

EVIDENCE WORKSHEET

Guideline 9.1.6: Management of a suspected spinal injury

ARC Subcommittee: BLS

Guideline author: Natalie HOOD

Clinical (PICO) question:

P: In victims with suspected spinal injury

I: does the use of spinal immobilisation (in-line manual immobilisation, head blocks, spinal boards, cervical collars)

C: compared with no immobilisation

O: effect neurological outcome or other outcomes (neurologically intact long term survival, patient comfort, pressure injury, intra-cranial pressure, aspiration)?

Search Strategies:

A. Ovid MEDLINE & Cochrane (CDSR / CENTRAL)

<1966 to August 2011>

- 1 exp spinal injuries/ (15354)
- 2 exp spinal cord injuries/ (34255)
- 3 ((spin\$ or cerv\$ or lumbar or thora\$ or neck or back) adj1 (injur\$ or trauma)).ti,ab. (13235)
- 4 or/1-3 (54837)
- 5 exp emergency treatment/ (83599)
- 6 exp emergency care/ (79598)
- 7 exp first aid/ (6653)
- 8 exp immobilization/ (21067)
- 9 (stabili* or immobili* or collar or back?board or spine?board or strap* or tap* or headblock or sand?bag* or orthosis).ti,ab. (414423)
- 10 or/5-9 (573773)
- 11 4 and 10 (5967)
- 12 limit 11 to (english language and humans and yr="1966 -Current" and (case reports or clinical trial, all or comparative study or controlled clinical trial or guideline or meta analysis or practice guideline or randomized controlled trial)) (1702)

Search results: 1702

B. EMBASE

- 1 'spine injury' / exp
- 2 'spinal cord injury' / exp
- 3 'spine fracture' / exp
- 4 ((spin\$ or cerv\$ or lumbar or thora\$ or neck or back) adj1 (injur\$ or trauma))
- 5 #1 OR #2 OR #3 OR #4
- 6 'emergency care' / exp OR 'prehospital care' / exp
- 7 (stabili* or immobili* or collar or back?board or spine?board or strap* or tap* or headblock or sand?bag* or orthosis)
- 8 #6 OR #7
- 9 #5 AND #8 (187)

Search results: 187

Databases / other sources searched:

Searching of reference lists of all relevant papers / reviews.

www.clinicaltrials.gov

Backward / forward searching via SCOPUS and GoogleScholar

Inclusion / exclusion criteria:

Inclusion criteria: Studies examining the effectiveness of spinal immobilisation in the emergency care of suspected traumatic spinal injuries. Studies of the patients with suspected spinal injuries or studies of healthy human volunteers. Studies available in English

Exclusion criteria

Non-systematic reviews / opinion papers, abstract-only studies, animal studies, studies examining advanced or surgical spinal stabilisation, studies examining helmet removal techniques, studies reporting on spinal clearance criteria.

Search results:

The combined searches outlined above yielded 688 studies, which were assessed for inclusion as evidence.

Number of studies meeting inclusion / exclusion criteria for further review: 33

Six LOE IV case series and 28 studies with extrapolated data from healthy volunteers, cadavers or multiple trauma patients provided the evidence for this guideline.

Methodological quality, levels of evidence & outcomes of studies examining spinal immobilisation for suspected spinal injury:

Good The methodological quality of the study is high with the likelihood of any significant bias being minimal	Fair The methodological quality of the study is reasonable with the potential for significant bias being likely.	Poor The methodological quality of the study is weak possessing considerable and significant biases
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1. Studies *supportive* of spinal immobilisation:

Good							
Fair						Brown et al. 2009 (E)	Cline et al. 1985 (A) Davies et al. 1996 (C) DeLorenzo et al. 1996 (D) Graziano et al. 1987 (A) Gerling et al. (2000) (A) Krell et al. 2006 (A) Nypaver et al. 1994 (D) Perry et al. 1999 (A) Schafermeyer et al. 1991 (C) Schriger et al. 1991 (D) Totten & Sugarman 1999 (C)
Poor							Boissy et al. 2011 (A) Conrad et al. 2010 (A) Gunn et al. 1995 (D) Huerta et al. 1987 (A) Mazolewski et al. 1994 (A) Podolsky et al. 1983 (A)
	I	II	III-1	III-2	III-3	IV	Extrapolated evidence
	NH&MRC levels of evidence						

2. Studies *neutral* for spinal immobilisation:

Good							
Fair						Flabouris et al. 2001 (E) Hauswald et al. 1998 (E) Cornwell et al. 2001 (E) Arishita et al. 1989 (E)	
Poor						Ramasamy et al. 2009 (E)	
	I	II	III-1	III-2	III-3	IV	Extrapolated evidence
	NH&MRC levels of evidence						

3. Studies *opposing* spinal immobilisation

Good							
Fair							Cordell et al. 1995 (B) Hauswald et al. 2000 (B) Lerner et al. 1998 (B) Walton et al. 1995 (B) Ben-Galim et al. 2010 (E)
Poor							Liew & Hill 1994 (C) Chan et al. 1996 (B) Main et al. 1996 (B) Houghton & Curley 1996 (C) Sheerin & deFrein 2007 (B)
	I	II	III-1	III-2	III-3	IV	Extrapolated evidence
	NH&MRC levels of evidence						

Endpoints:

- A = Prevention of movement
- B = Improve comfort / decrease pain
- C = cause medical complications
- D = optimise spinal positioning / alignment
- E = improve neurological outcome

The following systematic reviews were excluded from the evidence tables but are included in the citation list:

- Aram S, Bulstrode C. *Routine spinal immobilization in trauma patients: What are the advantages and disadvantages?* The Surgeon 2010; 8: 218-222.
- Ahn H, Singh J, Nathens A, MacDonald RD, et al. *Pre-hospital care management of a potential spinal cord injured patient: a systematic review of the literature and evidence-based guidelines.* J Neurotrauma 2011; 28 (8): 1341-61.
- Kwan I and Bunn F. *Effects of prehospital spinal immobilization: a systematic review of randomized trials on healthy subjects.* Prehosp & Dis Med 2005; 20 (1): 47-53.
- Kwan I, Bunn F and Roberts IG. *Spinal immobilisation for trauma patients.* Cochrane Database of Systematic Reviews 2009; (11).

Treatment recommendation:

Class B :

Summary of science

There are no published high level studies that assess the efficacy of spinal immobilisation in the emergency setting. Almost all of the current evidence related to spinal immobilisation is extrapolated data, mostly from healthy volunteers. Six Level IV studies were located. Only one of these supported spinal immobilisation and this study evaluated pre-hospital spinal immobilisation in patients with gunshot wounds to the torso. There were five studies (four fair and one poor) that were neutral: all were retrospective reviews and focused on transportation, neurologic outcome of patients with blunt traumatic spinal injuries, thoracolumbar immobilization for patients with torso gunshot wounds, risks and benefits of cervical spine immobilisation when applied in a hazardous environment and incidence of cervical spine injury following penetrating ballistic neck trauma.

Based on the current evidence it appears immobilisation does prevent movement but the clinical significance of movement prevention is unknown. There is some low level evidence that supports padding under head in adults and under shoulders in children to optimise spinal alignment. Spinal immobilisation is uncomfortable, particularly spinal boards, so consideration should be given to padding boards if possible. Spinal immobilisation may cause complications such as respiratory compromise, raised intracranial pressure, and pressure injuries, so protocols which recommend application of spinal immobilisation should give consideration to the risk versus benefits for specific patients. Further, collars may mask other injuries so delay diagnosis and definitive care. There were no studies that showed spinal immobilisation improved neurological outcomes as all studies using neurological outcome as an endpoint were neutral due to high mortality rates from other causes (mostly gunshot wounds).

Reviewer's final comments and assessment of benefit / risk:

There are no published high level studies that assess the efficacy of spinal immobilisation in the emergency setting. Almost all of the current evidence related to spinal immobilisation is extrapolated data, mostly from healthy volunteers. Spinal immobilisation may cause complications such as respiratory compromise, raised intracranial pressure, and pressure injuries, so protocols which recommend application of spinal immobilisation should give consideration to the risk versus benefits for specific patients.

Evidence gaps and research priorities:

The categories of research related to spinal immobilisation include i) prevention of movement, ii) improving comfort / decreasing pain, iii) medical complications, iv) optimal spinal positioning / alignment, and iv) improving neurological outcome. Most of the studies to date have been conducted in healthy volunteers in simulated environments. In all categories, prospective studies of patients at risk of, or with actual spinal injuries, are needed using real pre-hospital or clinical environments.

Citation List:

Abram S, Bulstrode C. Routine spinal immobilization in trauma patients: What are the advantages and disadvantages? The Surgeon 2010; 8: 218-222

Routine spinal immobilization for trauma patients has become established in developed countries throughout the world. Cervical spinal injury is, however, relatively rare in trauma patients, and immobilization practice was developed largely without firm supporting evidence. In recent years, published evidence has suggested that spinal immobilization may in some cases be harmful. The purpose of this article is to critically review the evidence and the implications for trauma patient management and outcomes. We searched MEDLINE, the Cochrane Database, Index Medicus and article references with a broad search strategy. Relevant results were analysed and critically reviewed in the context of trauma patient management. Our findings present a growing body of evidence documenting the risks and complications of routine spinal immobilization. There is a possibility that immobilization could be contributing to mortality and morbidity in some patients and this warrants further investigation.

NHMRC: Systematic review of trials on healthy volunteers

QUALITY: not rated

OUTCOME:

Ahn H, Singh J, Nathens A, MacDonald RD, et al. Pre-hospital care management of a potential spinal cord injured patient: a systematic review of the literature and evidence-based guidelines. J Neurotrauma 2011; 28 (8): 1341-61

An interdisciplinary expert panel of medical and surgical specialists involved in the management of patients with potential spinal cord injuries (SCI) was assembled. Four key questions were created that were of significant interest. These were: (1) what is the optimal type and duration of pre-hospital spinal immobilization in patients with acute SCI?; (2) during airway manipulation in the pre-hospital setting, what is the ideal method of spinal immobilization?; (3) what is the impact of pre-hospital transport time to definitive care on the outcomes of patients with acute spinal cord injury?; and (4) what is the role of pre-hospital care providers in cervical spine clearance and immobilization? A systematic review utilizing multiple databases was performed to determine the current evidence about the specific questions, and each article was independently reviewed and assessed by two reviewers based on inclusion and exclusion criteria. Guidelines were then created related to the questions by a national Canadian expert panel using the Delphi method for reviewing the evidence-based guidelines about each question. Recommendations about the key questions included: the pre-hospital immobilization of patients using a cervical collar, head immobilization, and a spinal board; utilization of padded boards or inflatable bean bag boards to reduce pressure; transfer of patients off of spine boards as soon as feasible, including transfer of patients off spinal boards while awaiting transfer from one hospital institution to another hospital center for definitive care; inclusion of manual in-line cervical spine traction for airway management in patients requiring intubation in the pre-hospital setting; transport of patients with acute traumatic SCI to the definitive hospital center for care within 24h of injury; and training of emergency medical personnel in the pre-hospital setting to apply criteria to clear patients of cervical spinal injuries, and immobilize patients suspected of having cervical spinal injury.

NHMRC: Systematic review of trials on healthy volunteers

QUALITY: not rated

OUTCOME: Patient comfort, prevention of movement, pressure injuries

Reported on 'optimal type and duration of prehospital spinal immobilisation'.

Arishita GI, Vayer JS, Bellamy RF. Cervical spine immobilization of penetrating neck wounds in a hostile environment. J Trauma. 1989 Mar;29(3):332-7.

Current guidelines concerning trauma suggest that cervical spine immobilization be performed on all patients with penetrating wounds of the neck. This study was undertaken to examine the risks and benefits likely to be found when such care is provided in a hazardous environment, such as the battlefield, or the scene of a terrorist attack or domestic criminal action. Data for casualties from the Vietnam conflict were reviewed to determine the potential benefit of cervical spine immobilization on the battlefield. In this population, penetrating cervical cord injury was always fatal and usually immediately so. Only 1.4% of all casualties who were candidates for immobilization might have benefitted from the care. However, the risk of performing immobilization in a hazardous environment is

substantial since about 10% of casualties are incurred while helping other casualties. Mandatory immobilization of all casualties with penetrating neck wounds sustained in an environment hazardous to first aid providers has an unfavorable risk/benefit ratio.

NHMRC: Patients with penetrating neck wounds

QUALITY: Fair

OUTCOME: Prevention of movement

Examine the risks and benefits of cervical spine immobilisation when applied in a hazardous environment, such as the battlefield, or the scene of a terrorist attack or domestic criminal action

Ben-Galim P, Dreiangel N, Mattox KL, Reitman CA, Kalantar SB, Hipp JA. *Extrication collars can result in abnormal separation between vertebrae in the presence of a dissociative injury.* J Trauma. 2010 Aug;69(2):447-50.

BACKGROUND: Cervical collars are applied to millions of trauma victims with the intent of protecting against secondary spine injuries. Adverse clinical outcomes during the management of trauma patients led to the hypothesis that extrication collars may be harmful in some cases. The literature provides indirect support for this observation. The purpose of this study was to directly evaluate cervical biomechanics after application of a cervical collar in the presence of severe neck injury. METHODS: Cranial-caudal displacements in the upper cervical spine were measured in cadavers from images taken before and after application of collars following creation of an unstable upper cervical spine injury. RESULTS: In the presence of severe injury, collar application resulted in 7.3 mm +/- 4.0 mm of separation between C1 and C2 in a cadaver model. In general, collars had the effect of pushing the head away from the shoulders. CONCLUSIONS: This study was consistent with previous evidence that extrication collars can result in abnormal distraction within the upper cervical spine in the presence of a severe injury. These observations support the need to prioritize additional research to better understand the risks and benefits of cervical stabilization methods and to determine whether improved stabilization methods can help to avoid potentially harmful displacements between vertebrae.

NHMRC: Cadavers – extrapolated data

QUALITY: Fair

OUTCOME: Prevention of movement

Evaluated cervical biomechanics after application of a cervical collar in the presence of severe neck injury.

Boissy P, Shrier I, Briore S, Mellete J, et al. *Effectiveness of Cervical Spine Stabilization Techniques.* Clin J Sport Med 2011; 21 (2): 80-8

Objective: To compare head motions that occur when trained professionals perform the head squeeze (HS) and trap squeeze (TS) C-spine stabilization techniques. Design: Cross-over design. Participants: Twelve experienced lead rescuers. Main Outcome Measures: Peak head motion with respect to initial conditions using inertial measurement units attached to the forehead and trunk of the simulated patient. We compared both HS and TS during lift-and-slide (L&S) and log-roll (LR) placement on spinal board, and agitated patient trying to sit up (AGIT-Sit) or rotate his head (AGIT-Rot). The a priori minimal important difference (MID) was 5 degrees for flexion or extension and 3 degrees for rotation or lateral flexion. Results: The L&S technique was statistically superior to the LR technique. The only differences to exceed the MID were extension and rotation during LR (HS > TS). In the AGIT-Sit test scenario, differences in motion exceeded MID (HS > TS) for flexion, rotation, and lateral flexion. In the AGIT-Rot scenario, differences in motion exceeded MID for rotation only (HS > TS). There was similar intertrial variability of motion for HS and TS during L&S and LR but significantly more variability with HS compared with TS in the agitated patient. Conclusions: The L&S is preferable to the LR when possible for minimizing unwanted C-spine motion. There is little overall difference between HS and TS in a cooperative patient. When a patient is confused, the HS is much worse than the TS at minimizing C-spine motion.

NHMRC: Healthy Volunteers – extrapolated data

QUALITY: Poor

OUTCOME: Prevention of movement

Examined the amount of c-spine movement with different immobilization techniques on 2 healthy volunteer “patients”.

Brown JB, Bankey PE, Sangosanya AT, Cheng JD, Stassen NA, Gestring ML. *Prehospital spinal immobilization does not appear to be beneficial and may complicate care following gunshot injury to the torso.* J Trauma 2009;67(4):774-8

Background: Prehospital spinal immobilization (PHSI) is routinely applied to patients sustaining torso gunshot wounds (GSW). Our objective was to evaluate the potential benefit of PHSI after torso GSW versus the potential to interfere with other critical aspects of care. Methods: A retrospective analysis of all patients with torso GSW in the Strong Memorial Hospital (SMH) trauma registry during a 41-month period and all patients with GSW in the National Trauma Data Bank (NTDB) during a 60-month period was conducted. PHSI was considered potentially beneficial in patients with spine fractures requiring surgical stabilization in the absence of spinal cord injury (SCI). Results: Three hundred fifty-seven subjects from SMH and 75,210 from NTDB were included. A total of 9.2% of SMH subjects and 4.3% of NTDB subjects had spine injury, with 51.5% of SMH subjects and 32.3% of NTDB subjects having SCI. No SMH subject had an unstable spine fracture requiring surgical stabilization without complete neurologic injury. No subjects with SCI improved or worsened, and none developed a new deficit. Twenty-six NTDB subjects (0.03%) had spine fractures requiring stabilization in the absence of SCI. Emergent intubation was required in 40.6% of SMH subjects and 33.8% of NTDB subjects. Emergent surgical intervention was required in 54.5% of SMH subjects and 43% of NTDB subjects. Conclusions: Our data suggest that the benefit of PHSI in patients with torso GSW remains unproven, despite a potential to interfere with emergent care in this patient population. Large prospective studies are needed to clarify the role of PHSI after torso GSW.

NHMRC: Patients with GSW to torso

QUALITY: Fair

OUTCOME: Improved neurological outcome

Evaluated pre-hospital spinal immobilisation in patients with gunshot wounds to the torso

Chan D, Goldberg RM, Mason J, Chan L. *Backboard versus mattress splint immobilization: A comparison of symptoms generated.* J Emerg Med 1996; 14 (3): 293-8

The study objective was to compare spinal immobilization techniques to a vacuum mattress-splint (VMS) with respect to the incidence of symptoms generated by the immobilization process. We used a prospective, crossover study in a university hospital setting. Participants consisted of 37 healthy volunteers without history of back pain or spinal disease. Interventions consisted of two phases. In Phase I, subjects were randomly assigned to be immobilized on either a wooden backboard or a mattress-splint for 30 min. The incidence and severity of any symptoms generated by the immobilization process were recorded. In Phase II, the two groups were again tested after a 2-week washout period, with the method of immobilization being reversed. Symptoms and severity were again recorded. Pain symptoms were confined to four anatomic sites: Occipital prominence, lumbosacral spine, scapulae, and cervical spine. After adjusting for the effect of order of exposure, subjects were 3.08 times more likely to have symptoms when immobilized on a backboard than when immobilized on the VMS. They were 7.88 times more likely to complain of occipital pain and 4.27 times more likely to complain of lumbosacral pain. Severity of occipital and lumbosacral pain was also significantly greater during backboard immobilization. We conclude that, when compared to a VMS, standard backboard immobilization appears to be associated with an increased incidence of symptoms in general and an increased incidence and severity of occipital and lumbosacral pain in particular.

NHMRC: Healthy Volunteers - extrapolated data

QUALITY: not rated

OUTCOME: Patient comfort

Comparison of backboard to vacuum bag measuring patient comfort

Cline JR, Scheidel E, Bigsby EF. *A Comparison of Methods of Cervical Immobilization Used in Patient Extrication and Transport.* J Trauma 1985; 25 (7): 649-53

We radiographically studied the efficacy of seven methods of cervical immobilization used in the prehospital setting. The methods were: Philadelphia collar, Hare extrication collar, rigid plastic collar, Philadelphia collar + short board, rigid plastic collar + short board and the short board used alone. Ninety-seven normal volunteers were randomized to one of these seven methods and each volunteer served as his or her own control. Efficacy was expressed as per cent reduction of baseline movement in the sagittal, frontal and horizontal planes. The short board technique appeared superior to all three collars studied. The collars provided no augmentation of immobilization over that

provided by the short board alone. We believe that the short board technique described herein, which is commonly used in the prehospital setting, can be used as the standard of comparison against which newer prehospital devices can be objectively compared.

NHMRC: Healthy Volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Spinal movement

Comparison of seven combinations of collar and board types, on prevention of spinal movement, measured radiologically.

Conrad BP, Reicht G, Weight M, Clarke J, Horodyski M. *Motion in the unstable cervical spine during hospital bed transfers.* J Trauma 2010; 69 (2): 432-6

Hospital bed transfers, moves to examination room, X-ray, hospital bed, and/or surgery, have the potential of causing harm to a patient with an unstable cervical spine. This study evaluated motion generated in an unstable segment of the cervical spine during hospital bed transfers. A secondary goal purpose was to assess reduction in cervical motion using three collars and a no collar condition. METHODS: Cervical spine instability was created at C5-C6 in cadavers. A repeated measures design was used to compare bed transfer techniques: manual transfer performed by six trained individuals and a transfer made by two people using the On3 lateral transfer device. Both techniques were tested under four collar conditions. Cervical spine motion was measured using an electromagnetic motion analysis device with sensors fixed to the anterior bodies of C5 and C6. RESULTS: No significant differences were observed between transfer techniques (flexion, [p = 0.325]; axial rotation [p = 0.590]; lateral bending [p = 0.112]). Nor were there significant differences among the three collars used (flexion [p = 0.462]; axial rotation [p = 0.434]; lateral bending [p = 0.250]). For all transfers, using no collar resulted in more motion than using a collar; but was not statistically significant. CONCLUSIONS: Bed transfers made with a lateral transfer device seem to be as safe as those made by the lift and slide manual transfer. None of the collars tested were significantly better at preventing cervical spine motion during a transfer, but each allowed less movement than no collar.

NHMRC: Cadaver study - extrapolated study

QUALITY: Fair

OUTCOME: Spinal movement

Comparison of immobilization and transfer techniques on 3 cadavers with cervical fractures. Spinal movement measured with sensors.

Cordell WH, Hollingsworth JC, Olinger ML, Stroman SJ, Nelson DR. *Pain and tissue-interface pressures during spine-board immobilization.* Ann Emerg Med 1995; 26 (1): 31-6

Although spine boards are one of the main EMS means of immobilization and transportation, few studies have addressed the discomfort and potential harmful consequences of using this common EMS tool. We compared the levels of pain and tissue-interface (contact) pressures in volunteers immobilized on spine boards with and without interposed air mattresses. DESIGN: Prospective crossover study. SETTING: Emergency department of Methodist Hospital of Indiana, Indianapolis, Indiana. PARTICIPANTS: Twenty healthy volunteers who had not taken any analgesic drugs in the preceding 24 hours, were not experiencing any pain at the time of the study, and did not have history of chronic back pain. INTERVENTIONS: To simulate prehospital transport conditions, we immobilized volunteers with hard cervical collars and single-buckle chest straps on wooden spine boards with or without commercially available medical air mattresses. The crossover order was randomized. After 80 minutes, immobilization measures were discontinued and the subjects were allowed to get off the boards for a recovery period of 60 minutes. Subjects were then studied for a second 80-minute period with the opposite intervention. At baseline and at 20-minute intervals, the level of pain was rated with a 100-mm visual analog scale. Tissue-interface pressures were measured at the occiput, sacrum, and left heel. RESULTS: Mean pain on the visual analog scale was 9.7 mm at the end of the mattress period and 37.5 mm at the end of the no-mattress period (P = .0001). Although there were no significant differences in pain between the two groups at time 0, volunteers reported significantly more pain during the no-mattress period at 20 (P = .003), 40 (P = .0001), and 60 minutes (P = .0001). All 20 subjects reported that immobilization on the spine board with the mattress was "much better" (five-point scale) than that without the mattress. Interface pressure levels were significantly less in the mattress period than in the no-mattress period measured at occiput (P = .0001), sacrum (P = .0001), and heel (P = .0001). CONCLUSION: In a simulated

immobilization experiment, healthy volunteers reported significantly less pain during immobilization on a spine board with an interposed air mattress than during that on a spine board without a mattress. Tissue-interface pressures were significantly higher on spine boards without air mattresses. This and previous studies suggest that immobilization on rigid spine boards is painful and may produce tissue-interface pressure high enough to result in the development of pressure necrosis ("bedsores"). Emergency care providers should consider the use of interposed air mattresses to reduce the pain and potential tissue injury associated with immobilization on rigid spine boards.

NHMRC: Healthy volunteers - extrapolated study

QUALITY: Fair

OUTCOME: Patient pain and interface pressure.

Comparison of board and collar immobilization with and without mattress between patient and spine board.

Cornwell EE 3rd, Chang DC, Bonar JP, Campbell KA, Phillips J, Lipsett P, Scalea T, Bass R. Thoracolumbar immobilization for trauma patients with torso gunshot wounds: is it necessary? Arch Surg. 2001 Mar;136(3):324-7.

BACKGROUND: Previous studies have suggested that patients transported by emergency medical services (EMS) following major trauma had a longer injury-to-treatment interval and a higher mortality rate than their non-EMS-transported counterparts. HYPOTHESIS: There is little actual benefit of thoracolumbar immobilization for patients with torso gunshot wounds (GSW). DESIGN: Retrospective analysis of prospectively gathered data from the Maryland Institute for Emergency Medical Service Systems State Trauma Registry from July 1, 1995, through June 30, 1998. SETTINGS: All designated trauma centers in Maryland. PATIENTS: All patients with torso GSW. MAIN OUTCOME MEASURES: (1) A patient was considered to have benefited from immobilization if he or she had less than complete neurologic deficits in the presence of an unstable vertebral column, as shown by the need for operative stabilization of the vertebral column; (2) mortality. RESULTS: There were 1000 patients with torso GSW. Among them, 141 patients (14.1%) had vertebral column and/or spinal cord injuries. Two patients (0.2%) (95% confidence interval, -0.077% to 0.48%) required operative vertebral column stabilization, while 6 others required other spinal operations for decompression and/or foreign body removal. The presence of vertebral column injury was actually associated with lower mortality (7.1% vs 14.8%, $P < .02$). CONCLUSIONS: This study suggests that thoracolumbar immobilization is almost never beneficial in patients with torso GSW, and that a higher mortality rate existed among those GSW patients without vertebral column injury vs those with such injuries. The role of formal thoracolumbar immobilization for patients with torso GSW should be re-examined

NHMRC: Patients with torso GSW

QUALITY: Fair

OUTCOME: improve neurological outcome.

Evaluated thoracolumbar immobilization for patients with torso gunshot wounds (GSW).

Davies G, Deakin C, Wilson A. The effect of a rigid collar on intracranial pressure. Injury 1996; 27 (9): 647-9

Spinal immobilization and the application of a rigid collar to protect the neck forms an integral part of care of the injured. The very nature of collar design predisposes to vascular obstruction of blood draining from the brain and theoretically may raise intracranial pressure (ICP). We analysed this effect prospectively in a series of injured patients using the Stifneck rigid collar, the most popular collar used in the UK. Comparison of the ICP before, during and after collar application showed a significant rise ($P < 0.001$), a mean rise in ICP of 4.5 mmHg, with a standard deviation of 4.1 mmHg. Insignificant changes in mean arterial pressure suggested that this effect is a response to distortion of venous drainage rather than cutaneous stimulation alone. Since head-injured patients with lowered level of consciousness form a key group who require cervical spinal immobilization it is essential that secondary insults producing raised ICP are minimized. Alternative forms of cervical spinal immobilization should be considered if collars impede venous drainage through the neck.

NHMRC: Prospective study of head injured patients wearing collars. Patients with #'s excluded. - extrapolated data

QUALITY: Fair

OUTCOME: Intracranial pressure

Study of injured patients who required both collars and intracranial pressure monitors. Patients found to have cervical fractures excluded.

De Lorenzo RA, Olson JE, Boska M, Johnston R, Hamilton GC, Augustine J and Barton R. *Optimal positioning for cervical immobilization. Ann Emerg Med 1996; 28 (3): 301-8*

We hypothesized that optimal positioning of the head and neck to protect the spinal cord during cervical spine immobilization can be determined with reference to external landmarks. In this study we sought to determine the optimal position for cervical spine immobilization using magnetic resonance imaging (MRI) and to define this optimal position in a clinically reproducible fashion. METHODS: Our subjects were 19 healthy adult volunteers (11 women, 8 men). In each, we positioned the head to produce various degrees of neck flexion and extension. This positioning was followed by quantitative MRI of the cervical spine. RESULTS: The mean ratio of spinal canal and spinal cord cross-sectional areas was smallest at C6 but exceeded 2.0 at all levels from C2 to T1 ($P < .05$). At the C5 and C6 levels, the maximal area ratio was most consistently obtained with slight flexion (cervical-thoracic angle of 14 degrees) ($P < .05$). For a patient lying flat on a backboard, this corresponds to raising the occiput 2 cm. More extreme flexion or extension produced variable results. CONCLUSION: In healthy adults, a slight degree of flexion equivalent to 2 cm of occiput elevation produces a favourable increase in spinal canal/spinal cord ratio at levels C5 and C6, a region of frequent unstable spine injuries.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair - not randomised

OUTCOME: Spinal cord compression.

MRI study of the neck in volunteers, to determine head position that optimizes spinal canal diameter.

Flabouris A. *Clinical features, patterns of referral and out of hospital transport events for patients with suspected isolated spinal injury. Injury 2001; 32 (7): 569-75*

Prehospital diagnostic accuracy and risks of transportation associated neurological deterioration for patients with spinal injury remain imprecise. METHODS: Retrospective review of medical records for patients with suspected spinal injury assessed and escorted by medically staffed team. RESULTS: One hundred and ninety six patients had follow up for spinal injury, 61% with actual injury. Of the 196 patients, 93% involved helicopter transport, 3.5% road vehicle and 3.5% fixed wing transports. Fifty one percent were interhospital transfers. Medical team's scene diagnostic accuracy of spinal injury was 31%. Scene medical interventions were those consistent with current paramedical skills. Of interhospital transferred patients, 19% had no injury. Cervical injuries as part of mixed injuries were the most often missed injuries. Abnormal neurological findings occurred equally amongst patients with and without spinal injury. Transport related incidents were documented for 15%. Interhospital transport patient related incidents occurred for 12% helicopter and 36% road vehicle transports ($P=0.094$). No transport related neurological injury or other morbidity was documented. CONCLUSION: Prehospital diagnosis of spinal injury, even by medical teams remains imprecise. Choice of helicopter transport, based purely upon the suspected presence of spinal injury could not be supported.

NHMRC: Retrospective chart review of patients with suspected spinal cord injuries, IV

QUALITY: Fair - no control, observational study, some secondary transfer patients, not specific to PICO Q

OUTCOME: Neurological outcome.

Retrospective chart review reporting patient demographics, injuries, transport methods, incidents during transport, morbidity and mortality.

Gerling MC, Davis DP, Hamilton RS, Morris GF, Vilke GM, Garfin SR and Hayden SR. *Effects of cervical spine immobilization technique and laryngoscope blade selection on an unstable cervical spine in a cadaver model of intubation. Ann Emerg Med 2000; 36 (4): 293-300*

Orotracheal intubation (OTI) is commonly used to establish a definitive airway in major trauma victims, with several different cervical spine immobilization techniques and laryngoscope blade types used. This experimental, randomized, crossover trial evaluated the effects of manual in-line stabilization and cervical collar immobilization and 3 different laryngoscope blades on cervical spine movement during OTI in a cadaver model of cervical spine injury. METHODS: A complete C5-C6 transection was performed by using an osteotome on 14 fresh-frozen cadavers. OTI was performed in a randomized crossover fashion by using both immobilization techniques and each of 3 laryngoscope blades: the Miller straight blade, the Macintosh curved blade, and the Corazelli-London-McCoy hinged blade. Intubations were recorded in real time on fluoroscopy and then transferred to video and colour still images. Outcome measures included movement across C5-C6 with regard to angulation expressed in degrees of rotation and

axial distraction and anteroposterior displacement with values expressed as a proportion of C5 body width. Cormack-Lehane visualization grades were also recorded as a secondary outcome measure. Data were analysed by using multivariate analysis of variance to test for differences between immobilization techniques and between laryngoscope blades and to detect for interactions. Significance was assumed for P values of less than .05. RESULTS: Manual in-line stabilization resulted in significantly less movement than cervical collar immobilization during OTI with regard to anteroposterior displacement. Use of the Miller straight blade resulted in significantly less movement than each of the other 2 blades with regard to axial distraction. The Cormack-Lehane grade was significantly better with manual in-line stabilization versus cervical collar immobilization; no differences were observed between blades. CONCLUSION: Manual in-line stabilization results in less cervical subluxation and allows better vocal cord visualization during OTI in a cadaver model of cervical spine injury. The Miller laryngoscope blade allowed less axial distraction than the Macintosh or Corzelli-London-McCoy blades. The clinical significance of this degree of movement is unclear.

NHMRC: Cadaver study - extrapolated data

QUALITY: Fair

OUTCOME: Cervical movement during intubation

Fluoroscopy study comparing manual in-line stabilization and cervical collars on 14 cadaver, measuring ease of intubation and spinal movement.

Graziano AF, Scheidel EA, Cline JR and Baer LJ. A radiographic comparison of prehospital cervical immobilization methods. Ann Emerg Med 1987; 16 (10): 1127-31

Three methods of prehospital cervical immobilization were studied radiographically and compared to the short board technique (SBT). The methods were California Stif-Neck Immobilizing Collar (CSC), Kendrick Extrication Device (KED), and Extrication Plus-One (XP-One). Forty-five volunteers were immobilized in the short board (SB) and one of the test devices studied. Cervical movement in the sagittal and frontal planes was measured radiographically. Movement in the horizontal plane was measured directly. Two-tailed, paired t test analysis was performed comparing test devices to the SBT. The SBT proved to be significantly better (P less than .05) in the following comparisons: the CSC in extension and lateral bending; the KED in lateral bending; and the XP-One in extension. We confirm the SBT as the standard of comparison against which newer prehospital devices can be compared objectively. Of the three devices compared against the SBT, the factory-fabricated short board devices (KED and XP-One) provided the greatest degree of immobilization, in addition to logistical advantages over the SBT.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Spinal movement

Comparison of immobilization devices; hard collar, 2 extrication devices, short board technique, with cervical spine movement measured radiologically.

Gunn BD, Eizenberg N, Silberstein M, McMeeken JM, et al. How should an unconscious person with a suspected neck injury be positioned? Prehosp Dis Med 1995; 10 (4): 239-44

Awareness of the risk of spinal-cord damage in moving an unconscious person with a suspected neck injury into the "lateral recovery position," coupled with the even greater risk of inadequate airway management if the person is not moved, has resulted in a suggested modification to the lateral recovery position for use in this circumstance.

HYPOTHESIS: It is proposed that the modification to the lateral recovery position reduces movement of the neck. In this modification, one of the patient's arms is raised above the head (in full abduction) to support the head and neck. The position is called the "HAINES modified recovery position." HAINES is an acronym for High Arm IN Endangered Spine. METHODS: Neck movements in two healthy volunteers were measured by the use of video-image analysis and radiographic studies when the volunteers were rolled from the supine position to both the lateral recovery position and the HAINES modified recovery position. RESULTS: For both subjects, the total degree of lateral flexion of the cervical spine in the HAINES modified recovery position was less than half of that measured during use of the lateral recovery position (while an open airway was maintained in each). CONCLUSION: An unconscious person with a suspected neck injury should be positioned in the HAINES modified recovery position. There is less neck movement (and less degree of lateral angulation) than when the lateral recovery position is used, and, therefore, HAINES use carries less risk of spinal-cord damage.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Poor - ? relevance to PICO Q (HAINES not listed as cx spine immobilisation)

OUTCOME: Spinal movement

Comparison of log roll techniques, measuring spinal alignment radiologically.

Hauswald M, Hsu M and Stockoff C. *Maximizing comfort and minimizing ischemia: a comparison of four methods of spinal immobilization.* Prehosp Emerg Care 2000; 4 (3): 250-2

OBJECTIVE: To determine which of four methods of spinal immobilization causes the least ischemic pain. METHODS: A prospective, nonblinded comparative trial was conducted at a statewide emergency medical services training facility using a convenience sample of emergency medical technician students. After lying motionless for 10 minutes, students evaluated each device using a 10-centimeter visual analog scale. Subjective comfort was used as a measure of ischemia. RESULTS: Comfort scores were significantly different for all methods ($F = 101$, $p < 0.001$). A backboard padded with a gurney mattress and eggcrate foam (the equivalent of a spinal rehabilitation bed) caused the least ischemic pain (9.6 cm, 95% CI, 8.9 to 9.8 cm). A backboard padded with a gurney mattress was the second most comfortable device (7.0 cm, 95%/CI, 6.4 to 7.4 cm). A backboard padded with a folded blanket was the third most comfortable (3.3 cm, 95% CI, 2.6 to 4.9 cm). The backboard alone caused the most pain (0.8 cm, 95% CI, 0.7 to 2.1 cm). CONCLUSION: Increasing the amount of padding on a backboard decreased the amount of ischemic pain caused by immobilization.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Patient comfort

Comparison of backboard with no padding with various padded backboards on comfort of volunteers lying for 10 minutes on each device.

Hauswald M, Ong G, Tandberg D and Omar Z. *Out-of-hospital spinal immobilization: its effect on neurologic injury.* Acad Emerg Med 1998; 5 (3): 214-9

OBJECTIVE: To examine the effect of emergency immobilization on neurologic outcome of patients who have blunt traumatic spinal injuries. METHODS: A 5-year retrospective chart review was carried out at 2 university hospitals. All patients with acute blunt traumatic spinal or spinal cord injuries transported directly from the injury site to the hospital were entered. None of the 120 patients seen at the University of Malaya had spinal immobilization during transport, whereas all 334 patients seen at the University of New Mexico did. The 2 hospitals were comparable in physician training and clinical resources. Neurologic injuries were assigned to 2 categories, disabling or not disabling, by 2 physicians acting independently and blinded to the hospital of origin. Data were analyzed using multivariate logistic regression, with hospital location, patient age, gender, anatomic level of injury, and injury mechanism serving as explanatory variables. RESULTS: There was less neurologic disability in the unimmobilized Malaysian patients (OR 2.03; 95% CI 1.03-3.99; $p = 0.04$). This corresponds to a <2% chance that immobilization has any beneficial effect. Results were similar when the analysis was limited to patients with cervical injuries (OR 1.52; 95% CI 0.64-3.62; $p = 0.34$). CONCLUSION: Out-of-hospital immobilization has little or no effect on neurologic outcome in patients with blunt spinal injuries.

NHMRC: Retrospective chart review IV

QUALITY: Good - Fair observational study,

OUTCOME: Neurological outcome at discharge.

Retrospective chart review of comparing a cohort of patients with spinal immobilization with a cohort of patients receiving no immobilization .

Houghton DJ & Curley JWA. *Dysphagia caused by a hard cervical collar.* British Journal of Neurosurgery 1996;10(5):501-502

It is important to consider unusual neck anatomy when fitting hard cervical collars after neurosurgical procedures. A collar which fits too tightly may restrict laryngeal movement during swallowing causing dysphagia, which could be mistaken for damage to neuromuscular function in this group of patients.

NHMRC: Extrapolated data

QUALITY: Poor – case study study (n = 1)

OUTCOME: N/A

Single patient case study of dysphagia caused by hard cervical collar in patient with cervical myelopathy secondary to rheumatoid arthritis

Huerta C, Griffith R and Joyce SM. *Cervical spine stabilization in pediatric patients: evaluation of current techniques.* Ann Emerg Med 1987; 16 (10): 1121-6

We evaluated the performance of commercially available infant and pediatric cervical collars, both alone and in combination with commonly used supplemental devices (eg, Kendrick Extrication Device, half-spine board). One infant and 11 pediatric-sized collars were tested on mannequins representing an infant and a 5-year old child. Maximum forces generated by cooperative children were measured, then applied to the mannequins to reproduce head and neck flexion, extension, rotation, and lateral motion. Limitation of motion was measured in each direction for each collar and combination method. In general, collars of rigid plastic construction performed better than did foam types. However, when used alone none of the collars provided acceptable immobilization, with even the best allowing 17 degrees flexion, 19 degrees extension, 4 degrees rotation, and 6 degrees lateral motion. When combined with supplemental devices, immobilization to 3 degrees or less in any direction could be achieved. Findings were verified using cooperative children and selected collars. Overall, combination methods were more effective than cervical collars alone (P less than .001) or supplemental devices alone (P less than .05). The modified half-spine board used with a rigid collar and tape was the most effective combination method. We conclude that prehospital cervical spine stabilization in pediatric patients is best accomplished using a rigid-type cervical collar in combination with supplemental devices as described.

NHMRC: Healthy volunteers and mannequin study - extrapolated data

QUALITY: Poor

OUTCOME: Spinal movement

Comparison of different collars, extrication devices, spine boards, tapes, head brace devices, bean bags and combinations of these devices.

Krell JM, McCoy MS, Sparto PJ, Fisher GL, Stoy WA, Hostler DP. *Comparison of the Ferno Scoop Stretcher with the long backboard for spinal immobilization.* Prehosp Emerg Care 2006; 10 (1): 46-51

OBJECTIVES: Spinal immobilization is essential in reducing risk of further spinal injuries in trauma patients. The authors compared the traditional long backboard (LBB) with the Ferno Scoop Stretcher (FSS) (Model 65-EXL). They hypothesized no difference in movement during application and immobilization between the FSS and the LBB. METHODS: Thirty-one adult subjects had electromagnetic sensors secured over the nasion (forehead) and the C3 and T12 spinous processes and were placed in a rigid cervical collar, with movement recorded by a goniometer (a motion analysis system). Subjects were tested on both the FSS and the LBB. The sagittal flexion, lateral flexion, and axial rotation were recorded during each of four phases: 1) baseline, 2) application (logroll onto the LBB or placement of the FSS around the patient), 3) secured logroll, and 4) lifting. Comfort and perceived security also were assessed on a visual analog scale. RESULTS: There was approximately 6-8 degrees greater motion in the sagittal, lateral, and axial planes during the application of the LBB compared with the FSS (both $p < 0.001$). No difference was found during a secured logroll maneuver. The FSS induced more sagittal flexion during the lift than the LBB ($p < 0.001$). The FSS demonstrated superior comfort and perceived security. CONCLUSION: The FSS caused significantly less movement on application and increased comfort levels. Decreased movement using the FSS may reduce the risk of further spinal cord injury.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair, study funded by Ferno - CoI

OUTCOME: Spinal movement, patient comfort

Comparison of long back board with scoop stretcher when moving collared volunteers.

Kwan I and Bunn F. *Effects of prehospital spinal immobilization: a systematic review of randomized trials on healthy subjects.* Prehosp & Dis Med 2005; 20 (1): 47-53

OBJECTIVE: To evaluate the effects of spinal immobilization on healthy participants. METHODS: A systematic review of randomized, controlled trials of spinal immobilization on healthy participants. RESULTS: Seventeen randomized, controlled trials compared different types of immobilization devices, including collars, backboards, splints, and body strapping. For immobilization efficacy, collars, spine boards, vacuum splints, and abdominal/torso strapping provided a significant reduction in spinal movement. Adverse effects of spinal immobilization included a significant increase in respiratory effort, skin ischemia, pain, and discomfort. CONCLUSIONS: Data from this review provide the best available evidence to support the well-recognized efficacy and potential adverse effects of spinal immobilization. However, comparisons of different immobilization strategies on trauma victims must be considered in order to establish an evidence base for this practice.

NHMRC: Systematic review of trials on healthy volunteers - extrapolated data

QUALITY: not rated - for information only

OUTCOME: Patient comfort, interface pressure, spinal movement, respiratory effort

Systemic review of randomized, controlled trials of spinal immobilization on healthy volunteers

Kwan I, Bunn F and Roberts IG. *Spinal immobilisation for trauma patients.* Cochrane Database of Systematic Reviews 2009; (11)

Background, Spinal immobilisation involves the use of a number of devices and strategies to stabilise the spinal column after injury and thus prevent spinal cord damage. The practice is widely recommended and widely used in trauma patients with suspected spinal cord injury in the pre-hospital setting., Objectives, To quantify the effect of different methods of spinal immobilisation (including immobilisation versus no immobilisation) on mortality, neurological disability, spinal stability and adverse effects in trauma patients., Search strategy, We searched the Cochrane Central Register of Controlled Trials (CENTRAL), the Cochrane Injuries Group's specialised register, MEDLINE, EMBASE, CINAHL, PubMed, National Research Register and Zetoc. We checked reference lists of all articles and contacted experts in the field to identify eligible trials. Manufacturers of spinal immobilisation devices were also contacted for information. Searches were last updated in July 2007., Selection criteria, Randomised controlled trials comparing spinal immobilisation strategies in trauma patients with suspected spinal cord injury. Trials in healthy volunteers were excluded., Data collection and analysis, We independently applied eligibility criteria to trial reports and extracted data., Main results, We found no randomised controlled trials of spinal immobilisation strategies in trauma patients., Authors' conclusions, We did not find any randomised controlled trials that met the inclusion criteria. The effect of spinal immobilisation on mortality, neurological injury, spinal stability and adverse effects in trauma patients remains uncertain. Because airway obstruction is a major cause of preventable death in trauma patients, and spinal immobilisation, particularly of the cervical spine, can contribute to airway compromise, the possibility that immobilisation may increase mortality and morbidity cannot be excluded. Large prospective studies are needed to validate the decision criteria for spinal immobilisation in trauma patients with high risk of spinal injury. Randomised controlled trials in trauma patients are required to establish the relative effectiveness of alternative strategies for spinal immobilisation.

NHMRC: Cochrane systemic review

QUALITY: not rated - for information only

OUTCOME: neurological outcome, spinal movement, adverse effects, mortality

Systemic review to quantify the effects of different methods of spinal immobilization on outcomes.

Liew SCC & Hill DA. *Complication of hard cervical collars In multi-trauma patients.* Aust NZ J Surg. 1994; 64, 139-140.

All multi-trauma patients with suspected cervical spine injury should have their cervical spine protected while other life-threatening injuries are being managed. The application of a hard cervical collar is an acceptable method of temporarily immobilizing the cervical spine. Two cases of significant occipital pressure ulceration associated with the use of hard cervical collar are presented.

NHMRC: Extrapolated data from multiple trauma patients

QUALITY: Poor – case study study (n = 2)

OUTCOME: N/A

Two patient case reports of significant pressure ulceration requiring additional surgical intervention in the operating theatre caused by cervical immobilisation (both patients managed with a hard cervical collar, plus cervical traction in one case).

Lerner EB, Billittier AJ, Moscati RM. *The effects of neutral positioning with and without padding on spinal immobilization of healthy subjects. Prehosp Emerg Care 1998; 2 (2): 112-6*

OBJECTIVES: To compare the incidences and severities of pain experienced by healthy volunteers undergoing spinal immobilization in the neutral position with and without occipital padding. To compare the incidence of pain when immobilized in the neutral position with the incidence in a nonneutral position. **METHODS:** Thirty-nine healthy volunteers over the age of 18 years who had no acute pain or illness, were not pregnant, and had no history of back problems or surgery voluntarily participated in a prospective, randomized, crossover study conducted in a clinical laboratory setting. Appropriately sized rigid cervical collars were applied to the subjects, who were then immobilized on wooden backboards with their cervical spines maintained in the neutral position using towels (padded) or plywood (unpadded) under their occiputs. The subjects were secured to the board with straps, soft head blocks, and tape for 15 minutes to simulate a typical ambulance transport time. The straps, head blocks, and tape were removed, and the subjects remained on the board for an additional 45 minutes to simulate a typical emergency department experience. The subjects were then asked to identify the location(s) of any pain on anterior and posterior body outlines and to indicate the corresponding severity of pain on a 10-cm visual analog scale. The subjects were also asked questions about movement, respiratory symptoms, and strap discomfort in an attempt to distract them from the true focus of the study (i.e., pain). A similar survey was given to each participant to complete 24 hours later. The same subjects were immobilized with the alternate occipital material a minimum of two weeks later utilizing the same procedure. They again completed both surveys. **RESULTS:** Pain was reported by 76.9% of the subjects following removal from the backboard for the unpadded trial and 69.2% of the subjects following the padded trial ($p < 0.45$). Twenty-three percent (23.1%) of the subjects reported neck pain after the unpadded trial, while 38.5% reported neck pain after the padded trial ($p < 0.07$). Occipital pain was reported by 35.9% in the unpadded trial and 25.6% in the padded trial ($p < 0.29$). Twenty-four hours later, pain was reported by 17.9% of the subjects following the unpadded trial and 23.1% of the subjects following the padded trial ($p < 0.63$). Eight percent (7.7%) reported neck pain 24 hours after the unpadded trial and 12.8% after the padded trial ($p < 0.5$). Occipital pain was reported by 7.7% of the subjects 24 hours after the unpadded trial and 2.6% after the padded trial ($p < 0.63$). This study had a power of 0.90 to detect a difference of 30% between the trials. The authors found a significantly lower incidence of pain ($p < 0.01$) and occipital pain ($p < 0.01$) in their unpadded trial compared with that reported by Chan et al., who used neither padding nor neutral positioning to immobilize subjects. **CONCLUSIONS:** Pain is frequently reported by healthy volunteers following spinal immobilization. Occipital padding does not appear to significantly decrease the incidence or severity of pain. Alignment of the cervical spine in the neutral position may reduce the incidence of pain, but further studies should be conducted to substantiate this observation.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Patient comfort

Comparison of collar and backboard with or without padding under the head.

Main PW and Lovell ME. *A review of seven support surfaces with emphasis on their protection of the spineally injured. J Acc Emerg Med 1996; 13 (1): 34-7*

The aim was to evaluate seven evacuation support surfaces. These included the conventional spinal board, two designs of vacuum stretcher, a prototype support surface which was a combination of both principles, and three conventional stretchers. Interface pressures were evaluated in four healthy volunteers. The sacral and thoracic interface pressures were measured. Mean sacral readings were: spinal board 233.5 mm Hg, old vacuum stretcher 139 mm Hg, new design 94.8 mm Hg, prototype board 119.5 mm Hg, York Two stretcher 46 mm Hg, Army stretcher 61 mm Hg, and the PVC and aluminium stretcher 66 mm Hg. Thoracic pressure readings were: spinal board 82.9 mm Hg, old design vacuum stretcher 58 mm Hg, new design 37.8 mm Hg, prototype board 53.7 mm Hg, York two 21 mm

Hg, army stretcher 35.4 mm Hg, and PVC stretcher 38.5 mm Hg. Analysis of variance showed both distributions to be highly significant ($P < 0.001$). The spinal board has several deficiencies, including lack of support for the lumbar lordosis. It should not be the preferred surface for the transfer of patients with spinal injuries.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Poor

OUTCOME: Interface pressure

Comparison of difference stretchers and spinal backboards.

Mazolewski P and Manix TH. *The effectiveness of strapping techniques in spinal immobilization.* Ann Emerg Med 1994; 23 (6): 1290-5

STUDY OBJECTIVES: To test the effectiveness of strapping techniques in reducing lateral motion of volunteers restrained on a backboard. DESIGN: Randomized block experimentation. SETTING: Medical products research and design laboratory. PARTICIPANTS: Healthy adult volunteers with no history of head, neck, or back trauma. INTERVENTIONS: Subjects were restrained on a wooden backboard using a control and three variations of strapping techniques. The backboard was rolled 90 degrees to the side, and lateral motion of the torso was measured. MEASUREMENTS AND MAIN RESULTS: Nineteen subjects participated. Technique 2, which added an abdominal strap to the control technique, reduced 26% of the lateral motion. CONCLUSION: Additional, specifically placed strapping should be added to the torso to reduce lateral motion on a backboard. Further study is needed to determine the effect of lateral motion in the spine and potential benefits of reduced motion.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair Poor - ? relevanceto PICO Q

OUTCOME: Patient movement

Comparison of different strapping techniques in the prevention of lateral body movement when moved on a spine board.

Nypaver M and Treloar D. *Neutral cervical spine positioning in children.* Ann Emerg Med 1994; 23 (2): 208-11

STUDY OBJECTIVES: To determine the height of back elevation required to place the cervical spine of children less than 8 years old in neutral position and whether agreement on the height required for neutral position could be reached by two independent observers. STUDY DESIGN: Prospective. SETTING: Pediatric emergency department and outpatient clinics. TYPE OF PARTICIPANTS: Convenience sample of children less than 8 years old. INTERVENTIONS: Independent placement of children in neutral position by two observers using standard sized padding with or without shims to raise the back off a backboard. MEASUREMENTS AND RESULTS: All children required elevation of the back for correct neutral position (mean height, 25.4 +/- 6.7 mm; range, 5 to 41 mm). Children less than 4 years old required more elevation than those ≥ 4 years old (27 +/- 7.2 vs 22 +/- 4.2 mm, $P < .05$). Independent observer measurements were similar (mean, 25 +/- 8.0 vs 25.7 +/- 6.8 mm; interobserver kappa = .56). CONCLUSION: Children less than 8 years old require back elevation to achieve neutral position while lying supine on a backboard. Also, independent observers can agree on what constitutes neutral position in most children.

Nypaver M

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Correct (neutral) spinal alignment determined by observation.

Determination of back elevation required to place cervical spine of children < 8 in a neutral position.

Perry SD, McLellan B, McIlroy WE, Maki BE, Schwartz M and Fernie GR. *The efficacy of head immobilization techniques during simulated vehicle motion.* Spine 1999; 24 (17): 1839-44

STUDY DESIGN: Laboratory experiment. OBJECTIVE: To compare the efficacy of different head immobilization techniques during motion simulating ambulance transport. BACKGROUND: A significant number of neurologic injuries associated with cervical spine fractures arise or are aggravated during emergency extrication or patient transport. Previous studies have not addressed the effect of head immobilization on the passive motion that could occur across the neck during transport. METHODS: Three different head-immobilization methods were compared in six healthy young adults by using a computer-controlled moving platform to simulate the swaying and jarring

movements that can occur during ambulance transport. In all tests, the trunk was secured by means of a commonly used "criss-cross" strapping technique. Efficacy of head immobilization was evaluated using measures of head motion and neck rotation. RESULTS: None of the three immobilization techniques was successful in eliminating head motion or neck rotation. Movement of the trunk contributed substantially to the lateral bending that occurred across the neck. A new product involving the placement of wedges underneath the head provided some small, but statistically significant improvements in fixation of the head to the fracture board; however, there was no improvement in terms of the relative motion occurring across the neck. CONCLUSIONS: Somewhat improved fixation of the head to the fracture board can be achieved by placing wedges under the head; however, the benefits of any fixation method, in terms of cervical spine immobilization, are likely to be limited unless the motion of the trunk is also controlled effectively. Future research and development should address techniques to better control head and trunk motion.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Neck movement

Comparison of head brace, rolled towels and wedges in the prevention of movement of collared patients strapped on a spinal backboard.

Podolsky S, Baraff LJ, Simon RR, Hoffman JR, Larmon B, Ablon W. *Efficacy of cervical spine immobilization methods.* J Trauma. 1983 Jun;23(6):461-5.

Cervical spine immobilization devices are widely used to stabilize the cervical spine and prevent neurologic deficits associated with unstable fractures. In order to quantitate their efficacy we measured controlled cervical spine motion in three axes, using six different immobilization methods in 25 volunteers instructed to actively move their necks as much as possible in the directions of flexion, extension, rotation, and lateral bending while lying supine. Control measurements were made with no device and measurements were repeated following immobilization with: soft collar (SC), hard collar (HC), extrication collar (EC), Philadelphia collar (PC), bilateral sandbags joined with 3-inch cloth tape across the forehead (ST), and the combination of sandbags, tape, and the Philadelphia collar (ST/PC). Neck movements were reported in degrees recorded on a hand-held goniometer. There were no significant differences between control and SC measurements except in rotary movement. PC was not significantly better than the other two types of hard collars, except in limiting extension. ST immobilization was significantly better than any of the other four methods used alone, for all four movements. The addition of PC to ST was significantly more effective in reducing extension only.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Poor

OUTCOME: Prevention of movement

Compared soft collar (SC), hard collar (HC), extrication collar (EC), Philadelphia collar (PC), bilateral sandbags joined with 3-inch cloth tape across the forehead (ST), and the combination of sandbags, tape, and the Philadelphia collar (ST/PC).

Ramasamy A, Midwinter M, Mahoney P, Clasper J. *Learning the lessons from conflict: pre-hospital cervical spine stabilisation following ballistic neck trauma.* Injury. 2009 Dec;40(12):1342-5.

BACKGROUND: Current ATLS protocols dictate that spinal precautions should be in place when a casualty has sustained trauma from a significant mechanism of injury likely to damage the cervical spine. In hostile environments, the application of these precautions can place pre-hospital medical teams at considerable personal risk. It may also prevent or delay the identification of airway problems. In today's global threat from terrorism, this hostile environment is no longer restricted to conflict zones. The aim of this study was to ascertain the incidence of cervical spine injury following penetrating ballistic neck trauma in order to evaluate the need for pre-hospital cervical immobilisation in these casualties. METHODS: We retrospectively reviewed the medical records of British military casualties of combat, from Iraq and Afghanistan presenting with a penetrating neck injury during the last 5.5 years. For each patient, the mechanism of injury, neurological state on admission, medical and surgical intervention was recorded. RESULTS: During the study period, 90 casualties sustained a penetrating neck injury. The mechanism of injury was by explosion in 66 (73%) and from gunshot wounds in 24 (27%). Cervical spine injuries (either cervical spine fracture or cervical spinal cord injury) were present in 20 of the 90 (22%) casualties, but only 6 of these (7%)

actually survived to reach hospital. Four of this six subsequently died from injuries within 72 h. Only 1 (1.8%) of the 56 survivors to reach a surgical facility sustained an unstable cervical spine injury that required surgical stabilisation. This patient later died as result of a co-existing head injury. **CONCLUSIONS:** Penetrating ballistic trauma to the neck is associated with a high mortality rate. Our data suggests that it is very unlikely that penetrating ballistic trauma to the neck will result in an unstable cervical spine in survivors. In a hazardous environment (e.g. shooting incidents or terrorist bombings), the risk/benefit ratio of mandatory spinal immobilisation is unfavourable and may place medical teams at prolonged risk. In addition cervical collars may hide potential life-threatening conditions.

NHMRC: Military casualties with penetrating neck injury

QUALITY: Poor

OUTCOME: Prevention of movement

Retrospective medical record review to determine the incidence of cervical spine injury following penetrating ballistic neck trauma in order to evaluate the need for pre-hospital cervical immobilisation in these casualties.

Schafermeyer RW, Ribbeck BM, Gaskins J, Thomason S, Harlan M and Attkisson A. *Respiratory effects of spinal immobilization in children.* Ann Emerg Med 1991; 20 (9): 1017-9

STUDY OBJECTIVE: To assess the restrictive effects of two spinal immobilization strapping techniques on the respiratory capacity of normal, healthy children. **DESIGN:** Prospective study with each subject serving as his own control. **PARTICIPANTS:** Fifty-one healthy children 6 to 15 years old. **INTERVENTIONS:** Participants' forced vital capacity (FVC) measurements were first obtained with children standing and lying supine and then in full spinal immobilization using two different strapping configurations, cross straps and lateral straps. Straps were tightened to allow one hand to fit snugly between the strap and child. **MEASUREMENTS AND MAIN RESULTS:** Supine FVC was less than upright FVC (P less than .001). FVC in spinal immobilization ranged from 41% to 96% of supine FVC (80 +/- 9%). There was no difference in FVCs between strapping techniques (P = .83). **CONCLUSION:** Spinal immobilization significantly reduced respiratory capacity as measured by FVC in healthy patients 6 to 15 years old. There is no significant benefit of one strapping technique over the other.

NHMRC: Healthy volunteers - extrapolated data, some evidence of potential for harm

QUALITY: Fair

OUTCOME: Respiratory capacity (FVC)

Comparison of strapping techniques in paediatric patients.

Schriger DL, Larmon B, LeGassick T and Blinman T. *Spinal immobilization on a flat backboard: does it result in neutral position of the cervical spine?* Ann Emerg Med 1991; 20 (8): 878-81

STUDY OBJECTIVES: To determine the amount of occipital padding required to achieve neutral position of the cervical spine when a patient is immobilized on a flat backboard. Neutral position was defined as the normal anatomic position of the head and torso that one assumes when standing looking straight ahead. **DESIGN:** Descriptive with hypothesis testing of selected descriptive elements. **SETTING:** University campus and hospital. **SUBJECTS:** One hundred healthy young adults with no history of back disease. **INTERVENTIONS:** Volunteers were measured in standing and supine positions. **MEASUREMENTS:** Occipital offset; height; weight; and head, neck, and chest circumferences were measured for each subject. **MAIN RESULTS:** The amount of occipital offset required to achieve neutral position varied from 0 to 3.75 in. (mean, 1.5 in.). Mean occipital offset for men (1.67 in.) was significantly greater than that for women (1.31 in.) Easily obtained body measurements did not accurately predict occipital offset. **CONCLUSION:** Immobilization on a flat backboard would place 98% of our study subjects in relative cervical extension. Occipital padding would place a greater percentage of patients in neutral position and increase patient comfort during transport.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Cervical spine positioning

Determination of occipital padding required for neutral spine positioning.

Sheerin F and de Frein R. *The occipital and sacral pressures experienced by healthy volunteers under spinal immobilization: a trial of three surfaces.* J Emerg Nurs 2007; 33 (5): 447-50

BACKGROUND: The development of a pressure ulcer is of great significance to the life-long rehabilitative management of the person with a spinal cord injury, and may indeed delay and repeatedly interfere with that process. That the period preceding admission to the specialized spinal injury unit is crucial with regard to pressure ulcer development is evident in the professional literature. Both anecdotal and empirical evidence indicates that a significant number of pressure ulcers occur as a result of management provided prior to admission, and that such ulcers are more likely to occur in those patients who have undergone a transfer process from a hospital distal to the specialist unit on a hard spinal board. AIM: In consideration of this and of the fact that, in Ireland, the interhospital transfer of spinal injured patients has usually involved the employment of such spinal boards to achieve immobilization, this study sought to identify whether or not the pressure experienced by individuals at two anatomical locations was dependent on the support surface employed. METHODOLOGY: Pressure under the occiput and sacrum of three healthy volunteers immobilized on three support surfaces was measured using air-filled pressure-measuring sacks. The surfaces employed were an uncovered spinal board; a spinal board with inflatable raft device; and a full-body vacuum splint. DISCUSSION: Marked reductions in pressure were measured when using the inflatable raft and the vacuum mattress. The results of this study will provide a basis for a larger study and, through that, the formulation of recommendations for standardized practice along a national care pathway.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Poor

OUTCOME: Interface pressure

Comparison of spine board with and without padding device, and vacuum mattress.

Totten VY and Sugarman DB. *Respiratory effects of spinal immobilization.* Prehosp Emerg Care 1999; 3 (4): 347-52

OBJECTIVE: To evaluate the effect of whole-body spinal immobilization on respiration. METHODS: This was a randomized, crossover laboratory study with 39 human volunteer subjects (20 males; 19 females) ranging in age from 7 to 85 years. Respiratory function was measured three times: at baseline (seated or lying), immobilized with a Philadelphia collar on a hard wooden backboard, and on a Scandinavian vacuum mattress with a vacuum collar. The comfort levels of each of the two methods were assessed on a forced Likert scale. RESULTS: Both immobilization methods restricted respiration, 15% on the average. The effects were similar under the two immobilization conditions, although the FEV1 was lower on the vacuum mattress. Respiratory restriction was more pronounced at the extremes of age. The vacuum mattress was significantly more comfortable. CONCLUSION: This study confirmed the previously reported respiratory restriction caused by spinal immobilization. Vacuum mattresses are more comfortable than wooden backboards.

NHMRC: Healthy volunteers - extrapolated data, ? some evidence of potential harm

QUALITY: Fair

OUTCOME: Respiratory function (FEV1), patient comfort

Comparison of control, backboard with collar, vacuum mattress with a vacuum collar.

Walton R, DeSalvo JF, Ernst AA and Shahane A. *Padded vs unpadded spine board for cervical spine immobilization.* Acad Emerg Med 1995; 2 (8): 725-8

OBJECTIVES: To determine whether padding the long spine board improves patient comfort, affects cervical spine (c-spine) immobilization, or increases sacral transcutaneous O₂ tension. METHODS: A prospective randomized, controlled crossover study of healthy volunteers was conducted over a two-week period. Participants included 30 volunteers with no previous history of c-spine injury or disease. The subjects were randomized to either padded or unpadded long spine board immobilization with serial measurements of discomfort (using a visual analog scale) and transcutaneous tissue O₂ tension obtained at zero and 30 minutes. Measurements of ability to flex, extend, rotate, and laterally bend the c-spine were made using a goniometer. The subjects then returned a minimum of three days later to complete the opposite half of the study (padded vs unpadded boards). RESULTS: Subject discomfort was significantly reduced in the padded group compared with the unpadded group ($p = 0.024$). There was no significant difference in flexion ($p = 0.410$), extension ($p = 0.231$), rotation ($p = 0.891$), or lateral bending ($p = 0.230$) for the two groups. There was no significant difference in the actual drop in sacral transcutaneous O₂ tension from time zero to 30 minutes for the padded and the unpadded groups (mean drop = 14.8% +/- 17.5% vs 12.2% +/- 16.8%,

respectively; $p = 0.906$). CONCLUSION: Adding closed-cell foam padding to a long spine board significantly improves comfort without compromising c-spine immobilization. Sacral tissue oxygenation does not appear affected by such padding for healthy volunteers.

NHMRC: Healthy volunteers - extrapolated data

QUALITY: Fair

OUTCOME: Patient comfort, interface pressure, neck movement,
Comparison of spine board with and without padding.