Operative Management of Spinal Injuries

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Introduction

No greater tragedy can befall on a young adult in this most active period of life than a spinal injury strikes him/her. This changes the entire life of the patient, the family and everyone involved.

The most common cause of spinal injuries is vehicular accidents. Of course, men are more affected than women, probably because there are more male vehicle drivers than female. Moreover, woman drivers are not the cause of high-velocity accidents that result in spinal injuries. Sports are another common cause of spinal injuries, and today, people are involved in a variety of sporting activities. Christopher Reeves has come to embody everything discussed about spinal injuries; but in India, they are due to less dramatic causes like fall from trees.

Pathophysiology of Spinal Injuries

<table>
<thead>
<tr>
<th>Primary (immediate)</th>
<th>Secondary (3–8 h)</th>
<th>Delayed</th>
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</thead>
<tbody>
<tr>
<td>Hemorrhage</td>
<td>Edema</td>
<td>Ischemia</td>
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<tr>
<td>Contusion</td>
<td>Inflammation</td>
<td>Myelomalacia</td>
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<tr>
<td>Ischemia</td>
<td>Tumor necrosis factors</td>
<td>Syringomalacia</td>
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Types of Spinal Injuries

Spinal injuries include injuries to:

- Spinal cord.
- Vertebral column.

Injuries to the spinal cord could be either complete or incomplete.

- Complete injuries:
  - Transection.
  - Ischemia.
- Incomplete injuries:
  - Anterior cord syndrome.
  - Central cord syndrome.
  - Posterior cord syndrome.
  - Brown-Sequard syndrome.

Classification of Spinal Injuries

Classification of spinal injuries is important in order to maintain consistency and improve the understanding during discussions.

There are many systems of classification. Most of the classifications are based on the following:

- Mode of injury (mechanistic)
- Type of fracture (morphology)
- Degree of instability

Cervical spinal injuries, both high and low, and dorsolumbar injuries would be discussed further.

High Cervical Spinal Injuries

High cervical spinal injuries include the following:

- Occipital condyle fractures.
- Atlanto-occipital injuries.
- Fractures of the atlas.

The most frequent causes of high cervical injuries are vehicular accidents and falls from heights. These injuries are associated with a high degree of mortality.

Occipital Condyle Fractures

Occipital condyle fractures are extremely rare and also difficult to diagnose. The treating doctor needs to have a high index of suspicion. These fractures are associated with a high rate of mortality. In most cases, computed tomography (CT) scan offers the best modality for diagnosis. Occipital injuries have been classified by Anderson and Montesano as shown in Table 1.

Atlanto-Occipital Injuries

The Atlanto-occipital injuries are again associated with high-speed motor vehicular accidents. Most of the victims do not survive as the injury is to the respiratory centers, but those who do, often survive as pentaplegics. Classification of atlanto-occipital injuries is shown in Table 2.

Fractures of the Atlas

Fractures of the atlas are often complicated by craniofacial trauma, because it is due to direct injury to the head and face. It is often associated with hyperextension or axial loading, which are the typical mechanisms of injury. Isolated fractures often do not give rise to neurodeficits since there is a large area around the spinal cord at that level. Fractures of the atlas have been classified by Landeles as shown in Table 3.

Case Study 1: High Cervical Injury

This case was of a policeman who met with a road traffic accident. While doing his rounds on a bike, he had a collision with another vehicle and ran head-on into the bus in front of him. He sustained a fracture at the C0–C1 level and a burst fracture of the C4–C5. These are unusual injuries, and they can be treated conservatively. But in this case, the lower injury required surgery.

Fractures of the Odontoid

Fractures of the odontoid have always been of major interest for spine surgeons. Although in younger individuals it is due to high-velocity motor vehicle accidents like bike injuries, in the elderly, it can occur even due to low impact falls. Minor falls can result in a odontoid fracture and these are often missed. These fractures have been classified by Anderson and d’Alonzo as shown in Table 4.

As discussed in Table 4, type 1 fracture does not require surgery, but collar immobilization would suffice. It is only type 2 fracture that is associated with nonunion, because the blood supply at that level is very poor and requires odontoid fixations done anteriorly; after which the fracture is reduced and fixed usually with two screws. Type 3 extends into the body and can be treated with cervical arthrodesis.

Fractures of the Axis

The fractures of the axis are again due to the motor vehicular accidents, and this is the injury during a judicial hanging, euphemistically called the “Hangman’s fracture,” where there is a
traumatic spondylolisthesis of the axis over C3. The classification of the fractures of the axis is given in Table 5.

Apart from the above-described types of fracture of the axis, when there is a subluxation of the facet joints, this has to be reduced, closed or opened and then fixed both anteriorly as well as posteriorly.

**Case Study 2: Type III Injury**

Individual presented with type 3 injury. Although only minimal distraction was given, the patient over distracted. Fortunately, there was no increased deficit. The patient had a partial incomplete neurological injury. In order to manage the case, after a closed reduction of the fracture, an anterior surgery and then posterior wiring was done.

**Low Cervical Spinal Injuries**

Several systems of classification have been put forth for the classification of low cervical spinal injuries. They are as follows:

- Allen and Ferguson
  - Compressive flexion.
  - Distractive flexion.
  - Compressive extension.
  - Distractive extension.
  - Vertical compression.
  - Lateral compression.

- McAfee
- Frankel

**Dorsolumbar Spinal Injuries**

Several classifications have been proposed for dorsolumbar injuries. The first description of dorsolumbar injuries was way back in 1931 by Watson Jones, where he described only the flexion injuries. Later on, Holdsworth added the following types to the flexion injuries:

- Flexion rotation injuries.
- Extension injuries.
- Compression injuries.

Even in those days, Holdsworth gave importance to the posterior ligamentous complex, which plays a very important role in the long-term behavior of dorsolumbar injuries.

The well-known concept proposed by Denis is the three-column concept in order to assess the degree of stability or instability in an injured spine.
Of course, the most widely used classification currently is the one proposed by Magerl and Gertzbein, which is based on the severity of the injury:

- Type A (Figure 1): (1) Impaction fractures; (2) Spine fractures; and (3) Burst fractures.
- Type B (Figure 2): (1) Flexion distraction - ligament; (2) Flexion distraction - osseous; and (3) Hypertension shear.
- Type C (Figure 3): (1) Type A with rotation; (2) Type B with rotation; and (3) Rotational shear injury.

Type C injuries are almost always associated with severe neurological deficit.

### Management of Acute Spinal Injuries

#### Goals of Management

- Preservation of life.
- Preservation of intact neurological function.
- Restoration of spinal stability and prevention of spinal deformity (which is very important in the long-term).
- Treatment of associated injuries and prevention of complications (which impacts the decision of when to operate).

#### Table 6: ASIA Impairment scale

- Complete
- Incomplete sensory, complete motor
- Incomplete sensory and motor (<Grade 3)
- Incomplete motor (>Grade 3)
- Normal motor and sensory
- Enhancement of neurological recovery by realigning and decompressing the cord.
- Facilitation of functional recovery.

#### Immediate Management

Treatment of acute spinal injuries should ideally start at the site of injury. The Advanced Trauma Life Support Protocol (ATLS) has to be followed. Immobilization is absolutely essential. This could be done by keeping the patient supine on a spine board with strapping. The ATLS stresses on the maintenance of airway, breathing and circulation.

#### Clinical Assessment and Laboratory Investigations

At this stage, a neurological assessment is done. There are several classifications used to assess the degree of neurological impairment. Currently, the ASIA impairment scale is the most accepted classification for grading preoperatively, postoperatively and on follow-up (Table 6).

Whenever a patient is brought to the emergency room with a spinal injury, it is very important to take plain radiographs. In addition, if the patient is neurologically intact, a CT scan is more important than an MRI, but both could be done based on the facilities in the hospital.

#### Medical Management

The medical management involves administering oxygen by mask to maintain SpO2 at 100%. Additionally, methylprednisolone, according to the NASCIS III Protocol, interleukin (IL)-6 and GM-1 ganglioside are given.

#### Surgical Management

Currently, surgery plays a small but significant role in the management of spinal injury. Irrespective of the duration after the injury, it is very important to stabilize and decompress the cord, and it is here that surgery plays a very important role in improving the condition of the patient with spinal injury.

Spinal injuries could be either complete or incomplete, and surgery plays a bigger role in incomplete injuries helping in decompression of the cord and thus giving a better chance for it to recover. In complete injuries, early stabilization of the cord along with early rehabilitation is necessary.

Vertebral column injury includes not just bone injury but more importantly the soft-tissue injuries, predominantly ligamentous injury. These injuries depend on the mechanism and the velocity of the injury.

As discussed earlier, during transport of a patient, the instability could cause repeated cord injury, and an incomplete injury could become a complete one because of poor handling. Additionally, the compression of the cord plays an important role in aggravating the condition of the patient.

#### Indications

The indications of surgical management are

- Incomplete neurology.
Instability.

To prevent deformity when the patient has intact neurology.

**Timing of Surgery**

The timing of surgery is extremely important and depends upon the initial assessment of the patient. The decision basically depends upon the amount of neurological benefit that can be achieved with immediate surgery. If the patient has got compression or has partial paralysis, definitely immediate surgery is required. However, for completely flexed and paraplegic patients, surgery does not benefit much.

The advantage of an early surgery (<72 h after injury) is that it minimizes secondary pathological changes; but it is important to assess if the patient is fit for surgery at this stage. Else, it might have to be delayed as in late surgeries (>5 days after injury) since there is a school of thought who believe that patients are in a state of physiological instability after injury.

**Surgical Modalities Advocated in Different Types of Injuries**

**Cervical Injuries**

In case of a flexion distraction injury, which is a three-column injury (Figure 4), surgery both anteriorly and posteriorly is preferred. A closed reduction may also be done. In case that is not possible, then one should be operated posteriorly first and then anteriorly. When there is a dislocation as shown in Fig. 4, it is very important to have an MRI done to ensure that there is no trapped disc, since when a posterior reduction is done, the disc might get impinged and if the patient is neurologically incomplete, this may worsen the deficit.

In order to describe how innocuous trauma can lead to serious injuries, an example is quoted, where a senior surgeon from Chennai had a fall from a swing when he was sitting on it with his grandchild. When he was rushed to the hospital, everything was declared normal, but when he went back to perform surgeries, he started developing severe pain and weakness in both his limbs when he would flex his head down to look and operate. When flexion/extension studies were done, it was found that he had a missed subluxation at the C5–C6 level (Figure 5). Therefore, he was operated both anteriorly and posteriorly.

In case of bifacetal dislocation, as shown in Figure 6, patients generally present with a severe neurological deficit. The bifacetal dislocation has to be reduced and this is done both anteriorly and posteriorly, since the disc can impinge and give rise to worsening neurological deficit (Figure 7). Sometimes, the disc has to be removed anteriorly before the reduction maneuvers are done.

Figure 8 shows a 2-month-old flexion distraction injury, where the patient was neurologically intact but presented with severe radicular symptoms. It is a point to ponder over if such injuries have to be treated surgically or just left alone. While
managing these cases surgically, the fracture has to be reduced posteriorly first, fixed and then an anterior surgery is done. Currently, whether an anterior surgery in such a situation is required or not is debatable.

Thoracic Injuries

Thoracic injuries are always high-velocity injuries. The patients almost always have associated rib fractures, sometimes, a sternal fracture and damaged lungs. These patients are quite ill when they are brought to the hospital and the neurological deficit is almost always total. Surgery in these cases at the earliest is only to help rehabilitation. A posterior surgery without realignment of the spine is preferred. This is mainly because if the patient has a total neurological deficit, this kind of surgical approach helps in early rehabilitation.

In case of burst fractures with the neurological deficit, it is preferable to operate anteriorly and not posteriorly. A complete corpectomy can be done and then implants like a double-rod system could be used in order to achieve a very rigid fixation. In these fractures, the posterior ligamentous complex is almost always intact and it is important that it is maintained that way; otherwise, a posterior surgery may also be required.

The normal vertebrae above and below the injury may be fixed with a double-screw fixation in order to achieve a very rigid fixation. Then a corpectomy could be done. The cord has been completely decompressed, which is the most important part of the surgery. Once this is done, a graft or a cage could be used. Figure 9 shows a Harm’s type cage, which is cut to size and packed with lot of cancellous bone probably obtained from the ribs. This is now nicely tucked in under so that it goes in under good compression and finally the rods are fixed and the cage is compressed. This ensures very rigid fixation and allows immediate mobilization of the patient. Figure 10 shows the postoperative X-ray in this kind of a surgery.

Figure 11 shows a distraction with mild anterior slip. This is a three-column injury. Since there is a complete loss of the posterior ligamentous complex, the spine has to be realigned posteriorly. The number of levels of vertebrae above and below that had to be fixed in order to achieve immobilization are debatable. However, it is preferred to immobilize one vertebra distally and two above. If there is a very severe injury, a more extensive fixation is required. After this, the patient is operated anteriorly. A decompression of the disc and anterior reconstruction is done.

Figure 12 shows a case with injury to the soft-tissue, a large disc impingement and complete destruction of the posterior ligamentous complex. In this case, a small elegant fixation would suffice because the vertebrae are intact. A monosegmental fixation can be done anteriorly, then, a tiny little cage is inserted, which works well for the patient.

In case of a fracture and dislocation as shown in Figure 13, a monosegmental fixation can be done posteriorly. If the patient
is neurologically intact, the complete surgery can be done posteriorly.

In a more severe and extensive injury, a bigger fixation and realignment anteriorly are required (Figure 14). In case of a chance-type fracture, going all through the bone, the surgery is completely posterior with preservation of the facet joints.

The implants are removed 1 year later and the patient is allowed to be mobilized. No bone grafting of the posterior structures is required (Figure 15).

Figure 16 shows a burst fracture with three-column injury. In this case, the patient can be simultaneously operated both anteriorly and posteriorly.

Case Study 3: Burst Fracture

An inebriated patient jumped off the second floor and he had a two-level burst fracture (Figure 17). This patient was brought from Rajasthan over a 10-day period.

By the time he reached Chennai, he was in an emaciated condition with a big neurological deficit. Simultaneous surgery was done at both levels anteriorly and posteriorly, after which the patient had a reasonably good recovery.

Role of Rehabilitation in the Management of Spinal Injuries

Rehabilitation plays a major role in the management of patients with spinal injuries; good physio-occupational therapy offers many benefits to the patient. The patients may also be referred to specialized physiotherapy centers.

Conclusion

Spinal fractures are devastating injuries, the management of which requires utmost care. A sound knowledge of anatomy and mechanism of injury is a must. Surgery in the spinal injury is an important part of management, but obviously it is not the most important part. Apart from these, rehabilitation also has an important role in the management of spinal injuries.

References