Value of a rigid collar in addition to head blocks: a proof of principle study

M Holla

Correspondence to
M Holla, Department of Orthopaedic Surgery 357, Radboud University Nijmegen Medical Centre, Postbox 9101, 6500 HB Nijmegen, The Netherlands;
m.holla@orthop.umcn.nl

Accepted 9 August 2010
Published Online First
18 February 2011

ABSTRACT

Background All trauma patients with a cervical spinal column injury or with a mechanism of injury with the potential to cause cervical spinal injury should be immobilised until a spinal injury is excluded. Immobilisation of the entire patient with a rigid cervical collar, backboard, head blocks with tape or straps is recommended by the Advanced Trauma Life Support guidelines. However there is insufficient evidence to support these guidelines.

Objective To analyse the effects on the range of motion of the addition of a rigid collar to head blocks strapped on a backboard.

Method The active range of motion of the cervical spine was determined by computerised digital dual inclinometry, in 10 healthy volunteers with a rigid collar, head blocks strapped on a padded spine board and a combination of both. Maximal opening of the mouth with all types of immobiliser in place was also measured.

Results The addition of a rigid collar to head blocks strapped on a spine board did not result in extra immobilisation of the cervical spine. Opening of the mouth was significantly reduced in patients with a rigid collar.

Conclusion Based on this proof of principle study and other previous evidence of adverse effects of rigid collars, the addition of a rigid collar to head blocks is considered unnecessary and potentially dangerous. Therefore the use of this combination of cervical spine immobilisers must be reconsidered.

INTRODUCTION

All trauma patients with a cervical spinal column injury or with a mechanism of injury having the potential to cause cervical spinal injury should be immobilised at the scene, during transport and in hospital, until a spinal injury is excluded.[1 2] Immobilisation of the entire spine with a rigid cervical collar, head immobilisation, backboard, tape and straps is recommended in the Advanced Trauma Life Support guidelines by the American College of Surgeons.[2] More than five million patients require spinal immobilisation each year.[3] From a trial in 1983 it was concluded that the combination of a rigid collar with sandbags and tape was most effective in immobilisation of the cervical spine.[4] In the 1990s, the sandbags and tape were replaced by foam head blocks strapped to padded backboards. The combination of a rigid collar with foam head blocks strapped on a backboard is now commonly used world wide. The rationale for this technique is that two different immobilisers probably result in better immobilisation and are therefore safer. However, there is insufficient evidence to support these guidelines.[2] No scientific reports have been published about this method of double immobilisation. In this study the effects on the range of motion of the addition of a rigid collar to head blocks strapped on a backboard were analysed.

MATERIALS AND METHODS

For the rigid collar we used the Select Stifneck collar (Laerdal Medical Corp, Wappingers Falls, New York, USA), which is made of a hard polyethylene shell that can be closed with a Velcro band. It is padded with a 2 mm layer of soft foam. The collar immobilises the cervical spine by bridging the sternum, clavicles, trapezoidal muscles and upper back to the occipital bone and mandible. The collar was used according to the manufacturer's instructions.

Sof-Loc head blocks ((#35993 Iron Duck, Chicopee, Massachusetts, USA) were used. These two vinyl-dipped foam blocks were strapped with two Velcro straps on both sides of the head to a padded spine board (Traumatras, Almelo, the Netherlands). The skull and head blocks were fixed directly to the spine board, which in turn was connected to the thorax with straps.

Ten healthy subjects with different body types, as described in table 1, were selected to test the rigid collar, the head blocks strapped on the backboard and the combination of both. The volunteers were asked to flex, extend, laterally bend and rotate their head as much as possible with the different immobilisers on, as shown in figure 1. The range of motion was measured with a computerised digital inclinometer (EDI 320 CYBEX, Ronkonkoma, New York, USA) as described by the American Medical Association.[5]

The range of motion without an immobiliser was considered 100% of the normal range of motion.

The same volunteers were asked to open their mouth as far as possible with and without application of the immobilisers. The distance from the lower border of the upper incisors and the upper border of the lower incisors was measured three times with a ruler as described by Chin *et al*,[6] and the average calculated.

The mean active range of motion and SD was determined for each immobilising technique. A two-tailed paired Student t test and 95% confidence interval was calculated using SPSS 16.

RESULTS

The range of motion of the cervical spine with and without cervical immobilisation is presented in figure 2 and table 2. With the rigid collar on, the mean range of motion in all directions was limited

Table 1 Body characteristics and chosen Stifneck collar size of 10 healthy volunteers

Volunteer number	Gender	Age (years)	Body length (cm)	Body weight (kg)	BMI (l/h^2)	Distance mandibular corner—SC joint (cm)	Minimal neck diameter (cm)	Stifneck Select collar size
1	Male	31	185	85	25	14	39	Regular
2	Male	43	190	101	28	13	45	Short
3	Male	34	185	63	18	16	37	Regular
4	Male	31	198	101	26	15	41	Tall
5	Female	36	170	65	22	14	36	Regular
6	Male	26	191	78	21	15	37	Tall
7	Female	23	168	53	19	11	31,5	Short
8	Male	31	181	80	23	18	39	Tall
9	Female	47	167	58	21	16	34	Regular
10	Female	27	181	65	20	18	32	Tall

BMI, body mass index; SC, sternoclavicular.

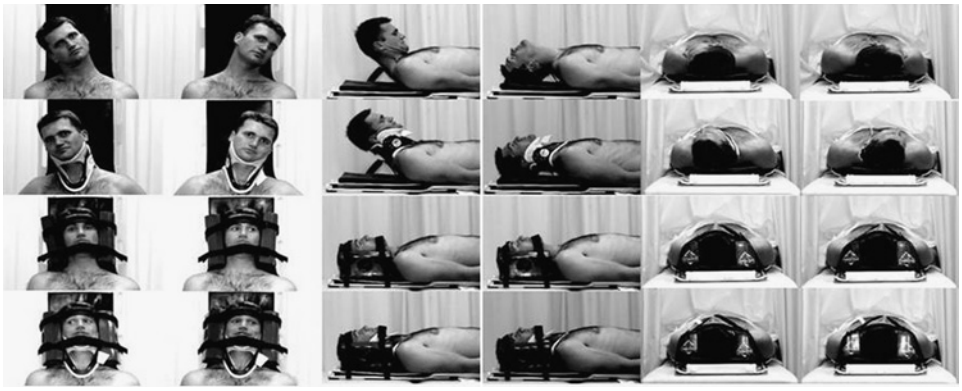

Figure 1 Range of motion of the cervical spine of a healthy subject with a rigid collar, head blocks on a spine board and a combination of both.

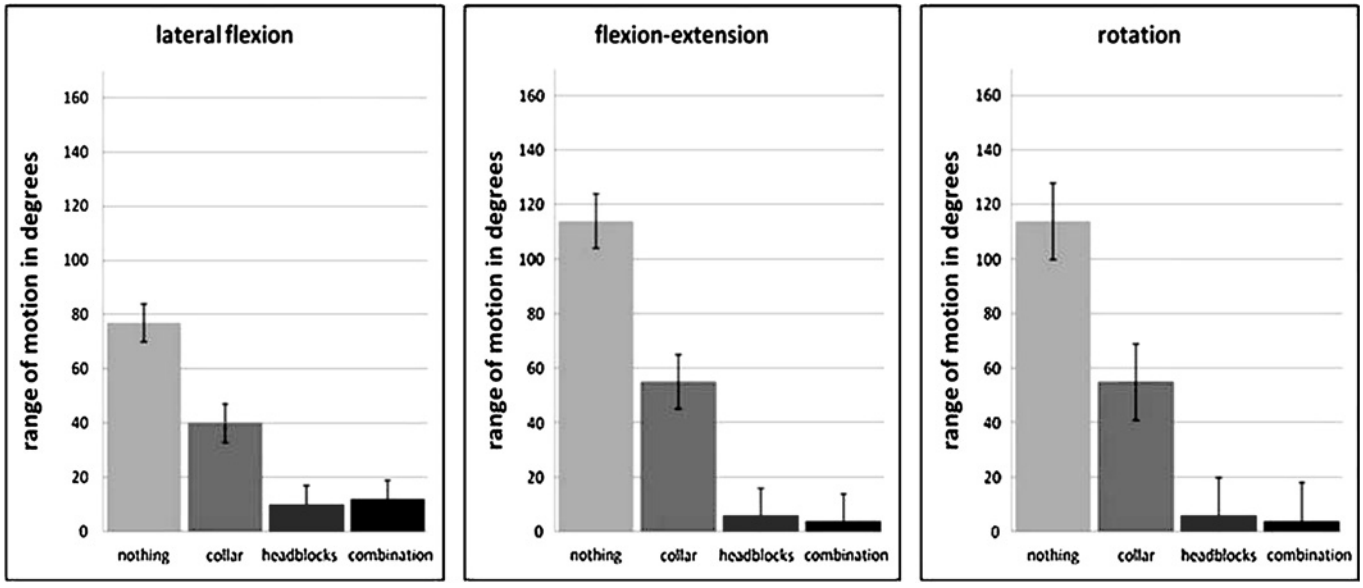

Figure 2 Mean range of motion of the cervical spine with a rigid collar, head blocks and a combination of both in 10 healthy subjects. The inserted lines represent the smallest detectable differences measured with the Cybex EDI-320 as reported by Hoving.[10]

to at least 34% of the normal range of motion. With the head blocks alone the mean range of motion was reduced to at least 12% of the normal range of motion. The range of motion in all directions was not reduced with the addition of a rigid collar to head blocks.

As described in table 3, the difference in the range of motion was significant reduced ($p<0.005$) by the collar compared with no immobilisation. A second significant decrease ($p<0.005$) in the range of motion in all directions was seen when the head blocks were compared with the rigid collar. No significant decrease ($p>0.05$) in the range of motion was observed when the collar was added to the head blocks.

The mean mouth opening was significant reduced ($p<0.01$) from 47 mm (SD 9 mm) without a collar to 34 mm (SD 11 mm) with a collar.

DISCUSSION

This proof of principle study demonstrates that the application of a rigid collar in addition to head blocks does not provide extra

Table 2 Mean range of motion (with SD) and percentage of range of motion (with SD) of the cervical spine with different cervical spine immobilisers

Type of immobiliser	Lateral bending	Flexion-extension	Rotation
None	77° (15°) 100% (19%)	114° (5°) 100% (4%)	151° (25°) 100% (17%)
Collar	40° (10°) 52% (8%)	55° (14°) 48% (11%)	53° (20°) 34% (9%)
Head blocks	10° (10°) 12% (10%)	6° (6°) 5% (5%)	8° (5°) 5% (3%)
Collar and head blocks	12° (9°) 14% (9%)	4° (5°) 3% (3%)	6° (5°) 8% (3%)

Table 3 Mean differences and 95% confidence intervals for difference between the range of motion of the cervical spine possible with different immobilisation methods

	Lateral bending	Flexion-extension	Rotation
None—collar	42°*** (34° to 49°)	58°*** (51° to 65°)	99°*** (89° to 101°)
Collar—head blocks	32°*** (26° to 38°)	48°*** (42° to 55°)	47°*** (37° to 58°)
Head blocks—collar and head blocks	**−1° (−6° to 4°)**	**2° (−1° to 6°)**	**−4°* (−7° to 0°)**

*p<0.05; ***p<0.005.

immobilisation of the cervical spine. No previous reports showing benefit of this combination of immobilisation are available. Nonetheless, this combination has been used world wide on millions of patients.[3]

It is well known that most commonly used collars do not fully immobilise the cervical spine.[7 8] At least 19° of flexion-extension, 46° of axial rotation, or 45° of lateral bending is possible with different collars.[8] Other rigid collars like the Aspen, Ambu and Miami J-collar function in a similar manner.[9]

The use of sandbags and tape was more effective in immobilisation of the cervical spine than any collar.[4] The addition of a Philadelphia collar to sandbags reduced the extension from 15° to 7°. Although the range of motion was measured with a hand-held goniometer and no significance analysis was reported in that study, the combination of a collar and sandbags with tape was previously advised.[4] However, the modern foam head blocks strapped to a spine board, as used in this study, limit all cervical motions, including extension to <15°. Therefore it is clear that the semi-constraining rigid collars do not add extra immobilisation to full-constraining head blocks. The assumption that a combination of two different immobilisers results in the best immobilisation is not true.

The number of subjects in this study is limited. After evaluation of a pilot study of 10 subjects, however, it became obvious that the best cervical immobiliser determines the range of motion of the cervical spine. Therefore it is not likely that increasing the number of healthy volunteers in this proof of principle, will affect the outcome of this study. However, a larger prospective trial with injured patients is needed.

No extremely obese, short or injured subjects were included in this study. It is unknown if, and how, the range of motion is affected by external immobilisers in these groups of patients. Further prospective clinical trials are needed to answer these questions.

Although the reliability for the range of motion for inclinometry is rated good, with an intraobserver and interobserver intraclass correlation coefficient of 0.85, 0.70, respectively, the smallest detectable differences with the Cybex EDI-320 go up to 10° for flexion-extension, 7° for lateral flexion and 14° for rotation.[10] However, despite the 95% CIs of this study, these measurement errors will not affect the clinical message of the study: a rigid collar does not provide additional immobilisation when used in combination with head blocks.

In agreement with other studies we found that the use of a rigid collar significantly reduces mouth opening.[11 12] All rigid collars immobilise the cervical spine by compression of the mandible. This forces the mandible upwards to close the mouth. If less pressure is applied to the mandible to increase the mouth opening more movement is possible in the cervical spine. Limited mouth opening will make removal of blood, broken teeth or artificial dentures and placing a tracheal tube more difficult. Some tubes cannot be placed when a rigid collar is in place.[13]

Apart from a lack of additional immobilisation and a limitation of the opening of the mouth a number of adverse side effect of rigid collars are described in the literature, as discussed in the following sections.[2]

Increased motion in the high cervical spine

The pressure of the collar on the mandible forces the skull to tilt backwards when the mouth is opened. A fluoroscopic study

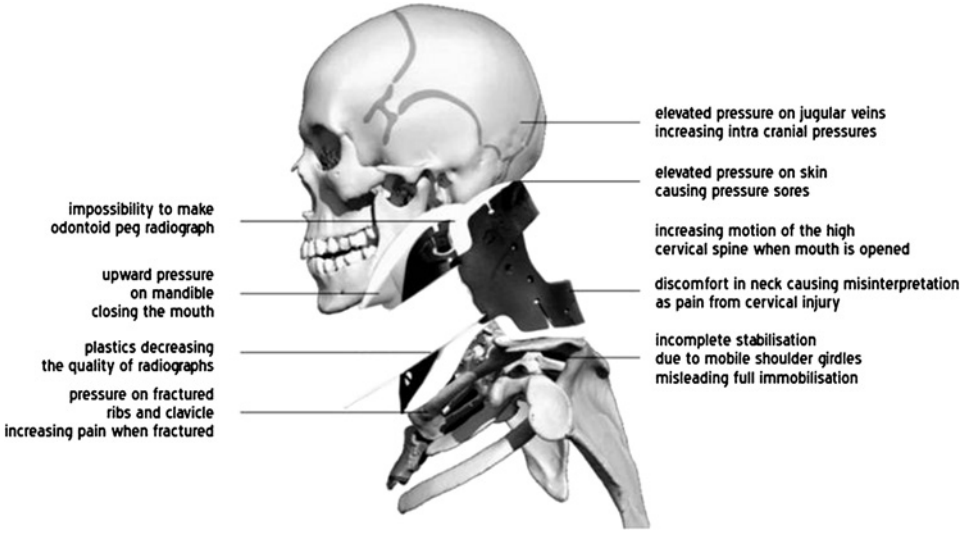

Figure 3 An overview of adverse effects of rigid collars.[6 11–13 15–30]

with chewing healthy people showed an increased motion at the higher levels of the cervical spine when wearing a rigid collar.[6] As upper cervical spine fractures occur relatively frequently, complete immobilisation of the total cervical spine is needed in patients with possible instability of the spine.[14]

Pressure sores of the skin

With rigid collars like the Stifneck, local pressures on the skin go up to 80 mm Hg.[15] This can cause collar-related decubitis ulcerations.[15–20] Pressure sores can complicate later surgery and make later immobilisation with an orthosis impossible.

Increased intracranial pressure

A rigid collar can act like a cervical tourniquet, since it compresses the jugular veins with interface pressures of >10 mm Hg.[21] Several studies describe an increase of intracranial pressure due to rigid collars.[22–26] Because trauma patients, especially those with cervical injuries, often have intracranial contusions,[14 27] it is clinically relevant to keep the intracranial pressure as low as possible.[23]

Increased pain and discomfort

As rigid collars rests upon the clavicles, sternum and upper ribs, fractures in this area will cause additional pain. Furthermore, a rigid collar can cause pain in an otherwise healthy subject.[28] The examining doctor can misinterpret this as pain from a cervical spinal injury.[29]

Difficulty in obtaining adequate radiographs

It is not possible to make an odontoid peg radiograph with a rigid collar on because the mouth cannot be fully opened. Temporary removal of the collar leads to extra manipulations and is time consuming. Furthermore, rigid collars are not completely radiolucent. The contrast of the image will decrease, and misleading distortions can occur at the edges of the collar.

False sense of full immobilisation

Complete immobilisation by a rigid collar is impossible because it rests on the mobile shoulder girdles and mobile mandible. A false sense of security that the cervical spine is fully immobilised with a rigid collar can be created.[30] Manual support of the head by an experienced person is always needed when a patient is log rolled with only a rigid cervical collar on.

The adverse effects of rigid collars are summarised in figure 3.

One might argue that a rigid collar may work as a reminder to the trauma team that the cervical spine is not cleared for instability. The head blocks, however, can work as a similar reminder.

The rigid collar can be useful in temporary immobilisation of the neck at extrication of patients in a sitting position in cars. However, based on the results of this study, the rigid collar should be removed when the head blocks are placed.

CONCLUSION

The results of this proof of principle study demonstrate that the addition of a rigid collar to head blocks does not provide any extra immobilisation of the cervical spine and is therefore considered unnecessary. Furthermore, this study showed that a rigid collar reduces the ability to open the mouth and clear the airway. In view of this and other known adverse effects of a rigid collar (increased motion at the level of the high cervical spine, increased intracranial pressures, pressure sores of the skin, increased pain and discomfort, poor quality of radiographs and a false sense of immobilisation), the combination of a rigid collar and head blocks should be reconsidered.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. **ACS.** *Advanced Trauma Life Support, Trauma CO. Advanced Trauma Life Support Program for Doctors*. 7th edn. Chicago, IL: American college of surgeons, 2004:187—202.
2. **Hadley MN,** Walters BC, Grabb PA, *et al*. *Guidelines for the management of Acute Cervical Spine and Spinal Cord Injuries*. Birmingham: American Association of Neurology Surgeons and Congress of Neurological Surgeons Alabama, 2001. http://www.spineuniverse.com/pdf/traumaguide/finished1116.pdf.
3. **Frohna WJ.** Emergency department evaluation and treatment of the neck and cervical spine injuries. *Emerg Med Clin North Am* 1999;**17**:739—91.
4. **Podolsky S,** Baraff LJ, Simon RR, *et al*. Efficacy of cervical spine immobilisation methods. *J Trauma* 1983;**23**:461—5.
5. **Cocchiarella L,** Andersson BJ. *Guides to the Evaluation of Permanent Impairment*. 5th edn. New York: American Medical Association, 2000:417—21.
6. **Chin KR,** Auerbach JD, Adams SB, *et al*. Mastication causing segmental spinal motion in common cervical orthoses. *Spine* 2006;**31**:430—4.
7. **James CY,** Riemann BL, Munkasy BA, *et al*. Comparison of cervical spine motion during application among 4 rigid immobilisation collars. *J Athl Train* 2004;**39**:138—45.
8. **Sandler AJ,** Dvorak J, Humke T, *et al*. The effectiveness of various cervical orthoses. An in vivo comparison of the mechanical stability provided by several widely used models. *Spine* 1996;**21**:1624—9.
9. **Del Rossi G,** Heffernan TP, Horodyski M, *et al*. The effectiveness of extrication collars tested during the execution of spine-board transfer techniques. *Spine* 2004;**4**:619—23.
10. **Hoving JL,** Pool JJ, van Mameren H, *et al*. Reproducibility of cervical range of motion in patients with neck pain. *BMC Musculoskelet Disord* 2005;**6**:59.
11. **Goutcher CM,** Lochhead V. Reduction in mouth opening with semi- rigid cervical collars. *Br J Anaesth* 2005;**95**:344—8.
12. **Komatsu R,** Nagata O, Kamata K, *et al*. Intubating laryngeal mask airway allows tracheal intubation when the cervical spine is immobilised by a rigid collar. *Br J Anaesth* 2004;**93**:655—59.
13. **Mercer MH,** Gabbott DA. Insertion of the Combitube airway with the cervical spine immobilised in a rigid cervical collar. *Anaesthesia* 1998;**53**:971—4.
14. **Holly LT,** Kelly DF, Counelis GJ, *et al*. Cervical spine trauma associated with moderate and severe head injury: incidence, risk factors, and injury characteristics. *J Neurosurg* 2002;**96**(Suppl 3):285—91.
15. **Plaisier B,** Gabram SG, Schwartz RJ, *et al*. Prospective evaluation of craniofacial pressure in four different cervical orthoses. *J Trauma* 1994;**37**:714—20.
16. **Ackland HM,** Cooper DJ, Malham GM, *et al*. Factors predicting cervical collar-related decubitus ulceration in major trauma patients. *Spine* 2007;**32**:423—8.
17. **Blaylock B.** Solving the problem of pressure ulcers resulting from cervical collars. *Ostomy Wound Manage* 1996;**42**:26—33.
18. **Hewitt S.** Skin necrosis caused by a semi—rigid cervical collar in a ventilated patient with multiple injuries. *Injury* 1994;**25**:323—4.
19. **Molano Alvarez E,** Murillo Perez Madel A, Salobral Villegas MT, *et al*. Pressure sores secondary to immobilisation with cervical collar: a complication of acute cervical injury. *Enferm Intensiva* 2004;**15**:112—22.
20. **Powers J.** A multidisciplinary approach to occipital pressure ulcers related to cervical collars. *J Nurs Care Qual* 1997;**12**:46—52.
21. **Ferguson J,** Mardel SN, Beattie TF, *et al*. Cervical collars: a potential risk to the head-injured patient. *Injury* 1993;**24**:454—6.
22. **Craig GR,** Nielsen MS. rigid cervical collars and intracranial pressure. *Intensive Care Med* 1991;**17**:504—5.
23. **Davies G,** Deakin C, Wilson A. The effect of a rigid collar on intracranial pressure. *Injury* 1996 Nov;**27**:647—9.
24. **Hunt K,** Hallworth S, Smith M. The effects of rigid collar placement on intracranial and cerebral perfusion pressures. *Anaesthesia* 2001;**56**:511—13.
25. **Mobbs RJ,** Stoodley MA, Fuller J. Effect of cervical hard collar on intracranial pressure after head injury. *ANZ J Surg* 2002;**72**:389—91.
26. **Raphael JH,** Chotai R. Effects of the cervical collar on cerebrospinal fluid pressure. *Anaesthesia* 1994;**49**:437—9.
27. **Iida H,** Tachibana S, Kitahara T, *et al*. Fujii Association of head trauma with cervical spine injury, spinal cord injury, or both. *J Trauma* 1999;**46**:450—2.
28. **Chan D,** Goldberg R, Tascone A, *et al*. The effects of spinal immobilisation on healthy volunteers. *Ann Emerg Med* 1994;**23**:48—51.
29. **March JA,** Ausband SC, Brown LH. Changes in physical examination caused by use of spinal immobilisation. *Prehosp Emerg Care* 2002;**6**:421—4.
30. **Webber-Jones JE,** Thomas CA, Bordeaux RE Jr. The management and prevention of rigid cervical collar complications. *Orthop Nurs* 2002;**21**:19—25.

Value of a rigid collar in addition to head blocks: a proof of principle study

M Holla

Emerg Med J 2012 29: 104-107 originally published online February 18, 2011
doi: 10.1136/emj.2010.092973