CASE REPORT

Tetraplegia following cervical spine cord contusion from indirect gunshot injury effects

SS Goonewardene[1], KS Mangat[1], ID Sargeant[1], K Porter[1], I Greaves[2]

[1]South Birmingham Trauma Unit, Selly Oak Hospital,Raddlebarn Road B29, [2]James Cook University Hospital, Marton Rd, Middlesbrough TS4 3BW

Abstract

We present the case of a 31 year old British soldier who sustained a high energy gunshot injury to the neck with delayed onset tetraplegia. The bullet's transcervical track was subsequently shown to have had no direct contact with the spinal cord, but four to five minutes after injury the patient developed tetraplegia. Subsequent Magnetic Resonance Imaging confirmed this to be due to contusion of the cervical spinal cord. This case illustrates the high levels of energy potentially transferred to surrounding tissues by the passage of a high available energy projectile, causing significant injury to nearby structures not actually impacted by the missile.

Introduction

The high tempo of deployed operations over recent years has resulted in a large spectrum of injuries varying both in their mechanism of injury and severity. Each case is clearly a potential tragedy for the patient, but it might be argued that for the first time since World War II, clinicians in field hospitals and at the Royal Centre for Defence Medicine (RCDM) are being enabled to develop genuine expertise in the management of battlefield injuries based on considerable clinical exposure. This must be of benefit to patients.

Acute spinal cord injury can be life threatening and result from both blunt and penetrating trauma. Gunshot injuries to the spinal cord itself account for up to 25% of all such injuries, with neurological deficit resulting from direct trauma to the nervous tissue as a result of direct impact by the bullet, bone, or displaced disc fragments (1,2). Fracture of bone by the close passage of a missile without direct contact is well recognized (3,4), and it is possible that a similar mechanism may injure the spinal cord. We present a case of spinal cord injury associated with the near passage of a high energy round but without direct injury to the cord manifest by delayed onset of tetraplegia – only one similar such injury to the spinal cord has previously been reported (1).

Case presentation

A 31 year old British soldier was wounded by enemy fire whilst on active duty in Afghanistan. He sustained a high energy gunshot wound to the neck. The bullet entered on the right side of the neck and exited from the left side. The path of the bullet was horizontal, with the track lying posterior to the cervical vertebral bodies (Figure 1). The patient himself reported a delay of a few minutes after the initial injury before he developed tetraplegia (loss of sensation and motor function in all four limbs). He was managed in accordance with the Battlefield Advanced Trauma Life Support (BATLS) (5) guidelines and

Correspondence to: Prof Keith Porter MBBS FRCS(Ed) FRCS (Eng) FIMCRCS(Ed) MFSEM (Ed)
Honorary Professor of Traumatology and Consultant Trauma Surgeon, South Birmingham Trauma Unit, Selly Oak Hospital,Raddlebarn Road B29

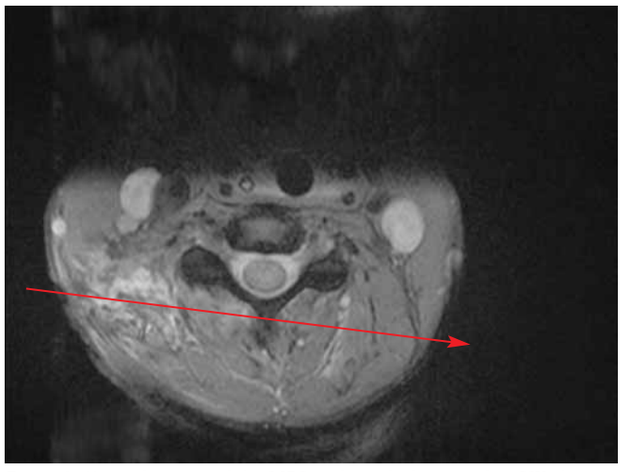

Figure 1. Coronal section of the MRI performed after arrival in UK showing the path of the missile away from the spinal canal and cord.

transferred via the evacuation chain to designated neurosurgical facilities in Muscat. Initial neurological examination revealed intact cranial nerves, with pupils equal in size and reacting to light. He had 0/5 power in all four limbs on the Medical Research Council (MRC) scale (6). Upper and lower limb reflexes were absent and there was disparity of the sensory level - C5 on the right and T2 on the left. No anal tone was present and the bulbocavernosus reflex was negative. There was no priapism and the patient was haemodynamically stable.

CT imaging revealed a fracture of the spinous process of C5, but without any obvious compromise of the spinal canal and there was no evidence of retained bullet fragments. Steroids were not administered. He was transferred by aeromedical evacuation to the RCDM, Selly Oak Hospital, Birmingham. In the U.K. repeated neurological examination showed 1/5 right shoulder abduction power now, but otherwise it remained 0/5 throughout the rest of the limbs. The sensory level bilaterally was now C5. The cervical spine injury was deemed stable and Magnetic Resonance Imaging (MRI) and Magnetic Resonance Angiogram (MRA) assessment were undertaken. The MRA demonstrated a non-haemorrhagic cord contusion from C2 to C7 (Figure 2), but no other vascular abnormality.

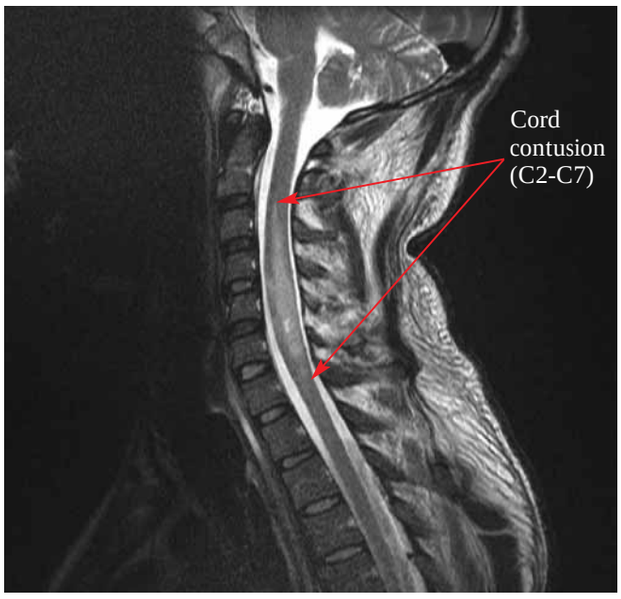

Figure 2: Sagittal MRI performed on return to UK demonstrating the contusion evident within the cord at 6 cervical levels.

A diagnosis of spinal cord contusion secondary to the radial dissipation of energy by the close passage of a high available energy bullet was made, and the patient treated conservatively. He continues with his rehabilitation at a specialist spinal injuries unit, but apart from some return of the ability to supinate his right wrist, there has been no significant change in his neurological status to date.

Discussion

A bullet, on entering a victim, dissipates its kinetic energy into the surrounding tissues, the energy transferred being equal to the difference between the kinetic energy on entering the body and the remaining kinetic energy when the bullet leaves the body. If the bullet does not exit the body all of its kinetic energy is transferred to the target tissues. As a bullet traverses tissues, it is retarded, its dynamics alter and it begins to yaw - increasing the angle between the long axis of the bullet and the direction of travel. This presents a greater surface area to the tissues, which thus exert a greater drag (retardation) and greater dissipation of energy. This energy is dissipated radially, physically pushing aside the surrounding tissues to form a temporary cavity, which as its name suggests then collapses. This whole process takes only 10-30ms (7) and reaches its maximal size (10-40 times diameter of the missile) within 1-4ms of impact (8). Thus tissues distant from the direct track of a missile may be disrupted. The size of the temporary cavity and also of the subsequent, much smaller permanent track after collapse of the cavity, depend on the tissues ability to withstand the stretch of temporary cavitation. Elastic tissues accept the stretch well with little permanent damage but inelastic or constrained tissues such as the brain with the bony skull or the liver within its fibrous capsule, cannot expand to accept the cavitation and shatter instead. What is left after the collapse of the temporary cavity, is a variable area of injured but potentially viable tissue - the so called zone of contusion which may extend several centimetres from the track of the bullet. Injury in this zone occurs at a microvascular level.

In the case we describe, the fact that a large number of cervical spine levels were contused suggests the large area over which energy dissipation occurred. The fracture of the C5 spinous process may have been caused by direct impact, or may have been the result of the shock wave from the passage of the missile at a distance, but there was no evidence of bone fragments within the spinal canal and a secondary fragment injury to the cord is therefore highly unlikely. We believe the most likely cause of his spinal cord injury was contusion from the radially dissipated energy wave emanating from the traversing bullet. The shockwave may potentially have been reflected from the inner surfaces of the laminar, pedicles and body of C5, leading to wave summation and increased clinical effects.

This might be explained by the shockwave having low enough energy to pass through the bony ring of the spinal column without damaging it, yet having enough remaining energy to cause spinal cord contusion. Bone is far denser than the delicate spinal cord, and can absorb a greater amount of energy without damage. In addition, reflection of the shock wave from bony surfaces would have increased the shock loading, exacerbating spinal cord contusion. Spinal cord MRA was normal suggesting, damage at a microvascular rather than macrovascular level, consistent with our postulated mechanism of injury. Diffuse axonal injury to the cervical spinal cord would be expected in such a contusion. Spinal cord contusion where the track of the projectile is away from the cord itself has been described previously in gunshot wounded patients only once (1).

Conclusion

We present a case of delayed onset tetraplegia without direct injury to the cord following the near passage of a high available energy projectile and offer explanations for the mechanism of injury. We believe however that it does not contradict the current policy of non-immobilisation of penetrating spine injuries on the battlefield.

References

1. Mirovsky Y, Shalmon E, Blankstein A, Halperin N, Complete paraplegia following gunshot injury without direct trauma to the cord. *Spine*. 2005; **30**(21):2436-8.
2. Buxton N. Spinal Injury. In Ballistic Trauma: a practical guide 2nd Edn. Mahoney PF Ryan JM Brooks AJ Schwab CW Eds. *Springer* 2005, London
3. Liu Y, Chen X, Chen SLX et al. Wounding effects of small fragments of different shapes at different velocities on soft tissue of dogs. *J Trauma* 1988; **28**: S95-S98
4. Hill PF. Intramedullary nailing of contaminated tibial fractures. M Chir Thesis. University of Cambridge 2000.
5. Battlefield Advanced Trauma Life Support. JSP 570. Third edition. Defence Medical Education and Training Agency, 2006
6. John J. Grading of muscle power: comparison of MRC and analogue scales by physiotherapists. *Int J Rehabil Res*. 1984; **7**(2):173-81.
7. Stapley SA, Cannon LB. An overview of the pathophysiology of gunshot and blast injury with resuscitation guidelines, *Current Orthopædics* 2006; **20**: 322-32.
8. Bartlett CS, Helfet DL, Hausman MR, Straus E. Ballistics and gunshot wounds: effects on musculoskeletal tissues. *J Am Acad Orthop Surg* 2000; **8**:21-36.