



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 authors are included here. Finally, we also 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 (mTBI).

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 and 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

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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, Zurich, Switzerland), 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 an mTBI.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

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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 Expedient 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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