

The military medical management of missile injury to the spine: A review of the literature and proposal of guidelines

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ABSTRACT

The management of missile injury to the spinal cord is controversial. The literature is reviewed and recommendations made about the management of these injuries. To surgeons in a country that is relatively safe such injuries are rare, this review provides useful information about this condition.

Introduction

Wartime experience of the management of missile injuries to the spine has shaped how they are now dealt with (1-9). This paper will review the findings from wartime and civilian experience with this devastating injury and present a plan for the management of such casualties. The need for such a review is the lack of experience that we in the UK have in dealing with gunshot wounds (GSW) to the spine when compared to other more violent cultures. It is this lack of baseline experience that may cause us as surgeons to act inappropriately in ignorance of what has been established by other's often bitter experience.

Historical perspective

Lord Nelson appears to be the first major figure to have been killed by a GSW causing spinal cord injury (SCI) (10,11) and it has been suggested that President JF Kennedy of the United States had such an injury from the first bullet (11).

Twentieth Century warfare experience has separated the management into a number of epochs. In World War I (WWI) the rationale was to perform delayed surgery, only on those with incomplete injuries whose neurological status was deteriorating (11). In World War II (WWII) the perception changed to operation on all patients to decompress and debride in order to improve neurological status and minimise the risk of infection (1, 2, 12); the emphasis turning to care of the urinary tract and prevention of decubitus ulcers in survivors (2). By the Korean War the emphasis had barely changed with decompression and debridement for all after definitive management of their other injuries, care to avoid decubitus ulcers and early mobilisation in braces starting as early as day 10, if

possible (3). The experience of the Vietnam War (4) was that with rapid evacuation to aggressive resuscitation and definitive surgical care morbidity and mortality improved but not neurological function, with or without surgery. The outcome continued to reflect the neurological status at presentation.

In the Iran-Iraq War it was felt that surgical exploration did not improve outcome (8); indeed surgery increased complication rates. Recent Balkan experience, where evacuation times to definitive surgical facilities were similar to those in the Vietnam War, showed no startling improvements, despite the availability of modern imaging techniques (13). They found that conservative management yielded good results, limiting surgery to those with cerebrospinal fluid (CSF) leaks, root pain, progressive neurological deficit and spinal instability, again confirming that presentation neurological status determines the outcome (6, 7, 9). Lebanon experience found that the most important factors for determining outcome were an early assessment of neurological status and a thorough rehabilitation programme (5).

Epidemiology

In the civilian setting in the United States (USA) GSW SCI is the second (14, 15) or the third (16-20) most common cause of SCI. This constitutes between 12-15% of all SCI (10, 16) although one source suggested 25% of all SCI were due to GSW (14). By comparison during a similar period 28% of SCI were due to road traffic accidents and 16% due to falls (6). More than 90% are males (15, 21), average age reported as 29.7 years (22) and, probably not surprisingly in the urban USA setting, 37% are under the influence of drugs, 26% of alcohol (10) and 40% are shot from behind (22). In Croatia 0.9% of all those injured by firearms had spine or spinal cord injury, with 55% of SCI being due to low velocity shell fragments (23).

One series reported 62% with complete paraplegia (8) whereas others suggest 29% have complete paraplegia, 28% incomplete quadraparesis, 23% incomplete paraparesis and 19% complete quadraplegia (16, 24). Associated injuries are seen in high percentages ranging from 25% to 100% (3,

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6, 9, 10, 21-23, 25-27). The level of injury varies between 19-27% for cervical, 30-54.5% for thoracic (80% of whom are complete (28)) and 19-33.5% for lumbar (7, 8, 15, 23, 28-30).

Simple ballistic implications

Most modern military injuries are due to small fragments; these are generally low velocity projectiles, and are less likely to cause SCI than high velocity military weapons (31).

With modern high velocity weapons a direct hit on the spinal cord is not required to cause devastating injury (11, 32-37). Indeed, experimentally, subdural haematoma along the whole length of the spinal cord can be achieved by hitting a spinous process with a high velocity projectile (35). Microscopic damage to the spinal cord is not confined to the level at which it is hit, with injury to cells being seen up to 15 cm from the level of primary injury (35).

Management

Resuscitation:

As many of those injured have other injuries, basic life saving principles apply from the point of wounding back to the Regimental Aid Post (RAP) using tried and tested BATLS/ATLS protocols (10). As part of the overall resuscitation the victim will need all life threatening injuries treated prior to consideration of his/her SCI (4,7,10,29,38-40). Zipnick (40) believes that spinal shock (hypotension and bradycardia) is rare in this type of injury and that hypotension must always prompt the search for bleeding from other injuries. In one series the mortality of 5% was due to the associated injuries (23) whilst others reported 4.2% (9). This is clearly an improvement over the 71.8% mortality that Cushing found in WWI (41).

After resuscitation, stabilisation and treatment of other injuries the evacuation chain may mean that it is sometime before a neurosurgeon sees the patient for assessment. Early assessment of the neurological status is deemed vital and should be carried out within 24 hours of the injury, after resuscitation, as the neurological and autonomic status has considerable implications for prognosis; assessment prior to resuscitation may give spurious results and delay treatment for life threatening injuries (5, 7, 22, 31, 38).

The third North American Spinal Cord Injury Study (NASCIS III) advocates the use of methylprednisolone (MP) in the management of blunt SCI (42). Levy *et al* (43) found the MP did not significantly improve the functional outcomes in GSW SCI, despite experimental evidence to the contrary (44). However, Isiklar (31) suggests that it may be indicated. The use of MP has been implicated in an increase in complications in these injuries (45) and may

even impair recovery (46). However, Aarabi in the Iran-Iraq War (8) routinely used dexamethasone.

Bladder catheterisation and measures to prevent decubitus ulcers and deep venous thrombosis are required early to maximise recovery (2, 3). This has implications for the intensive nursing of such patients. It is highly recommended that repeat examination from head to toe is undertaken periodically to minimise missing associated injuries (3).

Imaging the SCI:

Plain X-ray will demonstrate bone anatomy and presence and position of retained foreign bodies. For more detailed bone anatomy computerised tomography (CT) can provide good detail (13,31) which may require a mobile CT scanner with CT myelography, spiral and 3D reconstruction capability in the field.

Magnetic resonance imaging (MRI) is very useful for soft tissue appearances, especially of the cord itself. Early realisation that the cord is completely transected, for example, has enormous prognostic implications. However, MRI can cause FB movement and the FB may cause significant artifact although such patients have been imaged safely (47).

Prior to the exploration of neck injuries affecting the cervical spine angiography is recommended, especially for the vertebral artery anatomy (31).

Instability:

In blunt SCI, protocols such as ATLS are well established for treating such injuries as if they are unstable. However, on the battlefield such management may not be necessary as it is generally felt that war missile injuries to the spine do not result in instability (5,11,26, 31). Instability may be iatrogenic after decompression laminectomy (48,49), the facet joints must be preserved where possible. Treatment of an unstable spine will be discussed below.

Whilst some advocate that such injuries should be treated as if they are all unstable (31) this may actually be detrimental to the casualty. A recent review of penetrating neck injuries stabilised by a collar (50) found that the collar masked deterioration and other injuries and was not, in fact, needed as the spine was not unstable. They recommend avoiding the use of a stabilising collar in all such injuries.

Operation?:

Controversy exists regarding whether or not to decompress the spinal cord or theca. The most important factor for overall outcome is the initial neurological status. With this in mind there have been attempts to improve the neurological prognosis in all grades of SCI by decompressive laminectomy and removal of any FB impinging upon the cord

or theca. This rationale is largely based on protocols promulgated from WWII experience carried into Korea and Vietnam (1-4, 12, 28, 51, 52).

More recent experience with this type of injury in the civilian setting has brought about a change in the management, tending towards the conservative (21, 29, 48, 49, 53). Modern military experience has reflected this (5, 6, 8, 9).

However, Waters (28) did feel that, in incomplete injuries only, bullet removal improved overall motor function at 1 year from injury and Jallo (22) and Splavski (7) also recommend operative decompression. What has been found in these series (5, 6, 8, 9) is that with or without surgery, in complete or incomplete SCI, laminectomy and/or removal of FB does not actually improve the neurological status. What has been seen, unfortunately, is that some series have worse complication rates for the surgical cases than non-surgical (26, 27, 49, 54, 55). For lesions involving the cauda equina this is not necessarily the case. Many series have shown that removal of FB from the cauda equina improves neurological outcome (8, 28, 29, 49, 56). During surgery for the removal of the FB from the cauda equina finding the FB can sometimes be a problem as they can migrate (57-62) and having the patient slightly head up with fluoroscopy is recommended (63).

There is widely held agreement over spinal surgery for progressive neurological deficit, instability (up to 22.2% in one series (9), and closure of CSF leaks (64).

Removal of the FB to prevent future infection is controversial. Many feel that FB retention does not increase the risk of sepsis, especially if treated with high dose antibiotics for more than 7 days (2, 39, 54, 65-69). Injuries penetrating other viscera causing SCI occur in a high percentage of cases (25, 26) and thorough wound washout from anteriorly, coupled with prolonged high dose antibiotics, is recommended to reduce the risk of spinal infection especially in transperitoneal injury (39,68); those penetrating the colon appear to be at greatest risk of causing infection (69).

Retained FB can cause long term non-infectious problems. Lead poisoning secondary to GSW is well recognised with a case of disc space involvement with a latency of 12 years being reported (70). Copper jacketed projectiles are particularly toxic and it is recommended that they are removed early (22). Interestingly, there is a report of cauda equina syndrome due to a retained bullet herniating into the spinal canal from a disc space 9 years after being shot (71). They can cause low back pain and radicular symptoms due to the long term reactive tissue development around the FB up to 17 years after the initial injury (72,73). Osteomyelitis has also been reported due to

retained FB (74).

Surgery to remove the FB for pain relief does not decrease pain in the early period of rehabilitation (15, 28), although in WWII McCravey (2) and Pool (1) felt that pain relief could be obtained by FB removal. More recently this has been echoed by Robertson (54).

Prognosis:

Remembering that neurological improvement occurs with or without surgery and best in cauda equina lesions (8) the prognosis largely depends on the whole care of the patient with care for pressure areas, bladder, nutrition etc. Carillo *et al* (10) felt that there was an overall decrease in life expectancy for victims of such an injury. Samsa (75), looking at military veterans found a similar long term reduction in life expectancy. Early death, despite modern management can be seen in approximately 4-5% (9, 23) and is usually due to other injuries. McKinley (76) found that, despite it being a potentially worse injury, SCI secondary to GSW had similar lengths of stay in rehabilitation facilities as blunt SCI, and also had similar functional independence measure scores and discharge home rates. Therefore, although appearing to be a totally devastating injury a return to a useful life can be achieved in many who survive the acute phase.

Management recommendations and conclusions

After resuscitation and arrival at the RAP the injured soldier needs to be assessed, stabilised and made ready for evacuation. Although the risks of the spinal injury being unstable are small they should be treated as such, but care should be taken not to mask the deterioration of neck wounds by application of a stabilising collar without constant checking to make sure that wound complications do not go unnoticed. Other life threatening injuries take priority.

With regard to surgery of the spine NATO guidelines (64) state that complete injuries do not require surgery and that surgery is indicated for progressive neurological deficit and spinal instability. To this I would add CSF leaks, delayed infection or FB reaction, presence of a copper FB or lead FB in a joint or disc space and radicular pain where the FB can clearly be demonstrated to be compromising the root.

The use of steroids cannot be recommended at this time due to the uncertainty about their efficacy in penetrating spinal cord injury.

Decompression laminectomy and FB removal for the sake of it can no longer be justified.

High dose broad spectrum antibiotics for more than 7 days are indicated especially if

the FB is retained or a hollow viscus is traversed.

The most important factor for prognosis is presentation neurological status, 90% of presenting neurological deficits being permanent (23).

Such an injury in wartime is very intensive on personnel and resources, but such injuries can be survived and, especially if incomplete, the patient may make some useful recovery.

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