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Spinal immobilisation for trauma patients (Review)

Kwan I, Bunn F, Roberts IG

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[Intervention Review]

Spinal immobilisation for trauma patients

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ABSTRACT

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 methods

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.

PLAIN LANGUAGE SUMMARY

Spinal immobilisation for trauma patients

Spinal cord damage from injury causes long-term disability and can dramatically affect quality of life. The current practice of immobilising trauma patients before hospitalisation to prevent more damage may not always be necessary, as the likelihood of further damage is small. Means of immobilisation include holding the head in the midline, log rolling the person, the use of backboards and special mattresses, cervical collars, sandbags and straps. These can cause tissue pressure and discomfort, difficulty in swallowing and serious breathing problems.

The review authors could not find any randomised controlled trials of spinal immobilisation strategies in trauma patients. It is feasible to have trials comparing the different spinal immobilisation strategies. From studies of healthy volunteers it has been suggested that patients who are conscious, might reposition themselves to relieve the discomfort caused by immobilisation, which could theoretically worsen any existing spinal injuries.

BACKGROUND

The incidence of spinal cord injury (SCI) in the USA is estimated to be between 40 and 50 cases per million people per year (SCI Center 1998). Spinal cord injury results in long-term disability, often with profound effects on the quality of life of the affected individuals and their carers. In the USA, the lifetime medical costs resulting from spinal cord injury are estimated at nine billion dollars per year (Miller 1994). Existing data in developing countries are limited. A study from Beijing estimated the incidence of SCI at seven cases per million people per year (Wang 1990). Acute traumatic SCI occurs in about 3% of trauma admissions, and around half of these injuries involved the cervical spine (Burney 1993). In males under the age of 50, road traffic crashes are the most common cause of SCI (Burney 1993).

In response to the concern that an unstable spine will increase the frequency and severity of neurological injury, a number of approaches have been developed that aim to achieve spinal immobilisation. The two main methods are manual stabilisation and the use of orthotic devices such as backboards and splints, with a combination of adjuncts including cervical collars, sandbags and straps. Pre-hospital spinal immobilisation aims to stabilise the spine by restricting mobility, thus preventing secondary SCI during extrication, resuscitation, transport and evaluation of trauma patients with suspected spinal instability. It is estimated that 5% of trauma patients with cervical spinal injuries have missed or delayed diagnosis (Davis 1993), resulting in preventable mortality and morbidity. Occult cervical spine injuries may be more likely to be missed in obtunded patients with unstable spines, in whom it may be masked by the pain of multi-system injury and altered level of alertness. Spinal immobilisation is now routinely practised in the pre-hospital care of trauma patients and is widely recommended in a range of resuscitation guidelines (Advanced LS 1993, Advanced Paediatric Life Support, Pre-hospital Trauma Life Support, Advanced Life Support Group 1993, ACS 1997).

Despite the widespread use of spinal immobilisation, the clinical benefits of pre-hospital spinal immobilisation have been questioned. It has been argued that spinal cord damage is done at the time of impact and that subsequent movement is generally not sufficient to cause further damage (Hauswald 1998). Most trauma patients do not have spinal instability and, hence, will not benefit from spinal immobilisation. Nevertheless, largely in response to the fear of litigation, some five million patients in the US receive spinal immobilisation every year (Orledge 1998). However, there may be adverse effects. Observational studies have shown that rigid collars may cause airway difficulties, increased intracranial pressure (Davies 1996), increased risk of aspiration (Butman 1996), restricted respiration (Totten 1999), dysphagia (Houghton 1996) and skin ulceration (Hewitt 1994). Because any benefits of spinal immobilisation may be outweighed by the risks, the value of routine pre-hospital spinal immobilisation remains uncertain.

This systematic review aims to quantify the effect of different spinal immobilisation devices (including immobilisation versus no immobilisation) on their ability to immobilise the spine and on mortality, neurological injury, and adverse effects in trauma patients.

OBJECTIVES

- To quantify the effect of spinal immobilisation versus no spinal immobilisation on mortality, neurological injury, spinal stability and adverse effects in trauma patients.
- To quantify the effect of different spinal immobilisation strategies on mortality, neurological injury, spinal stability and adverse effects in trauma patients.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials.

Types of participants

Trauma patients with suspected spinal cord injury.

Types of interventions

All strategies of spinal immobilisation including:

- backboards, mattress splints
- rigid and soft collars
- sandbags, straps or tapes
- collar and backboard combinations
- holding the head in the midline
- log rolling the patient.

Types of outcome measures

- Mortality.
- Neurological injury.
- Degree of spinal stability.
- Adverse effects.

Search methods for identification of studies

Electronic searches

We searched the following electronic databases;

- Cochrane Injuries Group's specialised register
- Cochrane Central Register of Controlled Trials (CENTRAL)
- MEDLINE
- EMBASE
- CINAHL
- National Research Register
- ZETOC
- http://www.clinicaltrials.gov
- http://www.controlled-trials.com/mrct

These searches were last carried out in July 2007. The full search strategies are presented in the additional tables: Table 1 shows search strategies used previously in May 2003, Appendix 1 shows strategies used for the July 2007 update.

Searching other resources

Additionally all references in the background papers were checked and six authors contacted to identify potential published or unpublished data. Eight manufacturers of immobilisation devices were also contacted. There was no language restriction in any of the searches.

Data collection and analysis

Selection of studies

One author (IK) examined the electronic search results for reports of possibly relevant trials and these reports were then retrieved in full. One author (FB) examined 10% of the electronic search results to check for agreement on eligibility criteria. Two authors (FB, IK) applied the selection criteria independently to the trial reports, resolving disagreements by discussion with a third author (IR).

The following are the proposed methods which will be applicable if trials are found during subsequent updates of the review.

Data extraction and management

Two authors will independently extract data and information on the following:

- method of allocation concealment,
- number of randomised patients,
- type of participants,
- type of interventions,
- loss to follow-up,
- length of follow-up.

The authors will not be blind to the study authors or journal when doing this. Results will be compared and any differences resolved by discussion.

Where there is insufficient information in the published report, we will attempt to contact the trial authors for clarification.

Assessment of risk of bias in included studies

Since there is evidence that the quality of allocation concealment particularly affects the results of studies (Schulz 1995), two authors will score this quality on the scale used by Schulz as shown below, assigning C to poorest quality and A to best quality:

- A = trials deemed to have taken adequate measures to conceal allocation (that is, central randomisation; serially numbered, opaque, sealed envelopes; or other description that contained elements convincing of concealment)
- B = trials in which the authors either did not report an allocation concealment approach at all or reported an approach that did not fall into one of the other categories.
- C = trials in which concealment was inadequate (such as alternation or reference to case record numbers or to dates of birth).

If the method used to conceal allocation is not clearly reported, the trial author(s) will be contacted, if possible, for clarification.

Differences will be resolved through discussion.

We will assess the skewness of continuous data by checking the mean and standard deviation (if available). If the standard deviation is more than twice the mean for data with a finite end point, the data are likely to be skewed and it is inappropriate to apply parametric tests (Altman 1996). This is because the mean is unlikely to be a good measure of central tendency. If parametric tests cannot be applied, we will tabulate the data.

Assessment of heterogeneity

The groups of trials will be examined for statistical evidence of heterogeneity using a chi-squared test. If there is no obvious heterogeneity on visual inspection or statistical testing, pooled RR and 95% confidence intervals will be calculated using a fixed effects model.

Data synthesis

The following comparisons are proposed;

- spinal versus no spinal immobilisation,
- different strategies of spinal immobilisation.

For dichotomous outcomes, such as death, the relative risk (RR) will be calculated with 95% confidence intervals, such that a RR of more than 1 indicates a higher risk of death in the first group named. The RR will be used as it is more readily applied to the clinical situation.

Sensitivity analysis

The effect of excluding trials judged to have inadequate (scoring C) allocation concealment will be examined in a sensitivity analysis.

RESULTS

Description of studies

No randomised controlled trials comparing the effect of spinal immobilisation strategies on trauma patients were found.

Risk of bias in included studies

Not applicable.

Effects of interventions

Our search strategy identified 4453 potentially eligible reports. However, there were no trials meeting the inclusion criteria. A number of randomised controlled trials were identified comparing different spinal immobilisation strategies in healthy volunteers. The results of randomised controlled trials on healthy volunteers may provide some useful insights into their relative effectiveness in trauma patients. For this reason, although trials of healthy volunteers did not meet our inclusion criteria, we have summarised them in the additional tables (Table 2) of the review.

DISCUSSION

We did not find any randomised controlled trials comparing different strategies of spinal immobilisation in trauma patients. The effect of spinal immobilisation on mortality, neurological injury, spinal stability and adverse effects in trauma patients therefore remains uncertain.

We screened 4453 potentially relevant papers, checked their reference lists and contacted experts in the field. We also contacted manufacturers of immobilisation devices for additional information. While it is possible that we might have missed a randomised controlled trial comparing spinal immobilisation techniques in trauma patients, we believe that, due to our thorough search strategy, this is unlikely.

The current protocol for pre-hospital spinal immobilisation has a strong historical rather than scientific precedent, based on the concern that a patient with an injured spine may deteriorate neurologically without immobilisation. The medical and legal concern of missing a cervical spinal injury has lent strong support for the conservative approach of liberal pre-hospital spinal immobilisation to almost all patients with trauma and possible neck injury, regardless of clinical complaint (Butman 1996). It is also suggested that iatrogenic cord damage could be reduced with better paramedic training and improved immobilisation procedures (Perry 1999). However, it has been argued that considerable force is required to fracture the spine at the initial impact, and that any subsequent movements of the spine are unlikely to cause further damage to the spinal cord (Hauswald 1998). It has also been suggested that pre-hospital spinal immobilisation has never been shown to affect outcome and that estimates in the literature regarding the incidence of neurological injury due to inadequate immobilisation may have been exaggerated (Hauswald 1998; Hauswald 2000). This calls into question the present routine use of pre-hospital spinal immobilisation.

For some patients, effective spinal immobilisation is prudent and can be vital to prevent the devastating effects of cord damage, yet for many the excessive use of this precaution may not be beneficial or necessary. It is estimated that over 50% of trauma patients with no complaint of neck or back pain were transported with full spinal immobilisation (McHugh 1998). Unwarranted spinal immobilisation can expose patients to the risks of iatrogenic pain, skin ulceration, aspiration and respiratory compromise, which in turn can lead to multiple radiographs, resulting in unnecessary radiation exposure, longer hospital stay and increased costs. The potential risks of aspiration and respiratory compromise are of concern because death from asphyxiation is one of the major causes of preventable death in trauma patients.

A set of highly sensitive clinical criteria has been developed and validated (Hoffman 2000) to identify trauma patients at low risk of spinal injury and rule out their need for radiography. These are trauma patients with absence of: neck pain or tenderness, altered level of consciousness, neurological deficit, evidence of intoxication and painful distracting injury. It has been suggested that a similar decision instrument could be developed for use in the pre-hospital setting, to establish the need to immobilise or not to immobilise (Domeier 1999). This is in addition to the criteria of mechanism of injury as the main determinant for out-of-hospital spinal immobilisation.

There are a lack of data from randomised controlled trials to support the practice of pre-hospital spinal immobilisation in trauma patients. While it may not be possible to conduct randomised controlled trials of spinal immobilisation versus no immobilisation in trauma patients, it may be feasible to consider such trials, comparing the different spinal immobilisation strategies, in outcomes of immobilisation efficacy, respiratory effects, tissue pressure and patient comfort in this target population. Results of randomised controlled trials on healthy volunteers may provide some useful insights into their relative effectiveness in trauma patients. For this reason although trials of healthy volunteers did not meet our inclusion criteria we have summarised them in the additional tables section of the review. For example in healthy volunteers, short-board technique was reported to be more efficient than collars alone in reducing spinal mobility (Cline 1985); vacuum mattress and padded backboards more comfortable than rigid backboards (Hamilton 1996; Hauswald 2000; Johnson 1996; Walton 1995). From these studies on healthy volunteers, it has been suggested that patients on whom spinal immobilisation has been used, and who are conscious, might reposition themselves to relieve the discomfort caused by ischaemia, which could theoretically worsen any existing spinal injuries. Patients who are unable to move or feel pain due to trauma are at risk of soft tissue injuries (Hauswald 2000).

Due to the absence of randomised controlled trials quantifying the effect of spinal immobilisation in trauma patients, and the possible adverse effects of its application, the value of routine pre-hospital spinal immobilisation remains uncertain.

AUTHORS' CONCLUSIONS

Implications for practice

We found no randomised controlled trial which met our inclusion criteria in this review. The effect of pre-hospital spinal immobilisation on mortality, neurological injury, spinal stability and adverse effects in trauma patients therefore 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.

Implications for research

Large prospective studies are needed to validate the decision criteria for spinal immobilisation in trauma patients with high risk of spinal injury. In addition, randomised controlled trials to compare different immobilisation strategies on trauma patients need to be considered in order to establish an evidence base for the practice of pre-hospital spinal immobilisation.

ACKNOWLEDGEMENTS

We thank D Mohan, C Mock, R Norton and M Varghese of the WHO Pre-hospital Trauma Care Steering Committee for their comments and advice on the review.

We also thank R Wentz and K Blackhall for help with the searching, and Dr Jegede for help identifying useful background papers.

Finally, thanks to the authors of background papers and manufacturers for supplying additional information.

REFERENCES

References to studies excluded from this review

Black 1998 *{published data only}*

Black CA, Buderer NMF, Blaylock B, Hogan BJ. Comparative study of risk factors for skin breakdown with cervial orthotic devices: Philadelphia and Aspen. *Journal of Trauma Nursing* 1998;**5**(3):62-6.

Chan 1996 *{published data only}*

Chan D, Goldberg RM, Mason J, Chan L. Backboard versus mattress splint immobiliszation: a comparison of symptoms generated. *Journal of Emergency Medicine* 1996;**14**(3):293-8.

Cline 1985 *{published data only}*

Cline JR, Scheidel E, Bigsby EF. A comparison of methods of cervical immobilization used in patient extrication and transport. *Journal of Trauma* 1985;**25**(7):649-53.

Cordell 1995 *{published data only}*

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

Delbridge 1993 *{published data only}*

Delbridge TR, Auble TE, Garrison HG, Menegazzi JJ. Discomfort in healthy volunteers immobilized on wooden backboards and vacuum mattress splints. *Prehospital & Disaster Medicine* 1993;**8**(3 Suppl):S63.

Graziano 1987 *{published data only}*

Graziano AF, Scheidel EA, Cline JR, Baer LJ. A radiographic comparison of prehospital cervical immobilization methods. *Annals of Emergency Medicine* 1987;**16**(10):1127-31.

Hamilton 1996 *{published data only}*

Hamilton RS, Pons PT. The efficacy and comfort of full-body vacuum splints for cervical-spine immobilization. *Journal of Emergency Medicine* 1996;**14**(5):553-9.

Hauswald 2000 *{published data only}*

Hauswald M, Hsu M, Stockoff C. Maximising comfort and minimizing ischemia: a comparison of four methods of spinal immobilisation. *Prehospital Emergency Care* 2000;**4**:250-2.

Jedlicka 1999 *{published data only}*

Jedlicka DS. A comparison of the effects of two methods of spinal immobilization on respiratory effort in the older adult. *Dissertation Abstracts International* 1999;**58-05B**:2354.

Johnson 1996 *{published data only}*

Johnson DR, Hauswald M, Stockhoff C. Comparison of a vacuum splint device to a rigid backboard for spinal immobilization. *American Journal of Emergency Medicine* 1996;**14**(4):369-72.

Lerner 1998 *{published data only}*

Lerner EB, Billittier AJ 4th, Moscati RM. The effects of neutral positioning with and without padding on spinal immobilization of healthy subjects. *Prehospital Emergency Care* 1998;**2**(2):112-6.

Lunsford 1994 *{published data only}*

Lunsford TR, Davidson M, Lunsford BR. The effectiveness of four contemporary cervical orthoses in restricting cervical motion. *Journal of Prosthetics and Orthotics* 1994;**6**(4):93-9.

Manix 1995a *{published data only}*

Manix T, Gunderson MR, Garth GC. Comparison of prehospital cervical immobilization devices using video and electromyography. *Prehospital Disaster Medicine* 1995;**10**(4):232-8.

Manix 1995b *{published data only}*

Manix T. How effective are body-to-board strapping techniques?. *Journal of Emergency Medical Services* 1995;**20**(6):44-50.

Mazolewski 1994 *{published data only}*

Mazolewski P, Manix T. The effectiveness of strapping techniques in spinal immobilization. *Annals of Emergency Medicine* 1994;**23**(6):1290-5.

Perry 1999 *{published data only}*

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

Totten 1999 *{published data only}*

Totten VY, Sugarman DB. Respiratory effects of spinal immobilization. *Prehospital Emergency Care* 1999;**3**(4):347-52.

Walton 1995 *{published data only}*

Walton R, DeSalva JF, Ernst AA, Shahane A. Padded vs unpadded spine board for cervical spine immobilization. *Academic Emergency Medicine* 1995;**2**(8):725-8.

Additional references

ACS 1997

American College of Surgeons. Advanced trauma Life Support Program for Doctors. 6th Edition. Chicago: American College of Surgeons, 1997.

Advanced LS 1993

Advanced LS. Advanced Paediatric Life Support. Vol. **1st edn**, London: BMJ Publishing Group, 1993.

Altman 1996

Altman DG, Bland JM. Detecting skewness from summary information. *BMJ* 1996;**313**:1200.

Burney 1993

Burney RE, Maio RF, Maynard F, Karunas R. Incidence, characteristics, and outcomes of spinal cord injury at trauma centers in North America. *Archives of Surgery* 1993;**128**:596-9.

Butman 1996

Butman A, Schelble DT, Vomacka RW. The relevance of the occult cervical spine controversy and mechanism of injury to prehospital protocols: a review of the issues and literature. *Prehospital Disaster Medicine* 1996;**11**:228-33.

Davies 1996

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

Davis 1993

Davis JW, Phreaner DL, Hoyt DB, Mackersie RC. The etiology of missed spine injuries. *Journal of Trauma* 1993;**34**(3):342-6.

Domeier 1999

Domeier RM. NAEMSP Position Paper: Indications for prehospital spinal immobilisation. *Prehospital Emergency Care* 1999;**3**:251-3.

Hauswald 1998

Hauswald M, Ong G, Tandberg D, Omar Z. Out-of-hospital spinal immobilisation: its effect on neurologic injury. *Academic Emergency Medicine* 1998;**5**(3):214-9.

Hewitt 1994

Hewitt S. Skin necrosis caused by a semi-rigid cervical collar in a ventilated patient with multiple injuries. *Injury* 1994;**25**:323-4.

Hoffman 2000

Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker M. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. *New England Journal of Medicine* 2000;**343**:94-9.

Houghton 1996

Houghton DJ, Curley JW. Dysphagia caused by a hard cervical collar. *British Journal of Neurosurgery* 1996;**10**:501-2.

McHugh 1998

McHugh TP, Taylor JP. Unnecessary out-of-hospital use of full spinal immobilsation. *Academic Emergency Medicine* 1998;**5**:278-80.

Miller 1994

Miller TR, et al. Costs of head and neck injury and a cost-benefit analysis of bicycle helmets. In: Levine RS editor(s). Head and Neck Injury. New York: Society of Automotive Engineering, 1994:211-40.

Orledge 1998

Orledge JD, Pepe PE. Out-of-hospital Spinal Immobilization: Is It Really Necessary?. *Academic Emergency Medicine* 1998;**5**(3):203-4.

Schulz 1995

Schulz KF, Chalmers I, Hayes RJ, Altman D. Empirical evidence of bias. Dimensions of methodological quality associated with estimates of treatment effects in controlled trials. *Journal of the American Medical Association* 1995;**273**(5):408-12.

SCI Center 1998

The National Spinal Cord Injury Statistical Center. Spinal cord Injury: facts and figures at a glance. Birmingham, Alabama: University of Alabama at Birmingham National Spinal Injury Center, 1998.

Wang 1990

Wang D, Wu X, Shi G, Wang Y. China's first total care unit for the spinal cord injured. *Paraplegia* 1990;**28**:318-20.

CHARACTERISTICS OF STUDIES

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Black 1998	Participants were healthy volunteers.
Chan 1996	Participants were healthy volunteers.
Cline 1985	Participants were healthy volunteers.
Cordell 1995	Participants were healthy volunteers.
Delbridge 1993	Participants were healthy volunteers.
Graziano 1987	Participants were healthy volunteers.
Hamilton 1996	Participants were healthy volunteers.
Hauswald 2000	Participants were healthy volunteers.

Study	Reason for exclusion
Jedlicka 1999	Participants were healthy volunteers.
Johnson 1996	Participants were healthy volunteers.
Lerner 1998	Participants were healthy volunteers.
Lunsford 1994	Participants were healthy volunteers.
Manix 1995a	Participants were healthy volunteers.
Manix 1995b	Participants were healthy volunteers.
Mazolewski 1994	Participants were healthy volunteers.
Perry 1999	Participants were healthy volunteers.
Totten 1999	Participants were healthy volunteers.
Walton 1995	Participants were healthy volunteers.

ADDITIONAL TABLES

Table 1. Previous search strategies May 2003

May 2003
Cochrane Central Register of Controlled Trials (CENTRAL 2003,issue 2) 1. SPINE:TI or SPINAL:TI or CERVIX:TI or CERVICAL:TI or LUMBAR:TI or THORA*:TI or NECK:TI or WHIPLASH:TI 2. IMMOBILI*:TI or STABILI*:TI or STABLE:TI or COLLAR*:TI or BACKBOARD:TI or SPLINT*:TI or BOARD*:TI or STRAPPING:TI or STRAPPED:TI 3. HEADBLOCK:TI or SANDBAG:TI or ORTHOSIS:TI or ORTHOTIC:TI or BRACE*:TI 4. (#1 and #2) or #3
MEDLINE (1966-2003.5) 1. explode spine/ all subheadings 2. explode spinal injuries/ all subheadings 3.explode spinal cord injuries/ all subheadings 4. spine or spinal or cervix or cervical or lumbar or thora* 5. neck or whiplash 6. #1 or #2 or #3 or #4 or #5 7. immobili* or mobility 8. explode immobilization/ all subheadings 9. stabili* 10. collar* 11. backboard* or vacuum splint* or neutral position or strapping or strapped or straps or spine board* or tapes or taping 12. headblock* or sandbag* or (kendrick in ti,ab) or orthosis 13. orthotic 14. brace* 15. spine board* or splint* 16. #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 17. log rol* 18. #16 or #17 19. #18 and #6

Table 1. Previous search strategies May 2003 *(Continued)*

20. controlled clinical trial* or randomi* or explode research design / all subheadings or double blind or placebo or meta-analysis or metaanalys* or (clinical trial in pt)
21. #19 and #20

EMBASE (1966-2003.4)
1. explode spine/ all subheadings
2. explode "spinal-cord-injury"/ all subheadings
3. "cervical-spine-injury"/ all subheadings
4. explode "spine-injury"/ all subheadings
5. spine or spine or cervix or cervical or lumbar or thora*
6. neck or whiplash
7. #1 or #2 or #3 or #4 or #5 or #6
8. immobil* or mobility
9. stabili* or stable or collar*
10. backboard* or vacuum splint* or neutral position* or strapping or strapped or straps or spine board* or tapes or taping
11. headblock* or sandbag* or (kendrick in ti,ab) or orthodos* or orthotic* or brace*
12. spine board or splint* or halo
13. #8 or #9 or #10 or #11 or #12
14. #7 and #13
15. trial* or randomi*
16. double blind or placebo*
17. meta-analys* or metaanalys*
18. explode clinical trial/ all subheading
19. explode controlled study/ all subheadings
20. control*
21. #15 or #16 or #17 or #18 or #19 or #20
22. #21 and #14
23. human in de
24. nonhuman in de
25. #24 not (#24 and #23) *
26. #22 not #25

CINAHL (1982-2000.3)
1. (spine or spine or cervix or cervical or lumbar or thora*) in ti,ab,de
2. (neck or whiplash) in ti,ab,de
3. (immobil* or mobility) in ti,ab,de
4. (stabili* or stable or collar*) in ti,de,ab
5. (backboard* or vacuum splint* or neutral position* or strapping or strapped or straps or spine board* or tapes or taping) in ti,de,ab
6. (headblock* or sandbag* or (kendrick in ti,ab) or orthodos* or orthotic* or brace*) in ti,ab,de
7. (spine board or splint* or halo) in ti,de,ab
8. (trial* or randomi* or double blind or placebo*) in ti,ab,de
9. (meta-analys* or metaanalys* or control*) in de,ti,ab
10. #1 or #2
11. #3 or #4 or #5 or #6 or #7
12. #8 or #9 *
13. #10 and #11 and #12

Table 2. Table of randomised controlled trials on healthy volunteers

Authors	Title	Type of study	Participants	Intervention	Outcome measures	Results
Black 1998	Comparative study of risk factors for skin breakdown with cervical orthotic devices: Philadelphia and Aspen	Randomised controlled trial	20 healthy volunteers	Philadelphia collar vs Aspen Collar	Skin breakdown	No significant difference in occipital pressure and skin temperature between collars. Significant in-

Table 2. Table of randomised controlled trials on healthy volunteers *(Continued)*

						crease in relative skin humidity with Philadelphia Collar (P<0.001)
Chan 1996	Comparative study of risk factors for skin breakdown with cervical orthotic devices: Philadelphia and Aspen	Randomised controlled trial	37 healthy volunteers	StifNeck collar + Standard backboard vs StifNeck collar + Vacuum mattress splint	Pain	Subjects significantly more likely to complain of pain when immobilised on a backboard than on a vacuum mattress splint (P<0.001).
Cline 1985	Comparative study of risk factors for skin breakdown with cervical orthotic devices: Philadelphia and Aspen	Randomised controlled trial	97 healthy volunteers	Philadelphia collar vs Philadelphia collar + short board vs Hare extrication collar vs Hare extrication collar + short board vs rigid plastic collar vs rigid plastic collar + short board vs short board only	Immobilisation efficacy measured radiographically	Significant reduction in spinal mobility with the short board technique (P<0.001).
Cordell 1995	Pain and tissue-interface pressures during spine-board immobilisation	Randomised controlled trial	20 healthy volunteers	Collar + Spine board with air mattress vs Collar + Spine board without mattress	Pain Contact pressure	Significant increase in pain and tissue-interface pressures on spine board without air mattress (P<0.05)
Graziano 1987	A radiographic comparison of prehospital cervical immobilisation methods	Randomised controlled trial	45 healthy volunteers	StifNeck Collar vs Short board technique vs Kendrick Extrication Device vs Extrication Plus-One	Degree of immobilisation efficacy measured radiographically	Significant increase in cervical immobilisation efficacy with the Kendrick Extrication Collar and the Extrication Plus-One (P<0.05).
Hamilton 1996	The efficacy and comfort of full-body vacuum splints for cervical immobilisation	Randomised controlled trial	26 healthy volunteers	Stifneck collar + backboard vs Backboard vs Stifneck collar + vacuum splint vs Vacuum splint	Degree of immobilisation efficacy and comfort	Significant increase in immobilisation efficacy and comfort with the vacuum splint (P<0.05).
Johnson 1996	Comparison of a vacuum splint device to a rigid backboard for spinal immobilisation	Randomised controlled trial	30 paramedic students	Collar + vacuum splint vs Collar + backboard vs	Degree of immobilisation, comfort	No significant difference in degree of immobilisation with the vacu-

Table 2. Table of randomised controlled trials on healthy volunteers *(Continued)*

				Vacuum splint only vs Backboard only	and speed of application	um splint and the backboard, with or without collar. Significant faster application with the vacuum splint than the backboard (P<0.001). Significant improvement in comfort with the Vacuum splint (P<0.001).
Lerner 1998	The effects of neutral positioning with and without padding on spinal immobilisation of healthy subjects	Randomised controlled trial	39 healthy volunteers	Collar + backboard with occipital padding vs Collar + backboard without occipital padding	Incidence and severity of pain	No significant decrease in incidence and severity of pain between padded and unpadded wooden backboard.
Lunsford 1994	The effectiveness of four contemporary cervical orthosis in restricting cervical motion	Randomised controlled trial	10 healthy volunteers	No collar vs Philadelphia collar vs Miami J collar vs Malibu collar vs Newport collar	Degree of cervical motion measured with video frames	Significant reduced motion with each orthosis than 'no orthosis' (P<0.05). Significant more restriction in mobility with the Malibu collar (P<0.05).
Perry 1999	The efficacy of head immobilisation techniques during simulated vehicle motion	Randomised controlled trial	6 healthy volunteers	StifNeck collar + roller towel + fracture board vs StifNeck collar + headbed + fracture board vs StifNeck collar + wedge + fracture board	Efficacy of head immobilisation techniques	No effect in eliminating head movements with any of these techniques.
Totten 1999	Respiratory effects of spinal immobilisation	Randomised crossover trial	39 healthy volunteers	Vacuum collar + vacuum mattress vs StifNeck collar + wooden board	Respiratory effects	Significant respiratory restriction with whole-body spinal immobilisation compared with baseline (P<0.001). No significant difference in respiratory restriction with both wooden board and vacuum mattress.
Delbridge 1993	Discomfort in healthy volunteers immobilised on wooden backboards	Randomised controlled trial	12 healthy volunteers	Wooden backboard vs Vacuum mattress splint	Degree of discomfort	Significantly less discomfort with vacuum mattress splints (P<0.05).

Table 2. Table of randomised controlled trials on healthy volunteers *(Continued)*

	and vacuum mattress splints (Abstract)					
Walton 1995	Padded vs unpadded spine board for cervical spin immobilisation	Randomised controlled trial	30 healthy volunteers	Foam-padded spine board vs Unpadded spine board	Comfort Immobilisation efficacy Sacral tissue oxygenation	Significantly less discomfort with padded spine board (P=0.024). No significant difference in cervical range of motion. No significant difference in sacral tissue oxygenation.
Mazolewski 1994	The effectiveness of strapping techniques in spinal immobilisation	Randomised controlled trial	19 healthy volunteers	Backboards with 4 torso strapping techniques	Reduction in lateral motion	Significant improved lateral motion restriction with addition of abdominal straps (P<0.05).
Manix 1995a	Comparison of prehospital cervical immobilisation devices using video and electromyography	Randomised controlled trial	20 healthy volunteers	Corrugated board (A) vs Reusable foam board (B) vs Tape with towel rolls (C)	Relevant evaluation criteria: Motion restriction Ease of application Patient access Environmental testing Radiolucency Storage size	Significant motion restriction with A and C compared with B (P<0.05).
Jedlicka 1999	A comparison of the effects of two methods of spinal immobilisation on respiratory effort in the older adult	Randomised controlled trial	57 older adult volunteers	Full length wooden backboard vs Vacuum immobilizer device	Respiratory effort	Significant increased respiratory effort with backboard (P<0.05).
Hauswald 2000	A comparison of the effects of four methods of spinal immobilisation on ischaemic pain	Randomised controlled trial	22 adult volunteers	Traditional backboard vs Backboard padded with a folded blanket vs Backboard padded with a 3-cm gurney mattress vs Backboard and mattress padded with a 6-cm eggcrate foam pad	Ischaemic pain	Significant increase in comfort with padded backboards (P<0.05).

APPENDICES

Appendix 1. Search strategy

July 2007 update search strategies

INJURIES SPEICALISED REGISTER
(spine or spinal) AND (immobile or immobilize or immobilization or stabili* or stable or brace or splint*)

MEDLINE 2007/June week 4
1.exp Spinal Injuries/
2.exp Spinal Cord Injuries/
3.((spine or spinal or cervix or cervical or lumbar or thora$) adj3 (injur$ or trauma$)).ab,ti.
4.whiplash.ab,ti.
5.or/1-4
6.exp Immobilization/
7.exp Orthotic Devices/
8.(backboard$ or vacuum splint$ or neutral position or strapping or strapped or straps or spine board$ or tapes or taping or log roll$).ab,ti.
9.(headblock$ or sandbag$).ab,ti.
10.or/6-9
11.5 and 10
12.(randomised or randomized or randomly or random order or random sequence or random allocation or randomly allocated or at random or controlled clinical trial$).tw,hw.
13.clinical trial.pt.
14.12 or 13
15.exp models, animal/
16.exp Animals/
17.exp Animal Experimentation/
18.exp Disease Models, Animal/
19.exp Animals, Laboratory/
20.or/15-19
21.Humans/
22.20 not 21
23.14 not 22
24.11 and 23

EMBASE 2007/ week 27
1.exp Spinal Cord Injury/
2.exp Spine Injury/
3.((spine or spinal or cervix or cervical or lumbar or thora$ or neck) adj5 (injur$ or trauma$)).ab,ti.
4.whiplash.ab,ti.
5.or/1-4
6.exp IMMOBILIZATION/
7.exp ORTHOTICS/
8.(backboard$ or vacuum splint$ or neutral position or strapping or strapped or straps or spine board$ or tapes or taping).ab,ti.
9.(headblock$ or sandbag$ or orthosis or orthotic or brace$ or splint).ab,ti.
10.(immobili$ or mobility or stabili$ or collar$ or log roll$).ab,ti.
11.or/6-10
12.5 and 11
13.exp animal model/
14.Animal Experiment/
15.exp ANIMAL/
16.exp Experimental Animal/
17.13 or 14 or 15 or 16
18.Human/
19.17 not 18
20.(randomised or randomized or randomly or random order or random sequence or random allocation or randomly allocated or at random or controlled clinical trial$).tw,hw.
21.exp clinical trial/
22.20 or 21

23.22 not 19
24.12 and 23

Central 2007, issue 2 and National Research Register 2007, issue 2
#1MeSH descriptor Spinal Injuries explode all trees #2MeSH descriptor Spinal Cord Injuries explode all trees
#3injur* and (spine or spinal or cervix or cervical or lumbar or thora* or neck)
#4trauma* and (spine or spinal or cervix or cervical or lumbar or thora* or neck)
#5whiplash
#6(#1 OR #2 OR #3 OR #4 OR #5)
#7MeSH descriptor Immobilization explode all trees
#8MeSH descriptor Orthotic Devices explode all trees
#9immobili* or mobility or stabili* or collar* or orthotic or orthosis or brace* or splint*
#10backboard* or vacuum splint* or neutral position or strapping or strapped or straps or spine board* or tapes or taping or log roll*
#11headblock* or sandbag*
#12(#7 OR #8 OR #9 OR #10 OR #11)
#13(#6 AND #12)
#14(#13), from 2003 to 2007

www.clinicaltrials.gov and **http://www.controlled-trials.com/mrct**
(spine or spinal) AND (immobile OR immobilize or immobilization or stabilize or stable or brace or splint) [ALL-FIELDS]

ZETOC
Searched 11-07-07
spinal* immobil* trial*
or
spine* immobil* trial*
or
spinal immobil* random*
or
spine* immobil* random*

WHAT'S NEW

Date	Event	Description
11 September 2008	Amended	Converted to new review format.

HISTORY

Protocol first published: Issue 3, 2000
Review first published: Issue 2, 2001

Date	Event	Description
8 August 2007	New search has been performed	August 2007 An updated search was conducted in July 2007. No new randomised controlled trials comparing spine immobilisation strategies in trauma patients with suspected spinal cord injury were identified.

CONTRIBUTIONS OF AUTHORS

IK helped to design the protocol, examined search results, applied inclusion criteria and wrote the review. FB examined search results, applied inclusion criteria, and helped to write the review. IR commented on the protocol and helped to write the review.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- Institute of Child Health, University of London, UK.

External sources

- Global Programme on Evidence for Health Policy (GPE), World Health Organisation, Switzerland.

INDEX TERMS

Medical Subject Headings (MeSH)

*Immobilization; *Spinal Cord Injuries; Spinal Injuries [*complications]

MeSH check words

Humans