Management of Traumatic Spinal Cord Injuries:
current standard of care revisited

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Traumatic spinal cord injuries (TSCI) are life changing events. With expert, early, simultaneous Active Physiological Conservative Management (APCM) of the injured spinal cord and its effects, the impact on the patient and family members can be minimised in both the short and long term. Without surgical, pharmacological, or biological intervention over 70% of patients with complete motor paralysis but with sparing of pin prick sensation in the first 72 hours of injury recover motor power to ambulate. Those presenting within 72 hours of injury with motor sparing, however minimal, have an even better chance to walk, also without surgical, pharmacological or biological interventions. Patients who do not recover ambulation can, with APCM, ongoing expert monitoring, care and support, lead healthy, fulfilling, productive and competitive lives.

Active Physiological Conservative Management

Active simultaneous, non surgical management, from the early hours of injury, of

- the injured spine,
- the multisystem neurogenic effects of spinal cord injury on respiratory, cardiovascular, urinary, gastrointestinal, dermatological, sexual, reproductive functions,
- the associated psychological, effects,
- rehabilitation and
- environmental modifications

Unfortunately surgery has become the preferred method of management, also known as the "Standard of Care", of traumatic spinal injuries. Currently, about 80% of patients with TSCI are surgically decompressed and stabilised without the rigours of adequate research methodology or demonstration of superiority of neurological and/or other outcomes over APCM. This can be contrasted with practice in my orthopaedic institution (with four dedicated spinal surgeons) where less than 15% of patients are surgically managed and the majority of patients undergo APCM.

Currently, resources are relatively easily found for surgical implants and surgical procedures in both the developing and developed world. However, it is increasingly difficult to find resources for the management of the effects of the SCI and the rehabilitation of the patient in both the acute stage and in the long term. Consequently, the devastatingly wide range of medical effects and the psychological, social, emotional, financial, vocational, environmental and economic consequences are inadequately managed. Such inadequacy of management has implications for quality of outcomes, quality of life of patients and family members as well as implications for the cost to treat complications, the methods of prevention of which have been known for over six decades.

Effects and special characteristics of spinal cord injuries

A SCI causes widespread physiological impairments, medical and non medical problems. The functioning of the various systems of the body depends on reflex activity of the spinal cord segments distal to the lesion as well as on the intrinsic properties of the systems themselves. Changes in levels of reflex activity of the spinal cord occurs throughout the patient's life with unpredictable changes in the functioning of systems of the body. Continuing change of function invariably occurs during the transition between spinal shock and full return of reflex activity, hence the need for close monitoring and constant recalibration of management of the various systems of the body throughout the first few months following injury.

The sensory loss below the injury presents diagnostic challenges to the clinician. Conventional symptoms and signs of pathology are absent. This can result in a delay of diagnosis, usually with unpleasant consequences.

Each system malfunction is a source of one or more disabilities and a potential source of a wide range of complications of varying severity. Impairment of bladder function for example, can result in urinary incontinence, embarrassment and loss of confidence, bladder infections, pyelonephritis, calculi, hydronephrosis and renal failure.

In the acute stage complications such as hypoxia, hypotension and sepsis can cause further neurological deterioration or lack of recovery.

When a complication develops, the absence of higher co-ordinating and moderating functions of the brain over the spinal cord segments below the injury usually result in multiple and/or cascading intersystem effects that are rarely seen in other conditions. These are seldom easy to diagnose and manage. For example, an anal fissure, while painless in a tetraplegic or high paraplegic patient, can nevertheless cause autonomic dysreflexia and/or excess spasticity which in turn may cause a fall and fracture of a long bone. Alternatively or concomitantly if excess spasticity involves the pelvic floor muscles it can result in urinary infection, urinary retention, autonomic dysreflexia and possibly a cerebral haemorrhage. Almost all complications following SCI are preventable or can be minimised. Many are iatrogenic due to unfamiliarity with the pathophysiology of the spinal man/woman. The non-medical effects of spinal cord injury are equally devastating to patients and family members.

Fortunately, the incidence of spinal cord injuries is the lowest of all major trauma. The incidence in the UK ranges between 10-15 per million head of population per year. A district general hospital serving a population of 250,000 is likely to receive fewer than four newly injured patients per year. Unfortunately this small incidence limits the expertise required by a wide range of disciplines outside spinal injury centres.

Aims of the management of the spinal injury

The ultimate goals of management are to ensure maximum neurological recovery and independence, a pain free flexible spine, safe functioning of the various systems of the body with minimal or no inconvenience to patients and prevention or minimisation of complications. It is equally important to enable patients to regain assertiveness, take control of their own lives, re-engage in activities of their choice and whenever possible compete in some spheres of life. The importance of education of patients and ongoing support to maintain health and independence following discharge cannot be overemphasised.

Factors influencing management of the SCI

The majority of those who manage SCI patients in the acute phase have concerns about the biomechanical instability (BI) at the fracture site, further displacement and damage to neural tissues. Many strongly believe that canal encroachment and cord compression can prevent neurological recovery or indeed cause neurological deterioration. The injured cord with cellular and cell membrane disturbances, loss of auto regulatory functions and disruption of blood brain barrier is physiologically unstable.[1] It cannot protect itself from complications outside the spinal canal such as hypoxia, hypotension, hypertension, sepsis and hypothermia. These complications can potentially be as damaging to neural tissues through the physiological instability (PI) of the injured cord as the potential mechanical damage from the BI of the injured column.

Prognostic indicators of recovery

The neurological findings at 48-72 hours from injury are essential in predicting neurological recovery. Over 80% of tetraparetic patients who present in the first 72 hours from injury with any distal movement, however little and patchy (Frankel C, see Table to right), and over 70% of patients who present 48-72 hours from injury with no motor power but with preservation of pin prick sensation down to S3 (Frankel B) will recover to walk again[2,3,4] if they have not been harmed by the treatment. Patients with complete cord injury (Frankel A) and pin prick sensation in the zone of partial preservation will recover significantly and have useful motor power in these myotomes.[5] A neurological level higher than the bony level of fracture is another good prognostic indicator of zonal recovery.[5]

Traumatic biomechanical instability of the spinal column

The degree of BI is usually based on radiological investigations at the time of the presentation of the patient. It is perhaps worthwhile noting that most vertebral fractures heal within 6-12 weeks from injury when biomechanical stability (BS) is restored. Ligamentous injuries, however, can take much longer to heal. BI is therefore time related. During active physiological conservative management (APCM) containment of the BI is safely maintained in recumbency for 4-6 weeks followed by bracing during mobilisation for a further six weeks. The great majority of injuries become biomechanically stable and pain free. There is no evidence to suggest that surgical stabilisation enhances the speed of healing or achieves stability earlier than with APCM.

Admittedly the incidence of kyphotic deformities is lower following surgical stabilisation than following APCM, however the greatest majority of these kyphotic deformities are painless. The discrepancy between deformity and pain has been known for some time.[6] A painless kyphotic deformity enhances wheelchair bound patients' independence and is certainly, much preferable to a stiff straight neck or back following surgery.

Traumatic spinal canal encroachment

Some of the first case reports to suggest that traumatic canal encroachment as demonstrated by computerised tomography does not correlate with the degree of neurological impairment, does not prevent neurological recovery and does not result in neurological deterioration were published by El Masri et al in 1992.[7,8] The same conclusions were made by reviewing the outcome of conservative treatment of 50 consecutive patients with between 10% to 90% canal encroachment in Frankel C, D and E groups; patients in Frankel C&D group recovered ambulation and none of the patients deteriorated neurologically or otherwise.[9] Other groups have since published similar findings.[10,11,12] There is no evidence to suggest that surgical decompression achieves better or earlier neurological recovery than APCM in humans with incomplete cord or cauda equina injury. There is no evidence to suggest that surgical decompression is beneficial to humans with complete traumatic cord or cauda equina injury.

Traumatic spinal cord compression

In humans cord compression does not appear to prevent neurological recovery in patients with traumatic incomplete cord injuries.[13,6,14] Since the installation of the MRI scanner in our institution we have been monitoring (both prospectively and retrospectively) the neurological progress of conservatively managed patients with cord compression. The preliminary results indicate that the same clinical prognostic indicators of recovery apply whether there is cord compression or not.

Some advocate, however, early surgical decompression within four hours of injury. This is based on experimental findings in rodents, cats and dogs with 20-60 million years of evolution behind humans. Translation from the laboratory animal to the clinical situation requires caution.[23] Surgical decompression does not seem to be beneficial in either the laboratory animal or humans when the severity of the initial impact force is beyond a certain magnitude, as recovery will not occur.[15,16,17]

Natural history of complete and incomplete cord injuries

Fewer than 10% of patients initially with clinically complete spinal cord injuries (Frankel grade A, "FA") improve to make a significant recovery to ambulate.[18] Many more however, recover cord functions in one to four myotomal distributions below the level of the injury or improve to FB & FC.

Although increasingly since the 1980s anterior surgical decompression and arthrodesis have become established practice based on suggestions that surgery resulted in motor zonal improvement; to date there is no evidence that surgery provides added value. A series of 53 consecutive patients with complete traumatic tetraplegia, admitted to one centre within two days of injury, demonstrated that similar results can be achieved without surgical decompression or arthrodesis.[5]

Patients with incomplete cord injuries make significant neurological recovery irrespective of the degree of canal stenosis, canal encroachment, malalignment or cord compression[3,6,9,14] provided both the BI of the spinal

1. 'Complete' (A).
This means that the lesion was found to be complete, both motor and sensory, below the segmental level marked. If there was an alteration of level but the lesion remained complete below the new level, then the arrow would point up or down the 'complete' column.

2. 'Sensory only' (B)
This implies that there was some sensation present below the level of lesion but that the motor paralysis was complete below that level. This column does not apply when there is a slight discrepancy between the motor and sensory level but does apply to sacral sparing.

3. 'Motor Useless' (C)
This implies that there was some motor power present below the lesion but it was of no practical use to the patient.

4. 'Motor Useful' (D)
This implies that there was useful motor power below the level of the lesion. Patients in this group could move the lower limbs and many could walk, with or without aids.

5. 'Recovery' (E)
This implies that the patient was free of neurological symptoms, i.e no weakness, no sensory loss, no sphincter disturbance. Abnormal reflexes may have been present.

column and the PI of the spinal cord are well maintained. See case report and Figures 1-11 on the following page.

Although almost every patient is given a choice between conservative and surgical management the majority (85%) of patients with SCI in our institution are treated with APCM irrespective of malalignment, the degree of canal encroachment and the degree of cord compression.

Early mobilisation

Early mobilisation is advantageous to neurologically intact patients with stable fractures or following surgical stabilisation in unstable fractures. These patients can be discharged ambulating soon after surgery.

Patients with paralysis, general physiological impairment and multisystem malfunction do not benefit from early mobilisation, which indeed may be counter productive. Early mobilisation of patients is associated with a reduction of vital capacity[19] and a potential drop of oxygen saturation and / or postural hypotension. Individually or in combination these may further impair cord functions. Early mobilisation does not result in early completion of rehabilitation nor earlier discharge of patients with SCI.[1,6,7]

Indications for surgery at the Robert Jones and Agnes Hunt Orthopaedic Hospital

Until credible evidence demonstrates superiority of outcome with one method of treatment of the injured spine over the other, patients should be encouraged to make an informed choice between the various methods of management, assuming that the patient will receive treatment in an institution that can provide equally good APCM and surgical management. Certain groups of patients are likely to benefit from surgery and should be encouraged to consider the option. Neurologically intact patients with physiologically stable cord but unstable injured spine are less at risk from physiological deterioration than the neurologically impaired, do not require intensive prolonged treatment and rehabilitation, and can be discharged a few days following surgery. The uncontrolled epileptic, the mentally challenged and patients who are unable to comply with bed rest are safer following surgical stabilisation than with conservative management. Patients with biomechanical instability from pure ligamentous injuries without bony injury are at risk of developing late painful deformities and indeed may benefit from early surgery. Patients who exhibit signs of neurological deterioration with evidence of further neurological compression of neural tissues on MRI may benefit from surgical decompression.

Systems of management

The simultaneous management of the spinal injury and all its effects by a group of coherently managed multidisciplinary professional experts familiar with the patho-physiology of the SCI patient and proficient at treating all aspects of paralysis under one roof remains the safest, most efficient and most cost effective system of provision of service to these patients.[6] Irrespective of the method of treatment of the spine, patients with spinal injuries have less complications when treated comprehensively in SCI centres than when their management is fragmented.[6,7,20,21] The attention of health economists to this small group of patients which is perceived as expensive to treat is long overdue. It is essential to determine the monetary and human costs of management and compare these between the integrated system of management in specialised centres and the fragmented system of management that is increasingly prevailing.

Conclusions

The favourable neurological outcome of TSCI with APCM has been known for over four decades.[18]

A significant majority of patients who present with sensory sparing with or without motor sparing within the first 72 hours of injury will recover good motor power to ambulate irrespective of the degree of canal stenosis, encroachment, malalignment or cord compression and without surgical, pharmacological, biological or other intervention. Surgery to the injured human spine usually in isolation from the multitude of needs of the patient has become the Current Standard of Care without credible evidence of proof of superiority of outcomes (neurological or otherwise). Although the possibility of benefit from very early surgery in rodents, cats and dogs cannot be ruled out, the outcomes of early surgery in both the laboratory animal and in humans are still debatable.[22] Furthermore, translation from the laboratory to the clinical situation requires caution.[23]

I believe that it is appropriate to revisit both the science scientific and clinical evidence that led to the change of management of TSCI from APCM to surgical management, given the lack of credible evidence that surgery provides better outcomes and/or is not without risks and considering that the good outcomes of APCM are well established and predictable.

It is equally necessary to stop the fragmentation of treatment and to manage patients in adequately resourced specialised centres, capable of offering informed choice to patients, equally good surgical management when indicated by the patient or required, together with APCM of the spinal cord injury and all its effects in an integrated and effective manner. These centres should also be capable of conducting multicentre quality research, to address the real needs of patients with spinal cord injury as well as the various controversies in their management. ◆

REFERENCES

1. El Masry WS. *Editorial - physiological instability of the injured spinal cord.* Paraplegia 1993;31:273-5.
2. Folman Y, El Masri WS. *Spinal cord injury: prognostic indicators.* Injury 1989;20:92-3.
3. Katoh S, El Masry WS, Jaffray D, McCall IW, Eisenstein SM, Pringle RG, Pullicino V, Ikata T. *Neurologic outcome in conservatively treated patients with incomplete closed traumatic cervical spinal cord injuries.* Spine 1996;21:2346-51.
4. Katoh S, El Masry WS. *Motor recovery of patients presenting with motor paralysis and sensory sparing following cervical spinal cord injuries.* Paraplegia 1995;33:506-9.
5. Katoh S, El Masri(y) WS. *Neurological recovery after conservative treatment of cervical cord injuries.* J Bone Joint Surg Br 1994;76B:225-8.
6. El Masry WS. *Traumatic spinal cord injury: the relationship between pathology and clinical implications.* Trauma 2006;8:29-46.
7. El Masri W S, Jaffray, D. *Recent developments in the management of injuries of the cervical spine.* In: Vinken PJ, Bruyn GW, Klawans HL, Frankel HL, editor. *Spinal cord trauma.* Elsevier Science; 1992. *Handbook of Clinical Neurology*; rev. series; 17: vol. 61:Chapter 3.
8. El Masri WS, Meerkotter DV. *Early decompression of the spinal cord following injury: arguments for and against.* In: Illis LS, editor. *Spinal cord dysfunction Vol II: intervention and treatment.* Oxford University Press;1992:7-27.
9. El Masri (y) WS, Katoh S, Khan A. *Reflections on the neurological significance of bony canal encroachment following traumatic injury of the spine in patients with Frankel C, D and E presentation.* J Neurotrauma 1995;10(suppl):70.
10. Limb D, Shaw DL, Dixon RA. *Neurological injury in thoracolumbar burst fractures.* J Bone Joint Surg Br 1995;77B:774-7.
11. Rosenberg N, Lenger R, Weisz I, Stein H. *Neurological deficit in a consecutive series of vertebral fractures patients with bony fragments within the spinal canal.* Spinal Cord 1996;35:92-5.
12. Boerger TO, Limb D, Dickson RA. *Does canal clearance affect neurological outcome after thoracolumbar burst fractures.* J Bone Joint Surg Br 2000;82B:629-35.
13. El Masry WS, Osman AE. *Clinical perspectives on spinal injuries.* In: Cassar-Pullicino V, Imhof H. *Spinal trauma: an imaging approach.* New York, Thieme Medical; 2006. Chapter 1, p. 1-14.
14. Ibrahim A, Li Y, Li D, Raisman G, El Masry WS. *Olfactory ensheathing cells: ripples of an oncoming tide?* Lancet Neurol 2006;5:453-7.
15. Dolan EJ, Tator CH, Endrenyi L. *The value of decompression for acute experimental spinal cord compression injury.* J Neurosurg 1980;53:749-55.
16. Guha A, Tator C H, Endremni, L, Piper I. *Decompression of the spinal cord improves recovery after acute experimental spinal cord compression injury.* Paraplegia 1987;25:324-39.
17. Tator CH, Duncan EG, Edmonds VE, Lapczac LI, Andrews DF. *Comparison of surgical and conservative management of 208 patients with acute spinal cord injury.* Can J Neurol Sci 1987;14(1):60-9.
18. Frankel HL, Hancock DO, Hyslop G, Melzack J, Michaelis LS, Ungar GH, Vernon JD, Walsh JJ. *The value of postural reduction in initial management of closed injuries of the spine with paraplegia and tetraplegia.* Paraplegia 1969-70;7:179-92.
19. Morgan MDL, Silver JR, Williams SJ. *The respiratory system of the spinal cord patient.* In: Bloch RF, Basbaum M Eds, *Management of spinal cord injury.* Baltimore: Williams and Wilkins;1986:78-117.
20. Carvell JE, Grundy DJ. *Complications of spinal surgery in acute spinal cord injury.* Paraplegia 1994;2:389-95.
21. Aung TS, El Masry WS. *Audit of a British centre for spinal injury.* Spinal Cord 1997;35:147-50.
22. Fehlings MG, Perrin RG. *The role and timing of early decompression for cervical spinal cord injury: update with a review of recent clinical evidence.* Injury 2005;36: S-B13–26.
23. Courtine G, Bunge MB, Fawcett JW, Grossman RG, Kaas JH, Lemon R, Maier I, Martin J, Nudo RJ, Ramon-Cueto A, Rouiller EM, Schnell L, Wannier T, Schwab ME, Edgerton VR. *Can experiments in nonhuman primates expedite the translation of treatments for spinal cord injury in humans?* Nature Medicine 2007;13:561-6.

CASE REPORT

This 44-year-old lady sustained a fall in 1992 resulting in Frankel C tetraparesis from a C6/7 unilateral facet dislocation. She presented with weakness in both hands, profound paresis in both lower limbs and paralysis in the right ankle and foot. She was admitted the day of injury. Her motor score was 66/100 according to the ASIA scale. The dislocation was not reduced and the alignment was not restored. She was treated with six weeks of bed rest and APCM followed by six weeks in a Minerva cast. On discharge home (eight weeks following the accident) she had regained most of the motor power and was walking with two crutches for balance. She discarded the crutches four weeks later having recovered full motor power and good sphincter functions. She continues to enjoy a pain free full range of movement, unsupported ambulation and is able to run 17 years following the accident with unrelieved cord compression.

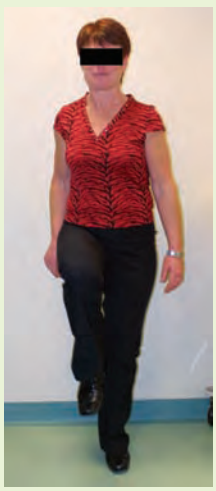
Figure 1 (left): Lateral Xray revealing Unilateral Dislocation C6/C7.

Figure 2 (middle): Oblique Xrays confirming the unilateral dislocation.

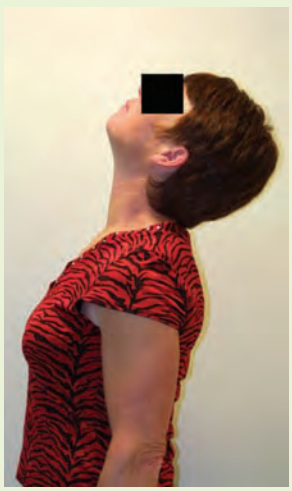
Figure 3 (right): Lateral CT confirming the malalignment and the canal encroachment.

Figure 4: Lateral MRI 3 years later confirms ongoing thecal and cord compression.

Figures 5 & 6: Lateral Flexion and Extension Xrays confirming restored stability in the dislocated position.



Figures 7 & 8: Demonstrating ability to stand unsupported on one leg at a time.



Figures 9, 10 & 11: Demonstrating unrestricted painless range of movement of the cervical spine.