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Review

Prehospital Use of Cervical Collars in Trauma Patients: A Critical Review

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Abstract

The cervical collar has been routinely used for trauma patients for more than 30 years and is a hallmark of state-of-the-art prehospital trauma care. However, the existing evidence for this practice is limited: Randomized, controlled trials are largely missing, and there are uncertain effects on mortality, neurological injury, and spinal stability. Even more concerning, there is a growing body of evidence and opinion against the use of collars. It has been argued that collars cause more harm than good, and that we should simply stop using them. In this critical review, we discuss the pros and cons of collar use in trauma patients and reflect on how we can move our clinical practice forward. Conclusively, we propose a safe, effective strategy for prehospital spinal immobilization that does not include routine use of collars.

Key words: cervical collar; cervical injury; cervical spine; prehospital; trauma

Introduction

Cervical collars are considered important measures in modern prehospital trauma care. The recommended practice of routine application of collars in trauma patients has largely been unchanged for more than 30 years.[1] It is featured as a prioritized procedure in the Advanced Trauma Life Support (ATLS) guidelines from the American College of Surgeons (ACS)[1] and the Prehospital Trauma Life Support (PHTLS) guidelines from the National Association of Emergency Medical Technicians (NAEMT).[2] These guidelines dominate the field of prehospital trauma care, and ATLS and PHTLS are implemented in 50–60 countries.[1,2] The use of collars is, in fact, regarded as so important that it is highlighted in the well-known ABCs of major trauma as a first measure, together with establishment of free airways.[1]

Collars were introduced to prevent secondary injury to the spinal cord by immobilizing a potentially unstable spine.[3–5] Many years have passed since, and this practice has evolved into a hallmark of modern state-of-the-art prehospital care.[6,7] Millions of trauma patients are currently fitted with a collar every year.[8] However, as evaluated in a Cochrane review in 2001 (updated in 2007), the documented evidence for our ongoing practice is rather limited: Randomized, controlled trials (RCTs) are largely missing, and there are uncertain effects on mortality, neurological injury, and spinal stability.[9] Moreover, and perhaps more concerning, there is a growing body of evidence and opinion against the use of collars.[9–14]

Improving prehospital management has a substantial effect on society as a whole and is a high-priority research area.[15] In this review, we argue that it is time to reconsider the unjustified dogma of collar use in prehospital trauma care.

Methods

We performed a literature search in the Medline database using a combination of relevant medical subject headings (MeSHs) and text words: (''cervical vertebrae''[MeSH] *or* ''neck''[MeSH] *or* cervical[text word]) *and* (''braces''[MeSH] *or* collar*[text words] *or* ''immobilization''[MeSH]) *and* (''wounds and injuries''[MeSH] *or* ''emergency medical services''[MeSH]). This search was limited to human studies in English available by April 2013. All authors contributed to the search strategy development. We found 1018 publications, of which 88 titles were considered relevant by one or two independent authors (T.S. and K.W.). Borderline titles were included. These publications underwent full review by the author group, and 50 articles were found relevant to prehospital use of collars in trauma patients by more than one author. These articles are included here. Finally, we searched the reference lists of retrieved articles and contacted experts in the field to identify pertinent studies. Articles published over the last 10–15 years were prioritized.

Epidemiology of Cervical Spine and Spinal Cord Injuries

Several reports state that approximately 2–4% of trauma patients have cervical spine injuries (CSIs),[16–26] of which roughly 20%

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have spinal cord injury (SCI),[22] 10% have multi-level injuries,[1,21,22] and 10% have pure ligamentous injuries.[16,18] The majority of patients with CSIs have injuries to other body regions, most frequently the head, chest, and extremities.[22] The reported rate of delayed diagnosis or missed CSI is very low (1.3% of all cervical injuries).[20] CSIs are more often observed in unconscious or obtunded patients than in those that are alert and communicable.[18,24,27]

The incidence of hospital-admitted cervical fractures in the general population was recently estimated at approximately 12 in 100,000 per year in a prospective observational cohort study.[28] Incidence increased with increasing age. Twenty-seven percent of patients in this cohort were operated on, 68% were treated with collars, and 5% did not receive any specific treatment. Approximately 80% of the patients had a normal neurological status at the time of diagnosis. The most common trauma mechanisms were falls (60%) and motor vehicle accidents (21%). In this study, Fredø and colleagues found a strong association between cervical fractures and traumatic brain injuries (TBIs), with 11% of patients having a moderate to severe TBI and 78% having a minimal to mild TBI.

Over the past 40 years, there has been a shift in functional outcome for patients with SCIs in Western countries: The percentage of incomplete tetraplegia has increased, whereas complete paraplegia or tetraplegia has decreased.[29] Survival after SCI is strongly related to the extent of neurological impairment,[30] and several studies have shown increasing survival rates and life expectancy.[31–33] These improvements in outcome can, for the most part, be attributed to systematic injury prevention strategies (e.g., education, legislation, and safety features of cars), rather than the implementation of evidence-based treatment guidelines, advances in emergency medical services (EMS), improvements in neurocritical care, or establishment of regional trauma centers.[31,34–37] The mean age of CSI and SCI patients has increased, and this has important implications for treatment and outcome.[29,37] Epidemiological trends and causality analyses in CSI and SCI are very similar to those observed in the related field of TBI.[38,39]

Current Recommendations

The American Association for Neurological Surgeons (AANS) and the Congress of Neurological Surgeons (CNS) Joint Guidelines Committee recently published a comprehensive update of the *Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injury*.[40] These guidelines provide 112 evidence-based diagnostic and treatment recommendations (77 level III, 16 level II, and 19 level I recommendations). The vast majority of treatment recommendations are level III, and all surgical recommendations, except one level II for type II odontoid fractures,[41] are level III recommendations.[40]

In the prehospital setting, the AANS/CNS recommends spinal immobilization of all trauma patients with a known or suspected CSI or SCI; however, experienced personnel should evaluate the need for immobilization during transport (level II).[42] Fully awake and communicable patients that are not intoxicated, without neck pain or tenderness, neurologically intact, and without distracting injuries should not be immobilized (level II).[42] The preferred method of immobilization is the combination of a rigid collar and supportive blocks on a spine board with straps (level III).[42] Sandbags and tape alone should not be used, and spinal immobilization in patients with penetrating trauma is not recommended (level III).[42]

The AANS/CNS guidelines are generally in line with the ATLS and PHTLS guidelines as well as other reviews and management guidelines for CSIs, and they all state that collars are effective in limiting motion of the cervical spine and should therefore be used until the patient is properly assessed and the cervical spine is cleared.[1,2,27,42–45]

Why Do We Use Cervical Collars? Looking Outside the Guidelines

CSIs are feared because of the inherent risk of permanent SCI with potential life-threatening and -changing consequences for patients. Moreover, there are important concerns about medicolegal liability, although not yet prevalent in Scandinavia; malpractice lawsuits in cases of avoidable SCI are very expensive, with compensations of approximately $3 million USD.[46] Further, collars are generally regarded as safe and effective, and few question their use in daily trauma practice; it makes good sense to stabilize an unstable injury. Collars have essentially become a symbol of high-quality trauma care, and in many EMS systems protocolized paramedics never deliver patients without a collar to the emergency department (ED). Besides, the ABCs of major trauma is a powerful mnemonic and a strong psychological premise for medical action in the field. Finally, and essential in this regard, it is better to have a protocol than no protocol, and it is better and cheaper to advocate an easy, uniform practice than a difficult, individualized one.

How Effective Are Cervical Collars?

It has been postulated that 3–25% of SCIs are secondary,[1,42,47,48] occurring either during prehospital or early hospital care, and are the result of ''inappropriate management,'' such as lack of spinal immobilization (as frequently cited previously[3,5,17,49–61]). This claim has, however, a number of limitations. First, it is not easy to identify a neurological decline throughout the prehospital phase. Second, extrapolation of results obtained in a hospital setting to the prehospital arena is questionable. Third, several of the cited studies were conducted many years ago with other treatment standards and available resources, so it is not always clear which factors really contributed to the clinical worsening, and there are significant concerns as to the evidence-based value of case series. Moreover, it is essential to understand that approximately 5% of patients with spinal injuries experience some degree of neurological worsening, even with good immobilization of the spine.[62] This clinical deterioration can be the result of well-known mechanisms, such as hematomas, edema, hypotension, hypoxemia, or inflammation.[63–65]

The collar should, in theory, protect patients from secondary spinal cord traumas by restricting inadvertent movements of unstable CSIs. However, we will probably never know how many secondary SCIs collars have prevented. Collar efficacy on motion control has never been examined in real trauma patients.[12] There are also no RCTs that address the effect of collars on outcomes after CSI and probably never will be. Conversely, a number of studies have examined spine movement in simulated environments (e.g., cadavers with or without rigor mortis or healthy volunteers) using a wide range of devices and assessment criteria, and the results of these studies are somewhat contradictory and confusing. For instance, studies have shown that collars can be placed and removed without large displacements,[66] a rigid collar can increase movement in the upper cervical spine,[67] there is similar restriction in cervical range of motion using soft and rigid collars,[68] there is less motion with a collar in place than without a collar,[69] using a collar does not effectively reduce motion in an unstable spine,[70,71] there is

no extra motion control by adding a collar to a spine board with head blocks,[72] a collar and spine board provide more immobilization than a collar alone,[73,74] a collar and a vacuum mattress offer greater stability and comfort than a collar and a spine board,[75,76] immobilization provided by the short board is superior to collars and not augmented by adding collars,[77,78] sandbags, collar, and tape is the most effective measure for motion control (the use of sandbags is limited though because of practical concerns),[55] a board, collar, and towels/foam wedges is the most stable immobilization,[79,80] and allowing an individual to exit a car under his own volition with a collar in place may result in the least amount of movement of the cervical spine.[81] Altogether, whereas any form of immobilization is superior to no immobilization, no available method is optimal, and there is no solid evidence to support the commonly accepted treatment standards of today.[6,42,82–85]

In the recent AANS/CNS guidelines, Theodore and colleagues reviewed different methods of prehospital spinal immobilization and cautiously concluded that the most effective immobilization method seemed to be a combination of a rigid collar with supportive blocks on a rigid spine board with straps.[42] To our knowledge, there are no studies showing a clinical benefit of using the double immobilization strategy with rigid collars and head blocks.[72]

Studying the natural course of overlooked or missed fractures is another way of looking into the efficacy of cervical immobilization. For this surrogate marker of instability, it is important to keep the different perspectives of time in mind: The application and removal of a trauma collar usually spans a couple of hours, whereas the window between trauma and diagnosis for missed injuries can be from days to weeks. In one large, multi-center study, missed CSI presenting with a neurological deficit occurred in less than 1 of 500 spine injury cases and 1 of 4000 trauma cases, with an average delay in diagnosis of approximately 20 days.[86] On one hand, there are studies where up to 8% of necks were not immobilized, seemingly without clinical consequences or progress to neurological deficits.[87–91] Conversely, Gerrelts and colleagues identified the development of temporary neurological symptoms before treatment, but were unable to identify permanent complications in those with missed cervical fractures.[92] Davis and colleagues and Platzer and colleagues reported that delayed diagnosis, in fact, resulted in permanent, severe deficits: Davis and colleagues reported 32,117 trauma patients, 740 cervical injuries, 34 injuries missed, 10 developed permanent deficits,[17] whereas Platzer and colleagues reported 367 cervical injuries, 18 injuries missed, 8 developed neurological symptoms, and 2 permanent deficits.[93]

Considerable force is required to fracture the spine, and subsequent low-energy movements are thus unlikely to cause secondary SCI.[94] Plumb and Morris recently proposed that we should simply stop using collars in obtunded patients, because ''it is likely that minor degrees of cervical spine movement are without consequence and more significant movement prevented by common sense.''[95] Moreover, awake patients generally maintain a stable neck position with muscle contractions that protect the spinal cord.[94] Additionally, and contrary to common belief, most spinal injuries are biomechanically stable in the acute phase, and unstable injuries that have not caused acute, irrevocable injuries are very rare.[96] Conclusively, given that collars are ineffective in motion control, we are apt to conclude that the risks of inadequate immobilization may be substantially overemphasized.[13,97]

It has been conservatively estimated that at least 50–100 patients have their neck immobilized for every patient that has a significant CSI.[12] This ratio implies that cervical immobilization, usually involving a collar, must be safe and effective to provide a reasonable cost-benefit relationship. In an interesting article from Ghana, aimed at improving prehospital trauma care in developing countries, Tiska and colleagues recommended abandoning the concept of strict spinal immobilization in favor of a more pragmatic practice with simple spinal precautions. In this case, resource considerations have motivated a practice that is truly based on the lack of evidence supporting rigorous spinal immobilization.[98]

In summary, the ATLS guidelines have significantly changed the way ambulance crews and hospital staffs think of and manage trauma patients, but there is little evidence to support a real benefit on patient outcome.[99,100] For spinal immobilization in general, and collars in particular, there is insufficient evidence to support the currently recommended treatment routines with regard to mortality, neurological injury, or spinal stability.[9]

Possible Adverse Effects of Cervical Collars

Collars may exacerbate CSIs, instead of protecting the individual from secondary progression.[101–104] In this regard, it is vital to be aware that many collars are not fitted correctly, and it is therefore reasonable to assume that this can reduce the potential for motion control as well as increase the risk for neurological compromise.[47,105] In a noteworthy study, though not without limitations, Hauswald and colleagues found an increased frequency of clinical deterioration and more overall neurological disability in patients with spinal injuries that were routinely fitted with a collar (Albuquerque, NM) than in patients that never received a prophylactic collar (Kuala Lumpur, Malaysia).[94] Further, some of the strongest evidence of harm from collars comes from studies of patients with ankylosing spondylitis (Morbus Bechterew), where extension of the cervical spine during standard prehospital immobilization is very dangerous.[65,106] This is not always evident at the trauma scene and not an uncommon disease; approximately 5% of all patients with cervical fractures had ankylosing spondylitis in Fredø and colleagues' study.[28]

Associated head and spinal injuries are frequent; the ATLS guidelines state that 5% of patients with a TBI have an associated spinal injury, whereas 25% of patients with a spinal injury have at least a mild TBI.[1] Avoiding or reducing an increased intracranial pressure (ICP) is fundamental in the management of TBI, and it is important to be aware that a collar may increase ICP by an average of 4.5 mmHg through jugular venous compression.[107–112] Interestingly, advanced life-support training of ambulance crews has been found to increase mortality among patients with a Glasgow Coma Scale (GCS) score <9 (typical cutoff for severe TBI), but whether this mortality increase is the result of complications associated with prehospital interventions, such as collar use, inadequate airway management, or transport delays to hospital is not established.[113] Moreover, venous congestion by collars can also exacerbate global brain injuries, such as those observed after attempted suicide by hanging.[114]

A key issue associated with collars in prehospital care is the increased difficulty it may entail for airway management.[72,115–126] Mouth opening can be compromised and aspiration can more easily result from vomiting, especially in the supine position.[72,127,128] Collars may also cause respiratory restriction, an effect that is more pronounced if spine boards are added.[61,129] Notably, endotracheal intubation of CSI patients in the ED setting has not been shown to worsen neurological outcome,[130–132] whereas reports on prehospital endotracheal intubation of TBI patients have shown better,[133–136] unchanged,[133,137–139] or impaired[140–143] morbidity

and/or mortality outcomes. Field intubation procedures are associated with more difficulty and complications than in-hospital procedures because of a wide range of factors.[144–150] Further, prehospital intubation is not always available and the ability to perform this procedure safely varies among prehospital EMS personnel, with physicians having the highest success rates.[144–151] Prioritizing advanced airway management and spinal immobilization may also delay release and rescue procedures as well as make the trauma examination more difficult, both at the scene, during transport, and at admittance.[13,96,152] Delayed definitive care can be detrimental for patients with non-neurological critical injuries, and importantly, also lead to neurological progression, because spinal injuries are often neurologically unstable, but biomechanically stable in the acute phase.[96] In conclusion, it is essential to provide prompt, careful transport to definitive care.[153] A number of practice options exist for airway management in CSI, but there are no outcome data that favor any particular practice.[154] Nevertheless, after checking airways and breathing, unconscious patients with unsecured airways should not be transported in the supine position, but preferably in the lateral trauma position[155,156] or HAINES (High Arm IN Endangered Spine) modified recovery position.[157,158]

In our experience, collars can have a tendency to ''paralyze'' some health care personnel; they see it as a sign of uncertainty and possible serious injury and it may therefore compromise their ability to perform the necessary examinations or actions. Moreover, bystanders acting to help trauma victims at the accident scene may be ''paralyzed'' by the fact that the patient's neck is not secured and hence not act to secure, for example, the airways.

There are some major problems with pressure ulcers that result from collars, resulting also from strapping on spine boards.[127,159–166] Additionally, discomfort, pain, and related stress responses are not an insignificant problem and can be a confounding factor in initial patient assessment and trauma management.[167–172]

Patients that have received spinal immobilization are more likely to proceed to radiological examinations to ''clear the neck.''[13,171,173] This is concerning, in light of the accumulating evidence on the unfavorable radiation effects of computed tomography (CT) scanning,[174–176] especially in children.[177–181]

Prehospital spinal immobilization has been associated with higher morbidity and mortality in penetrating trauma patients[152,182,183] and found unnecessary in patients with gunshot wounds to the head.[184] Routine spinal immobilization in penetrating trauma is therefore not recommended.[42,185]

Taken together, there is a large volume of studies disfavoring the routine use of collars. The accumulated information provided by these studies has, in our opinion, not been sufficiently appreciated and has had a marginal influence on the practice of prehospital spinal immobilization.

Specific Pediatric Concerns

The numerous concerns regarding collars in adult patients are mostly transferable to the pediatric population.[186] Moreover, most of the foundation for prehospital treatment of children with CSIs is based on adult studies, and the evidence favoring current management strategies is therefore even weaker than in adults.[186,187] Pediatric collars are adapted to the size and anatomy of children, whereas undesirable neck flexion on spine boards should be avoided by individual modifications.[188] No studies have been identified that compare spinal stabilization with or without collars in children.

CSI in pediatric blunt trauma victims is rare and occurs in approximately 1–2% of patients,[189–194] although more frequent with concomitant head injury.[195] The anatomy and injury patterns observed in children older than 8 years resemble those of adults.[186,194] Younger children have more high-level injuries, fewer fractures, more dislocations, and more SCIs because of their larger head/body ratio, greater ligament laxity, and more horizontal facet joints.[186,191,193,194,196] Outcomes are often poorer in younger than in older children.[191,193]

Despite presenting with comparable injury severity, children who undergo prehospital spinal immobilization have higher degrees of pain, are much more likely to undergo radiological examinations, and are more often admitted to hospital than those that are not immobilized.[173] Several studies have raised concerns about childhood exposure to ionizing radiation (particularly CT) and an increased lifetime risk of cancer.[177–181] Several low-risk prediction rules have been developed to avoid unnecessary prehospital spinal immobilization in children, but have proven difficult to validate, because these injuries are so uncommon.[186]

Clearing the Cervical Spine in Conscious and Unconscious Patients

Conscious patients

Cervical spine clearance in awake and alert patients is easier and better documented than in unconscious or obtunded patients.[11] There are several clinical approaches available to substantiate whether or not awake patients have a significant CSI and thus are in need of radiological examinations and/or specific treatment. One of the best validated algorithms is the Canadian C-spine Rule (CCR). This was originally published in 2001 as a tool to decide whether or not patients require radiology in the hospital setting.[26] In 2011, a revised edition was published for the prehospital setting, but now as a tool to decide whether patients require cervical spine immobilization or not.[197]

High-quality studies have shown that physicians in the ED can safely use the CCR as well as the NEXUS (National Emergency X-Radiography Utilization Study) criteria to rule out CSI.[23,26,198] Studies have also shown that the CCR is more sensitive and specific than the NEXUS criteria, and that using the CCR results in lower rates of radiological examinations.[199–201] Further, the CCR can be used with similar accuracy and reliability by triage nurses in the ED and paramedics in the prehospital setting.[202–204]

Education of prehospital personnel in clinical clearance of the cervical spine has a large potential for improving management, with an estimated 40% reduction in cervical spine immobilization (and subsequent radiological examinations).[43,197]

Radiological investigations are often deemed unnecessary for conscious patients without symptoms, neurological deficits, or distracting injuries and that have a full range of motion upon functional examination.[205] Evidence also suggests that this straightforward clearance approach can be simplified even further by ignoring distracting injuries,[206,207] perhaps except for injuries in the upper chest region.[208] Altogether, there is a wide range of algorithms based on different clinical criteria for clearance of the cervical spine in the prehospital setting.[87–91,205,208–218]

Patients with reduced consciousness

Patients with reduced consciousness have a higher prevalence of CSIs, and cervical spine clearance in such patients is not as clear cut as in conscious patients.[24,27] As a consequence, most patients are fitted with a rigid collar in combination with head blocks and strapped to a spine board during transport, and the collar remains on

until they can be evaluated by imaging.[1,27,42–45] However, based on the information presented so far, we can safely conclude that the presumed benefit of collars is highly questionable, and that there is a large body of evidence on the risks and complications of this practice. Particularly concerning for this patient category are the reports of increased ICP when collars are applied[107–112] as well as data suggesting increased mortality rates for patients with a GCS score <9 that have been managed by ambulance crews skilled in advanced life support.[113] Expeditious transport to definitive care is vital for unconscious CSI patients,[153] and this should take priority over rigorous immobilization measures. Moreover, and as previously discussed, unconscious patients with unsecured airways should not be transported in the supine position.[72,127,128,155–158]

Prehospital application of collars is well implemented, despite the lack of evidence to support this practice. Thus, it has been advocated that a practice change can only be initiated within the confines of a clinical trial, providing high-quality data on the benefits and risks of cervical immobilization. This will most likely require a large, multi-center RCT, which is a daunting task in itself, but even more so with certain challenges of prehospital research (e.g., ethical considerations, patient informed consent, randomization procedures, patient follow-up, time-pressured environment, and protocolized mindsets). Alternatively, one may explore the possibility of developing new clinical treatment guidelines through an expert consensus process involving both prehospital and hospital environments.[219]

Finally, it seems reasonable to strive for a more individualized prehospital approach to obtunded patients at risk of having a potential CSI. One way of doing this could be to incorporate knowledge from extensive epidemiological surveillance studies, such as a recent European multi-center study including more than 250,000 patients, which, by multivariate analysis, tried to identify various risk factors of CSI in trauma patients.[22] Efforts should also be concentrated on developing new devices that are more easy, safe, and effective to use.[85,220]

Conclusion

The existing evidence for using collars is weak, and our practice is mainly a result of the historical influence of poor evidence. More significant and concerning, there is a well of less-appreciated documentation of harmful effects from collars. A practice change seems warranted based on a critical evaluation of the pros and cons of prehospital collar use in trauma patients.

With this perspective, we propose a safe, effective immobilization strategy that will not require any new equipment and should be easy to implement; the main difference from current protocols is the omission of routine collar application.[1,2,27,42–45] Few patients are in need of spinal immobilization, and clearance protocols should be optimized to identify these high-risk patients. These patients should not be fitted with a collar, but immobilized on spine boards with head blocks and straps. Temporary use of a rigid collar is an option during extrication procedures from, for example, cars. Unconscious, nonintubated trauma patients should be transported in a modified lateral recovery position that maintains near neutral spine alignment and airway patency. Finally, prehospital management should, by no means, delay transportation of critically injured patients to definitive care.

Future efforts should also aim to discontinue the use of rigid spine boards in favor of vacuum mattresses or other softer boards that are more comfortable and adaptable to the individual variations in body composition.

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References

1. American College of Surgeons Committee on Trauma. (2012). *Advanced Trauma Life Support (ATLS) Student Course Manual*, 9th ed. American College of Surgeons: Chicago, IL.
2. Prehospital Trauma Life Support Committee of The National Association of Emergency Medical Technicians in Cooperation with The Committee on Trauma of The American College of Suregons. (2010). *Prehospital Trauma Life Support (PHTLS)*, 7th ed. Jones & Bartlett Learning: Burlington, MA.
3. Bohlman, H.H. (1979). Acute fractures and dislocations of the cervical spine. An analysis of three hundred hospitalized patients and review of the literature. J. Bone Joint Surg. Am. 61, 1119–1142.
4. Gunby, I. (1981). New focus on spinal cord injury. JAMA 245, 1201–1206.
5. Rogers, W.A. (1957). Fractures and dislocations of the cervical spine; an end-result study. J. Bone Joint Surg. Am. 39-A, 341–376.
6. De Lorenzo, R.A. (1996). A review of spinal immobilization techniques. J. Emerg. Med. 14, 603–613.
7. Dick, T., and Land, R. (1982). Spinal immobilization devices. Part 1: cervical extrication collars. J. Emerg. Med. Serv. 7, 26–32.
8. Frohna, W.J. (1999). Emergency department evaluation and treatment of the neck and cervical spine injuries. Emerg. Med. Clin. North Am. 17, 739–791, v.
9. Kwan, I., Bunn, F., and Roberts, I.; WHO Pre-Hospital Trauma Care Steering Committee. (2001). Spinal immobilisation for trauma patients. Cochrane Database Syst. Rev. Issue 2. Art. No.: CD002803.
10. Abram, S., and Bulstrode, C. (2010). Routine spinal immobilization in trauma patients: what are the advantages and disadvantages? Surgeon 8, 218–222.
11. Benger, J., and Blackham, J. (2009). Why do we put cervical collars on conscious trauma patients? Scand. J. Trauma Resusc. Emerg. Med. 17, 44.
12. Deasy, C., and Cameron, P. (2011). Routine application of cervical collars—what is the evidence? Injury 42, 841–842.
13. Hauswald, M., and Braude, D. (2002). Spinal immobilization in trauma patients: is it really necessary? Curr. Opin. Crit. Care 8, 566–570.
14. Sporer, K.A. (2012). Why we need to rethink C-spine immobilization: we need to reevaluate current practices and develop a saner cervical policy. EMS World 41, 74–76.
15. Snooks, H., Evans, A., Wells, B., Peconi, J., Thomas, M., Woollard, M., Guly, H., Jenkinson, E., Turner, J., and Hartley-Sharpe, C.; 999 EMS Research Forum Board. (2009). What are the highest priorities for research in emergency prehospital care? Emerg. Med. J. 26, 549–550.
16. Chiu, W.C., Haan, J.M., Cushing, B.M., Kramer, M.E., and Scalea, T.M. (2001). Ligamentous injuries of the cervical spine in unreliable blunt trauma patients: incidence, evaluation, and outcome. J. Trauma 50, 457–463.
17. Davis, J.W., Phreaner, D.L., Hoyt, D.B., and Mackersie, R.C. (1993). The etiology of missed cervical spine injuries. J. Trauma 34, 342–346.
18. Demetriades, D., Charalambides, K., Chahwan, S., Hanpeter, D., Alo, K., Velmahos, G., Murray, J., and Asensio, J. (2000). Nonskeletal cervical spine injuries: epidemiology and diagnostic pitfalls. J. Trauma 48, 724–727.
19. Goldberg, W., Mueller, C., Panacek, E., Tigges, S., Hoffman, J.R., and Mower, W.R.; NEXUS Group. (2001). Distribution and patterns of blunt traumatic cervical spine injury. Ann. Emerg. Med. 38, 17–21.
20. Grossman, M.D., Reilly, P.M., Gillett, T., and Gillett, D. (1999). National survey of the incidence of cervical spine injury and

approach to cervical spine clearance in U.S. trauma centers. J. Trauma 47, 684–690.
21. Hasler, R.M., Exadaktylos, A.K., Bouamra, O., Benneker, L.M., Clancy, M., Sieber, R., Zimmermann, H., and Lecky, F. (2011). Epidemiology and predictors of spinal injury in adult major trauma patients: European cohort study. Eur. Spine J. 20, 2174–2180.
22. Hasler, R.M., Exadaktylos, A.K., Bouamra, O., Benneker, L.M., Clancy, M., Sieber, R., Zimmermann, H., and Lecky, F. (2012). Epidemiology and predictors of cervical spine injury in adult major trauma patients: a multicenter cohort study. J. Trauma Acute Care Surg. 72, 975–981.
23. Hoffman, J.R., Mower, W.R., Wolfson, A.B., Todd, K.H., and Zucker, M.I. (2000). Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. N. Engl. J. Med. 343, 94–99.
24. Milby, A.H., Halpern, C.H., Guo, W., and Stein, S.C. (2008). Prevalence of cervical spinal injury in trauma. Neurosurg. Focus 25, E10.
25. Stawicki, S.P., Holmes, J.H., Kallan, M.J., and Nance, M.L. (2009). Fatal child cervical spine injuries in motor vehicle collisions: analysis using unique linked national datasets. Injury 40, 864–867.
26. Stiell, I.G., Wells, G.A., Vandemheen, K.L., Clement, C.M., Lesiuk, H., De Maio, V.J., Laupacis, A., Schull, M., McKnight, R.D., Verbeek R., Brison R., Cass, D., Dreyer, J., Eisenhauer, M.A., Greenberg, G.H., MacPhail, I., Morrison, L., Reardon, M., and Worthington, J. (2001). The Canadian C-spine rule for radiography in alert and stable trauma patients. JAMA 286, 1841–1848.
27. Morris, C.G., McCoy, E.P., Lavery, G.G., and McCoy, E. (2004). Spinal immobilisation for unconscious patients with multiple injuries. BMJ 329, 495–499.
28. Fredø, H.L., Rizvi, S.A., Lied, B., Rønning, P., and Helseth, E. (2012). The epidemiology of traumatic cervical spine fractures: a prospective population study from Norway. Scand. J. Trauma Resusc. Emerg. Med. 20, 85.
29. The National Spinal Cord Injury Statistical Center. (2011). Complete public version of the 2011 annual statistical report for the spinal cord injury models systems. The National Spinal Cord Injury Statistical Center: Birmingham, AL.
30. Middleton, J.W., Dayton, A., Walsh, J., Rutkowski, S.B., Leong, G., and Duong, S. (2012). Life expectancy after spinal cord injury: a 50-year study. Spinal Cord 50, 803–811.
31. Oliver, M., Inaba, K., Tang, A., Branco, B.C., Barmparas, G., Schnüriger, B., Lustenberger, T., and Demetriades, D. (2012). The changing epidemiology of spinal trauma: a 13-year review from a Level I trauma centre. Injury 43, 1296–1300.
32. Strauss, D.J., Devivo, M.J., Paculdo, D.R., and Shavelle, R.M. (2006). Trends in life expectancy after spinal cord injury. Arch. Phys. Med. Rehabil. 87, 1079–1085.
33. van den Berg, M.E., Castellote, J.M., de Pedro-Cuesta, J., and Mahillo-Fernandez, I. (2010). Survival after spinal cord injury: a systematic review. J. Neurotrauma 27, 1517–1528.
34. Chesnut, R.M. (2004). Management of brain and spine injuries. Crit. Care Clin. 20, 25–55.
35. Gupta, R., Bathen, M.E., Smith, J.S., Levi, A.D., Bhatia, N.N., and Steward, O. (2010). Advances in the management of spinal cord injury. J. Am. Acad. Orthop. Surg. 18, 210–222.
36. Kelly, D.F., and Becker, D.P. (2001). Advances in management of neurosurgical trauma: USA and Canada. World J. Surg. 25, 1179–1185.
37. Lee, B.B., Cripps, R.A., Fitzharris, M., and Wing, P.C. (2013). The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. Spinal Cord Feb 26. doi: 10.1038/sc.2012.158. [Epub ahead of print].
38. Georgoff, P., Meghan, S., Mirza, K., and Stein, S.C. (2010). Geographic variation in outcomes from severe traumatic brain injury. World Neurosurg. 74, 331–345.
39. Stein, S.C., Georgoff, P., Meghan, S., Mizra, K., and Sonnad, S.S. (2010). 150 years of treating severe traumatic brain injury: a systematic review of progress in mortality. J. Neurotrauma 27, 1343–1353.
40. Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons (AANS) and the Congress of Neurological Surgeons (CNS). (2013). Guidelines for the management of acute cervical spine and spinal cord injuries. Neurosurgery 72, Suppl. 2, 1–259.
41. Ryken, T.C., Hadley, M.N., Aarabi, B., Dhall, S.S., Gelb, D.E., Hurlbert, R.J., Rozzelle, C.J., Theodore, N., and Walters, B.C. (2013). Management of isolated fractures of the axis in adults. Neurosurgery 72, Suppl. 2, 132–150.
42. Theodore, N., Hadley, M.N., Aarabi, B., Dhall, S.S., Gelb, D.E., Hurlbert, R.J., Rozzelle, C.J., Ryken, T.C., and Walters, B.C. (2013). Prehospital cervical spinal immobilization after trauma. Neurosurgery 72, Suppl. 2, 22–34.
43. Ahn, H., Singh, J., Nathens, A., MacDonald, R.D., Travers, A., Tallon, J., Fehlings, M.G., and Yee, A. (2011). Pre-hospital care management of a potential spinal cord injured patient: a systematic review of the literature and evidence-based guidelines. J. Neurotrauma 28, 1341–1361.
44. Como, J.J., Diaz, J.J., Dunham, C.M., Chiu, W.C., Duane, T.M., Capella, J.M., Holevar, M.R., Khwaja, K.A., Mayglothling, J.A., Shapiro M.B., and Winston E.S. (2009). Practice management guidelines for identification of cervical spine injuries following trauma: update from the eastern association for the surgery of trauma practice management guidelines committee. J. Trauma 67, 651–659.
45. Stein, D.M., Roddy, V., Marx, J., Smith, W.S., and Weingart, S.D. (2012). Emergency neurological life support: traumatic spine injury. Neurocrit. Care 17, Suppl. 1, S102–S111.
46. Lekovic, G.P., and Harrington, T.R. (2007). Litigation of missed cervical spine injuries in patients presenting with blunt traumatic injury. Neurosurgery 60, 516–522.
47. Bell, K.M., Frazier, E.C., Shively, C.M., Hartman, R.A., Ulibarri, J.C., Lee, J.Y., Kang, J.D., and Donaldson, W.F. (2009). Assessing range of motion to evaluate the adverse effects of ill-fitting cervical orthoses. Spine J. 9, 225–231.
48. Sundheim S.M, and Cruz M. (2006). The evidence for spinal immobilization: an estimate of the magnitude of the treatment benefit. Ann. Emerg. Med. 48, 217–218.
49. Brunette, D.D., and Rockswold, G.L. (1987). Neurologic recovery following rapid spinal realignment for complete cervical spinal cord injury. J. Trauma 27, 445–447.
50. Burney, R.E., Waggoner, R., and Maynard, F.M. (1989). Stabilization of spinal injury for early transfer. J. Trauma 29, 1497–1499.
51. Cloward, R.B. (1980). Acute cervical spine injuries. Clin. Symp. 32, 1–32.
52. Geisler, W.O., Wynne-Jones, M., and Jousse, A.T. (1966). Early management of the patient with trauma to the spinal cord. Med. Serv. J. Can. 22, 512–523.
53. Jeanneret, B., Magerl, F., and Ward, J.C. (1991). Overdistraction: a hazard of skull traction in the management of acute injuries of the cervical spine. Arch. Orthop. Trauma Surg. 110, 242–245.
54. Hachen, H.J. (1974). Emergency transportation in the event of acute spinal cord lesion. Paraplegia 12, 33–37.
55. Podolsky, S., Baraff, L.J., Simon, R.R., Hoffman, J.R., Larmon, B., and Ablon, W. (1983). Efficacy of cervical spine immobilization methods. J. Trauma 23, 461–465.
56. Prasad, V.S., Schwartz, A., Bhutani, R., Sharkey, P.W., and Schwartz, M.L. (1999). Characteristics of injuries to the cervical spine and spinal cord in polytrauma patient population: experience from a regional trauma unit. Spinal Cord 37, 560–568.
57. Reid, D.C., Henderson, R., Saboe, L., and Miller, J.D. (1987). Etiology and clinical course of missed spine fractures. J. Trauma 27, 980–986.
58. Rosen, P., and Wolfe, R.E. (1989). Therapeutic legends of emergency medicine. J. Emerg. Med. 7, 387–389.
59. Sussman, B.J. (1978). Proceedings of the Annual Scientific Meeting of the International Medical Society of Paraplegia held at Stoke Mandeville from 28–30 July 1977 (Part II). Fracture dislocation of the cervical spine: a critique of current management in the United States. Paraplegia 16, 15–38.
60. Toscano, J. (1988). Prevention of neurological deterioration before admission to a spinal cord injury unit. Paraplegia 26, 143–150.
61. Totten, V.Y., and Sugarman, D.B. (1999). Respiratory effects of spinal immobilization. Prehosp. Emerg. Care. 3, 347–352.
62. Marshall, L.F., Knowlton, S., Garfin, S.R., Klauber, M.R., Eisenberg, H.M., Kopaniky, D., Miner, M.E., Tabbador, K., and Clifton, G.L. (1987). Deterioration following spinal cord injury. A multicenter study. J. Neurosurg. 66, 400–404.

63. Huang, Y.H., Yang, T.M., Lin, W.C., Ho, J.T., Lee, T.C., Chen, W.F., Rau, C.S., and Wang, H.C. (2009). The prognosis of acute blunt cervical spinal cord injury. J. Trauma 66, 1441–1445.
64. Tator, C.H., and Fehlings, M.G. (1991). Review of the secondary injury theory of acute spinal cord trauma with emphasis on vascular mechanisms. J. Neurosurg. 75, 15–26.
65. Thumbikat, P., Hariharan, R.P., Ravichandran, G., McClelland, M.R., and Mathew, K.M. (2007). Spinal cord injury in patients with ankylosing spondylitis: a 10-year review. Spine (Phila Pa 1976) 32, 2989–2995.
66. Prasarn, M.L., Conrad, B., Del Rossi, G., Horodyski, M., and Rechtine, G.R. (2012). Motion generated in the unstable cervical spine during the application and removal of cervical immobilization collars. J. Trauma Acute Care Surg. 72, 1609–1613.
67. Chin, K.R., Auerbach, J.D., Adams, S.B., Sodl, J.F., and Riew, K.D. (2006). Mastication causing segmental spinal motion in common cervical orthoses. Spine (Phila Pa 1976) 31, 430–434.
68. Miller, C.P., Bible, J.E., Jegede, K.A., Whang, P.G., and Grauer, J.N. (2010). Soft and rigid collars provide similar restriction in cervical range of motion during fifteen activities of daily living. Spine (Phila Pa 1976) 35, 1271–1278.
69. Conrad, B.P., Rechtine, G., Weight, M., Clarke, J., and Horodyski, M. (2010). Motion in the unstable cervical spine during hospital bed transfers. J. Trauma 69, 432–436.
70. Horodyski, M., DiPaola, C.P., Conrad, B.P., and Rechtine, G.R. (2011). Cervical collars are insufficient for immobilizing an unstable cervical spine injury. J. Emerg. Med. 41, 513–519.
71. Lador, R., Ben-Galim, P., and Hipp, J.A. (2011). Motion within the unstable cervical spine during patient maneuvering: the neck pivot-shift phenomenon. J. Trauma 70, 247–250.
72. Holla, M. (2012). Value of a rigid collar in addition to head blocks: a proof of principle study. Emerg. Med. J. 29, 104–107.
73. Chandler, D.R., Nemejc, C., Adkins, R.H., and Waters, R.L. (1992). Emergency cervical-spine immobilization. Ann. Emerg. Med. 21, 1185–1188.
74. Hostler, D., Colburn, D., and Seitz, S.R. (2009). A comparison of three cervical immobilization devices. Prehosp. Emerg. Care 13, 256–260.
75. Hamilton, R.S., and Pons, P.T. (1996). The efficacy and comfort of full-body vacuum splints for cervical-spine immobilization. J. Emerg. Med. 14, 553–559.
76. Luscombe, M.D., and Williams, J.L. (2003). Comparison of a long spinal board and vacuum mattress for spinal immobilisation. Emerg. Med. J. 20, 476–478.
77. Cline, J.R., Scheidel, E., and Bigsby, E.F. (1985). A comparison of methods of cervical immobilization used in patient extrication and transport. J. Trauma 25, 649–653.
78. Graziano, A.F., Scheidel, E.A., Cline, J.R., and Baer, L.J. (1987). A radiographic comparison of prehospital cervical immobilization methods. Ann. Emerg. Med. 16, 1127–1131.
79. Huerta, C., Griffith, R., and Joyce, S.M. (1987). Cervical spine stabilization in pediatric patients: evaluation of current techniques. Ann. Emerg. Med. 16, 1121–1126.
80. Perry, S.D., McLellan, B., McIlroy, W.E., Maki, B.E., Schwartz, M., and Fernie, G.R. (1999). The efficacy of head immobilization techniques during simulated vehicle motion. Spine (Phila Pa 1976) 24, 1839–1844.
81. Shafer, J.S., and Naunheim, R.S. (2009). Cervical spine motion during extrication: a pilot study. West. J. Emerg. Med. 10, 74–78.
82. Del Rossi, G., Heffernan, T.P., Horodyski, M., and Rechtine, G.R. (2004). The effectiveness of extrication collars tested during the execution of spine-board transfer techniques. Spine J. 4, 619–623.
83. Karbi, O.A., Caspari, D.A., and Tator, C.H. (1988). Extrication, immobilization and radiologic investigation of patients with cervical spine injuries. CMAJ 139, 617–621.
84. Sandler, A.J., Dvorak, J., Humke, T., Grob, D., and Daniels, W. (1996). The effectiveness of various cervical orthoses. An in vivo comparison of the mechanical stability provided by several widely used models. Spine (Phila Pa 1976) 21, 1624–1629.
85. Smyth, M., and Cooke, M.W. (2013). Value of a rigid collar: in need of more research and better devices. Emerg. Med. J. 30, 516.
86. Levi, A.D., Hurlbert, R.J., Anderson, P., Fehlings, M., Rampersaud, R., Massicotte, E.M., France, J.C., Le Huec, J.C., Hedlund, R., and Arnold, P. (2006). Neurologic deterioration secondary to unrecognized spinal instability following trauma—a multicenter study. Spine (Phila Pa 1976) 31, 451–458.
87. Armstrong, B.P., Simpson, H.K., Crouch, R., and Deakin, C.D. (2007). Prehospital clearance of the cervical spine: does it need to be a pain in the neck? Emerg. Med. J. 24, 501–503.
88. Brown, L.H., Gough, J.E., and Simonds, W.B. (1998). Can EMS providers adequately assess trauma patients for cervical spinal injury? Prehosp. Emerg. Care 2, 33–36.
89. Domeier, R.M., Swor, R.A., Evans, R.W., Hancock, J.B., Fales, W., Krohmer, J., Frederiksen, S.M., Rivera-Rivera, E.J., and Schork, M.A. (2002). Multicenter prospective validation of prehospital clinical spinal clearance criteria. J. Trauma 53, 744–750.
90. Domeier, R.M., Frederiksen, S.M., and Welch, K. (2005). Prospective performance assessment of an out-of-hospital protocol for selective spine immobilization using clinical spine clearance criteria. Ann. Emerg. Med. 46, 123–131.
91. Stroh, G., and Braude, D. (2001). Can an out-of-hospital cervical spine clearance protocol identify all patients with injuries? An argument for selective immobilization. Ann. Emerg. Med. 37, 609–615.
92. Gerrelts, B.D., Petersen, E.U., Mabry, J., and Petersen, S.R. (1991). Delayed diagnosis of cervical spine injuries. J. Trauma 31, 1622–1626.
93. Platzer, P., Hauswirth, N., Jaindl, M., Chatwani, S., Vecsei, V., and Gaebler, C. (2006). Delayed or missed diagnosis of cervical spine injuries. J. Trauma 61, 150–155.
94. Hauswald, M., Ong, G., Tandberg, D., and Omar, Z. (1998). Out-of-hospital spinal immobilization: its effect on neurologic injury. Acad. Emerg. Med. 5, 214–219.
95. Plumb, J.O., and Morris, C.G. (2013). Cervical collars: probably useless; definitely cause harm! J. Emerg. Med. 44, e143.
96. Hauswald, M. (2012). A re-conceptualisation of acute spinal care. Emerg. Med. J. 30, 720–723.
97. Lin, H.L., Lee, W.C., Chen, C.W., Lin, T.Y., Cheng, Y.C., Yeh, Y.S., Lin, Y.K., and Kuo, L.C. (2011). Neck collar used in treatment of victims of urban motorcycle accidents: over- or underprotection? Am. J. Emerg. Med. 29, 1028–1033.
98. Tiska, M.A., Adu-Ampofo, M., Boakye, G., Tuuli, L., and Mock, C.N. (2004). A model of prehospital trauma training for lay persons devised in Africa. Emerg. Med. J. 21, 237–239.
99. Jayaraman, S., and Sethi, D. (2009). Advanced trauma life support training for hospital staff. Cochrane Database Syst. Rev. Issue 2. Art. No.: CD004173.
100. Jayaraman, S., and Sethi, D. (2010). Advanced trauma life support training for ambulance crews. Cochrane Database Syst. Rev. Issue 1. Art. No.: CD003109.
101. Ben-Galim, P., Dreiangel, N., Mattox, K.L., Reitman, C.A., Kalantar, S.B., and Hipp, J.A. (2010). Extrication collars can result in abnormal separation between vertebrae in the presence of a dissociative injury. J. Trauma 69, 447–450.
102. Bivins, H.G., Ford, S., Bezmalinovic, Z., Price, H.M., and Williams, J.L. (1988). The effect of axial traction during orotracheal intubation of the trauma victim with an unstable cervical spine. Ann. Emerg. Med. 17, 25–29.
103. Papadopoulos, M.C., Chakraborty, A., Waldron, G., and Bell, B.A. (1999). Lesson of the week: exacerbating cervical spine injury by applying a hard collar. BMJ 319, 171–172.
104. Podolsky, S.M., Hoffman, J.R., and Pietrafesa, C.A. (1983). Neurologic complications following immobilization of cervical spine fracture in a patient with ankylosing spondylitis. Ann. Emerg. Med. 12, 578–580.
105. Engsberg, J.R., Standeven, J.W., Shurtleff, T.L., Eggars, J.L., Shafer, J.S., and Naunheim, R.S. (2013). Cervical spine motion during extrication. J. Emerg. Med. 44, 122–127.
106. Clarke, A., James, S., and Ahuja, S. (2010). Ankylosing spondylitis: inadvertent application of a rigid collar after cervical fracture, leading to neurological complications and death. Acta. Orthop. Belg. 76, 413–415.
107. Craig, G.R., and Nielsen, M.S. (1991). Rigid cervical collars and intracranial pressure. Intensive Care Med. 17, 504–505.
108. Davies, G., Deakin, C., and Wilson, A. (1996). The effect of a rigid collar on intracranial pressure. Injury 27, 647–649.
109. Hunt, K., Hallworth, S., and Smith, M. (2001). The effects of rigid collar placement on intracranial and cerebral perfusion pressures. Anaesthesia 56, 511–513.

110. Kolb, J.C., Summers, R.L., and Galli, R.L. (1999). Cervical collar-induced changes in intracranial pressure. Am. J. Emerg. Med. 17, 135–137.
111. Mobbs, R.J., Stoodley, M.A., and Fuller, J. (2002). Effect of cervical hard collar on intracranial pressure after head injury. ANZ J. Surg. 72, 389–391.
112. Stone, M.B., Tubridy, C.M., and Curran, R. (2010). The effect of rigid cervical collars on internal jugular vein dimensions. Acad. Emerg. Med. 17, 100–102.
113. Stiell, I.G., Nesbitt, L.P., Pickett, W., Munkley, D., Spaite, D.W., Banek, J., Field, B., Luinstra-Toohey, L., Maloney, J., Dreyer. J., Lyver, M., Campeau, T., and Wells, G.A.; OPALS Study Group. (2008). The OPALS Major Trauma Study: impact of advanced life-support on survival and morbidity. CMAJ 178, 1141–1152.
114. Lemyze, M., Palud, A., Favory, R., and Mathieu, D. (2011). Unintentional strangulation by a cervical collar after attempted suicide by hanging. Emerg. Med. J. 28, 532.
115. Aoi, Y., Inagawa, G., Nakamura, K., Sato, H., Kariya, T., and Goto, T. (2010). Airway scope versus macintosh laryngoscope in patients with simulated limitation of neck movements. J. Trauma 69, 838–842.
116. Criswell, J.C., Parr, M.J., and Nolan, J.P. (1994). Emergency airway management in patients with cervical spine injuries. Anaesthesia 49, 900–903.
117. Doran, J.V., Tortella, B.J., Drivet, W.J., and Lavery, R.F. (1995). Factors influencing successful intubation in the prehospital setting. Prehosp. Disaster Med. 10, 259–264.
118. Ghafoor, A.U., Martin, T.W., Gopalakrishnan, S., and Viswamitra, S. (2005). Caring for the patients with cervical spine injuries: what have we learned? J. Clin. Anesth. 17, 640–649.
119. Goutcher, C.M., and Lochhead, V. (2005). Reduction in mouth opening with semi-rigid cervical collars. Br. J. Anaesth. 95, 344–348.
120. Heath, K.J. (1994). The effect of laryngoscopy of different cervical spine immobilisation techniques. Anaesthesia 49, 843–845.
121. LeGrand, S.A., Hindman, B.J., Dexter, F., Weeks, J.B., and Todd, M.M. (2007). Craniocervical motion during direct laryngoscopy and orotracheal intubation with the Macintosh and Miller blades: an in vivo cinefluoroscopic study. Anesthesiology 107, 884–891.
122. Lubovsky, O., Liebergall, M., Weissman, C., and Yuval, M. (2010). A new external upper airway opening device combined with a cervical collar. Resuscitation 81, 817–821.
123. Robitaille, A. (2011). Airway management in the patient with potential cervical spine instability: continuing professional development. Can. J. Anaesth. 58, 1125–1139.
124. Rodriguez-Nunez, A., Oulego-Erroz, I., Perez-Gay, L., and Cortinas-Diaz, J. (2010). Comparison of the GlideScope Videolaryngoscope to the standard Macintosh for intubation by pediatric residents in simulated child airway scenarios. Pediatr. Emerg. Care 26, 726–729.
125. Santoni, B.G., Hindman, B.J., Puttlitz, C.M., Weeks, J.B., Johnson, N., Maktabi, M.A., and Todd, M.M. (2009). Manual in-line stabilization increases pressures applied by the laryngoscope blade during direct laryngoscopy and orotracheal intubation. Anesthesiology 110, 24–31.
126. Thiboutot, F., Nicole, P.C., Trépanier, C.A., Turgeon, A.F., and Lessard, M.R. (2009). Effect of manual in-line stabilization of the cervical spine in adults on the rate of difficult orotracheal intubation by direct laryngoscopy: a randomized controlled trial. Can. J. Anaesth. 56, 412–418.
127. Houghton, D.J., and Curley, J.W. (1996). Dysphagia caused by a hard cervical collar. Br. J. Neurosurg. 10, 501–502.
128. Lockey, D.J., Coats, T., and Parr, M.J. (1999). Aspiration in severe trauma: a prospective study. Anaesthesia 54, 1097–1098.
129. Bauer, D., and Kowalski, R. (1988). Effect of spinal immobilization devices on pulmonary function in the healthy, nonsmoking man. Ann. Emerg. Med. 17, 915–918.
130. Meschino, A., Devitt, J.H., Koch, J.P., Szalai, J.P., and Schwartz, M.L. (1992). The safety of awake tracheal intubation in cervical spine injury. Can. J. Anaesth. 39, 114–117.
131. Patterson, H. (2004). Emergency department intubation of trauma patients with undiagnosed cervical spine injury. Emerg. Med. J. 21, 302–305.
132. Shatney, C.H., Brunner, R.D., and Nguyen, T.Q. (1995). The safety of orotracheal intubation in patients with unstable cervical spine fracture or high spinal cord injury. Am. J. Surg. 170, 676–679.
133. Bernard, S.A., Nguyen, V., Cameron, P., Masci, K., Fitzgerald, M., Cooper, D.J., Walker, T., Std, B.P., Myles, P., Murray, L., Taylor, D., Smith, K., Patrick, I., Edington, J., Bacon, A., Rosenfeld, J.V., and Judson, R. (2010). Prehospital rapid sequence intubation improves functional outcome for patients with severe traumatic brain injury: a randomized controlled trial. Ann. Surg. 252, 959–965.
134. Bulger, E.M., Copass, M.K., Sabath, D.R., Maier, R.V., and Jurkovich, G.J. (2005). The use of neuromuscular blocking agents to facilitate prehospital intubation does not impair outcome after traumatic brain injury. J. Trauma 58, 718–723.
135. Davis, D.P., Peay, J., Serrano, J.A., Buono, C., Vilke, G.M., Sise, M.J., Kennedy, F., Eastman, A.B., Velky, T., and Hoyt, D.B. (2005). The impact of aeromedical response to patients with moderate to severe traumatic brain injury. Ann. Emerg. Med. 46, 115–122.
136. Winchell, R.J., and Hoyt, D.B. (1997). Endotracheal intubation in the field improves survival in patients with severe head injury. Trauma Research and Education Foundation of San Diego. Arch. Surg. 132, 592–597.
137. Eckstein, M., Chan, L., Schneir, A., and Palmer, R. (2000). Effect of prehospital advanced life support on outcomes of major trauma patients. J. Trauma 48, 643–648.
138. Gausche, M., Lewis, R.J., Stratton, S.J., Haynes, B.E., Gunter, C.S., Goodrich, S.M., Poore, P.D., McCollough, M.D., Henderson, D.P., Pratt, F.D., and Seidel, J.S. (2000). Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. JAMA 283, 783–790.
139. Murray, J.A., Demetriades, D., Berne, T.V., Stratton, S.J., Cryer, H.G., Bongard, F., Fleming, A., and Gaspard, D. (2000). Prehospital intubation in patients with severe head injury. J. Trauma 49, 1065–1070.
140. Bochicchio, G.V., Ilahi, O., Joshi, M., Bochicchio, K., and Scalea, T.M. (2003). Endotracheal intubation in the field does not improve outcome in trauma patients who present without an acutely lethal traumatic brain injury. J. Trauma 54, 307–311.
141. Davis, D.P., Hoyt, D.B., Ochs, M., Fortlage, D., Holbrook, T., Marshall, L.K., and Rosen, P. (2003). The effect of paramedic rapid sequence intubation on outcome in patients with severe traumatic brain injury. J. Trauma 54, 444–453.
142. Davis, D.P., Peay, J., Sise, M.J., Vilke, G.M., Kennedy, F., Eastman, A.B., Velky, T., and Hoyt, D.B. (2005). The impact of prehospital endotracheal intubation on outcome in moderate to severe traumatic brain injury. J. Trauma 58, 933–939.
143. Wang, H.E., Peitzman, A.B., Cassidy, L.D., Adelson, P.D., and Yealy, D.M. (2004). Out-of-hospital endotracheal intubation and outcome after traumatic brain injury. Ann. Emerg. Med. 44, 439–450.
144. Adnet, F., Cydulka, R.K., and Lapandry, C. (1998). Emergency tracheal intubation of patients lying supine on the ground: influence of operator body position. Can. J. Anaesth. 45, 266–269.
145. Combes, X., Jabre, P., Jbeili, C., Leroux, B., Bastuji-Garin, S., Margenet, A., Adnet, F., and Dhonneur, G. (2006). Prehospital standardization of medical airway management: incidence and risk factors of difficult airway. Acad. Emerg. Med. 13, 828–834.
146. Gunning, M., O'Loughlin, E., Fletcher, M., Crilly, J., Hooper, M., and Ellis, D.Y. (2009). Emergency intubation: a prospective multicentre descriptive audit in an Australian helicopter emergency medical service. Emerg. Med. J. 26, 65–69.
147. Helm, M., Hossfeld, B., Schäfer, S., Hoitz, J., and Lampl, L. (2006). Factors influencing emergency intubation in the pre-hospital setting—a multicentre study in the German Helicopter Emergency Medical Service. Br. J. Anaesth. 96, 67–71.
148. Hussmann, B., Lefering, R., Waydhas, C., Ruchholtz, S., Wafaisade, A., Kauther, M.D., and Lendemans, S. (2011). Prehospital intubation of the moderately injured patient: a cause of morbidity? A matched-pairs analysis of 1.200 patients from the DGU Trauma Registry. Crit. Care 15, R207.
149. Karch, S.B., Lewis, T., Young, S., Hales, D., and Ho, C.H. (1996). Field intubation of trauma patients: complications, indications, and outcomes. Am. J. Emerg. Med. 14, 617–619.
150. Rose, D.K., and Cohen, M.M. (1994). The airway: problems and predictions in 18.500 patients. Can. J. Anaesth. 41, 372–383.
151. Lossius, H.M., Røislien, J., and Lockey, D.J. (2012). Patient safety in pre-hospital emergency tracheal intubation: a comprehensive meta-analysis of the intubation success rates of EMS providers. Crit. Care 16, R24.

152. Haut, E.R., Kalish, B.T., Efron, D.T., Haider, A.H., Stevens, K.A., Kieninger, A.N., Cornwell, E.E., and Chang, D.C. (2010). Spine immobilization in penetrating trauma: more harm than good? J. Trauma 68, 115–120.
153. Theodore, N., Aarabi, B., Dhall, S.S., Gelb, D.E., Hurlbert, R.J., Rozzelle, C.J., Ryken, T.C., Walters, B.C., and Hadley, M.N. (2013). Transportation of patients with acute traumatic cervical spine injuries. Neurosurgery 72, Suppl. 2, 35–39.
154. Crosby, E.T. (2006). Airway management in adults after cervical spine trauma. Anesthesiology 104, 1293–1318.
155. Berlac, P., Hyldmo, P.K., Kongstad, P., Kurola, J., Nakstad, A.R., and Sandberg, M.; Scandinavian Society for Anesthesiology and Intensive Care Medicine. (2008). Pre-hospital airway management: guidelines from a task force from the Scandinavian Society for Anaesthesiology and Intensive Care Medicine. Acta Anaesthesiol. Scand. 52, 897–907.
156. Fattah, S., Ekås, G.R., Hyldmo, P.K., and Wisborg, T. (2011). The lateral trauma position: what do we know about it and how do we use it? A cross-sectional survey of all Norwegian emergency medical services. Scand. J. Trauma Resusc. Emerg. Med. 19, 45.
157. Blake, W.E., Stillman, B.C., Eizenberg, N., Briggs, C., and McMeeken, J.M. (2002). The position of the spine in the recovery position—an experimental comparison between the lateral recovery position and the modified HAINES position. Resuscitation 53, 289–297.
158. Gunn, B.D., Eizenberg, N., Silberstein, M., McMeeken, J.M., Tully, E.A., Stillman, B.C., Brown, D.J., and Gutteridge, G.A. (1995). How should an unconscious person with a suspected neck injury be positioned? Prehosp. Disaster Med. 10, 239–244.
159. Ackland, H.M., Cooper, D.J., Cooper, J.D., Malham, G.M., and Kossmann, T. (2007). Factors predicting cervical collar-related decubitus ulceration in major trauma patients. Spine (Phila Pa 1976) 32, 423–428.
160. Blaylock, B. (1996). Solving the problem of pressure ulcers resulting from cervical collars. Ostomy Wound Manage. 42, 26–33.
161. Hewitt, S. (1994). Skin necrosis caused by a semi-rigid cervical collar in a ventilated patient with multiple injuries. Injury 25, 323–324.
162. Hodgson, N.F., Stewart, T.C., and Girotti, M.J. (2000). Autopsies and death certification in deaths due to blunt trauma: what are we missing? Can. J. Surg. 43, 130–136.
163. Powers, J., Daniels, D., McGuire, C., and Hilbish, C. (2006). The incidence of skin breakdown associated with use of cervical collars. J. Trauma Nurs. 13, 198–200.
164. Sheerin, F., and de Frein, R. (2007). The occipital and sacral pressures experienced by healthy volunteers under spinal immobilization: a trial of three surfaces. J. Emerg. Nurs. 33, 447–450.
165. Walker, J. (2012). Pressure ulcers in cervical spine immobilisation: a retrospective analysis. J. Wound Care 21, 323–326.
166. Watts, D., Abrahams, E., MacMillan, C., Sanat, J., Silver, R., VanGorder, S., Waller, M., and York, D. (1998). Insult after injury: pressure ulcers in trauma patients. Orthop. Nurs. 17, 84–91.
167. Chan, D., Goldberg, R., Tascone, A., Harmon, S., and Chan, L. (1994). The effect of spinal immobilization on healthy volunteers. Ann. Emerg. Med. 23, 48–51.
168. Chan, D., Goldberg, R.M., Mason, J., and Chan, L. (1996). Backboard versus mattress splint immobilization: a comparison of symptoms generated. J. Emerg. Med. 14, 293–298.
169. Hauswald, M., Hsu, M., and Stockoff, C. (2000). Maximizing comfort and minimizing ischemia: a comparison of four methods of spinal immobilization. Prehosp. Emerg. Care 4, 250–252.
170. Main, P.W., and Lovell, M.E. (1996). A review of seven support surfaces with emphasis on their protection of the spinally injured. J. Accid. Emerg. Med. 13, 34–37.
171. March, J.A., Ausband, S.C., and Brown, L.H. (2002). Changes in physical examination caused by use of spinal immobilization. Prehosp. Emerg. Care 6, 421–424.
172. Walton, R., DeSalvo, J.F., Ernst, A.A., and Shahane, A. (1995). Padded vs unpadded spine board for cervical spine immobilization. Acad. Emerg. Med. 2, 725–728.
173. Leonard, J.C., Mao, J., and Jaffe, D.M. (2012). Potential adverse effects of spinal immobilization in children. Prehosp. Emerg. Care 16, 513–518.
174. Brenner, D.J., and Hall, E.J. (2007). Computed tomography—an increasing source of radiation exposure. N. Engl. J. Med. 357, 2277–2284.
175. Davis, F., Il'yasova, D., Rankin, K., McCarthy, B., and Bigner, D.D. (2011). Medical diagnostic radiation exposures and risk of gliomas. Radiat. Res. 175, 790–796.
176. Einstein, A.J. (2012). Effects of radiation exposure from cardiac imaging: how good are the data? J. Am. Coll. Cardiol. 59, 553–565.
177. Berrington de González, A., Mahesh, M., Kim, K.P., Bhargavan, M., Lewis, R., Mettler, F., and Land, C. (2009). Projected cancer risks from computed tomographic scans performed in the United States in 2007. Arch. Intern. Med. 169, 2071–2077.
178. Brenner, D., Elliston, C., Hall, E., and Berdon, W. (2001). Estimated risks of radiation-induced fatal cancer from pediatric CT. AJR Am. J. Roentgenol. 176, 289–296.
179. Broder, J., Fordham, L.A., and Warshauer, D.M. (2007). Increasing utilization of computed tomography in the pediatric emergency department, 2000–2006. Emerg. Radiol. 14, 227–232.
180. Mathews, J.D., Forsythe, A.V., Brady, Z., Butler, M.W., Goergen, S.K., Byrnes, G.B., Giles, G.G., Wallace, A.B., Anderson, P.R., Guiver, T.A., McGale, P., Cain, T.M., Dowty, J.G., Bickerstaffe, A.C., and Darby, S.C. (2013). Cancer risk in 680,000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians. BMJ 346, f2360.
181. Pearce, M.S., Salotti, J.A., Little, M.P., McHugh, K., Lee, C., Kim, K.P., Howe, N.L., Ronckers, C.M., Rajaraman, P., Craft, A.W., Parker, L., and Berrington de González, A. (2012). Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet 380, 499–505.
182. Barkana, Y., Stein, M., Scope, A., Maor, R., Abramovich, Y., Friedman, Z., and Knoller, N. (2000). Prehospital stabilization of the cervical spine for penetrating injuries of the neck—is it necessary? Injury 31, 305–309.
183. Connell, R.A., Graham, C.A., and Munro, P.T. (2003). Is spinal immobilisation necessary for all patients sustaining isolated penetrating trauma? Injury 34, 912–914.
184. Kaups, K.L., and Davis, J.W. (1998). Patients with gunshot wounds to the head do not require cervical spine immobilization and evaluation. J. Trauma 44, 865–867.
185. Stuke, L.E., Pons, P.T., Guy, J.S., Chapleau, W.P., Butler, F.K., and McSwain, N.E. (2011). Prehospital spine immobilization for penetrating trauma—review and recommendations from the Prehospital Trauma Life Support Executive Committee. J. Trauma 71, 763–769.
186. Tilt, L., Babineau, J., Fenster, D., Ahmad, F., and Roskind, C.G. (2012). Blunt cervical spine injury in children. Curr. Opin. Pediatr. 24, 301–306.
187. Foltin, G.L., Dayan, P., Tunik, M., Marr, M., Leonard, J., Brown, K., Hoyle, J., and Lerner, E.B.; Prehospital Working Group of the Pediatric Emergency Care Applied Research Network. (2010). Priorities for pediatric prehospital research. Pediatr. Emerg. Care 26, 773–777.
188. Herzenberg, J.E., Hensinger, R.N., Dedrick, D.K., and Phillips, W.A. (1989). Emergency transport and positioning of young children who have an injury of the cervical spine. The standard backboard may be hazardous. J. Bone Joint Surg. Am. 71, 15–22.
189. Brown, R.L., Brunn, M.A., and Garcia, V.F. (2001). Cervical spine injuries in children: a review of 103 patients treated consecutively at a level 1 pediatric trauma center. J. Pediatr. Surg. 36, 1107–1114.
190. Dietrich, A.M., Ginn-Pease, M.E., Bartkowski, H.M., and King, D.R. (1991). Pediatric cervical spine fractures: predominantly subtle presentation. J. Pediatr. Surg. 26, 995–999.
191. Kokoska, E.R., Keller, M.S., Rallo, M.C., and Weber, T.R. (2001). Characteristics of pediatric cervical spine injuries. J. Pediatr. Surg. 36, 100–105.
192. Patel, J.C., Tepas, J.J., Mollitt, D.L., and Pieper, P. (2001). Pediatric cervical spine injuries: defining the disease. J. Pediatr. Surg. 36, 373–376.
193. Platzer, P., Jaindl, M., Thalhammer, G., Dittrich, S., Kutscha-Lissberg, F., Vecsei, V., and Gaebler, C. (2007). Cervical spine injuries in pediatric patients. J. Trauma 62, 389–396.
194. Viccellio, P., Simon, H., Pressman, B.D., Shah, M.N., Mower, W.R., and Hoffman, J.R.; NEXUS Group. (2001). A prospective multicenter study of cervical spine injury in children. Pediatrics 108, E20.
195. Oluigbo, C.O., Gan, Y.C., Sgouros, S., Chapman, S., Kay, A., Solanki, G., Walsh, A.R., and Hockley, A.D. (2008). Pattern, management and outcome of cervical spine injuries associated with head injuries in paediatric patients. Childs Nerv. Syst. 24, 87–92.

196. Jones, T.M., Anderson, P.A., and Noonan, K.J. (2011). Pediatric cervical spine trauma. J. Am. Acad. Orthop. Surg. 19, 600–611.
197. Vaillancourt, C., Charette, M., Kasaboski, A., Maloney, J., Wells, G.A., and Stiell, I.G. (2011). Evaluation of the safety of C-spine clearance by paramedics: design and methodology. BMC Emerg. Med. 11, 1.
198. Coffey, F., Hewitt, S., Stiell, I., Howarth, N., Miller, P., Clement, C., Emberton, P., and Jabbar, A. (2011). Validation of the Canadian c-spine rule in the UK emergency department setting. Emerg. Med. J. 28, 873–876.
199. Michaleff, Z.A., Maher, C.G., Verhagen, A.P., Rebbeck, T., and Lin, C.W. (2012). Accuracy of the Canadian C-spine rule and NEXUS to screen for clinically important cervical spine injury in patients following blunt trauma: a systematic review. CMAJ 184, E867–E876.
200. Stiell, I.G., Clement, C.M., Grimshaw, J., Brison, R.J., Rowe, B.H., Schull, M.J., Lee, J.S., Brehaut, J., McKnight, R.D., Eisenhauer, M.A., Dreyer, J., Letovsky, E., Rutledge, T., MacPhail, I., Ross, S., Shah, A., Perry, J.J., Holroyd, B.R., Ip, U., Lesiuk, H., and Wells, G.A. (2009). Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. BMJ 339, b4146.
201. Stiell, I.G., Clement, C.M., McKnight, R.D., Brison, R., Schull, M.J., Rowe, B.H., Worthington, J.R., Eisenhauer, M.A., Cass, D., Greenberg, G., MacPhail, I., Dreyer, J., Lee, J.S., Bandiera, G., Reardon, M., Holroyd, B., Lesiuk, H., and Wells, G.A. (2003). The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. N. Engl. J. Med. 349, 2510–2518.
202. Miller, P., Coffey, F., Reid, A.M., and Stevenson, K. (2006). Can emergency nurses use the Canadian cervical spine rule to reduce unnecessary patient immobilisation? Accid. Emerg. Nurs. 14, 133–140.
203. Stiell, I.G., Clement, C.M., O'Connor, A., Davies, B., Leclair, C., Sheehan, P., Clavet, T., Beland, C., MacKenzie, T., and Wells, G.A. (2010). Multicentre prospective validation of use of the Canadian C-Spine Rule by triage nurses in the emergency department. CMAJ 182, 1173–1179.
204. Vaillancourt, C., Stiell, I.G., Beaudoin, T., Maloney, J., Anton, A.R., Bradford, P., Cain, E., Travers, A., Stempien, M., Lees, M., Munkley, D., Battram, E., Banek, J., and Wells, G.A. (2009). The out-of-hospital validation of the Canadian C-Spine Rule by paramedics. Ann. Emerg. Med. 54, 663–671.
205. Anderson, P.A., Muchow, R.D., Munoz, A., Tontz, W.L., and Resnick, D.K. (2010). Clearance of the asymptomatic cervical spine: a meta-analysis. J. Orthop. Trauma 24, 100–106.
206. Kamenetsky, E., Esposito, T.J., and Schermer, C.R. (2013). Evaluation of distracting pain and clinical judgment in cervical spine clearance of trauma patients. World J. Surg. 37, 127–135.
207. Rose, M.K., Rosal, L.M., Gonzalez, R.P., Rostas, J.W., Baker, J.A., Simmons, J.D., Frotan, M.A., and Brevard, S.B. (2012). Clinical clearance of the cervical spine in patients with distracting injuries. J. Trauma 73, 498–502.
208. Konstantinidis, A., Plurad, D., Barmparas, G., Inaba, K., Lam, L., Bukur, M., Branco, B.C., and Demetriades, D. (2011). The presence of nonthoracic distracting injuries does not affect the initial clinical examination of the cervical spine in evaluable blunt trauma patients: a prospective observational study. J. Trauma 71, 528–532.
209. Benner, J.P., Brauning, G., Green, M., Caldwell, W., Borloz, M.P., and Brady, W.J. (2006). Disagreement between transport team and ED staff regarding the prehospital assessment of air medically evacuated scene patients. Air Med. J. 25, 165–169.
210. Burton, J.H., Harmon, N.R., Dunn, M.G., and Bradshaw, J.R. (2005). EMS provider findings and interventions with a statewide EMS spine-assessment protocol. Prehosp. Emerg. Care 9, 303–309.
211. Burton, J.H., Dunn, M.G., Harmon, N.R., Hermanson, T.A., and Bradshaw, J.R. (2006). A statewide, prehospital emergency medical service selective patient spine immobilization protocol. J. Trauma 61, 161–167.
212. Campbell, P. (1987). Comparison of flight nurses' prehospital assessments and emergency physicians' ED assessments of trauma patients. J. Emerg. Nurs. 13, 219–222.
213. Domeier, R.M., Evans, R.W., Swor, R.A., Rivera-Rivera, E.J., and Frederiksen, S.M. (1997). Prospective validation of out-of-hospital spinal clearance criteria: a preliminary report. Acad. Emerg. Med. 4, 643–646.
214. Domeier, R.M., Evans, R.W., Swor, R.A., Hancock, J.B., Fales, W., Krohmer, J., Frederiksen, S.M., and Shork, M.A. (1999). The reliability of prehospital clinical evaluation for potential spinal injury is not affected by the mechanism of injury. Prehosp. Emerg. Care 3, 332–337.
215. Hankins, D.G., Rivera-Rivera, E.J., Ornato, J.P., Swor, R.A., Blackwell, T., and Domeier, R.M.; Turtle Creek Conference II. (2001). Spinal immobilization in the field: clinical clearance criteria and implementation. Prehosp. Emerg. Care 5, 88–93.
216. Meldon, S.W., Brant, T.A., Cydulka, R.K., Collins, T.E., and Shade, B.R. (1998). Out-of-hospital cervical spine clearance: agreement between emergency medical technicians and emergency physicians. J. Trauma 45, 1058–1061.
217. Muhr, M.D., Seabrook, D.L., and Wittwer, L.K. (1999). Paramedic use of a spinal injury clearance algorithm reduces spinal immobilization in the out-of-hospital setting. Prehosp. Emerg. Care 3, 1–6.
218. Sahni, R., Menegazzi, J.J., and Mosesso, V.N. (1997). Paramedic evaluation of clinical indicators of cervical spinal injury. Prehosp. Emerg. Care 1, 16–18.
219. Ringdal, K.G., Coats, T.J., Lefering, R., Di Bartolomeo, S., Steen, P.A., Røise, O., Handolin, L., and Lossius, H.M.; Utstein TCD expert panel. (2008). The Utstein template for uniform reporting of data following major trauma: a joint revision by SCANTEM, TARN, DGU-TR and RITG. Scand. J. Trauma Resusc. Emerg. Med. 16, 7.
220. Voss, S., Page, M., and Benger, J. (2012). Methods for evaluating cervical range of motion in trauma settings. Scand. J. Trauma Resusc. Emerg. Med. 20, 50.

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