

# Gunshot injuries of the spine – a review of 49 cases managed at the Groote Schuur Acute Spinal Cord Injury Unit

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## Summary

The Acute Spinal Injury Unit, relocated from Conradie Hospital to Groote Schuur Hospital in mid-2003, admitted 162 patients in the first year of its existence. A large number of these injuries were the result of interpersonal violence, particularly gunshot wounds.

*Aim.* To review patients with gunshot injuries to the spine, with reference to neurological injury, associated injuries, need for surgery and complications.

*Methods.* A comprehensive database is maintained to collect data on all spinal injury admissions. These data, as well as case notes and X-rays, were reviewed for all gunshot spine patients admitted to the Acute Spinal Injury Unit over a year.

Forty-nine patients were identified. Thirty-eight were male and 11 female with an average age of 27.5 years (range 15 - 51 ± 8.53). The average stay in the acute unit was 30 (4 - 109 ± 28) days.

*Results.* The spinal injury was complete in 38 and incomplete in 8, with 3 having no neurological deficit. The level was cervical in 13, thoracic in 24 and lumbar in 12. Only 9 patients improved neurologically. The spine was considered stable in 43 cases. Stabilisation was performed in the 6 unstable cases. The bullets were removed in 11 cases as they were in the canal.

There were 55 significant associated injuries, viz. 14 haemo-pneumothoraces, 16 abdominal visceral injuries, 3 vascular injuries, 4 injuries of the brachial plexus and 3 of the oesophagus, 2 tracheal injuries, 1 soft palate injury and 11 non-spinal fractures.

Complications included 3 deaths and discitis in 3 cases, pneumonia in 6 and pressure sores in 6.

*Conclusion.* Gunshot injuries of the spine are a prevalent and resource-intensive cause of paralysis. There is a high incidence of permanent severe neurological deficit, but usually the spine remains mechanically stable. Most of the management revolves around the associated injuries and consequences of the neurological deficit.

dence of gunshot injuries. The Groote Schuur Trauma Unit sees between 70 and 120 gunshot injuries a month. Many of these involve the musculoskeletal system, and some the spine. This is in stark contrast to the European experience. Of 34 903 trauma cases seen in Scotland over 28 years there was only 1 case of gunshot injury of the spine.<sup>1</sup>

The Acute Spinal Cord Injury Unit (ASCI), previously based at Conradie Hospital, was relocated to Groote Schuur Hospital in 2003 as part of the government's 2010 plan. This unit manages spinal cord injuries from the region on a referral basis. During the first year of opening, 162 patients were admitted with various spinal injuries. A large proportion of these were gunshot injuries of the spine.

A review of this subset of patients is presented.

## Method

All admissions to the ASCI unit are entered in a database. Included in the data recorded is the mode of injury and the neurological status. The latter is classified according to the American Spinal Injury Association (ASIA) scoring system, with motor function attributable to C5 - T1 and L2 - S1 roots allocated a score between 1 and 5 based on the Medical Research Council (MRC) power. This is done bilaterally. In addition sensation is scored in a similar fashion on a provided form. The subsequent management, complications and discharge neurological status are also recorded.

Patients with gunshot injuries of the spine were identified from this database. Their case notes and X-rays were reviewed retrospectively, with a view to procedures performed, complications and neurological change. The patients referred to the local rehabilitation service were reviewed for further change in neurological status.

A total of 49 patients with gunshot injuries of the spine were identified. Of these, 47 were from the ASCI service and 2 from the adjacent private facility (University of Cape Town Private Academic Hospital).

All the injuries were from low-velocity weapons, as is typical for our population. The most frequent calibre was 9 mm.

Of the 49 patients, 38 were male and 11 female. The average age was 27.5 (15 - 51 ± 8.53) years. The average in-hospital stay was 30 (4 - 109 ± 28) days. Once the acute

With the high level of crime in the Western Cape, the state hospitals have witnessed a tremendous increase in the inci-

management was completed patients were discharged or referred to the rehabilitation service depending on their neurological status. The rehabilitation service required patients to be free of pressure sores before admittance. This led to some of the prolonged hospital stays.

## Results

### Neurological status

The anatomical level and neurological status of the spinal injuries are tabulated in Table I. The vast majority were complete neurological injuries, with no incompletes in the thoracic group. Only 9 patients improved neurologically. Three cervical completes regained 5 - 7 ASIA motor points. This represents a single level of improvement, and probably indicates root escape rather than true cord recovery. One complete patient regained 10 motor points and good sensory recovery.

Of the 4 cervical incomplete injuries, 1 patient with no bony fracture recovered spontaneously. This was thought to be because of cord contusion as the bullet did not violate the canal or column. Another patient improved from a total of 85 motor points to 98 at 3 months. This patient had a body fracture. None of those who recovered had violation of their canals.

There was no recovery in the thoracic group.

Three patients improved in the lumbar injury group. One patient improved from 70 to 88 motor points, then plateaued. This patient is now ambulatory with crutches. Another had a 5-point improvement. Both of these were incomplete injuries. Another patient judged on admission to have a complete lumbar injury had return of distal motor function after removal of the bullet.

### Stability

The injury involved the posterior elements in 25 cases, the body in 15 cases, and both in 2. There were no fractures in 7 cases.

Our assessment of stability was based on the three-column system of Denis,<sup>2</sup> as described for thoracolumbar fractures from indirect forces. This was modified by the realisation that gunshot injuries are different to indirect forces, as they are not associated with posterior column ligamentous injuries. Six patients were assessed as unstable. This was usually based on severe comminution of the anterior column (Fig. 1), where it was felt that progressive kyphosis would occur. Three patients had cervical and 3 had thoracolumbar injuries. The cervical injuries were fused anteriorly by means of an autogenous bone graft and plate, whereas the thoracolumbar injury patients underwent posterior pedicle fixation.

**TABLE I. NEUROLOGICAL STATUS PER ANATOMICAL LEVEL.**

	Cervical	Thoracic	Lumbar	Total
Normal	1	1	1	3
Incomplete	4 (2)*	0	5 (2)*	8
Complete	8 (4)*	23 (0)*	6 (1)*	38
Total improved	6	0	3	9

\*Parentheses indicate number of patients with neurological improvement.



**Fig. 1. CT scan of comminuted body regarded as unstable.**

### Bullets in the canal

The bullet was found to be in the canal in 12 cases – 1 cervical, 4 thoracic and 7 lumbar. One patient absconded for fear of retribution. The rest underwent surgery to remove the bullet.

### Associated injuries

There were many associated injuries, as listed in Table II. Of the 4 brachial plexus injuries, 3 were related to the current injury and 1 to a previous gunshot wound. The latter patient's current injury was thoracic, and the brachial plexus injury was only explained when the X-ray revealed a previous bullet near the plexus. There was a high incidence of associated chest trauma, with 14 cases having haemothoraces, pneumothoraces or lung contusions. These required intercostal drains to be inserted. There were 2 vertebral arterial injuries, one arteriovenous fistula requiring repair and an axillary artery also requiring repair. Laparotomies were performed in 9 patients for visceral injuries (Table III).

**TABLE II. ASSOCIATED INJURIES (M)**

Tracheal	2
Oesophageal	3
Soft palate (Fig. 2)	1
Brachial plexus	4
Pneumo-/haemothorax	14
Non-spinal fractures	11
Vertebral artery	2
Axillary artery	1
Liver, spleen, pancreas	6
Bowel	6
Kidney	4
Diaphragm	1

**TABLE III. ABDOMINAL SURGERY (M)**

Splenectomy	2
Bowel repair	4
Loop colostomy	1
Hemicolectomy	1
Renal stent	1
Nephrectomy	3



**Fig. 2. Gunshot C1 (transoral) with C1 arch fracture, no neurology. The bullet was spontaneously spewed out and the patient discharged.**

### Complications

Six patients developed pneumonia, and 6 developed pressure sores. Only one deep-vein thrombosis was diagnosed. Three patients developed a pyogenic discitis (Fig. 3). Three deaths occurred and 1 patient developed postoperative sepsis.

### Discussion

Gunshot injuries of the spine are endemic in the Western Cape. Management protocols have evolved as the incidence has changed. Civilian low-velocity gunshot injuries are vastly different from the military experience which provided much of the earlier experience. As one would expect, survival is far likelier in the low-velocity group. Many facets of management have been adopted from management of spinal injuries resulting from indirect trauma. Not all of these are appropriate.

High-dose steroid administration for indirect, non-penetrating trauma has been promoted by Bracken and Shephard<sup>3</sup> in the first 8 hours following indirect spinal cord injury. Despite this being of doubtful clinical benefit in this non-penetrating trauma group, some still administer steroids to patients with gunshot wound injuries of the spine. Heary *et al.*<sup>4</sup> and Levy *et al.*<sup>5</sup> have shown that there is no benefit in terms of neurological recovery in penetrating injuries. If one considers the risks of infection and immune compromise, it is illogical to administer steroids if there is no evidence of neurological benefit. We therefore regard administration of steroids in the gunshot spine scenario as inappropriate.

The issue of spinal stability in mechanical terms is a difficult one, as there is no good classification for gunshot injuries, making interpretation somewhat subjective. Much of our knowledge and experience are based on indirect injuries. Many base this on the 3-column system of Denis,<sup>2</sup>



**Fig. 3. Magnetic resonance image of subsequent discitis following a gunshot injury of the spine.**

where if 2 columns are involved the spine is considered to be unstable. In an indirect non-penetrating force, one can extrapolate that if there is severe anterior column destruction, there is likely to be posterior ligamentous injury. One then has a clear indication for mechanical stabilisation. In gunshot injuries of the spine it is possible for a single column to be injured without associated ligamentous injury. Once there is an isolated body fracture it is often difficult to decide whether there will be progressive deformity or not. Our practice is conservative in this regard.

In the thoracic spine, where there is support from the thoracic cage, body fractures are generally regarded as stable. In the cervical spine, comminuted body fractures are regarded as being potentially unstable. Cervical kyphosis is extremely functionally limiting in cases of quadri- or paraplegia, and we therefore proceed to anterior instrumented fusion in these cases. Our conservative stance is echoed by others. Cornwell *et al.*<sup>6</sup> reported on 141 thoracic spine gunshot fractures. Only 2 required surgical stabilisation. Isiklar and Lindsey<sup>7</sup> found that 10% were unstable in their series. Three cases were cervical and 1 was lumbar.

Removal of bullets remains controversial. Concerns regarding lead toxicity (plumbism) have been reported.<sup>8,9</sup> The incidence is rare and should probably not be used as a reason to remove all bullets. Bullets in disc spaces and joints are more likely to release heavy metals. Scuderi *et al.*<sup>10</sup> found only 12 cases of bullets in disc spaces over a 24-year period among 238 gunshot injuries of the spine. Only 1 of these 12 developed clinical signs of lead toxicity. They recommend that rather than imperative bullet removal, signs of lead toxicity should be looked out for.

Bullets in the canal are more of a concern. Basic science research has shown that of the heavy metals likely to be in bullets, copper is the most toxic to the cord in the animal model.<sup>11</sup> Bono and Heary<sup>12</sup> reviewed the topic well and commented that firstly one should 'do no harm'. Removal of the bullet did appear to alter the rate and incidence of neurological recovery, but there was an increased incidence of infection in the operative group.



Waters and Adkins<sup>13</sup> reported that bullet removal did not alter infection rates or sensory recovery. However, in the cauda equina region they found that removal may increase the neurological recovery. This was also observed in our cohort. Of course one cannot be sure this was not simply a matter of passage of time rather than the actual intervention.

The current policy of our unit is to remove the round after a few days, to allow the dura to seal and inflammation to resolve. When retrieving bullets from the canal it is important to have recent X-rays available and imaging in theatre. The bullet may move. In our series there was a case of entry at L3, but the bullet was removed from S1 posteriorly. There are case reports that confirm this 'wandering' of the bullet.<sup>14,15</sup> This tends to be in a caudal direction because of widening of the canal from T10 downwards.

Decompression has frequently been performed in an attempt to improve neurological outcome. The results of intervention must be seen against natural history, where spontaneous improvement may occur. This may be an additional root level, as seen in our study, or more significant recovery in incomplete injuries where a degree of spinal cord contusion may have occurred. In our study no patient with cervical or thoracic canal violation showed recovery. In those who recovered, it would appear that the recovery was because of resolving cord contusion. These cases were body fractures and probably cord injuries owing to the local energy dissipation.

Various authors have reported on decompression in this scenario. Kahraman *et al.*<sup>16</sup> reported on 106 patients, where 60% were operated on. There was similar recovery in both the surgically managed group and the conservatively managed group. The study by Benzel *et al.*<sup>17</sup> showed root improvement in complete injuries as opposed to conservatively managed cases. The incomplete cord injury and cauda equina injury groups showed improvement irrespective of decompression. This has been echoed by other authors.<sup>18,19</sup> Stauffer *et al.*<sup>20</sup> reported 19% iatrogenic instability in their laminectomy group, which highlights a risk associated with posterior decompression. Our policy is not to decompress unless there is neurological deterioration subsequent to injury, with compression demonstrated on imaging.

The associated injuries are a major factor in the management of these patients. Transvisceral injuries are a particular concern because of possible infection of the spine. This seems to be a less frequent problem than expected. Kumar *et al.*<sup>21</sup> reported on 31 cases (13 transcolonic injuries) treated with antibiotics for 2 - 43 days. None of their cases developed a vertebral osteitis, and they recommend conservative treatment of the spine. Kihitir *et al.*<sup>22</sup> reviewed 21 transperitoneal gunshot injuries, including 5 transcolonic injuries. There were no vertebral infections. Roffi *et al.*<sup>23</sup> followed up 42 patients with 51 visceral perforations. These included 14 colonic and 15 small-bowel injuries. They used antibiotic cover and reported 3 spinal infections. They concluded that early bullet removal did not seem to be helpful.

## Conclusion

Gunshot injuries of the spine are devastating to the individual in terms of the severe neurological consequences.

Generally the spine is mechanically stable and the neurological status static. Management revolves largely around the associated injuries and supportive care of the paraplegia.

Steroid administration is not indicated in these injuries. Although bullets should not be removed routinely, there is a case for removal if they are in the canal, especially if the cauda equina is involved.

Because of the high incidence of associated injuries and permanent neurological deficit, gunshot injuries of the spine place a huge burden on our society.

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