TREATMENT OF COMPOUND SPINE INJURIES IN
FORWARD ARMY HOSPITALS

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WHILE complete standardization in treatment of compound spine injuries is impossible and must be modified by intelligent consideration of particular problems in individual cases, it has proved desirable to make their management as uniform as possible. This has always been a difficult and discouraging group of cases to treat and perhaps for this reason they have been neglected. The necessity for rapid evacuation, often under difficult circumstances, from the scene of injury plus the problems arising from handling large numbers of casualties at one time make the care of these injuries in military surgery an even more arduous task than in civilian practice.

Although optimum methods of treatment are still uncertain, at least many common errors, both of commission and omission, are avoidable. Astute medical judgement, skillful surgery, and most important of all, meticulous nursing care are all essential to adequate treatment in these cases. Observation of large numbers of spine injuries in forward medical installations in the European Theater of Operations between June, 1944 and February, 1945 has led to the conclusions outlined in this report.

CARE OF THE PATIENT IN THE HOSPITAL AND IN TRANSIT

When a casualty arrives at a Field or Evacuation Hospital with the diagnosis of spinal injury, or when this diagnosis becomes apparent after admission, neurological examination with careful notation of the findings should be part of the initial examination. If associated shock is present demanding immediate treatment, neurological examination should be made as soon as the patient's general condition warrants. It is most important that every patient with a wound of the neck, shoulders, thorax, abdomen, or back have sensation and voluntary motion of the extremities briefly checked to rule out the possibility of a spinal injury. This is particularly true of penetrating chest and abdominal wounds, where too often preoccupation with these lesions has resulted in unfortunate neglect of a spinal injury.

All of these patients should have an indwelling urethral catheter inserted under aseptic precautions at the earliest possible moment to obviate urinary retention and overflow incontinence. If marked distention is once permitted, subsequent recovery of bladder tone is greatly delayed. Repeated catheterizations must be avoided. Considerable care should be taken to use a sufficiently large catheter to prevent leakage, and to secure the catheter firmly in position. The drainage tubing should always be attached to the litter or cot in such a manner as to relieve any possibility of tension. Personal super-
vision of these details by medical officers is necessary to keep catheters from leaking and coming out unnecessarily. Indwelling urethral catheters should be irrigated at least once daily and changed weekly. Suprapubic cystostomy is not indicated in forward hospitals except in the presence of a purulent urethritis or some other local contraindication to an indwelling catheter. Tidal drainage has proved entirely impractical in forward units, where equipment, time, and trained personnel are all limited.

The importance of the earliest possible institution of measures for care of skin with impaired nerve supply cannot be overemphasized. The sequelae of severe pressure necrosis over bony prominences are so distressing that all possible measures of prevention, no matter how laborious or how time-consuming, should be attempted. As soon after admission to the hospital as possible, the patient should be placed on a "mattress" made of at least three folded dry blankets placed on the litter. This "mattress" should be covered at all times by a dry clean sheet stretched tightly and kept as free from wrinkles as possible. Support is placed at once under the calves so that the heels do not touch the bed at any time. It is unwise to place additional support under the sacral region, as is sometimes practised, unless an inflated rubber ring is available.

The care of the skin in the entire area below the level of the lesion, with especial attention to the sacrum, trochanters, and heels, is highly important. This entire area (not just the back) should be washed with soap and water, lightly massaged, carefully dried and powdered at least once and preferably twice daily. The patient’s position on the litter or cot should be adjusted at least every 4 hours day and night. This does not necessarily mean moving from back to abdomen or even from side to side. The buttocks can be raised alternately 2 to 3 inches by the use of small soft pillows or folded sheets or towels. The legs can be shifted a few inches or rotated a few degrees. They should always be kept separated. This type of adjustment can be carried out easily and safely by one attendant. Wet sheets or blankets demand immediate replacement. No adhesive tape is permissible on the anesthetic skin of back or legs. All of the foregoing measures are feasible in forward units except under the most extenuating circumstances.

If operation in a forward hospital is not contemplated, evacuation to a neurosurgical center must be expedited. The patient should never be evacuated, however, until the preparations outlined above have been carried out. That is, he should be lying on a "mattress" of blankets covered with a dry sheet, the heels should not be touching, an indwelling catheter should be in place and arrangements made so that it is never clamped off in transit. A small support, such as a folded towel or sheet, should be placed under the spine at the point of injury if it is in the lumbar region. If the cervical spine is involved, the shoulders should be raised 2–4 inches so as to allow the head to fall back slightly, and sand-bags, shoes, or a blanket-roll placed beside the head to prevent lateral deviation or rotation. The prone position is satisfactory often for short moves except in cervical lesions.
Perhaps the most difficult and controversial problem for the surgeon is the determination of which injuries due to gun-shot and shell-fragment wounds of the spine should be subjected to early surgery. Those that warrant laminectomy in forward units (i.e., Field Hospitals, Evacuation Hospitals, and General Hospitals in the Communication Zone with a 10-day holding policy) should be limited to the following groups of cases. It will be found that these constitute about 40 to 50 per cent of the total number of spine injuries seen. All others should be evacuated at once to neurosurgical centers in the rear for further care.

1. Patients who exhibit a neurological picture consistent with an incomplete transection of the spinal cord where this picture has altered since the time of injury, especially where the neurological deficit is increasing. These cases have been extremely rare.

2. Patients with a neurological picture of incomplete cord transection where X-rays reveal clear-cut encroachment on the spinal canal by a foreign body or reveal definite fracture of a lamina or pedicle with or without depressed bone fragments. If the foreign body lies on the same side of the spinal cord by X-ray as the wound of entrance, the prospects should be considered much more favorable than if it has crossed the midline.

3. Patients with a neurological picture of incomplete cord transection or of a cauda equina lesion who have associated thoracic or abdominal wounds requiring surgery and therefore making transportation undesirable for 10–14 days. In these cases it is frequently possible to perform laminectomy under local anesthesia within 48–72 hours after the chest or abdominal operation has been carried out, and certainly within a week.

4. Patients who have sizable wounds directly over or near the spinal column and are leaking spinal fluid profusely. If such a gross leak persists it is usually due to a spicule of bone or to a foreign body itself protruding through the dura and thus maintaining the opening. Adequate debridement of such a wound includes removal of comminuted and depressed bone fragments, following which the fluid leak is stopped by closure of the dura, if possible, or by careful approximation of muscle across the bony defect. Small wounds with only slight leakage of spinal fluid, especially if not directly over the spine, will usually seal themselves after debridement and may be safely watched.

When neurological examination reveals a complete physiological transection of the cord at a well-demarcated level and there is a history of instantaneous loss of all motion and sensation from the moment of injury with no subsequent change, then early operation is not indicated. If X-rays demonstrate that a foreign body has traversed the spinal canal or actually lies across the canal, or if bony fragments largely obliterate the canal in instances of complete physiological transection, the outlook is even more hopeless.

In the presence of either complete or incomplete physiological transection of the cord, laminectomy is not indicated in the absence of X-ray
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Evidence of fracture of the vertebrae or of a foreign body encroaching upon the spinal canal. This, of course, implies satisfactory X-rays, which may require some perseverance. Spinal shock as a result of trauma in the neighborhood of the spinal column without actual mechanical pressure on the cord or division of its continuity is a definite entity. Decompression of such a concussed cord by removal of normal laminae is felt to be of no avail. Any improvement which may follow such surgery probably would have occurred anyway in about the same period of time.

Most, if not all, spinal injuries involving the cauda equina should be explored. However, there is not the urgency for laminectomy here (below L-1) that there is at higher levels, since presumably in the nerve roots of the cauda regeneration after injury will take place and nerve suture may be possible. Therefore, unless the patient must be kept in a forward area because of associated injuries he should be evacuated as quickly as possible to a neurosurgical center for this procedure.

COMPLETE VS. INCOMPLETE TRANSECTION

The foregoing criteria for early surgery make it paramount that the difference between complete and incomplete physiological transection of the cord be appreciated as accurately as possible. To this end, the patient must be both questioned and examined with great care.

Except in high cervical lesions, these patients usually remain conscious and alert from the moment of injury and can give an account of their course with great accuracy. If there was abrupt and complete loss of motion and all forms of sensation from the instant of injury ("dead all over") with no subsequent change, the outlook is almost certainly hopeless. If, however, the patient has at any time experienced pain in the legs, sensations of warmth or cold, or paresthesias of any kind, or if he has been able to pass any urine spontaneously, the outlook should be considered much more favorable.

Clinical examination is more reliable. In complete transection of the cord there is a well-demarcated level of anesthesia which corresponds to the known anatomical segmental configuration. This level remains consistent. There may or may not be a band of hyperesthesia above this level. All forms of sensation are lost. It is important to test for light touch, pain, position sense, and especially deep pressure sense over the calves and soles of the feet. In total transections, flaccid paralysis is complete below the segment of the lesion and areflexia is present.* Urinary retention occurs. Priapism and vaso-motor changes may be present but are unreliable criteria.

On the other hand, if any appreciation of touch, pain, position, or deep pressure is present on either side below the level of injury to the cord, or if any reflex activity is present, or if there is any muscle tone or voluntary movement, the lesion must at least tentatively be considered an incomplete one. An accurate knowledge of the segmental level of muscle innervation is,

* Occasionally, immediately after injury, a slight sluggish dorsiflexion in response to plantar stimulation is found bilaterally.
of course, essential. In incomplete or suspected incomplete lesions, repeated neurological examination by the same examiner at frequent intervals together with consideration of the X-ray findings will determine disposition.

An incomplete lesion of the cord proper (cervical and thoracic spine) will not be confused with a complete but asymmetrical lesion of the cauda equina (lumbar and sacral spine) if it is remembered that the conus medullaris lies opposite D-12 and L-1. That is, there may be complete loss of sensation and motion below say L-2 on one side and below L-5 or S-1 on the other, which is in no sense an incomplete lesion.

Lumbar puncture and estimation of spinal fluid dynamics (Queckenstedt test) have been of no particular value in compound lesions of the spine in differentiating complete from incomplete transections, or in estimating suitability for operation. A foreign body or depressed laminar fragment may be present within the spinal canal producing local involvement of the long tracts of the cord in the presence of a normal rise and fall of spinal fluid pressure on jugular compression and also in the presence of clear spinal fluid. When there has been dural penetration with a spinal fluid leak, manometry becomes unsatisfactory, and this is the rule. Blood in the spinal fluid at lumbar puncture does not necessarily mean dural penetration as it may be found in simple concussion. Decision, therefore, as to operation is more intelligently made on the basis of the clinical criteria already discussed, and spinal fluid studies have been largely abandoned in forward hospitals.

LAMINECTOMY

Laminectomy is most satisfactorily carried out under local 1 per cent procaine anesthesia. Pre-medication with morphine sulphate is practised except in lesions of the cervical cord or whenever there is involvement of the accessory muscles of respiration, in which case it should be strictly avoided. Whether general or local anesthesia is used, special attention should be given to support the upper chest from the operating table so that respiratory excursion is not embarrassed. Constant bladder drainage is uninterrupted throughout operation.

Cases that are suitable for laminectomy usually do not involve more than one or two vertebrae and consequently a large exposure is not necessary. Stripping the muscles from the vertebral spines and laminae is the most shocking part of this operation and should be carried out on only one vertebra above and below the involved segments in most instances.

The most important step of the procedure is the complete removal of all bone fragments and foreign bodies that encroach upon the spinal canal. Laminectomy can usually be started at the site of the traumatic defect. If this defect is small, it may be wiser to start the removal of bone at an uninjured point. Wide decompression by removal of additional laminae that have not been fractured is unnecessary. The operator must be certain that displacement of the dural envelope from every aspect is relieved. Extradural blood clot should be thoroughly evacuated.
If the dura has been penetrated, exploration within is carried out and a small catheter passed upward and downward to make certain there is no unexposed encroachment on the cord. Operative manipulation of the cord proper is of no therapeutic value and should be avoided. The dura is closed with fine silk sutures if possible or with a fascial graft.

If the dura has not been penetrated, a tiny opening is usually made opposite the point of dural compression. This is of no therapeutic value but of considerable prognostic importance to subsequent management of the patient. The condition of the cord, the character of the spinal fluid, and the presence of obstruction to the passage of a small catheter are ascertained and recorded.

The human fibrin foam and thrombin now available are especially useful in controlling bleeding from epidural vessels and from fractured vertebral bodies and pedicles.

Unless gross sepsis is present, these wounds should be closed in layers without drainage, muscle being carefully approximated in the midline in the region of the bony defect. Penicillin and sulfanilamide powder are used locally. Wounds of entry or exit, unless exactly in the midline, are debrided separately. If the dura has been left open, one must be particularly careful to close at least the muscular layers of these separate wounds to prevent spinal fluid leakage.

**POSTOPERATIVE CARE**

After operation the patient is kept flat on his back from 12–24 hours unless vomiting, and from then on his position is changed every 2–4 hours. Care of the skin, with protection of bony prominences against pressure necrosis as previously outlined, is resumed immediately. The patient is transferred to a regular mattress, or air mattress if available, placed on a cot or firm bed. Constant bladder drainage should be uninterrupted. An enema every second day is administered as soon as the patient begins to eat.

These patients may be evacuated then to a neurosurgical center in 3–4 days if there are no complications, or otherwise whenever associated injuries permit. All precautions outlined for the transportation of a patient not operated upon should apply with equal rigidity to the patient who has undergone operation. Every effort should be made to expedite evacuation and prevent delays in transit.