

## Secondary In-Hospital Immobilization in Patients with Suspected Spinal Injury: Implications for Treatment and Outcome

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### Abstract

**Introduction:** In patients suspected of spinal-fractures arriving at the Emergency-Department (ED) without spinal-immobilization, the Advanced Trauma Life Support (ATLS) and European Trauma-Course (ETC) both advocate spinal-immobilization. However, introduction of pre-hospital spinal-immobilization protocol in the Netherlands (2016) led to discrepancies between protocol-recommendations applied in pre-hospital and in-hospital setting. We hypothesized this discrepancy is causing unnecessary immobilization of mobile and alert patients. Purpose of this study was to determine the proportion of non-immobilized patients suspected of spinal-fractures who are receiving secondary spinal-immobilization. Second, the incidence of spinal-fractures and effects of treatment-strategies on neurological outcome was determined.

**Methods:** Data was collected from all patients suspected for spinal-fractures presenting at the ED of a Dutch level-2 trauma-center between January 2010 and July 2012. Retrospective analysis was performed of patients who did and did not receive secondary spinal-immobilization. Measured outcomes were incidence of spinal-fractures, method of treatment-strategy and neurological outcome.

**Results:** Of 563 patients not receiving pre-hospital immobilization, 10% subsequently underwent secondary-immobilization at the ED. 87% of patients arriving without spinal-immobilization had not sustained a spinal-fracture. Incidence of spinal-fractures in patients receiving secondary-immobilization was 7% vs. 12.8% in those not receiving secondary-immobilization. Three patients had neurological symptoms which were present in pre-hospital setting.

**Conclusions:** A high proportion of non-immobilized patients suspected of spinal injury are not receiving secondary in-hospital immobilization of the spine in our study. Additionally, a considerable proportion of patients arriving at the ED without spinal immobilization do have spinal fractures. In three patients, symptoms of neurologic deficit were already present at ED arrival.

**Keywords:** Emergency; Prehospital; Spinal immobilization; Spinal injury; Trauma protocols

CCR: Canadian C-Spine Rule; ED: Emergency Department; ETC: European Trauma Course; ISS: Injury Severity Scale; NEXUS: National Emergency X-Radiography Utilization Study; PHTLS: Pre Hospital Trauma Life Support

## Introduction

The incidence of spinal injury in the United States is estimated at 2-6% of all trauma patients [1]. Approximately 10–30% of patients with spinal injuries have an unstable spinal fracture or damage to the spinal cord [2-8]. The overall incidence for Emergency Department (ED) visits due to spinal fractures is increasing [7]. If a patient is suspected of having a spinal injury, protocols of the international Advanced Trauma Life Support (ATLS), Pre-Hospital Trauma Life Support (PHTLS) and European Trauma Course (ETC) recommend precautions such as spinal immobilization until the spine has been cleared of injury [9,10]. This clearance of the spine includes radiologic imaging or clinical decision rules such as the National Emergency X-Radiography Utilization Study (NEXUS)-criteria or the Canadian C-spine Rule (CCR) [11-13]. The reason for spinal immobilization precautions is that unstable spinal injuries can deteriorate due to manipulation or movement, and cause secondary injury to the spinal cord [14]. Spinal immobilization protocols usually recommend the use of a rigid cervical collar and a spinal board [1,15-18].

Although spinal immobilization has become standard practice, to date no randomized controlled trials have been published on its effects [19-21]. In a retrospective chart review that evaluated the effects of spinal immobilization, Hauswald, et al. observed the incidence rate of neurological injury to be higher in an immobilized group than in a group without immobilization [22]. This study group concluded that spinal immobilization might not have any beneficial effect in preventing neurological injury after trauma. Since this study was published in 1998, several other groups have studied the benefits and drawbacks of spinal immobilization [8]. However, based on these results, no firm conclusions towards the use of spinal immobilization can be drawn [21,23,24]. While mentioned studies focused on spinal immobilization in the pre-hospital setting, we note that immobilization protocols may differ depending on the setting.

The Dutch emergency services are using a pre-hospital immobilization protocol, introduced in 2010 and updated in 2016 [25]. This protocol (appendix A and B) dictates that ambulant and alert patients who can extract themselves from the trauma scene and who are able to lay down on a vacuum mattress or spinal board should be transported to hospital with head blocks but without a rigid collar [26,27]. While this protocol is in accordance with recommendations in scientific literature, it has led to a discrepancy between the protocols currently used in the pre-hospital setting and those used in the in-hospital setting. The in-hospital protocol follows ATLS, PHTLS, and ETC guidelines, which all recommend full spinal immobilization including rigid collar and spinal board if a spinal injury is suspected. For patients presented at the ED without spinal immobilization, this implicates they potentially receive subsequently two kinds of treatment due to the clashing protocols. Usually these non-immobilized patients either present to the ED by self-referral or are not regarded by paramedics as being at risk of spinal injury upon on-scene evaluation. In literature there is only one study describing proportion of patients initially evaluated for

spinal injury who subsequently are diagnosed with actual injury, which is in 2-3% [28]. In addition, spinal immobilization itself is not completely without harm and has several disadvantages. Several studies published spinal immobilization to cause pressure sores, compromise respiration, necessitate aspiration after vomiting, raise intracranial pressure, and hamper airway management [29-32]. This raises the question upon the implications of the discrepancy between the pre-hospital and in-hospital protocols towards secondary immobilization at ED presentation in patients with suspected spinal injury in terms of treatment and neurological outcome.

The aim of this retrospective study was to determine the proportion of patients suspected of spinal injury who do in fact receive secondary in-hospital spinal immobilization at the ED of a Dutch level 2 trauma center. We also determined the incidence of spinal injuries and the effects of different treatment strategies on neurological outcome. To this end, we compared all patients diagnosed with a spinal fracture with those who did not receive secondary in-hospital spinal immobilization with patients who did.

## Material and Methods

### Design, Setting and Patient Characteristics

Data were retrospectively collected from all patients who were presented to the ED of a Dutch level 2 trauma center between 1 January 2010 and 1 July 2012. Patients were eligible for inclusion in our study if they had arrived at the ED without spinal immobilization and there was a clinical suspicion of spinal fracture. Patient characteristics were recorded, as well as the mechanism of injury, and the injury severity score was calculated (ISS) [33]. Data from two separate groups of patients were compared: the first group had received no in-hospital immobilization (I-) until completion of the diagnostic process and the second group who had received secondary in-hospital immobilization (I+) upon arrival. For each group, we recorded the incidence of spinal fractures and neurologic deficits, and the types of treatment, if any. No ethical approval for this retrospective study was required under Dutch Law.

### Data Analysis

All data were entered into an electronic database. We used descriptive outcome analysis to compare the outcomes of the two groups of patients who arrived at the ED without spinal immobilization and for whom there was clinical suspicion of spinal fracture. Data were described using means and standard deviations for normally distributed numerical data, medians and interquartile ranges for non-normally distributed numerical data, and numbers with percentages for categorical data. Normality of distribution was assessed visually by examining histograms. Differences between categorical variables were assessed by a chi-square-test or Fisher exact-test depending on expected frequencies, and between continuous variables by an unpaired t-test or Mann-Whitney U-

test depending on distribution. A P-value of  $< 0.05$  was considered statistically significant. Statistical analysis was performed using IBM® SPSS® for Windows® version 24 (IBM Corp., Armonk, NY, United States).

### Theory/calculation

The aim of this retrospective study was to determine the proportion of patients suspected of spinal injury who do in fact receive secondary in-hospital spinal immobilization at the ED of a Dutch level 2 trauma center. Primary outcome of this study was the incidence of spinal fractures in patients visiting the ED following trauma. Secondary outcomes were the method of definitive trauma care and neurological symptoms.

## Results

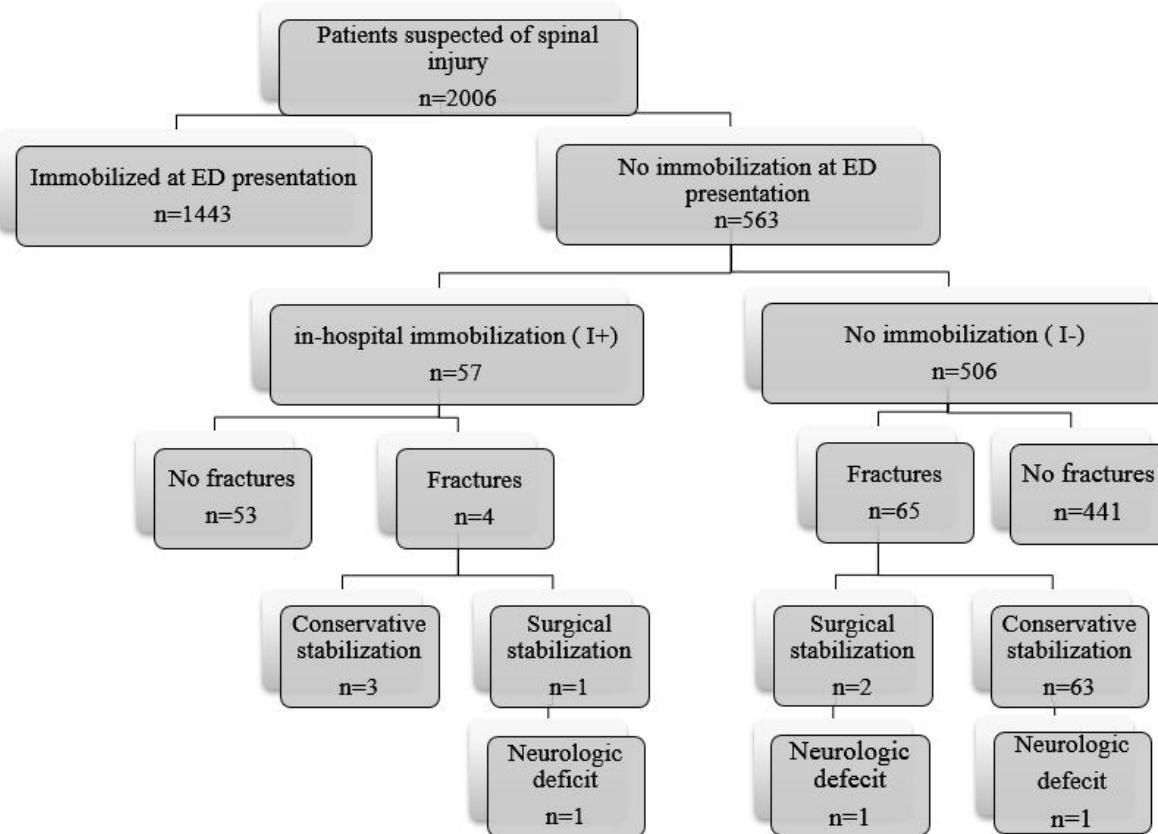
### Characteristics of Study Subjects

A total of 2,006 trauma patients presenting to the ED of our level 2 trauma center were retrospectively included in the database. Within this population, we selected the 563 patients (28.1%) presented to the ED without spinal immobilization. Of these patients, 57/563 (10%) had undergone secondary in-hospital immobilization (I+), while 506/563 (90%) patients remained without secondary in-hospital immobilization (I-) at the discretion of the treating physician on call at the ED. Spinal fractures were diagnosed in 69 patients, of which 65/69 (94%) did not receive secondary in-hospital immobilization (Figure 1). Of the included patients 50.9% was of male gender, the overall median age was  $41.3 \pm 34.6$  years (19-68). Presentation at the ED by self-referral was identified in 368/563 (65.4%) patients. A motor vehicle accident and a fall from heights lower than 2.5 meters were most common trauma mechanisms (Table 1).

		In-hospital immobilization		P-value
		Yes (I+)	No (I-)	
<b>Total</b>		57	506	
<b>Sex</b>	Male	29 (50.9%*)	257 (50.8%)	0.990
<b>Age</b>	median (IQR)	34 (19-60)	45 (22-68)	0.648
<b>ISS</b>	median (IQR)	5 (3-9)	4 (2-8)	0.058
<b>Trauma</b>				<0.001
	High-Energy Trauma (HET)	21 (36.8%)	76 (15.0%)	
	Multi-trauma (ISS $\geq 16$ )	1 (1.8%)	1 (0.2%)	
<b>ED presentation by self-referral</b>		32 (56.1%)	336 (66.4%)	<0.001
<b>Mechanism of injury</b>				<0.001
	Motor vehicle accident	23 (40.4%)	97 (19.2%)	
	Fall $>2.5$ meters	7 (12.3%)	42 (8.3%)	
	Fall $<2.5$ meters	12 (21.2%)	285 (56.3%)	
	Bike/person vs. car	1 (1.8%)	13 (2.6%)	
	Bike or horse accident	11 (19.3%)	45 (8.9%)	
	Fight or abuse	3 (5.3%)	21 (4.2%)	
	Parachute	0 (0.0%)	3 (0.6%)	
<b>Fractures</b>		4 (7.0%)	65 (12.8%)	0.203

\*Percentages are within group; ISS: injury severity score; IQR: interquartile range.

**Table 1:** Baseline characteristics of patients presented at the ED without spinal immobilization.



**Figure 1:** Flow diagram of patient inclusion and outcome parameters.

## Endpoints

In 4/57 (7.0%) patients who had received secondary immobilization were subsequently found to have sustained a spinal fracture; one of them (1.8%) had neurological symptoms and required surgical stabilization (Table 2). This patient had presented to the ED with neurological deficit in both legs and an unstable L3-fracture with spinal canal stenosis, four weeks after initial trauma. This patient was transferred to a level 1 trauma center, where a posterior spondylodesis was performed. The remaining three patients had no neurological deficits and underwent non-invasive treatment as shown in Table 2. In the group of patients who had

not received secondary in-hospital immobilization (I-), spinal fractures were identified in 65/506 (12.8%) patients. Two patients required stabilization using a halo frame (Table 2). Despite treatment, one of them developed rapidly progressive neurological symptoms and died. The other patient had no neurologic deficit and made a successful recovery. The other 63 patients diagnosed with a spinal fracture were treated conservatively (Table 2). One of them had permanent neurologic deficit but immobilization in this patient could not be applied due to morbid obesity. In all patients with neurological symptoms, the symptoms were already present prior to presentation to the ED.

	In-hospital immobilization		
	Yes (I+)	No (I-)	P-value
<b>Total</b>	57	506	
<b>Location of fracture</b>			0.382
Cervical spine	0	5 (1.0%)	
Thoracic spine	0	20 (4.0%)	
Lumbar spine	4 (7.0%)	40 (7.9%)	
<b>Type of fracture</b>			0.967
Body	4 (100%)	61 (93.8%)	
Transverse process	0 (0.0%)	1 (1.5%)	
Articular pillar	0 (14%)	2 (3.1%)	
Spinous process	0 (0.0%)	1 (1.5%)	
<b>Type of treatment</b>			0.003
Surgical stabilization	1 (1.8%)	0 (0.0%)	
Conservative stabilization	56 (98.2%)	506 (100%)	
<b>Conservative treatment</b>			<0.001
Collar	9 (16.1%)	4 (0.8%)	
Spinal brace	3 (5.4%)	61 (12.1%)	
Halo frame	0 (0.0%)	2 (0.4%)	
Analgesia	44 (78.6%)	439 (86.8%)	

\*Percentages are within-group

**Table 2:** Types of spinal fractures and the different types of treatment applied.

## Discussion

The results of this study in patients presenting to the ED of a Dutch Level II trauma center indicates that a high proportion of non-immobilized patients suspected of a spinal fracture are not receiving secondary in-hospital immobilization of the spine. In addition, a considerable proportion of patients arriving at the ED without spinal immobilization do have spinal fractures. The incidence of spinal fractures in patients who underwent secondary in-hospital immobilization 7% versus 12.8% to those who did not undergo secondary in-hospital immobilization at the ED. In three patients, symptoms of neurologic deficit present at ED arrival and was not deteriorated until after definitive treatment.

Even though the use of spinal immobilization has been questioned numerous times [22,23,28,34], spinal immobilization in case of suspected spinal fracture remains standard practice in many hospitals, including our own. Despite clear protocols at our ED, implementing in-hospital immobilization is challenging. Although there is a discrepancy in the incidence of spinal fractures in patients without secondary in-hospital immobilization versus

the group who did receive secondary in-hospital immobilization, it was not statistically significant. In 13% of patients not receiving secondary in-hospital immobilization a spinal fracture was diagnosed. Although there were no clear significant discrepancies in patient characteristics throughout both the immobilized and non-immobilized group, one could identify interesting correlations. In addition, the median age of patients not receiving secondary in-hospital immobilization seems higher than those receiving immobilization (34 vs. 45yrs, p=0.648). With referral to the severity of injury (ISS) and specific trauma mechanisms in both groups (Table 1), suggesting that there is a correlation of more severe injury in the group of patients receiving secondary in-hospital immobilization. In contrast, in both groups presentation at ED by self-referral was similar, but not significant.

Compared with the total number of patients who sustained a spinal fracture, the number of patients requiring invasive treatment was small. Our data indicate that most patients with a spinal fracture who arrive at the ED without spinal immobilization have sustained a fracture that is stable; they therefore receive conservative treatment. In our cohort, three of these patients required surgical

stabilization, two of whom had sustained permanent neurological damage in the pre-hospital setting.

While previous studies have shown that it is difficult—if not impossible—to determine the moment during or after a traumatic injury at which patients sustain spinal cord damage, it is thought that it is most likely to have already occurred before immobilization [22]. In this study, for all patients who had symptoms of neurologic deficit, those symptoms were already present before presentation to the ED. In 3 patient's symptoms of neurologic deficit were identified, only one of them received secondary immobilization at the ED. There was no alleviation or aggravation encountered in the patients suffering neurologic deficit until after definite treatment, of which two patients received surgical stabilization. The numbers in this study confirm neurologic deficit to be present in pre-hospital setting and emphasize again the difficulty of adequate implementation of in-hospital immobilization.

One of the main limitations of this study is the relatively low number of patients included in this study who underwent secondary in-hospital immobilization, which may have affected the results of this study, although these numbers situate a reflection of daily practice. Future studies on this topic should cover a larger time period for including trauma patients in order to state more definite conclusions. The level of training and experience of the hospital staff, including physicians, paramedics and nurses, could have biased some of the results as well, particularly referring to protocol adherence and identifying those in need of in-hospital immobilization of the spine. Implementation of clear clinical decision rules or criteria within in-hospital protocols, including the ones provided by the NEXUS-criteria and CCR, is highly recommended. Several studies concluded spinal immobilization to may do more harm than good, cautioning its use referring to various adverse effects [29-32]. However, a vulnerable subgroup still exists in which the diagnosis may not be clinically apparent. We are of the opinion that any protocol that reduces the use of in-hospital immobilization of the spine needs to effectively safeguard this subgroup until they have been diagnosed, since secondary injury could bare serious consequences for the patient. We therefore recommend that physicians take appropriate precautions until a spinal fracture has either been diagnosed or excluded, and treated if required. In cases where symptoms persist, the patient should be reassessed. For this specific subgroup of vulnerable patients, we recommend maintaining a low threshold for spinal immobilization, preferably achieved using head blocks only—if not already present—and no rigid collar according the Dutch Prehospital protocol.

## Conclusions

A considerable proportion of patients arriving at the ED without spinal immobilization are later diagnosed with a spinal fracture. Neurologic deficit was present in three patients at ED presentation and did not deteriorate until after final treatment. Although the proportion of patients with a spinal fracture does not appear to differ between patients who receive secondary in-hospital immobilization and those who do not, a vulnerable subgroup remains in which diagnosis may not be clinically

apparent. Maintaining a low threshold for spinal immobilization in this specific subgroup of vulnerable patients is recommended, preferably with minimal invasive measures. Future prospective studies are needed to obtain clear criteria for identifying those at need for secondary in-hospital immobilization of the spine.

**Conflict of Interest:** The authors declare that they have no conflict of interest.

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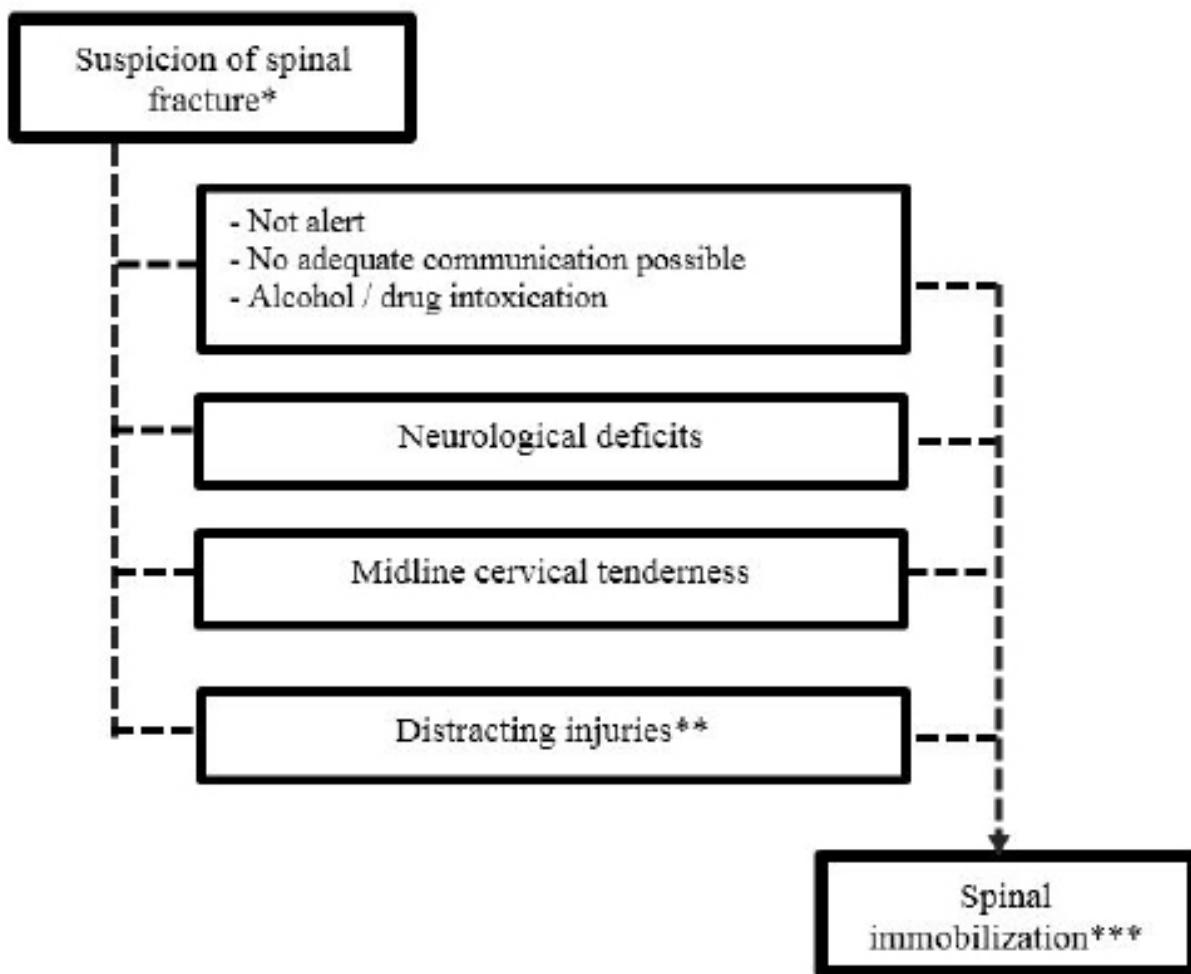
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**Appendix A: Indications for spinal immobilization.**

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\* Every trauma mechanism with a chance of vertebral injury: in case of doubt immobilize

\*\* Any painful injury that can cause spinal trauma to be missed

\*\*\* Immobilization may not lead to: delay of ABCD assessment; increased dyspnea, fear and / or anxiety.

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Immobilization is **not necessary** in case of:

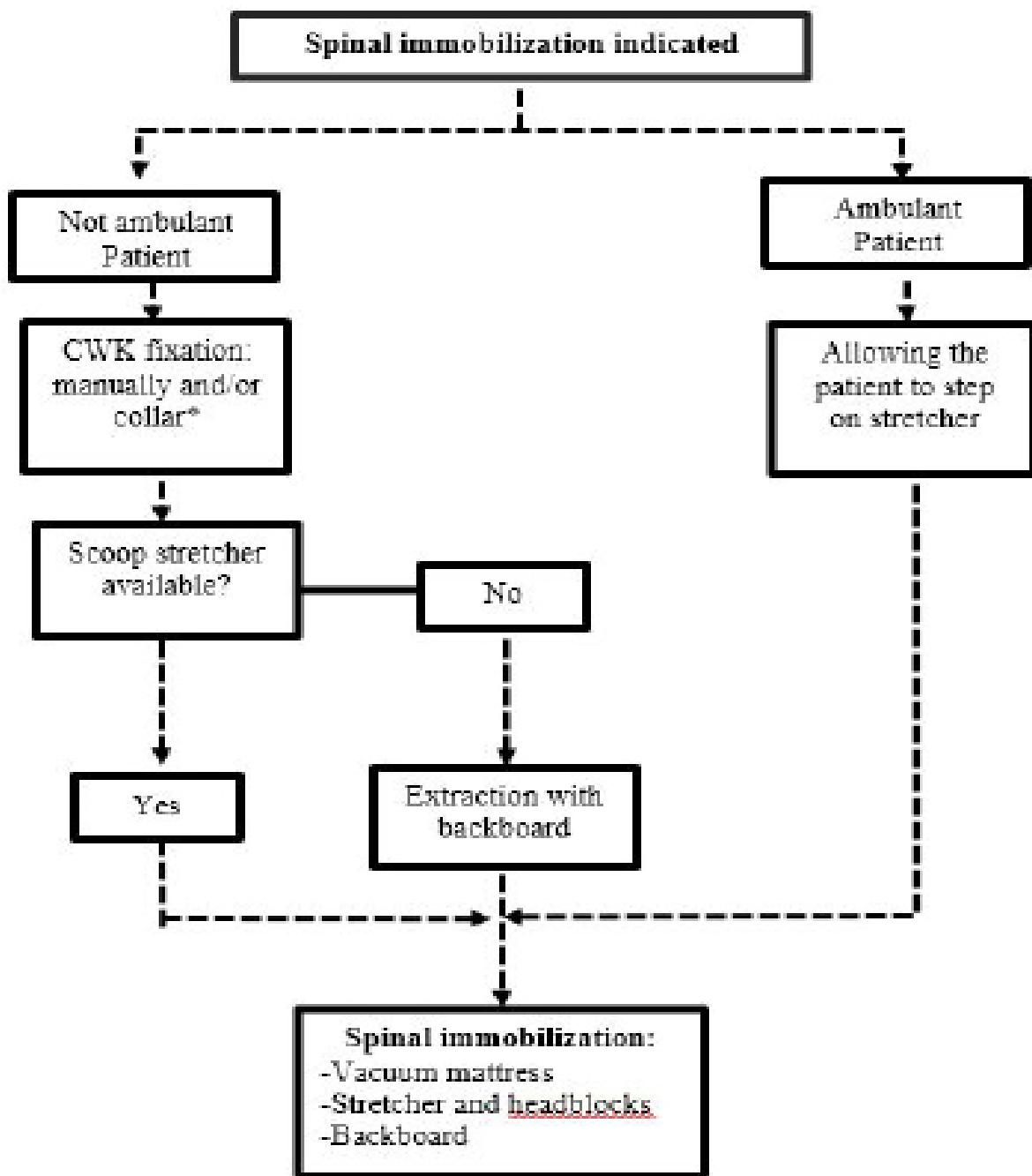
penetrating injury of the head, CWK, thorax or abdomen without neurological failure

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**Appendix B: Flow-chart for spinal immobilization.**

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\* Contra-indication collar: children and head/brain damage

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