The use of the spinal board after the pre-hospital phase of trauma management

D Vickery

Abstract

***Objectives*—For pre-hospital spinal immobilisation the spinal board is the established gold standard. There are concerns that its subsequent use in hospital may adversely affect patient outcome. This review examines the effect of prolonged patient immobilisation on the spinal board.**

***Methods*—A database search of the literature and review of relevant trauma texts.**

***Results*—Complications associated with the use of the spinal board were found in five clinically relevant categories: pressure sore development; inadequacies of spinal immobilisation and support; pain and discomfort; respiratory compromise; and quality of radiological imaging.**

***Conclusion*—The spinal board should be removed in all patients soon after arrival in accident and emergency departments, ideally after the primary survey and resuscitation phases.**

(*Emerg Med J* 2001;**18**:51–54)

Keywords: spinal board; pre-hospital care; trauma

The spinal board is considered to be the gold standard for spinal immobilisation during the pre-hospital phase of trauma management.[1] However, the length of time a patient subsequently remains on a spinal board in accident and emergency (A&E) varies widely. This may be because of a lack of understanding regarding the limitations of the spinal board, and be compounded by dogmatic interpretation of ATLS principles.[2 3]

There is concern that unnecessary and prolonged immobilisation on a hard spinal board may be deleterious to the outcome of the trauma patient.[4] The American College of Surgeons (ACS) has partly tackled some of the issues in the 1997 ATLS manual,[5] which will be discussed in more detail below.

This review will examine the factors influencing the timing of spinal board removal from the trauma patient in the A&E department.

Gloucestershire Royal Hospital, Department of Accident and Emergency Medicine, Gloucestershire Royal Hospital, Great Western Road, Gloucester GL1 3NN, UK

Correspondence to:
Mr Vickery, Consultant in Accident and Emergency Medicine
(davidvickery@yahoo.com)

Accepted 4 September 2000

Methods

A literature search was performed to identify relevant research papers and articles whose principal focus was spinal immobilisation in the management of trauma patients. The following databases from 1966 to 1998 were searched online—Medline, EmBase, Healthstar and the Cochrane library. Keywords used were: spinal board; spinal immobilisation; longboard immobilisation; and spinal injury. The following MeSH terms were used—"transportation of patients", "spinal cord injuries", "spinal injuries and splints". Reference lists of identified studies were reviewed, and a hand search of relevant published literature performed. Where appropriate, papers were critically appraised along standard guidelines. The focus was restricted to articles published in English.

Immediate clinical context

In 1967 Farrington first described the use of a spinal board during extrication of victims of road traffic accidents, and their subsequent transfer to hospital.[6] An adaptation of the original device was illustrated in a letter published in the *BMJ* in 1970.[7] Since then, there have been a number of modifications in design and material. In the UK and USA the conventional spinal board has now become the standard extrication device on most frontline ambulances.

The Faculty of Pre-hospital Care of the Royal College of Surgeons of Edinburgh and the Joint Royal Colleges Ambulance Service Liaison Committee (JCALC) have published a joint position statement on spinal immobilisation and extrication.[8] Clear guidance on the use of the spinal board in pre-hospital care is given. They acknowledge that the spinal board may facilitate extrication and removal of other groups of patients such as during cardiac arrest, and in awkward physical circumstances including upstairs rooms and staircases.

The benefits of using the spinal board are maximal in pre-hospital extrication and in short transport times to hospital. However, the risks associated with prolonged patient immobilisation on the spinal board are not widely known. These relate to the risk of pressure sores, inadequate spinal immobilisation and support, pain and discomfort, respiratory compromise, and difficulties with radiological imaging.

Pressure sores

Pressure sore development is multifactorial with localised mechanical pressure being the integral component—"where there is no pressure there is no sore".[9] Pressure sores are mainly attributed to prolonged localised pressure causing impaired capillary circulation, tissue hypoxia and necrosis.[10] Local and systemic factors determine the adequacy of peripheral perfusion and cellular metabolism. The rate of pressure sore necrosis is directly related to the level of applied pressure and to time.

In current A&E clinical practice, measures to minimise the risk of pressure sore development are routinely enacted. This particularly

applies with elderly patients after a suspected fractured neck of femur. These patients are transferred from the ambulance trolley on to pressure relieving mattresses as soon as they arrive in A&E, and their pressure areas regularly checked. The interface pressures (IPs) for the various support surfaces used by the ambulance services have been examined, and all demonstrate substantially higher pressures than conventional hospital mattresses.

Main and Lovell examined IPs experimentally in volunteers on seven pre-hospital support surfaces.[4] They found that the highest IPs at the sacrum and thorax were from the conventional spinal board. Mean sacral readings being 233.5 mm Hg and thoracic readings of 82.9 mm Hg. Experimental studies have suggested that a constant pressure of only 35 mm Hg exerted for two hours, or 60 mm Hg for one hour is sufficient to cause irreversible tissue damage.[11 12]

There are few prospective studies examining the use of the spinal board and pressure sore development in victims of trauma. Most of the published work is experimental and involves patients with established spinal cord injuries (SCI).The paper most commonly quoted is a case-control study by Mawson *et al* of 39 patients with a SCI. This demonstrated an association between time spent on the spinal board and subsequent development of pressure sores. This association was statistically significant at eight days after injury.[13] However, low systolic blood pressure and loss of consciousness were confounding factors in this association that limit the overall conclusions of the paper. In addition, the average time cases and controls spent on the spinal board (13 and 6 hours respectively) is substantially longer than in current clinical practice in the UK.

Patterson investigated the impact of different pressure loads on transcutaneous oxygen tension ($PtcO_2$). $PtcO_2$ being a validated indicator of the state of tissue oxygenation.[14] He demonstrated a significant difference in $PtcO_2$ levels (7.3 mm Hg: 27.2 mm Hg) between SCI patients and able bodied (AB) controls subjected to 30 mm Hg pressure loads on the flat anterior surface of the tibia. Interestingly, at a pressure load of 75 mm Hg the AB group also showed a significant fall in $PtcO_2$ levels to less than 10 mm Hg. This study demonstrated that SCI patients may be more likely to develop tissue ischaemia at moderate pressures and that this risk may be comparable for AB patients at higher pressures.

Mawson examined the importance of the support surface for SCI patients by measuring $PtcO_2$ at the sacrum in SCI patients and in AB controls.[15] Measurements were made continuously at the sacrum with subjects prone and supine on pressure relieving egg crate mattresses. SCI patients were shown to have significantly lower $PtcO_2$ than the controls, the difference being most marked in the supine position.

Other groups that are at high risk for developing pressure ulcers include those that are critically ill and injured, unconscious, and the anaesthetised and paralysed patient. The trauma victim on a spinal board in A&E is particularly at risk when these factors occur in combination.

Although direct causation between the use of the spinal board and development of pressure sores has not been shown, it is paradoxical that those patients with suspected or confirmed spinal cord injury are immobilised on a surface that has the potential for causing further harm.

Spinal immobilisation and support

The purpose of immobilisation in suspected spinal trauma is to maintain a neutral position and avoid displacement and secondary neurological injury. This must be initiated at the scene of an accident and continued until unstable spinal injuries are ruled out. Pre-hospital use of the spinal board facilitates extrication of a patient, and minimises the need for a further log-roll during transfer to hospital.

Adequacy of spinal immobilisation must be reviewed during the primary survey in the A&E department. The spinal board has several limitations in this respect: cervical spine position; lumbar spine support; and maintenance of spinal alignment if the patient needs urgently turning.

There is considerable variation in the best technique for pre-hospital cervical spine immobilisation. Some advise the use of 1 to 1.5 inches of padding under the head as standard, others that judgement on the use of padding be based on visual inspection.[1 16] Conversely, several trauma texts recommend placing the occiput directly against the spinal board. One US study showed that the use of a spinal board placed the necks of 98% of subjects in a relatively extended position.[17] In children occipital padding exacerbates forward flexion of the cervical spine, and hence a flat surface for the head and padding under the shoulders may be necessary.[18]

The lack of lumbar support from the spinal board is obvious in clinical practice with a visible gap between board and patient. Undue stress may therefore be placed in this region, which in the context of an unstable spinal injury may cause secondary spinal injury.[19]

One argument for keeping the patient on a spinal board is that it facilitates an urgent turn if vomiting occurs. This assumes that the patient is adequately immobilised so that the spine will not be jeopardised by turning the board on its side. In practice, it is common for the torso and limb straps to be undone during the primary and secondary surveys, and not re-secured. In addition, if straps are missing or if padding either side of the torso is not used for children or small adults then the spine will be at considerable risk.

Pain and discomfort

There is no doubt that the spinal board is a hard and uncomfortable surface on which to lie. The pressure effect on the occiput, thoracic spine, sacrum and other bony prominences will cause pain and discomfort in the conscious patient.

Several studies have investigated the possibility that spinal pain and tenderness may be

attributable to the spinal board itself. Barney found that in 21% (19 of 90) of trauma patients with cervical pain or tenderness while on the spinal board, these findings completely resolved once off the board.[20] Similarly lumbar pain or tenderness in 33% (19 of 58) of patients resolved once off the board.

Chan immobilised healthy volunteers on a spinal board for 30 minutes. All the subjects reported symptoms of pain: occipital headache, sacral, lumbar and mandibular pain being the most frequent.[21] The majority graded their symptoms as being moderate or severe.

It may be difficult to distinguish between the pain generated by spinal board immobilisation and that attributable to the initial trauma. Measures to minimise the pain from the hard surface and to improve patient comfort have a number of potential benefits, decreasing patient anxiety and increasing cooperation.

Once the patient is off the spinal board clinical assessment of the spine may be facilitated and unnecessary radiographs avoided. Barney calculated that 84% (16 of 19) of patients with cervical spine tenderness and 32% (6 of 19) of those with lumbar spine tenderness while on the spinal board had unnecessary radiographs.

Respiratory compromise

Concern has been expressed about the effect of immobilisation on pulmonary function in both adults and children.[22 23] An experimental study on healthy subjects supine on the spinal board with standard torso straps, demonstrated a significant reduction in FVC and FEV_1.[24] Strap tension needs to be adjusted so as not to restrict chest wall excursion.

The physiological effects of the supine position on pulmonary function may be accentuated in the trauma victim. This includes a fall in functional residual capacity (FRC) that can cause impaired oxygenation, particularly as supine closing capacity reaches FRC soon after 40 years of age. This may be of particular significance in patients with chest trauma or those with diminished cardiorespiratory reserve. In a haemodynamically stable patient in whom a spinal injury can be excluded, elevation of the trunk to a semi-erect position will increase FRC and potentially decrease work of breathing. If patients remain supine for prolonged periods of time on the spinal board, outcome may be adversely affected.

Radiological imaging

In trauma it is important to obtain the best quality radiological images to aid acute as well as definitive management. However, there is often a trade off between the optimal radiographic techniques and the acuity of life or limb threat. Trauma films of the chest are regularly obtained after the primary survey in the resuscitation room with the patient supine, and the *x* ray plate underneath the trauma trolley. The presence of the spinal board is another interface for *x* rays to penetrate as well as contributing to artefactual distortion of the final image. The metallic straps on the spinal board may obscure abnormalities on chest and pelvic radiograph, as well as creating scatter in computed tomography. The result is incomplete films, delayed patient evaluation and deficiencies in overall trauma management.

Alternatives and their comparisons

In general, the emergency medical services in the UK and North America use the spinal board, while the vacuum mattress is favoured in Europe. Comparisons between the two support surfaces have been made experimentally in healthy volunteers. In one study, the degree of immobilisation was similar, as was the speed of application. The vacuum mattress was found to be significantly more comfortable after 30 minutes,[25] and tissue IPs lower.[4] Symptoms of pain over the occiput, lumbosacral spine, scapulae and cervical spine were found to be significantly more common with the spinal board.[26] The main disadvantages of the vacuum mattress relate to: its size, bearing in mind the limited available space on frontline ambulance vehicles; the fact that it cannot be used as an extrication device; its susceptibility to damage and puncture; and its cost.

The addition of padding to the spinal board has been investigated, and although comfort improved among the subjects tested, there was no quantifiable improvement in sacral $PtcO_2$ levels.[19 27]

Proposed management of patients on spinal boards

In determining best practice the complications discussed above must be clearly understood. Although the ACS highlight the danger of pressure sore development, the other issues are inadequately resolved.[5] The ACS emphasise that the spinal board should only be used as a patient transportation device, but fail to establish clear guidelines on early removal of the board once in hospital. They allow for the patient to remain on the spinal board for up to two hours, after which, if the "appropriate specialist" has not evaluated the patient, then removal of the board is advised. In the UK many would argue that senior A&E staff are sufficiently skilled and trained to fulfil this role.

When dealing with a major trauma victim the spinal board should be removed after the primary survey and resuscitation while performing the log-roll. Early removal of the spinal board will optimise the quality of trauma radiographs taken after the primary survey. The ATLS guidelines that chest and pelvis radiographs should be obtained with the patient remaining on the spinal board should only be followed in exceptional circumstances. Patients should not be transferred on the spinal board to computed tomography, and A&E departments should determine appropriate alternatives for all transfers.

When there is a high index of suspicion for spinal injury, prompt and safe removal of the spinal board is mandatory; these patients are at the greatest risk of pressure sores. In fact, spinal immobilisation on the board may be inadequate, becoming apparent with tragic consequences if the patient and board are rapidly turned because of vomiting. ATLS incorrectly advocates that pre-hospital spinal

protective devices (that is, the spinal board) should be left in place until a spinal injury is excluded by clinical examination and radiography. This dictum needs to be corrected-.Vigilance and proactive measures are necessary once the patient is off the spinal board to minimise the chance of vomiting. Rapidly logrolling the patient or securing a definitive airway may be needed.

Conclusion

There is evidence that the spinal board may create more problems in the hospital phase of trauma care than it solves, and that the earlier the patient is removed from the spinal board the better. The degree of spinal immobilisation on a hard flat board may often be less than ideal, and indeed create iatrogenic complications. Any time saved by the pre-hospital use of the board may be negated by delays in removing the patient from the board, and possibly unnecessary or inferior quality radiographs. The development of pressure sores in an AB patient, let alone one with a spinal cord injury, may have devastating consequences long after the immediate trauma of an accident.

It is vital that experienced senior medical staff treat victims of trauma as soon as possible after arrival in the A&E department.[28] A clear management plan needs to be formulated and appropriate specialist advice sought early. Safe removal of every patient from the spinal board must be an early priority after the primary survey and resuscitation phases.

The author is very grateful for the constructive advice of Taj Hassan in the preparation of this review paper.

Contributor

David Vickery is the sole contributor and guarantor of the paper.

1 Butman AM, McSwain NE Jr, McConnell WK, *et al*. *Pre-hospital trauma life support*. Akron, Ohio: Emergency Training, 1986:136–43.
2 Cooke M. Spinal boards. [Letter]. *J Accid Emerg Med* 1996; **13**:433.
3 Bennett JR, Bodenham AR, Berridge JC. Advanced trauma life support. *Anaesthesia* 1992;**47**:798–800
4 Main PW, Lovell ME. A review of seven support surfaces with emphasis on their protection of the spinally injured. *J Accid Emerg Med* 1996;**13**:34–7.
5 American College of Surgeons. *Advanced trauma life support*. 6th ed. Chicago: ACS, 1997:217.
6 Farrington JD. *Bulletin of the American Colleges of Surgeons* 1967;**52**:121.
7 Easton KC. *BMJ* 1970;1:690:236–7.
8 Faculty of Pre-hospital Care of the Royal College of Surgeons of Edinburgh and JCALC. *Pre-hospital Immediate Care* 1998;**2**:169–72.
9 Guttmann L. *Spinal cord injuries: comprehensive management and research*. 2nd ed. Oxford: Blackwell, 1976.
10 Reuler JB, Cooney TG. The pressure sore: pathophysiology and principles of management. *Ann Intern Med* 1981;**94**: 661–6.
11 Hussain T. An experimental study of some pressure effects on tissue with reference to the bedsore problem. *J Pathol Bacteriol* 1953;**66**:347–58.
12 Kosiak M. Prevention and rehabilitation of ischaemic ulcers. In: Kothe FH, ed. *Krusen's handbook of physical medicine and rehabilitation*. Philadelphia: WB Saunders, 1982:881–8.
13 Mawson AR, Biundo JJ, Neville P, *et al*. Risk factors for early occurring pressure ulcers following spinal cord injury. *Am J Phys Rehabil* 1988;**67**:123–7.
14 Patterson RP, Cranmer HH, Fisher SV, *et al*. The impaired response of spinal cord injured individuals to repeated surface pressure loads. *Arch Phys Med Rehabil* 1993;**74**:947–53.
15 Mawson AR, Siddiqui FH, Connolly BJ, *et al*. Sacral transcutaneous oxygen tension levels in the spinal cord injured: risk factors for pressure ulcers. *Arch Phys Med Rehabil* 1993;**74**:745–51.
16 McSwain NE Jr. Acute management. In: McSwain NE Jr, Martienz JA, Timberlake GA, eds: *Cervical spine trauma: evaluation and acute management*. New York: Thieme, 1989: 107–9.
17 Schriger DL, Larmon B, Le Gassick T, *et al*. Spinal immobilisation on a flat backboard: does it result in neutral position of the cervical spine? *Ann Emerg Med* 1991;**20**:878–81.
18 Herzenberg JE, Hensinger RN, Dedrick DK, *et al*. Emergency transport and positioning of young children who have an injury of the cervical spine. *J Bone Joint Surg* 1989;**71A**:15–22.
19 Lovell ME, Evans JH. A comparison of the spinal board and the vacuum stretcher, spinal stability and interface pressure. *Injury* 1994;**25**:179–80.
20 Barney RN, Cordell WH, Miller E. Pain associated with immobilisation on rigid spine boards. [Astract]. *Ann Emerg Med* 1989;**18**:918.
21 Chan D, Goldberg R, Tascone A, *et al*. The effect of spinal immobilisation on healthy volunteers. *Ann Emerg Med* 1994;**23**:48–51.
22 Schafermeyer RW, Ribbeck RM, Gaskins J, *et al*. Respiratory effects of spinal immobilisation in children. *Ann Emerg Med* 1991;**20**:1017–19.
23 Totten VY, Sugarman DB. Respiratory effects of spinal immobilisation. [Abstract]. *J Accid Emerg Med* 1998;**15**: 406.
24 Bauer D, Kowalski R. Effect of spinal immobilisation devices on pulmonary function in the healthy nonsmoking man. *Ann Emerg Med* 1988;**17**:915–18.
25 Johnson DR, Hauswald M, Stockhoff C. Comparison of a vacuum splint device to a rigid backboard for spinal immobilisation. *Am J Emerg Med* 1996;**14**:369–72.
26 Chan D, Goldberg RM, Mason J, *et al*. Backboard versus mattress splint immobilisation: a comparison of symptoms generated. *J Emerg Med* 1996;**14**:293–8.
27 Walton R, DeSalvo JF, Ernst AA, *et al*. Padded vs unpadded spine board for cervical spine immobilisation. *Acad Emerg Med* 1995;**2**:725–8.
28 Gentleman D, Dearden M, Midgley S, *et al*. Guidelines for resuscitation and transfer of patients with serious head injury. *BMJ* 1993;**307**:547–52.