decussation. This conclusion is accepted with full recognition of the fact that the peripheral overlap of the tactile root fibres is greater than that of those concerned with pain and temperature. The same order holds for the upper dorsal segments, but here the obliquity of decussation is greater; pain and temperature impressions do not cross for at least two segments after their entry into the cord, and three are frequently required.

The higher we go in the cervical enlargement the slower does the decussation become. At the fourth cervical segment, for instance, the decussation of the pain impulses is not complete till five to six segments after their entry through the dorsal roots, and that of thermal impressions for four to five segments. In the cervical enlargement pain seems to cross within about four segments, thermal sensibility within three to four, and touch somewhat more obliquely than pain; as the upper margin of the anaesthesia to heat is generally slightly higher than that to cold it may be assumed that the afferent impulses that subserve the latter decussate more slowly.

When the lesion is not complete, and especially if it is unilateral, the upper border of the sensory loss frequently retreats caudalwards. In Case iv, for instance, the upper margin of the complete analgesia altered from the sixth cervical to the ninth dorsal root area in two months, and in another case of partial bilateral lesion it retreated from the upper margin of the right cervical root area to the level of the umbilicus within four weeks. A parallel recovery of thermal sensibility may be frequently observed, but it is usually much slower, and heat and cold are then frequently dissociated, the latter recovering as a rule earlier than sensation to heat; but the converse may occur. On the other hand, even when the lesion lies high in the cord, and has produced total or partial loss of sensation to the corresponding level, it is not uncommon to find the area of the lower spinal roots, and especially the skin in the region of the anus, sensitive to one or other mode of stimulation. Further, during recovery it is sometimes

in these regions in which sensation first reappears. In a case of injury of the fourth cervical segment, for instance, which produced thermal, pain, and tactile anaesthesia to the root of the neck, prick could be well appreciated on all the sacral and on the fifth lumbar root areas on the left side. And in another the third, fourth, and fifth sacral areas escaped, though there was otherwise total loss of sensation to the level of the umbilicus. There is generally a remarkable dissociation of sensation in this caudal area; occasionally only pain can be appreciated, but it is frequently sensitive to touch too, and either to heat or cold or to both. The area sensitive to thermal stimuli is, however, generally smaller than that in which pain can be felt. As a rule the caudal anaesthetic part in such cases corresponds roughly to areas of root distribution to the skin.

These two phenomena, the caudalward recovery of sensation and the escape or early reappearance of sensation in the caudal areas, throw light on the arrangement of the sensory fibres of the second order as they ascend through the ventrolateral columns. They indicate a lamellar arrangement in which the fibres that carry any specific form of sensation from successive dorsal roots lie in series; and as there is a general law that the longer ascending fibres lie nearer the periphery of the cord, those that convey impressions from the lower spinal roots are probably placed lateral to those that have later reached the contralateral side. The escape of the sacral root areas would therefore indicate a lesion that involves only the more mesial fibres of the sensory path, while an anaesthesia disproportionately low in relation to the level of the spinal injury would suggest a local destruction of its more lateral fibres. When it becomes possible to correlate the exact histological changes in these cases with the results of careful clinical examinations definite conclusions on the exact course of the fibres that carry various forms of sensation from different regions of the body will be possible.

Microscopical examination has shown that extensive softenings and even secondary changes occur frequently in the centre of the cord, especially in the cervical region, and we might consequently expect to find sensory disturbances resulting from interruption of the fibres that decussate at the level of such a lesion; certain of the sensory changes that occur in syringomyelia are due to this cause. The most striking example of this condition that we have seen was:

CASE VI.

Pte. H., 10162, was wounded on February 22nd, 1915, by a rifle bullet which entered just behind the middle of the right sterno-

Fig. 9.—The analgesia is indicated by vertical lines, the thermo-anaesthesia by oblique lines. All forms of sensation were lost on the parts of the right arm coloured black.

mastoid, and made its exit 1 cm. to the right of the first dorsal spine. He lost power in his legs at once, and his arms became

very weak two or three days later. He had no difficulty with micturition.

Both arms were flaccid when he was seen six days later; the right was completely paralysed, but all movements of the left were possible though weak. The right lower limb was weak in all movements, but the left was considerably stronger. His arm, knee, and ankle jerks were absent, and extensor responses were obtained on both sides. Sensation to touch, pain, and temperature were lost over the regions shown on the chart (Fig. 9), and in addition the sense of position and the appreciation of movement and vibration were abolished in his right arm and diminished in his right leg. His general condition and the power of movement, except in his right arm, which remained flaccid, improved during the following three weeks, but the only alteration in sensation was some return of sensibility to prick and temperature on the outer side of his left arm. The complete flaccid palsy and total sensory loss on his right arm was probably due to extensive destruction of the grey matter on this side, the remaining analgesia and thermo-anaesthesia to injury of the decussating sensory fibres.

But the remote disturbances of sensation include also those forms which are affected on the side of the injury, that is the sense of position, the appreciation of passive movement, vibration and form, and the discrimination of compass points. Of these, the sense of position and the recognition of movement were the most commonly lost, and as the dorsal columns through which the impulses that subserve them pass are especially liable to suffer in partial and indirect injuries they were frequently the only form of sensation affected in slight cases; on the other hand, these and the other components of sensation carried by the dorsal columns occasionally escaped, especially in unilateral lesions, though the remote loss of pain and temperature was complete.

The appreciation of vibration, too, was commonly affected on the side of the lesion, though there was frequently no close parallel between this and the state of the sense of position, as the latter was frequently abolished in parts in which vibration could be recognized, but then careful examination generally revealed diminished sensibility to the latter. On the other hand, the discrimination of compass points was, as a rule, more severely affected than either, but we found the reverse in three cases. In a partial injury of the sixth dorsal segment, for instance, even a strongly vibrating fork could be rarely recognized on the right leg, but the two compass points could be accurately distinguished on each sole when only 3 cm. apart, and on the front of each leg when separated to 10 cm. In another case with a unilateral lesion in the second cervical segment there was a marked loss of the sense of position in the right arm, but the threshold to the compass test was the same in both palms and well within the normal. We must consequently conclude that, though the impulses which underlie all these different forms of sensation pass through the homolateral dorsal column, they may be dissociated or affected in different degree by incomplete lesions. They are all independent of tactile sensibility, since they may be all abolished, though the threshold of the latter is unaltered.

In a few cases of high cervical injury we have had the opportunity of testing the power to recognize the form of objects placed in a hand in which tactile sensation is unaffected, and always found it absent if the other symptoms indicated a lesion in the homolateral dorsal column.

Consequently, we may assume that destruction of one dorsal column can produce homolateral astereognosis, which is, as it may be in cortical disease, independent of any tactile loss. This confirms the observations previously made by Dr. Henry Head and myself. The power to recognize differences in the texture of materials placed in one hand is also abolished by destruction of the homolateral dorsal column.

LOCAL SENSORY DISTURBANCES.

The local loss of sensation such as occurred in Case iv must be next considered. Here it was represented by abolition of all forms of cutaneous sensibility over areas of different extent, with absence of the sense of position in the whole limb and of the appreciation of vibration below the elbow. Such local sensory loss may occur with lesions of any level of the cord, but as it presents special features when present in the upper limb, it will be described in detail as it is seen here.

It may result, in the first place, from injuries of the dorsal roots as or before they enter the cord, which, as

might be expected, frequently happens with gunshot injuries of the spine, but as the sensory disturbances then produced are those generally seen with root lesions they require no special mention. Or, in the second place, it may be due to intramedullary lesions which interrupt some or all of the afferent sensory impulses after they enter the cord by one or several dorsal roots, either before or after they have been regrouped in the grey matter. Consequently, all forms of sensation may be affected or certain may escape. The most common type is that seen in Case iv, in which all forms of sensation are involved. Then the tactile loss is the most extensive, and the anaesthesia to pressure is almost coterminous with that to light contact. The thermo-anaesthesia, including loss to all degrees of temperature, is occasionally almost as wide, but it is frequently limited to the area of analgesia; this is generally much smaller. The sense of position and the appreciation of vibration were severely affected in every case, too. In another type only the appreciation of pain and temperature was affected, the impulses carried by the dorsal columns escaping.

But even more remarkable than the character of the local sensory loss on the upper limb is its distribution. In Case iv as well as from the other figures reproduced (Fig. 10), it

Fig. 10.

will be seen that it does not correspond either to the areas of any peripheral nerves or of any dorsal roots; in fact only the peripheral portions of the cutaneous areas of several roots were anaesthetic. On the other hand, it frequently showed a tendency to coincide with the segments of a limb. It has been generally found that when the upper part of the cervical enlargement was involved, the sensory loss extended higher on the radial than on the ulnar border of the arm, and that when it lay in the lower portion of the enlargement the loss was higher on the ulnar side. A similar area in which there is no sensory disturbance is seen on the left arm in Fig. 9.

A local lesion in the lateral part of Burdach's column can, of course, interrupt all the sensory impressions conveyed through this from the roots immediately below it, but the mode of occurrence of the cutaneous sensory disturbance is less obvious.

Its explanation must depend on the anatomical arrangement of the sensory paths. The tone of the muscles, as well as their co-ordinated actions, depends chiefly on afferent impulses that pass from the corresponding segment of the limb to the cord, and act through the grey matter on their final common path. If for the moment we consider only the intrinsic muscles of the hand, we may assume for them a group of cells in the lowest cervical and the first dorsal segments, which, however, receive afferent impressions from the whole hand, through reflex collaterals from at least four dorsal roots, that is, from the sixth cervical to the first dorsal. An interruption of these fibres as they enter this group of motor cells would then cut out all the non-sensory afferents that control the small hand muscles, but would leave intact the connexion of other collaterals from the same roots with the other motor cells that innervate the arm muscles. We would consequently have a segmental reflex palsy. Much the same probably holds for the fibres of cutaneous sensation. Those that convey impressions of pain, for instance, are not all relayed in the grey matter at the level at which they enter, but ascend and descend some distance in Lissauer's zone, and there are probably not grouped according to the roots by which they arrived as they enter the grey matter, but in relation to the segment of the limb from which they come. Thus those that carry impressions of pain from the hand may be relayed at one level, while other fibres of the same roots that carry similar impulses from the forearm

may end in the grey matter at another level (Fig. 11). If such an arrangement exists sensory disturbances similar in distribution to those described may be easily produced by isolated lesions. The type of the sensory loss would depend on whether the sensory afferents were interrupted before or after undergoing relay.

The commonness of these types of local sensory loss would then correspond to the frequency of lesions in the dorsal horns. Fig. M (Plate) represents such a lesion. When the neighbouring part of the dorsal column is also involved the sense of position would be affected in the corresponding limb; occasionally this occurs as an isolated phenomenon—that is, without disturbance of cutaneous sensibility. An interesting example of local loss due to a small lesion in the dorsal column, and probably limited to its root entry zone, was seen in one patient in whom the sense of position and of passive movement was lost at the left elbow and shoulder, though normal in the hand, while on the outer side of this arm he was unable to recognize the vibrations of a tuning-fork when applied to the soft tissues, to discriminate compass points even when separated to three times the threshold distance of the corresponding part of the right arm, or to distinguish texture. All these local sensory disturbances have a tendency to diminish or disappear more rapidly than the remote loss.

Fig. 11.—Diagram to illustrate the manner in which sensory impulses enter and are grouped within the spinal cord. The broken lines represent the fibres which carry the impulses that ascend through the dorsal columns, the continuous lines those that convey impressions of touch, pain, and temperature. The latter probably ascend or descend in Lissauer's zone before entering the grey matter.

SUBJECTIVE SENSORY SYMPTOMS.

Subjective sensory symptoms were not uncommon; pain, for instance, is very commonly present in the parts that correspond to the segmental level of the spinal injury, but here it may be due to irritation of the dorsal roots, or may be only associated with the hyperaesthesia which frequently occurs in this region. Distant pain—in a leg, for instance, when the spinal wound was in the cervical region—occurred, however, in a certain number of cases, and can be attributed only to the spinal lesion. It was frequently only transient or disappeared within one or two weeks, but occasionally persisted as long as we had the patients under observation, in one case for two months. It was generally described as a burning or an aching pain, sometimes only as a numbness or tingling, which increased when the part was touched or handled. In one patient it was so severe that it prevented sleep and needed morphine. It was generally most severe at night and in some instances increased when the part was exposed or moved, though there might be no demonstrable hyperaesthesia. It sometimes spread over the whole side of the body below the level of the injury, but it was frequently limited to the foot or leg. It occurred only with relatively slight or unilateral lesions, and in the latter case was always on the same side as the injury and on that on which there was no cutaneous sensory loss. In a few instances, however, no sensory loss could be discovered in either side, or, if any existed, it was only a slight diminution of sensibility to pain and temperature.

The condition known as hyperaesthesia was extremely

common; it may occur, as was originally described by Brown-Séquard, on the side of the injury when there is a unilateral lesion; or on areas which had been anaesthetic as sensation recovers, or even more commonly as a band on one or both sides of the trunk or down the limbs, at the upper margin of the sensory loss.

A homolateral hyperaesthesia in Brown-Séquard cases is by no means constant, though we observed it occasionally; it extended over the whole half of the body almost up to the segmental level of the injury. Here pin-prick, heavy pressure, and especially scraping, or even rubbing hair-clad parts with a wisp of cotton-wool, produced severe pain and much more reaction than these stimuli on normal parts. The application of cold, too, usually evolved pain, and heat of 45° C. and upwards caused a severe burning sensation. In one case pin-prick not only gave more discomfort than normal, but this persisted abnormally long. This distant hyperaesthesia always showed, however, a tendency to diminish rapidly and disappeared in some cases while they were under our observation. Its pathogenesis has been already the subject of much discussion and experiment. The hypothesis that it is due to section of efferent inhibitory fibres seems very improbable, while the fact that it is generally transient or disappears rapidly is more in favour of the view that it is due to an inflammatory reaction, or rather to oedema and other such changes, at the site of the lesion than to overloading of the afferent tracks that remain open to sensory impulses.

An excellent example of hyperaesthesia in areas in which sensation is recovering was a case in which, owing to a transverse wound across the back of the neck which fractured the sixth and seventh cervical spines as well as the lamina of the sixth vertebra, a complete paraplegia with analgesia and thermo-anaesthesia to the level of the eighth cervical root areas set in at once. Within a fortnight, however, there was complete pain loss only below the umbilicus, and the appreciation of thermal stimuli was only diminished above this level; in the area in which sensation had recovered pricks produced an extremely unpleasant burning sensation, and high and low degrees of temperature gave much more discomfort than on normal parts. He later came under the care of Dr. Head, who found the same condition more than two months after the infliction of the wound.

Finally we come to the hyperaesthesia which is so commonly found at the upper level of the sensory loss on one or both sides, with either complete or partial lesions. On the trunk it is generally associated with a girdle sensation of pain, burning, tingling, or constriction, and on the limbs with pain or paraesthesia over the areas of one or more dorsal roots. It may persist for weeks, but usually diminishes. When severe the lightest contact, or even the approach of any one to his bedside, may be feared by the patient, and the movement of his bedclothes, or the removal of his shirt or bandages, may excite severe pain. Local muscular contractions are frequently associated with it. The state of sensation in the hyperaesthetic area has been carefully worked out in several cases; it is found to be variable. No loss to light contact was ever found, and when they were used no raising of the threshold was discovered to von Frey's hairs, but in three cases contact with No. 4 and No. 5, which only gave a maximal threshold reading on normal parts, produced a sharp stinging or burning, "like a red-hot iron," on the hyperaesthetic zone. Pain was most readily produced by any moving stimulus, as a wisp of cotton-wool, or by scraping with any rough or sharp object, but, on the other hand, moderate pressure generally gave no discomfort.

The state of sensibility to pain and temperature varied; in one group the threshold to pain was, if anything, diminished, while that to temperature was unaffected, but any degree of cold, and heat above 45° C., evoked much pain. In the other class sensibility to pain and temperature were lost or diminished over part of the area that was painful to rubbing or scraping.

The origin of this hyperaesthesia is interesting; it is most commonly attributed to irritation of the corresponding dorsal roots, and this seems to be frequently the actual cause, but there are many facts which prevent us from accepting this explanation in every case. It is often, for instance, much more extensive than it would be if due to irritation of even two pairs of roots in the neighbourhood

of the wound; in one case of injury to the spine of the axis it extended over both upper limbs and to the level of the nipples, and in another patient in whom the fourth cervical vertebra was damaged it spread not only over both arms, but to the base of the xiphoid. But an even stronger argument is the fact that in cases of the Brown-Séquard syndrome, in which there were both hyperaesthesia of the homolateral side and a local area of pain and tenderness at the level of the lesion, no essential difference may be found between them. It is therefore probable that in many cases at least the cause of the pain is to be found within the cord, and that it is due to oedema, circulatory disturbances, or slight diffuse lesions, as Brown-Séquard originally postulated as the explanation of the local contralateral hyperaesthesia he described. Finally, in several cases we have found no injury, on *post-mortem* examination, to the roots which corresponded to the areas that were hyperaesthetic.

PROGNOSIS.

The prognosis during the first two weeks in any one case is extremely difficult, and it must be admitted that there is no one sign or symptom from which we can draw reliable conclusions on the severity of the lesion, or from which we can say, when there is complete motor and sensory paralysis, as there nearly always is in the earliest stages, whether the cord is completely divided or not. It must be remembered that though neither the cells nor the fibres of the spinal cord do regenerate, very considerable improvement may occur, as at least part of the early symptoms are due to oedema, circulatory disturbances, and to incomplete damage. The structural damage is consequently not always parallel to the functional loss. We have seen that the knee-jerks are absent for a time with lesions of all degrees of severity, and this consequently cannot be a guide in prognosis. The most reliable information is perhaps given by the state of tone in the muscles of the lower limbs; after three or four days the legs are generally very flaccid and their muscles toneless when the lesion is severe and irrecoverable, and gradually become more so and waste. The preservation of tone in the muscles is, on the other hand, an indication that some improvement may be expected. Valuable information can be also obtained by stimulation of the soles, as the amount of reflex movement that results varies more or less inversely with the severity of the injury. When this is complete, no reflex muscle contraction can be, as a rule, elicited, while in all stages of slighter damage a brisk withdrawal reflex can be obtained.

Probably no serviceable recovery can be expected if the plantar responses are flexor.

In less severe cases in which all forms of sensation are not abolished, the amount of disturbance of the latter is an indication of the amount of the cord damaged; we have generally seen the promise of useful recovery when tactile stimuli could be felt in the lower limbs within the first two or three days.

When the cervical region is injured the upper limbs are usually more paralysed than the lower, and remain flaccid and waste while these show signs of recovery; histological examination shows that this atrophic palsy of the arms is due to extensive softening of and haemorrhages into the ventral horns, and as the motor cells contained in them are readily destroyed the chance of much improvement is slight.

If recovery sets in early, steadily progressive improvement may be, however, expected, unless complications occur. We know of a few patients, however, in whom the symptoms increased after movement, as Case IV, who lost again the power of movement he had regained in his right leg during his transference to England; and in one other case we observed syringomyelia develop some time after the infliction of the injury.

TREATMENT.

Owing to the nature of the lesions the treatment of these spinal injuries is naturally unpromising. The damage to the spinal cord is done when the wound is inflicted, and we are unable to influence it by treatment. In many cases surgical intervention and the removal of missiles or displaced bone which compress the cord have given a hope of greater recovery, and should be attempted if the symptoms or an *x-ray* examination make it probable that the cord is

compressed, and that there is any prospect of recovery. But it must be realized that in such cases the symptoms are certainly more dependent on intramedullary changes produced at the time rather than on compression.

Dr. A. R. Allen¹³ showed experimentally some years ago that the symptoms produced by severe contusion of the cord can be relieved and recovery made possible by incising the dorsal columns at the level of the injury, thus draining away oedematous fluid and intramedullary haemorrhages, and allowing the swollen fibres to expand, but it is necessary that this operation should be performed within a few hours of the infliction of the injury. This is rarely possible in warfare, and the early symptoms are so equivocal that if resorted to more harm than good might be easily done.

A large proportion of cases of spinal injury die soon after the infliction of the wound from shock or associated wounds of the chest or abdomen. Among those that survive the greatest danger is from cystitis and pyelonephritis and the development of extensive bedsores. A large part of the responsibility consequently falls on the nursing. When cystitis is threatened or has developed, we have seen excellent results from suprapubic drainage. Finally the danger of moving the patient must be borne in mind; the risk is obvious if the vertebral column is fractured, and if detached pieces of bone lie within the canal these may be displaced and lacerate the cord during transit. Further, we have evidence that secondary changes are more liable to develop after movement; absolute rest is consequently advisable during the first few weeks if the symptoms hold out any prospect of useful recovery.

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Memoranda:

MEDICAL, SURGICAL, OBSTETRICAL.

A NEW CATARACT OPERATION.

THE following is a preliminary note on a new cataract operation which is now being performed in Delhi. This operation, which embodies several new features, was conceived and perfected by my assistant, Pundit Hari Shanker. The essential feature of the operation is a preliminary conjunctival flap cut so as not to hamper the movements of the knife in making the incision in the eyeball. The lens is removed entire in its capsule either with or without a preliminary iridectomy.

The advantages of the operation, as shown by the results obtained in some 1,500 cases performed this year, are:

1. The wound in the eyeball is closed at once by the flap so that the risk of subsequent infection is nil.
2. Prolapse of the iris and vitreous are prevented from occurring.
3. The flap is firmly adherent to the globe within a few hours, and in a large majority of cases the dressing can safely be then removed.
4. Cataract cases are now treated in this hospital as out-patients, and they can go home immediately after operation, returning next day to have the dressing removed permanently.
5. No photophobia is present subsequent to the operation, even on the second day, when the patients are provided with glasses, and can see well.
6. The usual corneal astigmatism is very much less than is generally found after other operations.

Delhi.

M. CORRY, M.D., Major I.M.S.

IMPROVED TECHNIQUE FOR INTRAVENOUS INJECTIONS AND REMOVAL OF BLOOD FROM VEINS.

THE chief remaining difficulty of this practice is that of properly entering and canalizing the vein, especially when the veins are small or deep, as often happens when the

superficial veins in front of the elbow form a plexus of small veins instead of the relatively large trunks of the textbooks. The application of a bandage in this case produces a series of veins scarcely as large as the needle, and canalization is difficult or impracticable. But by using a sphygmomanometer instead of the bandage, and then compressing to just short of blood pressure point, say 120 to 150 mm. Hg, the hitherto small veins will stand out turgidly, and can easily be punctured and canalized, for the vein stands up to the needle, and will not yield before it. Even in the case of the largest veins the manoeuvre is more easily accomplished by this method.

After the canalization, in the usual way, the cutting or removal of the bandage often causes movement of the arm and endangers the possibility of second puncture. But with the sphygmomanometer all that is necessary is to release the escape cock without disturbing the compression bag. The latter should in the first place be carried right up into the axilla, and in primary and secondary cases at least should have a sheet of Billroth's cambric interposed between it and the skin to avoid infection. The one I have used has been the Herbert French pattern, but any having a similar pressure bag would be equally serviceable.

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Reports of Societies.

FIBROSITIS.

At a meeting of the West London Medico-Chirurgical Society on December 3rd the president, Dr. LEONARD DOBSON, in the chair, a discussion was held on fibrositis. Dr. GRAINGER STEWART, in opening it from the medical aspect, said that quite apart from acute traumatism, a large number of soldiers had been invalided with subacute and chronic rheumatism, both articular and muscular. Most of those cases occurred in middle-aged men or in those who had previously been the victims of chronic rheumatism, and there was nothing special to discuss in regard to them. As regards the wounded, it appeared to him that the occurrence of fibrositis was more frequent and the degree more severe than in cases of injury received in civil life. He had been struck by the rapidity with which adhesions formed, not only around and in the joints, but also in the tendon sheaths and muscular structures. He thought that several factors were present which might account for this: (1) Infection from wounds; (2) the effects of chill, strain, or exposure; (3) the protective strain on the muscles guarding the injured part; (4) the complete cessation of functional activity in the wounded limb as the result of its being bound up in splints, and the impossibility of carrying out passive movements and massage of those parts of the limb not directly involved by the injury. Early passive movement and massage would do much to prevent the formation of adhesions, would speed the recovery of the slightly wounded, and would prevent many of the more severely wounded, who would not be fit for further service in the army, from becoming economically a burden to the State in after-years, by keeping the joints supple and the muscles in good condition until the patient had recovered from the primary injury, whether it involved injury to the bone or to the nerves. Personally he regarded immobility as the chief cause of those fibrous adhesions, and, that being so, it was of prime importance to insist on the daily movement of the joints of the affected limb as far as that was compatible with the surgical necessities of the case. Mr. H. S. SOUTTAR, in dealing with the surgical aspects of the question, said that his main contention was that many of the after-effects of injuries and diseases incidental to war, which might be classed under the heading of fibrositis, were preventable, and that, applying the lessons of recent researches in the treatment of fractures, it was of the first importance to avoid anything in the way of too prolonged or too complete immobility of the affected parts. The President, Drs. BROUGHTON, RICKARD LLOYD, F. G. LLOYD, JOBBSON SCOTT, and CLIPPINGDALE took part in the discussion which followed, and Dr. GRAINGER STEWART and Mr. H. S. SOUTTAR replied.