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Review article

Spinal cord injury—The role of surgical treatment for neurological improvement

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ABSTRACT

Acute spinal cord injury (ASCI) is common and no consensuses have been reached regarding timing of surgical decompression. This article highlights the main issues regarding surgical management of ASCI patients. The importance of timing of surgery along with physiological stability of the cord, and indications for surgery has been discussed to facilitate better understanding of the condition. The importance of the type of injury to the spinal column, besides the cord injury, is also discussed. A brief review of relevant literature has been done to try and answer the question whether early or late surgical treatment for ASCI is better than conservative management, reflecting the ethos of treatment for these problems in Robert Jones And Agnes Hunt Orthopaedic Hospital in Oswestry.

1. Introduction

Acute Spinal Cord Injury (ASCI) is a common condition predominantly affecting younger population. It accounts for 16 per million population in Western Europe[1] and 750 per million worldwide, with an increasing incidence in recent years.[2] The functional impact to the patient and economical burden to the society following such an injury is well documented[3] and it is understandable that any therapeutic intervention aimed towards reducing the tissue damage and improve outcome is of paramount importance. However, controversies exist regarding the optimal timing of surgery.

The pathophysiology of ASCI consists of initial primary followed by secondary mechanism.[4–6] The primary insult is due to rapid direct compression and contusion of the cord, which initiates inflammatory response leading secondary insult. The role of neuro-protection and therapeutic intervention lies in the preventing and mitigating such secondary injuries.

The clinical presentation of ASCI following primary injury to the cord varies depending on extend and type of tracts involved. American Spinal Injury Association impairment scale (ASIA), a modification of Frankel classification facilitates initial classification of these injuries.[7] If all the tracts are damaged, with complete discontinuity, a complete cord injury results, commonly referred to as ASIA A or Frankel A injury, where there are no sensations or motor power distal to the level of the lesion and no bladder/bowel (S4 and 5) function. It is also described as " No Sacral Sparing injury".[8] Other injuries have an incomplete damage to the sensory/motor tracts, resulting in different patterns of clinical presentation, depending on how many tracts are affected. Frankel B injuries have some sensations distal to the lesion, but no motor power distally, implying continuity of some sensory tracts only. Type C has some motor fibers intact, but these are unlikely to give useful (more than MRC grade 3 power in major muscle groups) lower limb motor recovery. Type D injuries have useful motor function, implying that more than 50% of the motor tracts are intact across the injury site. Type E injuries have fully intact sensory and motor function distal to the lesion, implying that most fibers are intact at the level of injury.

There are different types of Cord injury patterns and it is further classified based on pattern of primary tracts injuries. The most common pattern is Central Cord syndrome,[9] where the central tracts are injured due to shearing and compressive demyelination in the center of the spinal cord. Other injury patterns are anterior cord syndrome where motor pyramidal and spino-thalamic tracts are affected or Brown-Sequard lesions where one half of the cord is affected. It is absolutely important to determine whether an injury is complete or incomplete as soon as possible after the injury, preferable before spinal shock has set in, as it has an important bearing on the prognosis. The presence of intact differentiation of dull and sharp ends of a neurotip in S4 and S5 dermatomes may be the only clue to the presence of an incomplete injury. Complete

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injuries are unlikely to have any recovery distal to the lesion, but incomplete injuries do have some recovery. If injuries are not documented thoroughly and an incomplete injury is documented as complete, then any recovery would be wrongly attributed to a particular type of treatment- surgical or non-surgical- resulting in false interpretations.

The spinal cord is injured when there is damage to the functional unit of spine – vertebral bodies, discs, anterior and posterior longitudinal ligaments, posterior bony elements and the posterior ligamentous complex. Different injury patterns for the spinal column have been described, ranging from wedge compression fractures, burst fractures, flexion distraction injuries to complete dislocations, depending on mechanism and which parts of the spinal column are injured. Some of the injuries to the cord occur without any major radiological damage to the spinal column, described as SCIWORA (Spinal Cord Injury without radiological abnormality). First described by Pang and group in children's,[10] however the same principles can be applied to section of adult population where the spinal canal is congenitally narrow, resulting in a reduction of the protective space around the spinal cord by the cerebrospinal fluid column. Similarly, others have a variety of degenerative spinal disorders that result in narrowing of the space available for the cord, like multiple level disc protrusions, calcified ligamentum flavum lesions and hypertrophy or Ossification of Posterior Longitudinal Ligaments (OPLL).

2. Why do we need to treat?

Spinal cord injury cannot be managed in isolation and surgical strategies should include detailed analysis of the functional unit. Stability of the functional unit has to be taken into account while drawing the management strategies in order to help patients with ASCI.

In Oswestry, the concept of 'Wizard of Oswestry triangle' is used to assess stability and management of a spinal column injury. The three main components of any spinal column injury evaluated are as follows:

1. Displacement- if it is left in that position, will it result in a functional disability; does it therefore need any reduction?
2. Stability- if left untreated, will it loose position from reduced or unreduced state; does it therefore need fixation?
3. Biology- will it heal? Is there any cord and/or root injury- and will that heal?

In most patients with Spinal Column injury without neurological deficit, as long as there is no dislocation, early mobilization can safely be done without surgical interventions.[11]

Primary insult has already occurred to the tracts in patients with ASCI. This happens due to compression/shear injury of these tracts, or damage by a fracture, or shear and rotational forces in a dislocation of the spinal column. This primary injury is irreversible, and is followed by natural cascade of inflammation that sets in following the injury. Compared to primary, secondary insult is reversible and is due to release of cytokines from various cells. These changes result in damage to tracts due to hypoxia, vasospasm, apoptosis and deposition of granulation tissues.

The mainstay of management of ASCI patients, therefore, is to mitigate and prevent secondary cord damage. The care given to patients with ASCI determines the extent of secondary damage. Both the anatomical stability and optimal physiological management has to be addressed to minimise the secondary injury. Medical issues like hypotension, infection, anemia or autonomic crisis are going to cause secondary damage to the cord and should be managed along with any surgical intervention needed. Likewise, an unstable segment if not stabilised at an anatomically acceptable position, will cause repeated insults and further more secondary damage. Surgical intervention per se can trigger secondary insult due to hypotension and cord handling. Cord handling can raise the intra-dural pressure and may overcome the low anterior spinal artery pressure, resulting in cord ischaemia. The primary goal for surgical management in ASCI is either to stabilise the spinal column or to decompress the cord to prevent secondary damage. This holds especially true if there is compressive lesion or a congenitally narrow canal, the hypothesis being that release of pressure on the spinal cord will help it recover better by minimising secondary insult.

3. Who do we need to treat surgically?

There are only a few absolute indications for surgery in ASCI patients.

1. Progressive neurological deficit in the presence of cord compression.
2. Dislocation type injury to the spinal column

Both of these situations warrant decompression +/– stabilization. All other indications of surgery are relative, and pros and cons have to be carefully considered.

4. When is surgery best performed?

Timing of the surgery may therefore be of paramount importance in management of cord injuries. It makes sense to try and ease the pressure or compression on the spinal cord as soon as possible, provided surgery doesn't harm the cord. However, excessive spinal cord handling and hypotension can damage the blood supply to the spinal cord, causing a secondary damage over and above the primary damage that happens at the time of trauma. The timing of surgery thus has to be correlated to the anatomical and physiological stability of the cord.

Traditionally these patients ware treated with conservative (non-operative) management with bed rest, believing that this will provide the best chance for the cord to recover. The rationale being the influence of gravity on the blood supply to record is eliminating by lying flat and at the same time, it takes a few weeks for the systemic and local inflammatory mechanisms to subside. Appropriate and meticulous medical management of these patients during these 4–6 weeks is critical. Majority of the spinal fractures (not dislocations) will heal during same time and rendering the injury stable. The autonomic control of the spinal cord is thereafter assessed by tilt table studies. Once the spinal cord has regained its autonomic control the patients are safely mobilised.

Surgical as well as anesthetic techniques have evolved and so have the understanding of pathophysiology of ASCI. More attention is given to maintaining the Mean Arterial Blood pressure above 85 mmHg during and after surgery in patients with ASCI, and is best kept elevated at that level for a week.[12] Surgery is usually performed in the first 24 h, or after 4–6 weeks in order to prevent secondary cord damage. There are a lot of studies in the literature recently that are looking into the matter of timing of surgery and its effect on recovery and complications. However, there is no conclusive level 1 clinical data that suggest an enhanced benefit of surgery over conservative treatment approaches.[13–15] There is level 2 evidence that suggests early surgical intervention (<24 h) is safe and effective, though no standardized guidelines or algorithms exist regarding the timing and optimal surgical intervention in acute SCI.[14,15]

5. Relative indications for decompressive surgery in ASCI patients- brief literature review

To understand the pathophysiology better, it is important to appreciate the difference between two broad categories of spinal cord injury. One group consists of central cord syndrome with minimal spinal column damage, which generally has a good outcome. The other group would be traumatic spinal cord injuries with damage to the stability of the spinal column.

Traumatic central cord syndrome is the most common type of ASCI, and frequently presents without major spinal column injury. The primary cause is mostly due to presence of a narrow space available for the cord ranging from congenital to degenerative causes.

In a multicenter prospective study of 34 ASIA B&C patients no difference was found in the outcome between surgical and conservative groups.16 However, others in a single center retrospective review of 126 patients, 67 treated with surgery and 59 without surgery, reported improved neurological recovery in patients managed with surgery as compared to those who didn't, but the timing of surgery (within 24 h, mean of 6 days or in second hospital admission) didn't make a difference to the outcome.17

In a systematic review, Anderson and group reported low level evidence supporting early surgery within 24 h, and that there is no difference in length of hospital or ICU stay between the early or delayed surgery group. They report moderate level evidence that surgery within 2weeks is better than surgery after two weeks, as far as neurological recovery is concerned.18

Lenehan and group based on their systematic review concluded that in ASIA C patients, it is reasonable and safe to consider early surgical decompression, but with those with ASIA D deficit can be initially treated with observation with surgery reserved for a later date depending on recovery.19

More recently, in a mete-analysis Liu and group compared between early (<24 h) and delayed (>24 h) surgery group. They especially looked at neurological improvement, length of stay in intensive unit, length in hospital stay, complications and mortality. 20 The review concluded significantly better neurological improvement rate, an early discharge from ICU/hospital and lower complication rate in early surgical group, whereas no difference was found in the mortality rates between these two groups.

5.1. Traumatic ASCI- complete or incomplete

As discussed previously, many recent studies have looked at the question of early versus late surgery in this group of patients. McKinley et al. and group based on a multicenter national spinal injury database concluded that early surgery was equivalent to late surgery in terms of improvement, and was associated with shorter length of stay and reduced complications.21

The STASCIS trial reported on 313 patients out of which 182 underwent early surgery, and 131 had late surgery. They report that early surgery is safe and has better outcomes than late surgery. However, a sub-analysis of the groups show differences in neurological improvement were mainly seen in ASIA B&C patients, not in ASIA A&D's.15

More recently, in a Canadian cohort study of 1410 patients with traumatic spinal cord injuries, Dvorak and group reported similarly that early surgery (within 24 h post injury) was better for motor improvement (mean improvement of 6.3 motor points on ASIA motor scale). However, similar improvement was not seen in patients with ASIA A complete injuries.22

5.2. Conservative versus surgical treatment

There is a paucity of studies regarding conservative versus surgical treatment in this group of patients. Therefore we have chosen to compare the results of the non-operative conservative management of these injuries with the results of the early surgery group from the STASCIS trial.

Katoh & El Masry et al. (1996) reported results of conservative treatment in 44 patients from Oswestry with incomplete cervical cord injuries. The outcome following early surgery has been well documented in the STASCIS trial.15

In a group of 63 consecutive incomplete ASCI patients treated conservative, Katoh et al. demonstrated 76% and 94% improvement in Frankel B's and C respectively.23 With early surgery in STASCIS trial (2012), a similar improvement of 74% and 91% was seen for ASIA B & C groups. However, only 35% improvement was seen for ASIA D's with early surgery, which is much lower than the 50% reported by Katoh group (1996).

6. Conclusion

While comparing conservative versus surgical management in traumatic ASCI's, there is not much difference in the neurological improvement of Grade B & C patients. With early surgery being safe, and having a shorter length of stay, and lower complications, it may be best to consider surgery within 24 h in some of these patients, provided it can be safely done. Otherwise conservative management in a spinal injury unit remains the safe option. Grade A & D's are better left with conservative management initially.

Early surgery within 24 h post injury is safe and better than late surgery. However, it may be best to avoid any secondary cord damage with surgery after 24 h. In the cases of central cord syndrome without spinal column instability, surgery within two weeks is better than after two weeks in Frankel B&C patients, but conservative management is better in Frankel A& D's.

We have to also understand that delay in surgery can be due to multiple factors. Studies have shown upper cervical injuries and patient with higher Charlson Comorbidity Index as the main factors in delay.24 This highlights the need of expedited and focused care for these groups of patients, as better results can be achieved. We strongly recommend that a much larger multicenter study is needed to evaluate and compare the true outcome between conservative and early operative management.

Conflicts of interest

None.

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