transverse incision across the pubic hair field. This is a great advantage in relatively young women, especially if unmarried, for it leaves no visible scar. To send a woman back to daily life without mark or blemish, cured of a serious disability and danger, is an achievement of high artistry.

LAMINECTOMY FOR GUNSHOT WOUND.

WITH A RECORD OF THREE SUCCESSFUL CASES.

BY

D. M. HUGHES, M.B.LOND., F.R.C.S.ENG.,

MAJOR R.A.M.C.,

OFFICER IN CHARGE OF SURGICAL DIVISION, EDMONTON.

SURGEONS who have had a large experience of the spinal injuries of industrial practice cannot help being impressed by the high proportion of severe and inoperable cases found in comparison with the condition of things in war surgery. The reason for this difference is not far to seek. The coal mines furnish a large proportion of these cases, and the causal agent is so massive (a fall of roof in the pit, for example) that the lesion is necessarily widespread whether caused by direct or indirect violence. In gunshot wounds, on the other hand, a larger proportion of incomplete injuries is seen, and these are due to small missiles which, though they hit the spine, do not often make a direct hit upon the theca. When the theca is directly hit the lesion is complete in all senses of the term, and it is scarcely conceivable that even a part of the theca could be hit without causing such profound changes in the remainder of the segment as to cause, or at any rate initiate, a "complete" lesion.

Complete and Incomplete Lesions.

Complete gunshot lesions of the spine are due to direct hit of the theca, either by the missile itself or by the driving in of a part of the spine. Such cases show a complete interruption in the tracts of the cord—evinced by flaccid paralysis and loss of reflexes and sphincter control. If the theca be exposed by operation gross damage will usually be found, but occasionally the cord will appear uninjured (as has happened in my experience) and yet be completely and irrecoverably damaged.

In incomplete injuries, on the other hand, the missile hits the spinal column, but the theca is not hit either by the missile or by displaced bone, and the resulting paraplegia—

- (1) May be quite transitory and flaccid, but apparently complete;
- (2) May or may not have a transitory period of flaccidity and completeness, merging more or less rapidly into a spastic condition of any degree;
- (3) May only appear after an interval.

The pathological conditions underlying these three possibilities are pressure or irritation caused by effusion (intraspinous, subdural, or intramedullary), by granulation tissue in relation to a sinus or a retained missile, or by callus; with or without a preliminary condition of concussion. Incomplete lesions include a large proportion of conditions that hold out good hope of recovery, either spontaneously when the paraplegia is due to concussion, or in some cases to effusion, or after operation when a definite lesion is present. The indications for operation are so evident in cases of paraplegia arising after an interval that they require no discussion. When, however, a spastic paraplegia is present from the beginning the question whether or not to operate may be very difficult.

The indications for operation given by Sir George Makins from experiences in the South African campaign are so helpful and explicit that I will venture to quote them:

1. Excessive pain in the area above the paralysed segment; operation is here of doubtful practical use except in so far as it relieves the immediate suffering of the patient.
2. An incomplete or recovering lesion, when such is accompanied by evidence furnished by the position of wounds, pain and signs of irritation, of pressure from without, or possibly palpable displacement of parts of the vertebrae, that the spinal cord is encroached upon by fragments of bone.
3. Retention of the bullet accompanied by signs similar to those detailed under 2. . . .

Operation, if decided upon in either of the two latter circumstances, may be performed at any date up to six weeks, but if pressure be the actual source of trouble it is obvious that the more promptly operation is undertaken the better.

The purpose of this paper is to examine the outstanding features of traumatic paraplegia in the light of these indications and with reference to the possibility of treating underlying causes; to endeavour to show that the causes are very often extra-theical and therefore amenable to a comparatively safe operation; to indicate one or two practical points respecting the operation that have impressed themselves upon me; and to give a short account of three illustrative cases.

Prognosis.

The gravest sign is, of course, flaccid paralysis, which indicates a complete physiological interruption in conduction. It entails complete sphincter, motor, and sensory paralysis below the lesions, and is necessarily bilateral. It may, however, be quite transitory, as I have good cause to remember, having given a bad prognosis in an industrial accident of this kind, in which a month afterwards the patient was walking about. Persistent flaccid paralysis, it need scarcely be mentioned, places the case beyond scope of operation, except perhaps for the relief of girdle pain. Spastic paralysis, however, merits further inquiry, and I believe that involvement of the sphincters is of great prognostic importance.

Except in lesions of the lower cauda equina, where, in fact, involvement of the third and fourth sacral nerves frequently appears to be the salient feature, sphincter paralysis rarely appears without a high degree of motor involvement. I have met only one case, a mid-dorsal wound, and even in that, though the gait was not noticeably affected, the reflexes were very active and sensation diminished in both legs. The bladder trouble, which was of the nature of precipitancy rather than dribbling, had existed from the time of wounding; and in the absence of gross motor symptoms it is reasonable to suggest that the trouble might be due to intramedullary injury, perhaps a minute haemorrhage picking out the bladder-controlling fibres and exerting slight but not destructive pressure upon adjacent tracts. This reasoning is based upon the probability of the bladder fibres lying deeper and therefore less exposed to pressure from without than the tracts to the limbs, as the signs of a slowly increasing paraplegia would suggest. The slow progress of caries paraplegia gives good opportunity for prolonged observation. A definite order of involvement of nerve tracts is seen; motion is first affected, and very soon sensation, but a considerable degree of impaired sensation may exist with slight loss of motion. Sensation, however, is usually lost before the sphincters are affected. In recovery, sensation returns before motion, and sphincter activity precedes both. It is reasonable to conclude that a prolonged period of sphincter paralysis should affect prognosis adversely, especially when the compressing agent is displaced bone or callus, as may occur in gunshot wound. In caries paraplegia spontaneous recovery occurs in the remarkable proportion of 83 to 95 per cent. of cases (Tubby). It is to be noted, however, that many orthopaedists regard involvement of the sphincters as gravely affecting the prognosis, and this even in a condition in which the compressing or irritative agent is nearly always granulation tissue or pus, and not bone. In traumatic paraplegia, on the other hand, though in one of the cases described below (Case III) the causal agent seemed to be granulation tissue in contact with the theca, the offending body is usually something far less kind. Hence the smaller likelihood of recovery without operation, and, in fact, the probability, in the absence of operation, that complete sclerosis of the cord at the point of pressure will follow. It would be difficult to deny that sphincter paralysis is at least as grave a symptom in traumatic paraplegia as it is in caries. When it occurs from the first and does not rapidly improve, it indicates a lesion not amenable to operation; when late, it may indicate that the time for operation has passed, and this as much in relation to the fitness of the patient to undergo a severe operation as to the recovery of the cord itself.

Spontaneous Recovery.

Spontaneous recovery in concussion, when the whole thickness of the cord has been temporarily put out of

action by shock, has already been referred to, but a large number of cases of definite spastic paraplegia also improve or recover with rest. These phenomena are evidently the expression of vascular changes, varying from temporary anaemia of the cord to actual extravasation of blood in relation to the theca. It is highly probable that the spinal cord reacts to injury to its bony casing in much the same way as the brain. Cushing has shown that concussion of the brain is after all nothing more than a stage of compression and dependent upon the immediate vascular changes caused by the injury, the later stages of pressure causing anaemia and the earlier, with its clinical picture of irritation, congestion. The cord, however, is less closely applied to its dura than is the brain, and this would favour rapid "recoil" of the circulation following the anaemia primarily produced and encourage the production of minute intramedullary haemorrhages. The degree of recovery is closely related to the extent of these minute extravasations. They may be entirely absent (concussion with recovery), may be so small as only to cause a train of neurasthenic symptoms, or may cause an amount of intramedullary destruction and pressure varying from a slight nuclear or tract involvement to a complete transverse lesion.

It is hardly necessary to say that intramedullary haemorrhage is not of operative interest. Subdural haemorrhage from shock applied to the spine is a most unlikely event. If it occurred it would be small in amount, and there is ample space between the cord and the dura to allow it to develop without causing urgent pressure symptoms, and spontaneous absorption would probably follow. If the subdural haemorrhage followed a direct hit of the theca its presence would be masked by other severer signs. Intraspinal haemorrhage, however, is probably of great importance, as it is almost necessarily present in injuries to the bony tube, and, with or without the reparative effusion which accompanies the healing of fractured bones, accounts for the pressure in those cases of spastic paraplegia that recover without operation.

Distribution of the Paralysis.

With the possible exception of Case III, I have not met a unilateral lesion. One lower limb will frequently be affected more than the other, but a purely one sided lesion in trauma must be very uncommon and the Brown-Séquard syndrome consequently must rarely be seen. Case III seemed to have shown this phenomenon in France, but by the time he reached this hospital the paralysis and anaesthesia were certainly most evident in the same limb, and the patient himself was emphatic that this had been the condition of things throughout. In the light of experimental section of the cord by Mott, Horsley, and others, however, this is what might have been expected.

A Retained Missile.

I have observed five cases in which the missile lay in the spinal canal and all were complete lesions. The temptation to remove the offending missile in such a position is great, and in three cases this was done. In one the exposure of the laminae disclosed a circular aperture through which peeped a shrapnel bullet, and the theca showed no damage. No improvement followed even in this case, and it is fair to conclude that the presence of a missile within the spinal canal is of very grave significance. Missiles in relation to other parts of the spine are fairly common, and if the theca has not been directly hit by them in their path, the paraplegia, if present, is of extra-thecal origin and therefore amenable to treatment. This goes to prove that the etiological classification of gunshot wounds of the spine into complete and incomplete cases has a prognostic basis also.

The Question of Operation.

My own operative experience of laminectomy is limited to seven cases. Four were instances of flaccid paralysis with sphincter involvement and bedsores, and operation was undertaken for some specific reason—agonizing girdle pain, or the presence of a missile within the spinal canal, the removal of which, it was hoped, might improve matters. No improvement resulted; in two cases gross damage to the spinal cord was seen, and one patient, in whom the removal of the missile was followed by escape of turbid cerebro-spinal fluid, died. In the three remaining

cases, described below, operation was undertaken for spastic paraplegia of different degrees. In none was there involvement of the sphincters, and recovery of health and function was complete in each case.

To attempt to generalize from such limited experience would be of no value, but it is permissible to summarize the points that appeal to the operator. In the first place, it may reasonably be stated that the difficulties of the operation, though great, are not so formidable as is taught. The wound becomes very deep as the operation proceeds, and oozing is always troublesome. A free muscular separation, though it may weaken extension of the spine, benefits the patient by shortening the operation, and can be met by prolonged recumbency afterwards. Retraction cannot be efficiently effected by one assistant. The use of very hot lotion to stop oozing serves well to indicate those bleeding points which require ligature, and the operator should obtain as complete haemostasis as possible before the laminae are divided, for the intraspinal veins will give enough trouble without the added annoyance of blood trickling in from above. After the removal of the laminae, lotion hot enough to be really haemostatic might be harmful, and gentle patient swabbing until the fatty sheath can be opened and pressed aside is quite effective. When the dura spinalis is exposed firm pressure can be applied in a lateral direction and a complete examination made. Opening the theca admits such a great additional risk that the indications must be very definite to justify it, but my experience tends to show that in recoverable injuries the cause lies outside the dura.

It can be asserted that the special dangers of sepsis are small, provided it is not necessary to open the theca. A prolonged operation is always likely to admit a degree of sepsis even when performed under the best conditions. Hence, when a coarse decompression has been performed and the theca exposed, the surgeon may well ask himself what condition due to gunshot wound would indicate opening it with a prospect of success that would justify the risk. In each of the cases described below a degree of sepsis was present. Case I was postponed on account of the septic condition of the emergent bullet wound until it was thought unwise to put off the decompression any longer. The laminectomy wound as a matter of fact healed primarily. In Case II pus was encountered in the callus in the spinal canal and the wound was drained for a few days. In Case III operation was undertaken in the presence of a freely discharging sinus leading to the body of a vertebra; this sinus was probably the cause of the delay in recovery, acting possibly by inducing a mild localized myelitis or perhaps a local oedema of the cord. It is common knowledge that a paralysed peripheral nerve adjacent to a bone sinus, and thought previously to have been severed, will often recover spontaneously when the sinus has been efficiently dealt with.

The risks, then, of the operation in reasonably capable hands and with a practised anaesthetist are sufficiently small to warrant the statement that when there is only a chance of benefiting the patient operation should be performed. This is not to say that it should be urged upon him. In fact the patient himself, realizing he has no hope apart from operation, and that even that is slender, will sometimes desire operation when the surgeon realizes its hopelessness. Whether to buoy up the hopes of a patient doomed to permanent paralysis, or to inflict the additional misery of despair by strict truthfulness, is an ethical problem not likely ever to be settled.

CASE I.

Sergt. C., aged 31, was wounded on March 2nd, 1916, by a bullet which passed through the laminae of the seventh cervical and first dorsal vertebrae, fracturing both. Entry wound at root of the neck on the left side, healed. Emergent wound over the right acromion was a septic crater with bare bone at the bottom. On admission, March 10th, sensation was absent in both feet, dull in legs and thighs, and absent about the lower part of the thorax and up to the nipples. Movements of the lower limbs present everywhere, weakly executed, and readily fatigued. Reflexes very active and passing into clonus. No sphincter trouble. Further history is one of increasing paraplegia until voluntary movement ceased entirely and sensation was practically gone from nipples downwards. About March 28th involuntary clonic movements started in the legs, coming on in paroxysms, which awoke him at night. A necrotic patch appeared on the left heel. Fear of sepsis from the shoulder wound preventing earlier operation, laminectomy was not performed until April 22nd. The shoulder wound was covered by

a collodion dressing and the last cervical and first dorsal laminae removed. This was done piecemeal, as the laminae were represented by an indefinite mass of old and new bone, and it was very difficult to determine when the spinal canal was reached. This was, however, eventually well opened up, the fatty sheath separated, and the theca well exposed and lifted gently to free it. Pulsation good. Wound closed without drainage. Three days afterwards the patient volunteered that he could "feel his feet." Lower limbs immobile, very spastic, and involuntary movements as troublesome as ever. Within ten days the patient could, however, control the "spinal convulsions," and considerable muscular power was evident. By the end of June he could walk without support, and on August 25th was invalided, walking quite normally. Reflexes active, no clonus, anaesthesia about upper part of thorax.

CASE II.

Pte. G., aged 18, was wounded on March 20th, 1916, by a fragment of shell, which entered on the left side of the spine in the interscapular region; on the right side of the same region a counter opening had been made. Missile not removed. Admitted March 25th; x rays showed a piece of metal between the angles of the fourth and fifth ribs (right side) and damage to the right side of the fifth dorsal vertebra and neck of the fifth rib. No chest symptoms. Both wounds healed without removal of the missile and patient was sent to an auxiliary hospital on May 3rd. On May 28th the patient, who had been walking about quite actively for some weeks, was suddenly seized with weakness of both legs, especially the left, which gave way under him, and he fell to the ground. He was at once returned to this hospital. On readmission there was paralysis of the whole left leg, except for some fruitless twitchings of the front of the thigh. Superficial and deep reflexes grossly exaggerated; no Babinski. Right leg definitely weak, but all movements could be executed. No sphincter trouble. Partial anaesthesia in both limbs, with tracts of complete anaesthesia on outer side of the left leg and thigh. Wounds soundly healed. Operation June 3rd; the fifth and sixth dorsal laminae removed. When the theca was well exposed a nodule of soft vascular bone was seen projecting against the right side of the dura. The projection was continuous with a mass on the right side about the pedicles of the vertebrae, was easily lifted out, and showed a central core of soft granulation tissue, continuous with septic granulation tissue in the new bone close by. Theca gently freed and observed to pulsate well. Wound drained. Convalescence interrupted by pneumonia on second day; patient had to be placed in a sitting position with shoulders strapped to the bed-rest for two days; after that nursed on each side alternately. Temperature normal in six days. Recovery of paralysis by the end of June was nearly complete. Invalided out, walking quite normally, in August.

CASE III.

Pte. M., aged 20, was wounded on September 20th, 1916, by a shrapnel ball which entered between the vertebral border of the left scapula and the spine, and was localized as lying "behind or in the body of the third dorsal vertebra." He had been operated upon in France for removal of the missile, but his condition forbade completion of the operation. Notes from France indicated that a left motor and right sensory paralysis had existed from the nipple lines downwards.

On admission to this hospital on November 3rd, 1916, there was a discharging sinus in the centre of a wide vertical scar about two inches from the middle line. Movements of the right limbs were not affected. The left was paralysed below the knee and its reflexes were very active. Sensation was impaired on the same side, especially in the foot, and in the right limb, though not acute, was better than in the left. Condition slowly improved until hip and thigh movements were quite strong, but not more than a flicker of movement was possible below the knee. The sinus discharged as freely as ever, hence it was decided to attempt to remove the missile. This was done on January 7th, 1917, and as any attempt to explore the sinus would be dangerous unless its exact relation to the theca were known, the latter was deliberately exposed by the removal of the greater part of the third and fourth dorsal laminae. A probe was then passed forwards by the side of the left edge of the theca into the body of the third dorsal vertebra. The theca being protected by a small spatula, the ball was easily removed, together with a quantity of septic granulation tissue. The laminectomy incision was closed entirely and lateral drainage with gauze carried out along the course of the original sinus. Suppuration was free for two or three weeks, then rapidly improved, as did the paralysis. At the end of March the patient was walking with the aid of a walking-stick, and by the end of May walked quite normally.

Summary.

In Case I the paralysis, slight at first, increased to complete immobility of the lower limbs. In Case III the paralysis also existed from the time of wounding, but recovered to a considerable degree before operation. In Case II the paralysis occurred quite suddenly about nine weeks after the injury in a patient who was well and active. In no case was the Brown-Séquard syndrome (paralysis and hyperaesthesia of one side and anaesthesia of the other) seen, although Cases II and III were mainly unilateral lesions as far as motor paralysis was concerned.

Case II showed a patchy anaesthesia most marked on the outer side of the paralysed thigh, but the other limb was dull to pinprick; the fact being that when sensation is involved on both sides differences of degree are hard to detect, and, unfortunately, no attempt was made to discriminate between painful, thermal, and tactile impressions.

In each case (a) the paralysis was incomplete in the sense that sphincter trouble was absent; (b) the injury was indirect, and due to damage to the spinal column and not to the cord itself, and (c) recovery was complete.

The immediate effects of the operation in restoring or improving the circulation in the cord were not determined in any case. Decompression in laminectomy is a gradual procedure, and probably pressure is relieved long before the theca is exposed. The dura was not opened in any one of the three cases.

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FIVE INTESTINAL OPERATIONS ON THE SAME PATIENT.

By HAROLD HARTLEY, M.D.LOND., F.R.C.S.ENG.,

SURGEON TO THE STOKES-ON-TRENT WAR HOSPITAL.

THE following case is interesting, not only because the patient had to be submitted to five intestinal operations in four years, but on account of its course and the difficult clinical problems it presented. The patient was a man born in 1894.

I.

Appendectomy, for acute appendicitis, at the North Staffs Infirmary in July, 1913; no drainage. Afterwards he had frequent attacks of sharp colicky pain in the right iliac fossa, but was not confined to bed.

II.

Exploratory laparotomy, at Hull Naval Hospital, in December, 1915, for severe pain in the right iliac fossa, with vomiting. The abdomen was opened near the appendectomy scar and closed without drainage.

III.

Ileostomy, for acute intestinal obstruction. He was admitted to the Stoke-on-Trent War Hospital late at night on January 14th, 1916. No satisfactory history could be obtained. The abdomen was opened by a median subumbilical incision. The small intestine was greatly distended; the large intestine loaded with hard scybalous masses. In the right iliac fossa was a mass of large and small bowel, inextricably matted together by very numerous and tough adhesions. There was great abdominal distension and profuse stercoraceous vomiting. He appeared to be moribund. A piece of ileum, as near the caecum as possible, was brought into the wound, stitched there, and opened at once. The stomach was washed out. The artificial anus acted well, but the skin around it became very foul and sore, and the man begged for a further operation.

IV.

Intestinal anastomosis, with bilateral exclusion of intestine, leaving mucous fistula. On February 11th, 1916, the artificial anus was plugged, and the soiled skin excluded, as far as was possible, by a sheet of sterilized batiste fastened down with I.R. strapping. A large flap of skin (Fig. 1) was marked out on the left side above the umbilicus, and turned over to the right. The abdomen was then opened just to the left of the middle line. The intestine was doubly clamped in two places—the ileum as near the artificial anus as was feasible, and the transverse colon in its distal third. Later, anastomosis was made between the ileum and the transverse colon (Fig. 2). Then the ileum was divided distal to the anastomosis and the transverse colon proximal to the anastomosis. Both ends of

FIG. 1.