Spinal injuries

Facts and fiction

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CHAPTER 3

Prehospital care of spinal injuries: a historical quest for reasoning and evidence

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Abstract

Purpose

The practice of prehospital immobilization is coming under increasing scrutiny.Unravelling the historical sequence of prehospital immobilization might shed more light on this matter and help resolve the situation. Main purpose of this review is to provide an overview of the development and reasoning behind the implementation of prehospital spine immobilization.

Methods

An extensive search throughout historical literature and recent evidence based studies was conducted.

Results

The history of treating spinal injuries dates back to prehistoric times. Descriptions of prehospital spinal immobilization are more recent and span two distinct periods. First documentation of its use comes from the early 19th century, when prehospital trauma care was introduced on the battlefields of the Napoleonic wars. The advent of radiology gradually helped to clarify the underlying pathology. In recent decades, adoption of advanced trauma life support has elevated in- hospital trauma-care to an high standard. Practice of in-hospital spine immobilization in case of suspected injury has also been implemented as standard-care in prehospital setting. Evidence for and against prehospital immobilization is equally divided in recent evidence-based studies. In addition, recent studies have shown negative side-effects of immobilisation in penetrating injuries.

Conclusion

Although widely implementation of spinal immobilization to prevent spinal cord injury in both penetrating and blunt injury, it cannot be explained historically. Furthermore, there is no high-level scientific evidence to support or reject immobilisation in blunt injury. Since evidence in favour and against prehospital immobilization is equally divided, the present situation appears to have reached something of a deadlock.

Introduction

The estimated incidence of spinal injury in the United States (US) is 2-6% of all trauma patients.[1] Approximately one-third of patients with spinal injuries are diagnosed with an unstable spinal fracture or injury of the spinal cord.[2-6] When spinal injury is suspected, precautions including spinal immobilization are taken until physicians have 'cleared' the spine of injury. Clearing the spine of injury usually involves radiologic imaging or applying protocols which include those recommended or issued by the Advanced Trauma Life Support (ATLS) training programme, the European Trauma Course (ETC), the National Emergency X-Radiography Utilization Study (NEXUS), as well as the algorithm defined in the Canadian Cervical Spine (C-spine) Rule.[7-10]

Spinal immobilization is indicated based on the assumption that spinal injuries can deteriorate due to manipulation or movement, thereby causing secondary injury to the spinal cord,[11] and it has been accepted and implemented as the standard of care for decades despite the lack of clear evidence to support this practice.[12-16] Although immobilization measures can have adverse effects, they continue to be implemented in modern trauma protocols, with approximately five million patients in the US receiving spinal immobilization every year.[17] Throughout Europe, prehospital emergency medical services are guided by national trauma protocols based on the Prehospital Trauma Life Support (PHTLS) programme and the European approach to trauma care supported by the ETC.[18-21] While the treatment of spinal injuries is known to date back to prehistoric times, the development and rationale behind the implementation of prehospital spine immobilization is only 50 years old.[22, 23]

The main aim of this article is to provide a brief literature review of the history of spinal immobilization and thereby answer the following question: can spinal immobilization be explained historically?

Before prehospital care

The history of treating spinal fractures dates back as far as ancient times. The earliest description dates to 3,000 years B.C. in ancient Egypt: the Edwin Smith Papyrus[24] describes six injuries of the cervical spinal cord, concluding that the best treatment is rest and support (Figure 1). It therefore appears that the Egyptians did not treat spinal cord injuries with surgical intervention.

Later on, in a text from ancient Greece, Hippocrates (460 –377 B.C.) stated that if a fracture was presented with paralysis, no treatment options were possible; he believed that these unfortunate individuals were destined to die. But for deformities of the spine he introduced the extension bench and other methods to reduce such deformities (Figure 2).[25] The methods of Hippocrates were still being taught in Europe in the sixth century A.D.

In the third and fourth century A.D., non-invasive treatment of spinal fractures was described in India and these descriptions included the care of cervical dislocations which involved

reduction, bandages, splints and bed rest. Lower spine injuries were treated by immobilization; patients were placed on a board and tied down with ropes.[26]

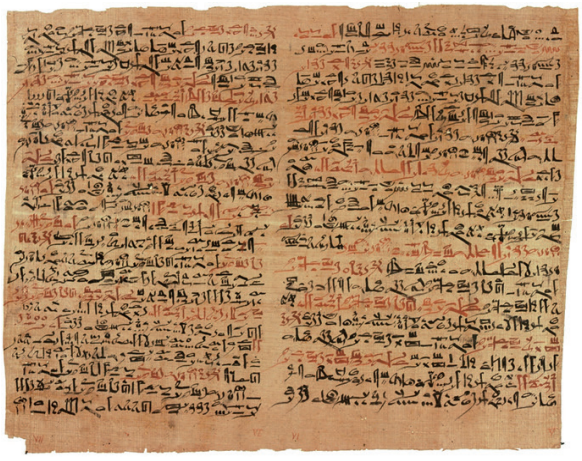

Figure 1. Plates VI & VII of the Edwin Smith Papyrus at the Rare Book Room, New York Academy of Medicine

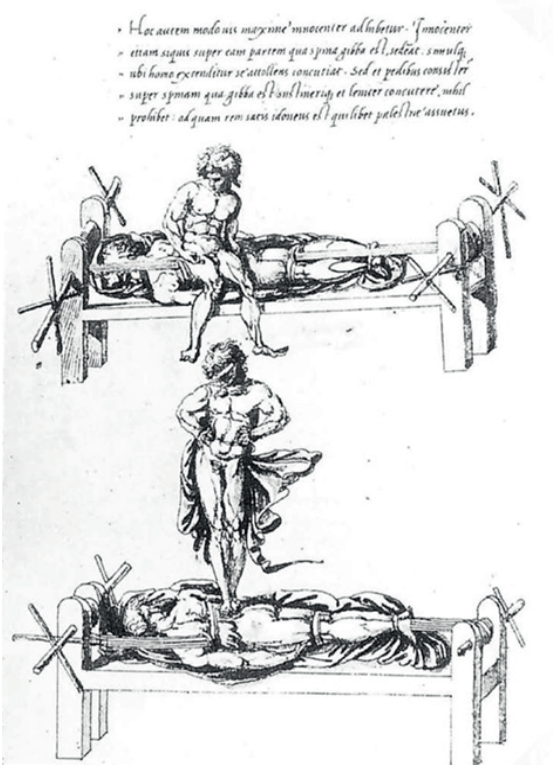

Figure 2. The extension bench with reduction methods on the Hippocratic board, Paris National Library.

Western medicine however remained very primitive, and no recordings of spinal fracture management can be found in sources from the middle ages (700–1400 A.D.).[22] It was not until the Renaissance that European physicians started to publish works on this topic. In his book *Dix Livres de Chirurgie,* the French barber-surgeon Ambroise Paré (1510–1590) mentions repositioning spine fractures by suspending the patient, with the upper body fastened and the feet dangling.[27] Similar accounts can be found in ancient Arab and Chinese literature (Figure 3). Prehospital care for spinal injuries did not exist until the 18th century, during which immobilization was only used as a method of in-hospital treatment.

Figure 3. Treatment of the spinal column Golden Mirror of Medicine, Ciba periodical 1959;94:8.

Prehospital care

Prehospital care for any type of injury, spinal or otherwise – it is thought to have been started by Napoleon's surgeon, Dominique-Jean Larrey (1766–1842). He developed the *ambulances volantes* (flying ambulances) to evacuate casualties from the battlefield during the Italian Campaign of 1797. Flying ambulances were horse-drawn wagons for collecting and carrying the wounded from the battlefield to hospitals (Figure 4). Attending personnel included a doctor, a quartermaster, an officer and infantrymen. Larrey also introduced the first descriptions of triage. Triage derives from the French verb *trier* (meaning 'to pick'), originally describing how early French wool traders sorted wool into various categories according to its quality. The primary purpose of military triage was to prioritize care according to the severity

of injury and the chances of survival. In Larrey's *Memoires de chirurgie militaire et campagnes* he described the immobilization of open fractures, concluding that immobilization facilitated healing. However, spinal injuries are rarely mentioned in Larrey's work [28] and up until the 20th century, prehospital spinal immobilization was not implemented into prehospital care.

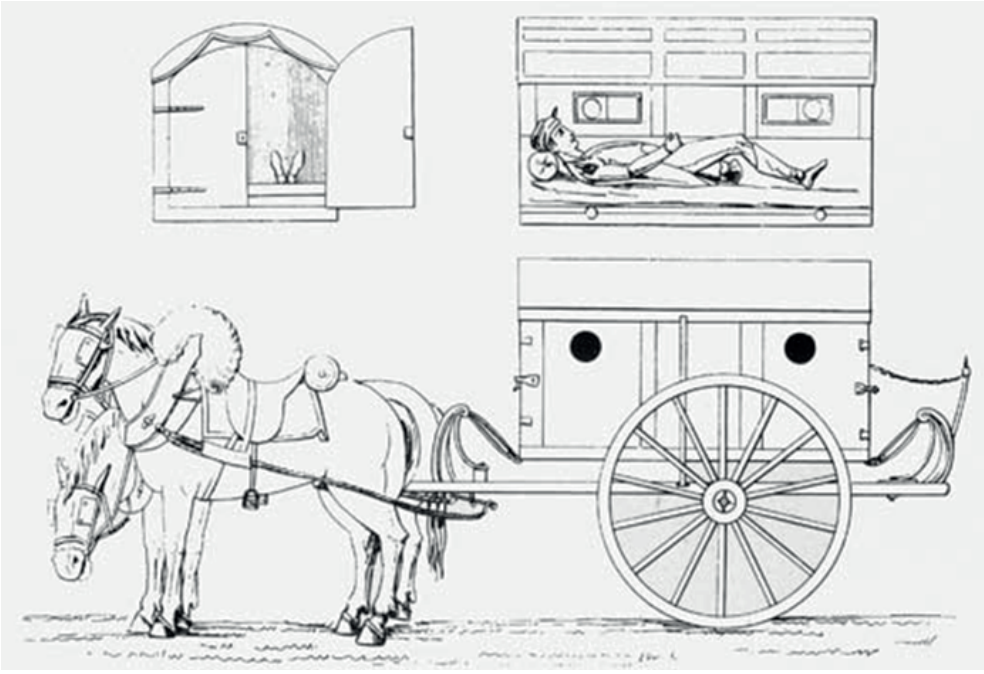

Figure 4. A horse-drawn ambulance designed by Dominique-Jean Larrey, The National Library of Medicine.

Prehospital immobilization

The theory that spinal immobilization prevents secondary neurological deterioration dates from 1966, when Geisler published a retrospective analysis of 958 patients with spinal cord injuries.[29] This article described 29 patients who experienced neurological deterioration after spine injury and concluded that each case of paralysis occurred due to a failure to recognize injury or to protect from the patients from the consequences of their unstable spine.[29] This provided the fundament for the idea that prehospital immobilization could prevent neurological deterioration. Practical implementation of prehospital immobilization is credited to Louis Kossuth, who in 1966 developed a short spine board that stopped at the waist.[30, 31] He later developed a full-body board which was the predecessor of the modern spine board.[32] At the time that Kossuth was popularizing his theory, prehospital care itself was undergoing a significant reorganization.

Until the 1970s, most ambulance services were run by personnel with little training in trauma care.[33] The first basic training in prehospital care for emergency medical technicians (EMTs)

developed from the training of fireman in the 1950s, which was started by Deke Farrington in Chicago and later on in Wisconsin. After publication of Farrington's article 'Death in a Ditch' in the *Bulletin of the American College of Surgeons,* the importance of prehospital care started to be recognized. The subsequent development of a training programme for EMTs encompassed Kossuth's spinal immobilization algorithm.[30]

In 1979, in-hospital trauma care took a giant step forward with the implementation of the ATLS principles.[34] A trauma surgeon affiliated with the ATLS programme, Norman McSwain, subsequently developed a prehospital version of the ATLS programme [35] known as Prehospital Trauma Life Support (PHTLS), and the first PTHLS course was launched in 1983. This programme was based on the theory that spinal immobilization prevents neurological deterioration and reduces risk of secondary injury, and has since been implemented globally.[18] When the need arose for a European approach to trauma care, the ETC was developed – an intensive training module adapted to practice in Europe that provided physicians with guidelines and that took into account international recommendations supported by various training modules.[10]

An evidence-based medicine approach to penetrating trauma

Since the introduction of the trauma care guidelines in the 1980s, spinal immobilization has become standard practice. Nevertheless no randomized controlled trials have ever been published on the effects of spinal immobilization, as highlighted in various review articles.[20, 21, 36, 37] In fact, for penetrating trauma, the results of several studies suggest that spinal immobilization has a negative effect. For example, rigid cervical collars (c-collars) are widely implemented for suspected cervical spine injury (CSI) and four recent observational studies have reported on the effects of applying c-collars for suspected CSI in penetrating trauma.[38-41] In addition, a retrospective chart review conducted by Vanderlan et al. in patients with penetrating cervical trauma reported that, in isolated CSI, cervical spine immobilization using a c-collar was associated with a higher mortality rate when compared with no immobilization (OR 8.82, 95% CI, 1.09-194, p=0.038).[38] In the same study, patients who had undergone cervical spine immobilization had a higher risk of requiring cardiopulmonary resuscitation upon arrival at the emergency department (OR 3.53, 95% CI, 1.06 – 12.95, p=0.037). These results suggest that immobilizing the cervical spine could mask important clinical signs, block access to injury sites, and impair intubation.[38] A large retrospective study by Haut et al. in patients with suspected CSI also reported that cervical spine immobilization was associated with a higher mortality rate when compared with no immobilization (14.7 vs 7.2%, P<0.001), even among patients with lower injury severity scores.[39]

These findings are supported by the results of a retrospective review conducted by Barkana et al. using data from 44 military causalities, which suggest that c-collars can potentially conceal underlying neck injuries, including tracheal deviation, large expending haematoma, and diminished or absent pulse of the carotid artery.[40] Immobilizing the cervical spine is also thought to increase intracranial pressure, thereby impairing the patient's neurological status, as described in a case study by Lemyze et al.[41] All included studies are summarized in table 1 accompanied by the main outcome.

An evidence-based medicine approach to blunt trauma

Although trauma from impaction clearly differs from penetrating trauma, similar results have been described for spinal immobilization following blunt trauma. Data from a large retrospective chart review by Hauswald et al. (table 1) showed no beneficial effect of spinal immobilization on neurological outcome, with the incidence of neurologic injury in the immobilized group almost double those in the non-immobilized group (OR 2.03, 95% CI, 1.03 – 3.99, p=0.04).[42] They suggest that spinal cord injury is primarily the result of the initial impact, and that secondary injuries are not the result of unrestricted movement of the spine.[42] Such secondary injuries can be caused by swelling, formation of free radicals and other chemical mediators.

Table 1. Overview of characteristics and main outcome of included evidence-based studies.

Authors (year)	Study design	Country (study period)	N	Mean age (± *SD*)	Comparison	Main outcome
1. penetrating trauma						
A. Vanderlan et al. (2009)	Retrospective cohort	US (9.3 *yrs*)	188	*NR*	c-collar *vs.* no c-collar	1. Mortality rate OR 8.82 (95% *CI*, 1.09-194, p=0.038) 2. Requiring CPR OR 3.53 (95% *CI*, 1.06-12.95, p=0.037)
B. Haut et al. (2010)	Retrospective cohort	US (3 *yrs*)	45,284	Median 29 *yrs*	c-collar *vs.* no c-collar	Mortality rate 14.7 vs. 7.2% (p<0.001)
C. Barkana et al. (2000)	Case series	Israel (4.5 *yrs*)	44	*NR*	c-collar alone	Potentially concealing underlying neck injury
D. Lemyze et al. (2011)	Cave study	-	1	32	strangulation by hanging alone	Increase of intracranial pressure
2. Blunt trauma						
A. Hauswald et al. (1999)	Retrospective cohort	US, Malaysia (5 *yrs*)	334, 120 (454)	34, 35	C-spine immobilization *vs.* no immobilization	Incidence of neurologic injury OR 2.03 (95% *CI* 1.03-3.99, p=0.04)
B. Lin et al. (2011)	Retrospective cohort	Taiwan (2 *yrs*)	5139	38	c-collar *vs.* no c-collar	No significant correlation of cervical spine injury

Table 1. continues on next page

Continuation of Table 1.

Authors (year)	Study design	Country (study period)	N	Mean age (± *SD*)	Comparison	Main outcome
C. Kreinest et a. (2016)	Review	-	-	-	C-spine immobilization *vs.* no immobilization	Strong associations adverse effects (respiratory compromise, neck and back pain, pressure sores)

Yrs: years, *SD*: standard deviation, *NR*: not reported, *CI*: confidence interval, *vs*: versus.

Similar results were published by Lin et al., who analysed the application of c-collars in victims of lightweight motorcycle accidents with cervical spine injuries.[43] The authors found no significant correlation of cervical spine injury between the patients who had been immobilized and those who had not and they concluded that c-collar application during prehospital care may not always be necessary.[43] In addition, the need for cervical immobilization following motor sport accidents was analysed by Kreinest,et al. who criticizes the application of the c-collar in all trauma patients and developed more selective immobilization criteria.[44]

Despite the assumption that immobilization minimizes spinal movement and thereby reduces risk of secondary injury, there is a lack of high-level evidence that this improves patient outcome. Furthermore, several studies have found strong associations between immobilization and the adverse effects, including respiratory compromise, neck and back pain, and pressure sores, even when immobilization is properly applied.[19, 21, 43, 44, 45, 46] In addition, findings from a recent study by our group suggest that paramedics cannot accurately predict spinal injury in the prehospital setting, and that they fail to identify the subgroup most likely to benefit from cervical spine immobilization.[47]

Given the lack of clear conclusions regarding spinal immobilization, there is a clear need for prospective studies that analyse both its benefits and drawbacks, as others have also indicated.[48, 49]

Discussion

The current standard in prehospital care in trauma patients suspected of spinal injury is to immobilize the spine to prevent secondary spinal cord injury. Although widely implemented, spinal immobilization cannot be explained historically, nor is there any high-level scientific evidence to support or reject it. The first use of prehospital immobilization of the spine was based on the assumption that minimizing spinal movement reduces the risk of secondary injury to the spinal cord and facilitates transportation,[28] although we now know that this is certainly not always the case.[42, 48, 49]

Since the 1970s, the implementation of immobilization in prehospital care has improved through the use of various trauma care algorithms and the application of the principles of the ATLS training programme in the US or as provided in Europa by the ETC.[10, 19, 20, 21, 34] Although these protocols are applied on a large scale, clear evidence to support the rationale for immobilization in prehospital care is lacking [49] and large retrospective studies in patients with penetrating injury have described no beneficial effect on neurologic outcome.[34, 38] Moreover, Hauswald et al. have suggested that the risk of neurologic deterioration in immobilized patients suffering blunt trauma could be twice as high as in non-immobilized patients, thereby casting doubt on immobilization as a preventive measure in both penetrating and blunt trauma.[38] Indeed, an increasing number of studies are now doubting the necessity of applying spinal immobilization and are reporting the associated risks of adverse effects.[38, 42] Spinal immobilization of just the cervical spine using a c-collar in penetrating injuries is known to be associated with an increased risk of respiratory compromise, pain, pressure sores, and increased intracranial pressure.[38, 37] Immobilization is also associated with higher mortality rates as it can mask important clinical signs and underlying injuries, as well as blocking access to injury sites.[34, 35]

Although widely implementation of spinal immobilization to prevent spinal cord injury in both penetrating and blunt injury, it cannot be explained historically. Recent studies have shown negative side-effects of immobilisation in penetrating injuries. Furthermore, there is no high-level scientific evidence to support or reject immobilisation in blunt injury. Paramedics and other health professionals therefore need to be aware of the potential drawbacks of immobilization. Trauma protocols should therefore be critical towards routinely immobilizing trauma patients. Future large prospective trials are needed to provide clear and evidence based criteria in applying spinal immobilization.

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