

CORRESPONDENCE

Ludwig Guttmann's Memorandum: a review on the surgical aspects of spinal cord injuries written in 1944 for the Nerve Injury Committee of the Medical Research Council: with notes and commentary

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INTRODUCTION

During the Second World War, George Riddoch, chairman of the Nerve Injuries committee of the Medical Research Council (MRC), asked Ludwig Guttmann to carry out a review of the surgical aspects of spinal cord injuries (Figure 1). The resulting memorandum, written prior to the opening of the spinal unit at Stoke Mandeville Hospital in February 1944, was thought lost until it was unexpectedly found among a bundle of George Riddoch's papers.¹ These recently (2017) came into my possession owing to Jill Blau, widow of Nat Blau (1928–2010), a neurologist at Queen Square. This newly discovered document provides a unique insight into the development of the speciality and reveals Guttmann's debt to his predecessors. This debt to forefathers was aptly described by Isaac Newton in a letter to Robert Hooke in 1676 when he declared: '*If I have seen further it is by standing on the shoulder of giants*'. In view of (Sir) Ludwig Guttmann's seminal contribution to the treatment of spinal injuries, this memorandum is published in full with a commentary that draws on the author's long professional association with Ludwig Guttmann, which started in 1956, and his work over many years at Stoke Mandeville Hospital.

Born in Silesia in 1899, Ludwig Guttmann worked as a medical orderly at the accident hospital for coal miners in Königshütte where Wagner had treated spinal injury patients 20 years previously. After the First World War, he trained as a doctor and qualified in 1923. He worked in Breslau under Otfried Foerster who had a major influence on his future approach and philosophy towards spinal injury treatment. Foerster, who was a master in rehabilitation and the first neurosurgeon in Europe, was described as a doctor who could make the blind see and the lame walk.² Guttmann received a thorough training in neurology, neurosurgery and in rehabilitation of peripheral nerve injuries as Foerster treated over 4000 such cases.³ When the Nazis came to power, Guttmann lost his position as Foerster's assistant and worked for 5 years at the Jewish hospital in Breslau. In 1939, he escaped to England but could not practice clinical medicine for 5 years as his qualification was not recognised. He worked in the Department of Surgery under Professor Hugh Cairns, carrying out research on peripheral nerve injuries but was extremely frustrated and considered leaving to enter general practice. His unique knowledge of rehabilitation of peripheral nerve injuries was recognised and he gave a lecture on the subject in the distinguished company of Geoffrey Jefferson at the Royal Society of Medicine, which was published in 1941.³ Guttmann was curiously reticent about this paper, although his ideas on peripheral nerve

rehabilitation were subsequently incorporated into spinal cord rehabilitation.

Historical context

As Hitler's aggression spread across Europe, a resumption of hostilities was inevitable. Unlike the First World War, when casualties had all been servicemen, many civilian casualties were anticipated because of bombing. In 1939, Riddoch was appointed consultant neurologist to the army with the rank of Brigadier. He was chairman of the MRC committee on peripheral nerve injury, with responsibility for setting up spinal injury units. On the eve of the Second World War, only three British doctors had any experience of treating spinal injury cases; George Riddoch who was Resident Medical Officer in charge of a spinal unit at the Empire Hospital during the First World War, and Gordon Holmes and Henry Head who had both treated cases during the First World War. The Staff were not appropriately trained; physiotherapy was not yet fully established so exercise was not being used to rehabilitate patients. Occupational therapy was in its infancy as a profession with an ill-defined role; 'any activity, mental or physical... hastening recovery from disease or injury'.⁴

A series of spinal units under the direction of Frank Holdsworth, an orthopaedic surgeon, and the neurosurgeons Geoffrey Jefferson and Norman Dott were opened on Riddoch's recommendation to treat spinal injury cases; these units were not properly staffed and the patients lingered in appalling conditions.⁵ At 63 and 78, respectively, Holmes and Head were too old to take an active part in treating casualties with spinal injuries. In contrast, Riddoch was 51 and worked tremendously hard, not only setting up the units but visiting them, advising the consultants, treating the patients and offering to carry out the neurology at the spinal unit at Stoke Mandeville as there was no neurologist. Riddoch invited Ludwig Guttmann to write a review of the surgical aspects of spinal injuries for the nerve injuries committee of the MRC because of his extensive experiences in the rehabilitation of peripheral nerve injuries. This memorandum is written from the Department of surgery in Oxford where Guttmann, then aged 40, was working for Hugh Cairns until 1944. The background to this document is curious. No other copy could be found in the Guttmann archives at the Wellcome Library, in the Stoke Mandeville Hospital Library archives or in the Public Record Office. A comparison with his own handwriting confirms that Riddoch extensively annotated Guttmann's draft document, mainly to correct the English and the use of medical terminology but also where Riddoch's own work is discussed on pages 10 and 11. Unfortunately, these notes are in pencil and difficult to decipher.

This memorandum is valuable on three counts: firstly, it delineates the contemporaneous level of understanding of the treatment of spinal injuries. Secondly, it reveals Ludwig Guttmann's early thoughts and opinions on how best to treat such patients and, finally, it marks the beginning of the comprehensive

CONFIDENTIAL.P.N.I. 44NERVE INJURIES COMMITTEE

of the

Medical Research CouncilA REVIEW ON THE SURGICAL ASPECTS OF SPINAL CORD INJURIES

by Ludwig Guttmann

(From the Department of Surgery, University of Oxford)

INTRODUCTION

In this collective review an attempt has been made to present as briefly as possible the various concepts of the treatment of spinal cord injuries current among workers in foreign countries. The works of American, French and especially German experts on this subject during and since the last war are quoted.

The review is mainly concerned with the problems of orthopaedic and operative treatment, though emphasis has also been laid on first-aid management and pre- and post-operative care. Other methods of treatment such as exercise and occupational therapy have not been included but a detailed description can be found in the writer's review of methods of rehabilitation following lesions of the nervous system (1941).

Statistics - Classification

Haumann (1926) found in 843 cases of closed vertebral injuries 62 (23%) spinal cord lesions. The highest record of spinal cord lesions 94 (43%) was found in injuries to the cervical spine, whereas injuries to the thoracic spine showed 49 (42%) and those to the lumbar spine 43 (91%) spinal cord lesions. The spinal cord lesion was a complete transverse lesion in 50%. Schmeiden (1930) recorded in his statistics of 3014 fractures of the spine 1105 cases, e.g., 36% with partial or complete lesions of the spinal cord. Marburg (1936) found in 50,000 casualties 100 cases with vertebral injuries, 50% of which were spinal cord lesions.

Statistics on war injuries of the spine with spinal cord lesion have been published by Marburg and Ranzi (1918) with 155 cases (145 gunshot injuries), Cassirer (1921) with 184 cases (174 gunshot injuries) and Foerster (1929) with 395 cases (279 gunshot injuries). According to statistics of gunshot injuries in various countries and wars (G. Holmes, Graf and Hildebrand, Otis) gunshot injuries of the spinal cord are most frequent in the thoracic region. Retained bullet wounds are classified as extradural, intradural and intramedullary. Stab wounds of the spinal cord occur in the majority of cases in the upper thoracic and lower cervical regions. In Wagner's and Stolper's collection (1898) of 86 cases the upper thoracic region was injured in 52%, in Petrán's (1910), of 93 cases, 54% were in the upper thoracic region.

Besides gunshot and stab wounds the causes of war injuries to the spinal cord include explosions, falls from a height, "run over" accidents, direct blows upon the back by horse shoes and other objects, being buried in trenches, and blows from falling masonry. In peace time Morrison and Flanson (1935) have tabulated the causes of compression fractures of the spine as direct falls 69%,

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Figure 1. Ludwig Guttmann's Memorandum: a review on the surgical aspects of spinal cord injuries written in 1944 for the Nerve Injury Committee of the Medical Research Council.

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motor car and train accidents 16%, direct trauma 9%, forceful sitting 5%, heavy flexion in lifting 1%. In a recent American statistic Conwell (1939) reported that 8,000 of 13,000 fractures of the spine in the U.S.A. in 1937 were caused by motor car accidents.

Mechanism of Spinal Cord Lesions

During and since the last war the complicated mechanism of spinal cord injuries has been repeatedly discussed in many countries. Only a few points can be mentioned in this review. A blunt or penetrating force, striking the vertebral column, can produce a great variety of deformities of the spine, e.g., forward or lateral dislocation of one or more vertebrae, fracture-dislocation of any part of the arch of the vertebrae, etc. Similarly, either transitory or persistent narrowing of the spinal canal may result. The cord lesions (resulting from all these deformities) may vary from slight concussion, causing only a transient functional block, to a partial or complete transverse division. Further, according to Foerster and others, in many cases lesions may occur at various levels of the spinal cord above and below the level of the primary lesion, due to the transmission of the force of the blow to the column of the cerebrospinal fluid and to the spinal roots. This mechanism is also thought to explain those cases where the spinal cord lesions are more severe than one would expect from the degree of injury to the vertebral column; probably the force striking the vertebral column causes only a transitory deformity of the shape of the spinal canal, the bones returning to their normal position without gross injury; but the momentary deformation of the spinal canal may have been sufficient to produce a profound and persistent injury to the spinal cord. The dissociated cord lesions which can often be found in such cases have been attributed to a contrecoup mechanism caused by the lack of adaption of the spinal cord to the sudden movements of the vertebral column at the time of the impinging force. A transmission effect in transverse direction caused by the impact of a bullet has also been assumed in traction lesions after gunshot injuries which have involved a rib or shoulder girdle (Reinhardt, Heinecke, Leva, Mauss and Krueger, Foerster). The transmission effect in longitudinal direction seems to explain indirect lesions of the spinal cord following diving accidents or due to forceful sitting.

A lesion of the spinal cord due to gunshot injury can be associated with a fracture of the spine far away from the initial trauma due to sudden forceful contracture of the back muscles. Foerster (1929) has described such a case in which a gunshot injury of the 3rd. thoracic vertebra was associated with a unilateral fracture of the transverse processes of the 3rd. and 4th. lumbar vertebrae. He assumed that this fracture was caused by the acute strong unilateral contracture of the erector spinae. Similar cases have been recorded by Schlagwitz (1920) and Mauss and Krueger (1921). Recently this opinion has been confirmed by the experience with the metrazol shock therapy in psychosis. These experiences have eliminated any doubt that a sudden strong contracture of the back muscles can cause a fracture of the spine. Bennett and Fitzpatrick (1939) and Bennett and Hansa (1939) have reported that, in no less than 41% of cases treated by this method, the X-rays showed one or more fractures of the vertebrae. Polatin (1939) Friedman, Harris and Horwitz (1939) found fractures of the anterior parts of the bodies of the vertebrae in 43% of the treated cases. The bone lesion was found in the majority of cases between the 4th. and 10th. thoracic vertebrae. In this connection former experience of fractures of the vertebrae occurring during tetanus infection may also be mentioned.

Figure 1. Continued.

First Aid

The correct first aid treatment of a person with a vertebral and spinal cord injury may actually save his life or at least prevent his becoming a hopeless cripple. Special training should therefore be included in all first aid courses and is of particular value in dealing with injured persons in coalmines and air raid victims. The following measures for the transport of an injured person suspected of a vertebral and spinal cord lesion are recommended:

1. In order to prevent further dislocation of the fractured vertebrae the patient should never be moved by a single person. He should be kept flat on his back until three or four persons are available to lift him with the greatest care.
2. The patient should be transported on a rigid stretcher, or, if this is not available, on a board. Bandages round the paralysed legs and feet should not be too tight. Hard objects should be removed from his back pockets and places with prominent bones should be bolstered immediately, particularly if transport to the next casualty clearing station takes a long time.
3. If the dorsal, lumbar or sacral regions of the spine are injured, and a doctor is not readily available to correct the position of the patient, he should have a cushion or other improvised support under the small of his back and should have his arms folded above or behind his head. Some authors recommend turning the patient face downwards. As, however, the nature of the injury very often cannot be diagnosed by first-aid parties, it seems better policy not to undertake such alterations of position without medical supervision.
4. Patients with suspected cervical lesions should be transported with slight traction on the head and a slight hyper-extension of the cervical spine in order to reduce the possibility of cord involvement. The head should never be bent forward.
5. The patient should be covered with blankets to preserve the body heat and diminish general shock.
6. The same general care must be taken in transferring the injured from the stretcher to a bed, X-ray or operating table. This again has to be done by three persons. The rescuers should give the physician in the casualty clearing station a full account of the accident and their observations of the state of the patient immediately after it. It is especially important in deciding on treatment to know whether the patient was completely paralysed directly after the accident.

Treatment of the General Shock

It is beyond the scope of this review to describe all the details of treatment of general shock from which many patients suffer immediately after a spinal cord injury. One point, however, needs special consideration: the application of heat. It is interesting to note that in traumatic spinal cord lesions sweating in the supralesionary areas of the body induced by heat is a good objective sign that the patient has overcome the first traumatic shock (personal observation). It must, however, always be borne in mind, particularly after traumatic lesions of the middle and upper part of the thoracic region, and of the cervical region, that the thermoregulatory pathways in the spinal cord below the level of the lesion are interrupted, and that in many cases the function of a variable extent of the spinal cord above the level of the lesion is abolished by the spinal shock. This means that the greater part of the body surface is unable to eliminate heat by sweating. Heat should therefore not be used indiscriminately

Figure 1. Continued.

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after spinal-cord injury; it should only be applied under medical supervision and hot water bottles should never be allowed against the infralesionary anaesthetic areas of the body. The writer has repeatedly seen burns in such cases in surgical departments. In three cases the burns produced by hot water bottles were particularly extensive in the ankle and knee regions. In one case a radiant heat cradle had caused a moderate burn in the lower abdominal region.

Treatment of Closed Injuries to the Spine Without
and With Spinal Cord Involvement.

The present trend in the treatment of fractures and dislocation of the spine without spinal cord damage is definitely conservative. On the continent in recent years two opposed methods have been dogmatically recommended by their instigators: (1) Boehler's method of correct reduction and fixation followed by immediate and systematic exercise. This method is based on the ideas of Davis (1929) and Watson-Jones (1931), also Alfred Taylor of New York (ca 1928): (2) Magnus's method, based on Kocher's principles, which rejects manipulative reduction, except in particularly badly deformed vertebrae and in spine injuries with spinal cord involvement. He tries to get the best functional results by rest combined with immediate active exercise. It is beyond the scope of this review to discuss the details of these methods. Both authors and their followers claim excellent functional end results but no agreement has so far been reached. (Felsenreich (1933), Schleipen (1933), Boehler (1935), Karitzky (1937), Leser and Mayer (1937), Job (1937), Magnus (1938) and others). In America manipulative reduction has been adopted because of its better late results compared with older methods. Eikenbary (1928) estimates that only 2% of patients had less than 10% disability under older methods. Harbaugh and Haggard (1930) found in 37 consecutive cases of fractured dorso-lumbar spine an average of 45% disability (rated after 31 months) after treatment by rest, immobilisation and physical therapy; and 50% disability (rated after 50 months) after treatment by operative stabilisation (Albee grafts, Hibbs fusion).

A great number of authors in various countries believe that the keynote of the treatment in closed spine injuries with spinal cord involvement is also conservatism, and that laminectomy has only an exceptional place in these injuries. Stookey's arguments against laminectomy are: (1) better reduction can be accomplished by non-operative methods, (2) laminectomy removes much of the bone structure invaluable for stability of the vertebral column, (3) opening the dura may allow the cord to extrude and cause rupture of intact spinal cord substance, thus converting a partial lesion into a complete one. Earlier authors (Kocher, Thorburn, Wagner-Stolper, de Quervain, Nest-Kolb) had already emphasised that operative intervention, particularly early operation, represents a serious danger to life and to the damaged spinal cord.

Although some details of Stookey's arguments can certainly not be generalised, manipulation and reduction of fractures with a spinal cord lesion is believed by many authors to offer the best prospect for recovery. Boehler, for instance, claims that paralysis due only to pressure of the dislocated spine, blood clot or oedema, will disappear in a few days. He saw paralysed patients regain capacity for normal movement within a week, and sensation returned a few hours after reduction. Unfortunately, he has never given exact details about the clinical signs in such cases. In fractures of the cervical spine with cord involvement he rejects continuous traction by Glisson's sling because of the restlessness of the patient lying in the sling which in his opinion may increase oedema and haemorrhage. He found Glisson's sling successful only in partial dislocation. In cervical injuries reduction is carried

Figure 1. Continued.

out under local anaesthesia and in recent cases is usually obtained with a traction of 15-25 kg. after 1-3 minutes. As soon as reduction has been achieved the traction is reduced to 5-6 kg. If a lateral X-ray shows a good position of the spine the plaster cast is immediately applied. Boehler rejects, however, plaster cast in the thoracic and lumbar region because of the danger of sore by pressure.

Boehler's optimistic view about the value of manipulative reduction in fractures with spinal cord lesions has not been universally accepted. Magnus (1938) found this method unsatisfactory in his own cases and other authors are still using extension in Glisson's sling in cervical lesions. From my own experience I, too, cannot confirm Boehler's pessimism with regard to Glisson's sling in cervical injuries. Munro and Irwin (1939) found that manipulation is poorly tolerated in cervical injuries and is even worse than laminectomy. They agree with Crutchfield (1937) in giving trial traction varying from four to thirty-six hours; if there is no improvement laminectomy should be considered. This brings us to the discussion of the indication for operative treatment in spine injuries with cord lesions. There is great difference of opinion along neurologists, surgeons and orthopaedists as to the indications for operative intervention and in particular as to the best date for the operation. The greatest difficulty is that the term "early operation" is differently interpreted by different authors and has still to be defined. Yet to-day there is universal agreement on one point: guard shock is an absolute contraindication for any operation. In the last war in Germany, Hildebrandt, Borchard, A. Tietze, Foerster, and others recommended early operation, i.e. operation in the first days after injury as soon as the patient's general condition permitted. In their view all clinical signs were unreliable for the differentiation between anatomical transverse lesions and merely compression lesions of the cord due to impinged bone, haemorrhage, etc. They recommended operation as early as possible to remove any compression from the cord. Foerster stressed the point that early operation may even prevent development of a post-traumatic oedema. This radical standpoint has been abandoned by the majority of surgeons since the introduction of the Queckenstedt test (Coleman, 1937) and of myelography (Peiper, (1926), Heymann (1927)), which facilitate such a differentiation. If, for instance, in a case with a complete transverse syndrome no manometric block is found early operation can presumably be rejected. Dowman (1930) has emphasised that the manometric test should be repeated as the block found immediately after injury may only be transitory. I can confirm this view. In 1936 a patient showed a complete cauda syndrome due to fracture-dislocation of the 2nd. and 3rd. lumbar vertebrae following a skiing accident. The manometric test about 14 days after the injury showed, besides a yellowish stained cerebrospinal fluid a complete block. The patient refused operation, yet in the following period she improved spontaneously although the recovery was not complete (persistent interruption of the 5th. lumbar - 5th. sacral roots in the left side at the time of discharge from hospital about 8 months after injury). Two lumbar punctures at later dates showed only an incomplete manometric block.

The diagnostic value of a complete and persistent manometric block is also limited in those cases in which a compression of the spinal cord - say by dislocated bone - is associated with an irreversible lesion of the spinal cord itself.

No definite conclusion can be drawn from the literature about the value of myelography in acute spinal injuries with and without spinal cord involvement. Peiper (1926) could recognise by myelography rupture of the dura in one case. This was verified at

Owen/

Figure 1. Continued.

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operation. Heymann (1927)³⁶ stated that an incomplete block of the injected lipiodol indicates a greater chance of a successful immediate operation than a complete and permanent lipiodol stop.

Summarising the various views of authors with great surgical experience in spinal cord injuries the following statement may be made:-

1. Early Operation.

Operation in the first days after an injury, providing the patient's general condition is satisfactory, may be indicated in the following circumstances:-

(a) Direct pressure on the cord by dislocated bone or bone fragments shown by X-ray. Cases showing an incomplete transversal syndrome require immediate operation the more urgently to prevent further damage to the cord by the bone fragment. Operative interference should especially be considered where manipulative reduction has been unsuccessful. It may be mentioned that even Boehler recommends operation as early as the first day in cases of fracture-dislocation of the lumbar spine without fracture of the articular processes if hyperextension has not succeeded.

(b) Complete or incomplete transversal syndrome of the cord or cauda equina with complete manometric or lipiodol block in cases without any appreciable fracture or dislocation of the spine. Blood-stained cerebro-spinal fluid without manometric block does not justify immediate operation.

(c) Paralysis developing hours or days after the accident indicating progressive haemorrhage or oedema. Foerster in particular has drawn attention to the danger of progressive paralysis in longitudinal direction following cervical spine injuries. With regard to the particularly dismal prognosis of conservative treatment in such cases early operative interference may become imperative as the only chance to save the life of the patient. In Foerster's Case 192 following fracture of the 4th. and 5th. cervical vertebrae, described in his book (1929), a progressive transverse syndrome developed within two days after accident with early respiratory paralysis. At operation the cord was found to be very oedematous particularly at the level of the 3rd. cervical segment. The most prominent part of the cord corresponding to the left antero-lateral tract was incised and detritus with serous fluid was removed, leaving behind a small cavity in the cord. A few hours after operation the motor function of the right arm and leg, and on the next day also of the left arm, returned; the motor function of the left leg recovered a week later. Thereafter the motor function recovered completely. The only residual sign was a thermal analgesia of the right side of the body below C₄. One and a half years later there was only isolated anaesthesia for cold with paradoxical warm sensation in that area. Foerster emphasised that in such cases lumbar puncture as recommended by Borchardt, and even a decompressive laminectomy without incision of the cord may not prevent the progress of the oedema. The same operative procedure is recommended in cases in which the progressive symptoms are caused by traumatic haematomyelia. A mere decompressive laminectomy is useless as shown in Foerster's Case 185.

A larger subdural haematoma, although certainly rare as the consequence of a spinal injury, can also be responsible for the development of such a progressive transverse syndrome in the first days after injury and represents also an indication for immediate operation. An interesting example of this group is Foerster's Case 182 (1929):

Figure 1. Continued.

A patient developed severe pain of girdle type in the middle thoracic region several hours after a fall down the steps. The pain gradually increased in a downward direction. On the following day there was severe pain in both legs and in the coccyx. On the third day there was marked paresis in both legs with bladder disturbances; pain continued, especially in the 5th. and 6th. thoracic dermatomes. On the fourth day there was complete transverse syndrome below the 4th. thoracic dermatome. Pain was absent below that level, but was present above it in the upper thoracic dermatomes. No operation was possible in this case because of additional pneumonia. At autopsy an intradural haematoma was found compressing the cord severely at the level of the 4th. thoracic segment and extending downwards to the cauda equina. The origin of this haemorrhage was a ruptured aneurysm of the radicular artery of the left 3rd. thoracic root. The vertebral column was intact.

Early operation may be of particular importance in cases in which a large subdural haematoma involves the roots of the cauda equina. Even a more conservative surgeon like Elsberg (1940) recommends early operation in such a case. Besides the fact that early removal of a big haematoma in this region may have an immediate beneficial effect in improving the bladder function, early operation may also prevent the dense adhesions which usually result from the organisation of such a haematoma. Moreover, suture of divided roots is certainly easier at an early operation. It must, however, again be emphasised that slight or moderate discolouration of the cerebro-spinal fluid does not justify an early operation.

④ A similar development of symptoms occurs in a progressive epidural haemorrhage following spinal injuries. Usually in such cases the irritative symptoms (pain, muscle spasm) are predominant and, unless there is an additional primary cord lesion, the spinal symptoms are in general slight or negligible. However, de Quervain (1908) and Foerster (1929) have pointed out that an extradural haematoma can produce a transverse lesion of the cord, especially when developing in the cervical region. The reason is that in that region of the spine the venous plexuses are particularly large and the epidural space on the other hand very small. In 1935 A.J. McLean described the excellent operative result in a case of fracture-dislocation of the 11th. dorsal vertebra with epidural haematoma: 12 hours after the accident the 16-year old patient showed, besides marked tenderness in the 11th. and 12th. thoracic dermatomes, only analgesia of the 1st. and 2nd. lumbar dermatomes. The entire saddle area as well as the tendon reflexes were normal. The symptoms gradually increased and 30 hours after the accident there was practically complete paraplegia with absent reflexes and sensory disturbances, more marked in all lumbar than in sacral regions. At operation 48 hours after the accident the dislocation of the vertebra was confirmed and partially corrected and an epidural haematoma compressing the cord was removed. A thick posterior plaster shell was moulded to the patient before he was removed from the table. The clinical signs receded within a period of 9 weeks. In the 14th. week he was fitted with a Taylor brace and began to sit upright. During the 20th. week he began to walk with a stick. At the 38th. week the residual syndrome was an incomplete Brown-Sequard complex.

(d) Irritation of spinal roots. There is no doubt that severe and persistent irritation of spinal roots after spinal injuries caused by impinging bone fragments, etc., may be an indication for early operation. This condition, however, is very rare. Elsberg (1940) has seen only one case of incomplete spinal lesion in the last 20 years in which the severe root pain was sufficient indication for early surgical interference. Other cases have been described by Foerster.

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Figure 1. Continued.

2. Late Operation.

There are no great differences in opinion about the beneficial effect of operative treatment in later periods after spinal cord injuries and both the Queckenstedt test and myelography can greatly facilitate the decision for operative interference. The indications for late operation can be summarised as follows:-

(a) Compression of spinal cord and spinal roots by deformities of the spine. Experienced authors agree on the beneficial effect of laminectomy in cases of spinal compression due to marked angulation, callus formation, prolapsed intervertebral disc, and other deformities of the spine. Foerster (1929) stressed the point that a remarkable functional recovery may follow the removal of such a compression even when carried out a long while after the injury. As examples of this group the following cases, described by this author, may be mentioned:

Flow long

decubitus
motor and sensory
lower limbs

Case 174. Fracture of the 8th. and 9th. thoracic vertebrae. Complete transverse lesion below the 11th. thoracic dermatome. Motor paralysis at first flaccid, later spastic. Flexion reflex elicited up to L₁. At operation 9 months after injury the cord was found strongly compressed at the level of the 11th. thoracic segments by the dislocated bone. There was immediate good pulsation of the cord after decompression. After operation hyperextension was applied. Gradual, marked improvement of motor and sensory function of the lower limbs. Voluntary action of the bladder.

decubitus
motor and sensory
lower limbs

Case 175. Fracture of the 3rd. lumbar vertebra with complete cauda equina syndrome below L₂. Severe cystopyelitis, septic temperatures, decubitus at the sacrum. Decompression of the severely compressed cauda equina 8 months after injury. Very remarkable improvement of motor, sensory and bladder function. Two and three-quarter years after operation the patient was able to walk for 1 - 2 hours.

decubitus
motor and sensory
lower limbs

Case 151. Fracture of the 6th. and 7th. cervical and of the 1st. thoracic vertebrae. Operation 2 years after injury because of increase of spinal symptoms due to callus formation. After operation gradual improvement. Two years after operation even the intrinsic muscles showed definite signs of recovery. Only the abductor pollicis brevis remained paralysed. (At operation the 1st. thoracic root was found severed, and a suture was not possible).

(b) Meningopathia. A progressive compression of the spinal cord by chronic pachy- or leptomeningitis has been repeatedly described. According to de Quervain post-traumatic pachymeningitis results from organised epi- and subdural haematomas or bone fragments.

Elsberg and Foerster found this condition particularly in traumatic lesions of the cauda equina. Foerster used to replace the excised thickened dura by a graft taken from the fascia lata.

Flow long

decubitus
motor and sensory
lower limbs

Of greater practical importance is the leptomeningitis serosa seu "arachnitis chronica progressiva cystica adhaesiva" (Oppenheim, Krause, Foerster, Warburg, Cassirer, Souques, Gauduchau, Bouthier, and others). This condition has been described either as additional noxis to the initial spinal cord or root lesions or as a quite independent one in cases without any or only minute initial spinal symptoms, following injury. As characteristic signs for the diagnosis of this condition are described: (1) stagnation or increase of spinal symptoms after initial improvement; (2) fluctuation of spinal symptoms in extent and intensity; (3) increased pressure of the cerebro-spinal fluid with and without serological changes; (4) complete or incomplete manometric block; (5) complete or (frequently) partial lipidol block. Although in general meningopathy more usually develops after a longer interval it may occasionally be found very marked only a fortnight after injury.

Figure 1. Continued.

Foerster, although describing several cases with good operative results emphasised that, in the majority of cases with chronic meningitis serosa, the improvement of the spinal symptoms was not very marked, and he assumed that in these cases a post-traumatic vasopathic process with progressive thrombosis of the spinal cord vessels, as described by Marburg and others, was responsible for the irreversible cord lesion. At operation the findings are sometimes most impressive. The spinal cord is not only compressed by one or several cysts, but it is also displaced and even twisted by the traction of the fibrous adhesions (personal observation).

(c) Haematomyelia. Elsberg (1940) recommended laminectomy and incision of the cord in cases of haematomyelia in which marked symptoms persist or in which many months after injury an increase of symptoms occurs due to an increase in the fluid in the cord cavity. In two cases remarkable improvement in the power of the lower limbs resulted.

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is not common
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is not common
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(d) Osteomyelitis. Osteomyelitis following closed injuries of the spine is very rare. Foerster has described only two cases. The first case in which osteomyelitis developed one year after the accident did not improve in spite of radical operative intervention, and the patient died of meningitis. In the second case osteomyelitis occurred about 6 months after the accident during an angina infection. This case healed by conservative treatment with 6 months rest and extension of the spine.

trauma

(e) Irritative syndromes. Since the last war persistent severe pain by irritation of spinal roots following spinal injury has become an important indication for surgical interference. In some cases pain may be improved and even relieved by repeated paravertebral novocain or alcohol injections. In cases of post-traumatic irritation of lumbar and sacral roots removal of a prolapsed intervertebral disc or of the thickened ligamentum flavum has been carried out successfully in recent years in various countries. There is hardly any doubt that after the war this operation may play a most important part in the treatment of post-traumatic "sciatica". A great number of cases with post-traumatic irritation of spinal roots has been treated with section of posterior roots. Indeed, this operation has proved very successful, particularly if at least three neighbouring roots are divided. In cases, however, in which the pain cannot be attributed to individual roots and involves larger areas of the body the surgical method of choice is bilateral cordotomy. As far as Foerster's and my own experience with this method are concerned unilateral cordotomy has proved useless in the majority of cases. It was the practice in Foerster's clinic to carry out root section and in particular cordotomy under local anaesthesia. It may be emphasised, however, that the indication for cordotomy in irritation syndromes following spinal injuries is very rare.

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(f) Palliative surgical treatment for spastic and flaccid paralysis. In a certain number of cases with incomplete transverse lesions following spinal cord injury rehabilitation is prevented or delayed by the persistent spasticity of the lower limbs which renders locomotion impossible despite good motor power. The methods recommended for reducing spasticity are: (1) section of posterior roots as introduced by Foerster; (2) partial resection of peripheral nerve trunks combined with plastics on tendons and muscles as described by Stoffel, Gocht, Foerster, and others. In recent years section of posterior roots for reducing moderate spasticity has rarely been carried out. It should be reserved for extreme flexion spasm in complete transverse lesions where it gives the patient great relief, and greatly facilitates his

operation
low

Figure 1. Continued.

cases. As mentioned before the upper thoracic and lower cervical regions are involved in the majority of cases. The upper thoracic region was injured in 52% of Wagner's and Stolper's (1898) 86 cases, and in 54% of Petren's (1910) 93 cases. Foerster has described stab wounds between 4th.-5th., 5th.-6th. and 8th.-9th. thoracic vertebrae. In numerous cases the knife blade was broken off and a piece remained stuck in the spinal canal or in the bone. As a rule the lesion of the spinal cord is immediate. Yet there are a few exceptional cases in which the retained knife blade was undiscovered for many years and was first found when spinal symptoms developed many years later (Peugniotz, Perthes, van Gehuchten). In general, a transverse lesion follows immediately on the injury, but if the cord is not completely divided, the symptoms subside more or less rapidly and the residual syndrome is that of a partial cord lesion. In a case of Foerster's clinic (1932) following stab injury between the 3rd. and 4th. thoracic vertebrae there was at first a nearly complete transverse lesion below Th₄ with sparing only of the right spino-thalamic tract. In the left analgesic part of the body below the level of the lesion nociceptive stimuli (pin-prick, pulling hairs) could, however, not be differentiated. After removal of the broken blade, about 14 days after injury, there was a gradual marked improvement of the spinal symptoms. The residual spastic paresis of the lower limbs, especially the left, was further improved by tendon plastic. Surgical treatment has also proved successful in cases described by other authors. According to the literature the danger of meningitis following stab wounds of the spinal cord is apparently small.

hampy
 Subtotal
 operations

Care of the bladder and intestines.

It is universally recognised that the paralysis of the bladder and bowels following spinal cord injury demands the most careful attention from the outset. Neglect of the appropriate measures or delay in adopting them may postpone or render useless the most skilful surgical treatment. Yet in practice it is still not fully appreciated that both the medical and nursing staff in casualty clearing stations, etc., must be familiar with the principles and methods of the treatment of the various kinds of bladder dysfunction. Moreover, it should be remembered that in some cases of injury to the vertebral column the spinal lesion of the bladder may also be associated with a lesion of the peripheral nervous pathways of this organ due to prevertebral haematoma, etc.

requiring
 assured
 necessary
 function
 skills and
 surgical treatment
 is required

The key-points in the treatment of a paralysed bladder after spinal cord injury are: (1) Drainage of the urine must be continuous and distension of the bladder should never be allowed. (2) Meticulous care and cleanliness must be observed whatever method of drainage is adopted. It must be borne in mind that no method so far devised can completely prevent a bladder infection, but in many cases the infection can be prevented from spreading to the kidneys. No definite conclusions can so far be drawn from the literature whether suprapubic cystostomy, with the use of irrigation apparatus such as introduced by Munro (1935, 1937) is the method of choice for bladder drainage. On the continent many clinicians still prefer the use of an indwelling catheter, combined with irrigation with 3-4% boric acid solution or hivanol solution (3:1000) once or twice a day to prevent accumulation of phosphates at the base of the bladder and on the inner surface of the tube. Opinions regarding the frequency of change of the catheter vary from 2 days to several weeks. It is not generally appreciated that, whatever method may be used, catheterisation and irrigation should only be done by the medical officer and not by the nursing staff. This point cannot be overemphasised. (3) Restriction of fluid by mouth in the early stages has been recommended (Stinchfield, 1940), but the general opinion is that the patient should be encouraged to drink freely and that the urine

Drainage of bladder should be such that distension is prevented

Bladder irrigation is indicated
 ?
 To be changed every 2-4 days according to state of the bladder & catheter

Figure 1. Continued.

should be prevented from becoming alkaline. This can be achieved by some herbal decoction or by acid mixtures. (4) Re-education of the bladder should be begun as soon as possible to facilitate a co-ordinated function of the bladder. In this connection it may be mentioned that Riddoch's studies and findings on the "mass reflex" (1917) have proved to have important practical application. It was common practice in Foerster's clinic and the writer's own department to use these reflexes at regular intervals as active exercise for the bladder. In agreement with Head and Riddoch its success was found, however, to be small and delayed in those cases in which in the early stages the intravesical pressure had not been controlled by appropriate measures and in which the bladder had become overdistended, thus causing, in addition to the spinal damage of the bladder, a peripheral lesion of this organ. Methods therefore which even recommend overdistension of the bladder should be condemned. Riddoch's findings that the "mass reflex" is lost in toxic febrile complications were also confirmed. (5) Dietetic care has also been recommended and in the writer's opinion the use of vitamins, particularly B¹, may be an additional factor in improving the bladder function.

Riddoch's mass reflex better

high vitamin diet

When caring for the bladder attention must also be paid to the bowels. Constipation and retained scybala may lead to an invasion of kidneys and bladder by B. coli, and must therefore be prevented from the first day after the injury. This can easily be done by an aperient or enema either daily or at least on every second day. It is surprising how often this precaution is neglected in practice. Gastric-intestinal intoxication can also be diminished by acidophilus milk. Where temporary ileus occurs after spinal and spinal cord injury, especially in the thoracic region, eserine has been found valuable. *provided that the bowel contents are not dry and hard. Do not cause diarrhoea. Give 1/20, 1/30 the first 24 hours by abdominal Nursing and rectum as usual if necessary.*

Herbal decoction also indicated

Eserine

Authors in all countries agree that in addition to the care of the bladder and intestines good general nursing of the paralysed patient is of the utmost importance for accelerating rehabilitation. The most skilful operation on the most suitable case will prove useless if the many little details of good nursing care are not fully understood. To prevent pressure and sores upon the back, sacrum and hips, the patient is usually placed on an air- or water-mattress. He must be turned frequently; his skin must be rubbed with alcohol and powdered; the sheets must be kept clean and dry, and free from any irritating substance. This meticulous care of the skin in both infra- and supraleSIONary parts of the body is particularly necessary in view of the disturbances of sweating (reflex-hydrosis) which frequently develop after spinal cord lesions (Head and Riddoch, 1917). In the first period after spinal cord injury profuse spontaneous sweating may occur in the supraleSIONary parts of the body, particularly in the border zones above the level of the lesion (L. Guttman, 1931). This hyperactivity of the sweat and sebaceous glands can become a great nuisance, particularly in hot surroundings and can lead to maceration and infection of the skin, especially on the back where it spreads easily to the infralesIONary parts. Sores on the heels are best prevented by cotton pads or rubber rings or by placing the legs on Braun's splints, the feet being kept in dorsiflexion, and pressure on the feet avoided by placing a wire cradle over the legs. There is considerable difference of opinion concerning the advisability in cases where vertebral fractures are combined with spinal cord lesions of applying continuous traction by pins or wires through the tibial tubercles of the paralysed legs, as recommended by Boehler. But adhesive plaster cases for traction on the paralysed legs can unhesitatingly be condemned because they certainly produce pressure sores very readily.

Compensation clean up heat by hand

air mattress

What about feet? Can be also to diminish pressure

Boehler's method

Figure 1. Continued.

The practice in Foerster's clinic was to place the feet in dorsiflexion while avoiding rigid fixation and traction of the lower limbs. Passive movements and massage of the paralysed limbs were applied as early as possible following injury, and, as soon as the legs regained any active movement, a systematic active exercise treatment was begun. The details of this are described in the writer's review on the methods of rehabilitation following lesions of the nervous system (1941).

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Figure 1. Continued.

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Figure 1. Continued.

treatment of spinal injuries. These notes are not meant to be an exhaustive criticism armed with hindsight of the memorandum. It is the memorandum that is of prime importance as it marks the start of the comprehensive treatment of spinal injuries.

OVERVIEW

General remarks

Despite the fact that he had not treated patients for 5 years while he was carrying out research and for the previous 7 years he had been working at the Jewish Hospital, away from Foerster's specialised unit, his observations are acute, practical and well thought out. Guttman was erudite and scholarly in his research, and he provides a very detailed and thorough analysis of the literature, especially the German contribution. This was a formidable task in those days before the Internet, unlike today when a literature search is available at the press of a button. His knowledge was not just theoretical, derived from study of the literature; he clearly had treated patients in Foerster's department and could evaluate the different forms of treatment in light of his own experience.

He repeatedly emphasises how the doctor should be in total charge of the patient, a cornerstone of his treatment. He does not discuss exercise in detail or occupational therapy as these have been addressed in a previous article on peripheral nerve injury (1941), but Guttman uses the same methods to rehabilitate spinal injury patients as applied to peripheral nerve injury patients.³

Detailed remarks

Mechanism of spinal cord lesion. He knew about fractures in tetanus infections in metrazol shock therapy due to the strong contraction of the erector spinal muscles and multiple fractures at different levels. He describes the mechanics of injury and the dissociation of cord injury from the site of the injury, the contrecoup mechanism seen in gunshot wounds of the spinal cord with the fracture far away from the initial trauma.

First aid. With regard to the administration of first aid, his management of the patient cannot be bettered, stressing the need for a doctor to supervise the lifting and transfer of the patient and obtaining an accurate history from the outset.

Treatment of closed injuries of the spine. He reviews the literature with a careful analysis of the arguments for and against surgical intervention and fixation, and the whole passage can be read with profit today. He discusses two different forms of treatment, manipulative reduction followed by fixation as described by Boehler as opposed to Magnus whose method based on Kocher's work that rejected manipulative reduction. He does not come to any conclusion but, fascinatingly, he adopted Magnus's method, called it postural reduction, as his standard method of treatment, rejecting all forms of surgery on the basis that it destabilised the spine and could lead to deformity. He discusses the dangers of laminectomy, in that it destabilises the spine, and later in his own practice he became vehemently opposed to this, based on his own experience in the management of these cases and how general shock is contra-indication to any operation. This has been underlined by Riddoch in the document, suggesting that it is of prime importance. He devotes eight pages to the treatment of the fracture in spinal injuries. He discusses critically the indications for surgery and, contrary to his later views, he favours early operation where there is direct pressure on the cord, the rapid development of progressive paralysis or the presence of a haematoma. He would later abandon these views in favour of more conservative management of the fracture.⁴ He discusses palliative surgical treatment for spastic and flaccid paralysis where he discusses section of the posterior roots introduced by Foerster. He subsequently rejected this form of treatment and carried out an alcohol block.

Management of the bladder. In the First World War, the majority of patients died rapidly of urinary infection spreading to the kidneys. Thomson-Walker found that out of 339 patients with spinal cord injuries between 1915 and 1919, 47 died from urinary tract infection 8–10 weeks following injury.⁶ Guttman discusses



Figure 2. Ludwig Guttman teaching in the physiotherapy department at Stoke Mandeville Hospital. Personal photograph taken from History of the Treatment of Spinal Injuries, 2003, JR Silver, Chapter 3, p.86. Reproduced by kind permission of Springer Science+Business Media BV.

the methods of draining the bladder. This section is widely annotated by Riddoch who emphasises the danger of over-distension of the bladder. Guttman only mentions the danger of infection spreading to the kidneys; he does not address the mortality. He discusses whether the methods of drainage should be continuous or whether there should be washouts. He does not fascinatingly discuss the method of intermittent catheterisation as practiced by Wilhelm Wagner, William Thorburn and John Hulke, and which he subsequently introduced at Stoke Mandeville Hospital.⁷ He does stress, however, that the overall care of the bladder must be the responsibility of the doctor and not the nursing staff.

Pressure sores. Despite the overwhelming danger of pressure sores, he only mentions these in a few lines. He does not discuss how pressure sores can penetrate the skin, involve the bone and cause death.

General care of the patient. He devotes a passage to the position of the patient to prevent contractures and shows his profound knowledge of physiotherapy and nursing. He was light years ahead of anything in the UK, and he taught the students of the School of Masseurs at Stoke Mandeville Hospital how to treat patients (Figure 2). His teaching and precepts served as an inspiration to physiotherapists throughout the UK and beyond.

Thermoregulation. He stresses the impaired sweating caused by paralysis.

CONCLUSION

Ludwig Guttman had direct experience of spinal cord injuries, which he drew upon to treat the patients. He stressed that a doctor should be in charge of all aspects of treatment. Despite the fact that it was a surgical paper, he dealt with pressure sores and the care of the bladder. Clearly at this stage his mind was open and various ideas that he had from his own experiences and review of the literature were not fixed into dogma. The cornerstone of his treatment, which he maintained throughout his professional career, was the holistic care of the patient that all aspects of treatment must be integrated as a whole.

'The most skilful operation on the most suitable case will prove useless if the many little details of good nursing care are not fully understood'.

COMPETING INTERESTS

The authors declare no conflict of interest.

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