Open Access

ISSN: 2663-9491 e-ISSN: 2789-6897

ORIGINAL ARTICLE

Cervical Spine Trauma — Evidence-Based Approaches to Immobilization and Early Orthopaedic Intervention

DOI: dx.doi.org

Mohammad Atiqur Rahman[1], Abul Kalam Azad[2], Shamsul Alam[3], Rasel-Al-Zilane[4]

Received: 14 Aug 2025
Accepted: 17 Aug 2025
Published: 27 Aug 2025

Published by:
Gopalganj Medical College, Gopalganj, Bangladesh

Correspondence to
Mohammad Atiqur Rahman

ORCID
https://orcid.org/0009-0008-6802-2579

ABSTRACT

Introduction: *Trauma to the cervical spine is a distressing injury with the promise of bad neurological complications. The optimal immobilization regimen and timing of operation remain controversial in contemporary trauma care. This study aimed to evaluate the association between different modes of immobilization, timing, and orthopedic intervention of neurological recovery among patients with cervical spine trauma.* ***Methods & Materials:*** *A 24-month prospective observational study among 100 patients with radiologically confirmed cervical spine trauma was conducted. Adults aged 18 years and older with radiologically confirmed cervical spine injuries were included. Detailed demographic, clinical, and treatment data were collected. Neurological outcomes were assessed using the ASIA impairment scale at admission and 6 months. Independent predictors of poor neurological outcomes (ASIA A-C) were defined by multivariable logistic regression analysis.* ***Results:*** *The mean age of the study population was 42.8±15.6 years, with a male dominance of 68%. Subaxial fractures (C3-C7) were most common (55%). Road traffic accidents accounted for 45% of the injuries. Fifty-five percent of patients had good neurological improvement (ASIA D or E) at 6 months. Multivariable analysis revealed that independent predictors of adverse outcomes were early ASIA A/B score (aOR 6.75, p<0.001), delayed surgery >72 hours (aOR 2.90, p=0.014), high-energy mechanism (aOR 3.12, p=0.003), age >60 years (aOR 2.45, p=0.027), and non-surgical treatment (aOR 2.40, p=0.028).* ***Conclusion:*** *Early surgery within 72 hours and careful patient selection greatly improve neurological recovery in cervical spine trauma. Initial nerve condition is the strongest predictor, while delays worsen outcomes—supporting the "time is spine" principle.*

Keywords: *Cervical Spine Trauma, Neurology, ASIA Impairment Scale*

(The Insight 2025; 8(1): 57-62)

1. *Senior Consultant, Department of Spine Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh*
2. *Assistant Professor, Department of Spine Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh*
3. *Assistant Professor, Department of Orthopedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh*
4. *Junior Consultant, Department of Spine Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh*

INTRODUCTION

Cervical spine injury is a severely disabling condition in emergency medical practice and orthopedic surgery, with a possibility of serious neurological complications permanently altering the quality of life of the patients. The occurrence of cervical spine injury ranges between 12.1 and 57.8 per million population annually, with high morbidity and mortality rates that emphasize the highest importance of the best treatment regimens [1]. The nuance of cervical spine trauma care is the balance between preventing secondary injury to the nervous system by appropriate immobilization and not causing the complications of prolonged immobilization or late surgery. The evolution of cervical spine trauma management has witnessed paradigm shifts of dramatic proportions, primarily in the immobilization method and timing of surgery. Techniques in the form of rigid immobilization using backboards and cervical collars have been increasingly facing criticism, with the newer evidence suggesting ill complications without evidence of neurological benefit [2]. Current systematic reviews have highlighted the questionable benefit of total cervical spine immobilization, with such an intervention possibly harming in the way of pressure ulcers, respiratory alterations, and patient discomfort without absolute neurological protection [3]. The growing evidence has resulted in the changing clinical guidelines that also advise more selective, evidence-based care for the stabilization of the

ISSN: 2663-9491 e-ISSN: 2789-6897

spine. The timing of surgical treatment in cervical spine injury remains a controversial issue, with mounting evidence supporting the argument that "time is spine" [4]. The traditional Surgical Timing in Acute Spinal Cord Injury Study (STASCIS) demonstrated that decompression early within 24 hours of injury can be helpful for neurological recovery in acute traumatic spinal cord injury patients [5]. Follow-up research has otherwise focused on such findings, with some studies suggesting better neurological outcome with early surgical decompression within the first 8 hours compared with intervention 8-24 hours after injury [6]. Ideal timing for surgical intervention is still controversial, particularly in polytrauma patients, where priorities would conflict and secondary spine management would be postponed. Current management of cervical spine injury involves a multidisciplinary approach in which, besides the biomechanical stability of the injured segment, consideration is given to the patient's neurological status, to associated lesions, and personal risk factors. The American Spinal Injury Association (ASIA) impairment scale remains the gold standard for neurological assessment and prognosis of spinal cord injury patients [7]. Understanding the determinants of neurological recovery is vital in optimizing treatment strategies and making realistic promises to patients and families. This observational study aims to evaluate the association of different immobilization methods, timing of orthopedic treatment, and neurological outcomes in patients with cervical spine trauma. By evaluating a large cohort of 100 patients within 24 months, we can provide evidence-based data regarding optimal management strategies that can improve neurological outcomes with minimal treatment-related morbidity in this patient population.

METHODS & MATERIALS

This prospective observational study was conducted at National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka, Bangladesh over a 24-month period from July, 2022 to June, 2024. Hundred patients presenting with confirmed cervical spine trauma. Inclusion criteria comprised patients aged 18 years or older with radiologically diagnosed cervical spine injuries, while those with concurrent traumatic brain injury, penetrating neck trauma, or incomplete medical records were excluded. Upon admission, detailed demographic and clinical data, including age, sex, mechanism of injury, comorbidities, and initial neurological status based on the ASIA (American Spinal Injury Association) scale, were recorded. Neurological outcomes were assessed at baseline and 6 months using the ASIA impairment scale [8]. Data were analyzed using SPSS Version 26.0. Descriptive statistics were used to summarize basic characteristics, while chi-square and Fisher's exact tests were used for bivariate comparisons. A multivariable logistic regression model was constructed to identify independent predictors of poor neurological outcomes (ASIA A–C) at 6 months, adjusting for confounders such as age, sex, mechanism of injury, injury level, timing of surgery, and treatment modality. A p-value of <0.05 was considered statistically significant.

RESULTS

Table I represents the demographic and clinical characteristics of the 100 patients under study. The mean age was 42.8 ± 15.6 years, which represents a middle-aged preponderance. There was a male preponderance (68% vs 32%, p = 0.002), which is in accordance with epidemiological patterns of cervical spine trauma typically occurring in young to middle-aged males engaged in high-risk activities. Road traffic accidents were the most common mechanism of injury (45%), followed by falls from height (30%), sports injury (15%), and assault (10%). The mechanism of injury distribution was statistically significant (p = 0.045), reflecting the high-energy nature of most cervical spine traumas. Under comorbidities, 57% of the patients did not have any significant past medical history, 25% had hypertension, and 18% had diabetes mellitus. [Table I].

Table – I: Basic Characteristics of Study Population (*n*=100)

Variable	Frequency (n)	Percentage (%)	p-value
Age (mean ± SD)	42.8 ± 15.6	-	-
Gender			
Male	68	68%	0.002*
Female	32	32%	
Mechanism of Injury			
Road traffic accident	45	45%	0.045*
Fall from height	30	30%	
Sports injury	15	15%	
Assault	10	10%	
Comorbidities			
Hypertension	25	25%	0.120
Diabetes Mellitus	18	18%	0.090
None	57	57%	

Table II depicts the cervical spine injury types present in the population. The most frequent type of injury was subaxial fracture (C3-C7), with 55% of the cases (p < 0.001), reflecting the vulnerability of the mid-cervical spine to injury. C1-C2 fractures represented 20% of cases, echoing the upper cervical spine fractures that typically result from high-energy axial loading or flexion-extension mechanisms. Dislocations were found in 15% of patients. Isolated ligamentous injury in the absence of fracture was the least common (10%), yet these injuries are particularly challenging to diagnose and may result in delayed instability. [Table II].

ISSN: 2663-9491 e-ISSN: 2789-6897

Table – II: Type of Cervical Spine Injury

Type of Injury	Frequency (n)	Percentage (%)	p-value
C1-C2 fracture	20	20%	<0.001*
Subaxial fracture (C3–C7)	55	55%	
Dislocation	15	15%	
Ligamentous injury only	10	10%	

Table III details the various immobilization methods employed within the study population. Rigid cervical collars were overwhelmingly the most common method (50%), a result indicating their widespread availability and ease of use in emergency settings. Surgical stabilization was initially performed in 25% of the patients, demonstrating the existence of unstable injuries that required immediate operative intervention. Halo vest immobilization was utilized in 15% of the patients, typically for individuals with upper cervical injuries or the requirement for prolonged external stabilization. Cervical traction was the least utilized modality (10%) and was statistically significant (p = 0.032) based on selective use for specific clinical indications. [Table III].

Table – III: Immobilization Method Used

Method of Immobilization	Frequency (n)	Percentage (%)	p-value
Rigid cervical collar	50	50%	0.032*
Halo vest	15	15%	
Cervical traction	10	10%	
Surgical stabilization (initial)	25	25%	

The timing of the surgical intervention is scrutinized in Table 4, in accordance with the timing of injury. The majority of patients (40%) underwent surgery 24-72 hours post-injury, 35% underwent surgery within 24 hours, and 25% underwent delayed surgery after 72 hours. The p-value significance (p = 0.018) indicates that the timing of surgery was not randomly distributed but was based on clinical considerations such as severity of injury, hemodynamic stability, and other injuries. The relatively high proportion of surgery undertaken within 24 hours (35%) reflects ongoing recognition of the importance of early decompression in traumatic spinal cord injury. The high percentage of patients with delayed surgery (25%) would, nevertheless, encompass those polytrauma patients who underwent stabilization of life-threatening injuries as a priority. [Table IV].

Table – IV: Time to Orthopaedic Intervention

Time to Surgery	Frequency (n)	Percentage (%)	p-value
<24 hours	35	35%	0.018*
24–72 hours	40	40%	
>72 hours	25	25%	

Table V represents neurological recovery outcomes at 6 months post-injury according to the standardized ASIA impairment scale. The outcomes exhibit a bimodal distribution with 30% of patients having ASIA D (incomplete motor function with functional strength) and 25% having ASIA E (normal neurological function). ASIA A (complete spinal cord injury) was seen in 15% of patients, which is the worst neurological outcome with no motor or sensory function below the injury level. ASIA B (incomplete sensory only) and ASIA C (incomplete motor non-functional) were 10% and 20% respectively, which indicated partial neurological improvement. Statistical significance (p = 0.008) suggests that treatment variables and patient factors influenced neurological outcomes. The relatively high rate of ASIA D or E patients (55% overall) indicates that more than half of the study population showed major neurological improvement. [Table V].

Table – V: Neurological Outcome at 6 Months (ASIA Scale)

ASIA Score at 6 Months	Frequency (n)	Percentage (%)	p-value
ASIA A (Complete)	15	15%	
ASIA B	10	10%	
ASIA C	20	20%	
ASIA D	30	30%	0.008*
ASIA E (Normal)	25	25%	

Table VI discusses the relationship between immobilization methods and complications. Pressure ulcers were the most common complication, with considerable variation between immobilization methods (p = 0.041). Halo vest and cervical traction immobilization had the highest rates of pressure ulcers (20% each), possibly due to pressure points and

ISSN: 2663-9491 e-ISSN: 2789-6897

prolonged contact with rigid surfaces. Initial surgical stabilization had the lowest pressure ulcer rate (4%), possibly due to reduced duration of external immobilization and improved patient mobility. Respiratory complications occurred in 4-8% of patients overall without difference (p = 0.230), suggesting that this complication is more patient-related than the immobilization method. Deep vein thrombosis and pulmonary embolism (DVT/PE) varied from 6-12% between methods without difference (p = 0.512). [Table VI].

Table – VI: Complications vs. Immobilization Method

Complication	Rigid Collar	Halo Vest	Traction	Surgery	p-value
Pressure ulcers	5 (10%)	3 (20%)	2 (20%)	1 (4%)	0.041*
Respiratory issues	2 (4%)	1 (6.7%)	0 (0%)	2 (8%)	0.230
DVT/PE	3 (6%)	1 (6.7%)	1 (10%)	3 (12%)	0.512

Tables 7(A) and 7(B) represent the Multivariable Logistic Regression Analysis and the interpretation of Poor Neurological Outcome. The strongest predictor of poor neurological recovery (ASIA A-C) at 6 months is the initial ASIA A/B, with 6.75-fold higher odds for poor recovery. Severe trauma to energy (aOR 3.12) and late operation (>72 hours, aOR 2.90) significantly worsen the outcomes, emphasizing the role of injury severity and timely intervention. Age >60 years (aOR 2.45) and non-surgical management (aOR 2.40) also pose risk, highlighting the impact of recovery limitations related to age and surgical advantage in some patients. [Table VII(A) and VII(B)].

Table – VII (A): Multivariable Logistic Regression Analysis for Risk of Poor Neurological Outcome (ASIA A–C)

Risk Factor	Adjusted Odds Ratio (aOR)	95% Confidence Interval (CI)	p-value
Age > 60 years	2.45	1.10 – 5.45	0.027*
Male sex	1.30	0.65 – 2.62	0.456
High-energy mechanism	3.12	1.45 – 6.69	0.003*
Subaxial fracture (C3–C7)	1.85	0.92 – 3.75	0.084
Delayed surgery (>72 hrs)	2.90	1.23 – 6.87	0.014*
Initial ASIA A/B score	6.75	3.20 – 14.2	<0.001*
Comorbidity (DM/HTN)	1.65	0.78 – 3.47	0.187
Non-surgical treatment	2.40	1.10 – 5.24	0.028*

Table – VII (B): Interpretation of Risk Factors for Poor Neurological Outcome in Cervical Spine Trauma

Risk Factor	aOR (95% CI)	Interpretation
Age > 60 years	2.45 (1.10–5.45)	Patients over 60 have 2.5 times higher odds of poor neurological recovery.
Male sex	1.30 (0.65–2.62)	Slightly higher odds in males, but not statistically significant.
High-energy mechanism	3.12 (1.45–6.69)	High-energy trauma is associated with over 3× higher risk.
Subaxial fracture (C3–C7)	1.85 (0.92–3.75)	Increased odds of poor outcome, trend toward significance.
Delayed surgery (>72 hrs)	2.90 (1.23–6.87)	Delay in surgery triples the risk of poor outcome.
Initial ASIA A/B score	6.75 (3.20–14.2)	Most significant predictor: ~7× more likely to do poorly.
Comorbidity (DM/HTN)	1.65 (0.78–3.47)	Higher risk with comorbidities, but not statistically significant.
Non-surgical treatment	2.40 (1.10–5.24)	Non-surgical patients have 2.4× higher risk of poor recovery.

DISCUSSION

The findings of this study provide important figures on the difficult management of cervical spine trauma and determinants of neurological recovery. Our data demonstrate that 55% of patients experienced significant neurological recovery (ASIA D or E) at 6 months, as described by Wilson et al., with recovery rates of 50-70% in similar patient populations[9]. The marked male dominance (68%) and excessive incidence of road traffic injuries (45%) agree with recognized epidemiological patterns of cervical spine injury with Jain et al., testifying to the vulnerability of young to middle-aged males engaging in dangerous endeavors[10]. The predominance of subaxial fractures (C3-C7) in our group (55%) is particularly noteworthy given that such injuries have been described to possess certain biomechanical characteristics and management challenges over the injuries

of the upper cervical spine. Early surgery should be performed in the case of evidence of spinal instability or continued compression of the spinal cord, and our findings support this recommendation by Ahuja et al., with 35% of patients being operated on within 24 hours[11]. Our multivariable analysis indicates that delayed surgery of greater than 72 hours significantly risks poor neurological outcome (aOR 2.90, p = 0.014), in strong evidence for the "time is spine" concept. This finding is in agreement with Yousefifard et al., evidencing that neurological recovery after traumatic cervical spinal cord injury is improved if the surgical instrumented fusion and decompression are performed within 8 hours compared to 8 to 24 hours after the injury[12]. The Japanese nationwide trauma database study also demonstrated better outcomes resulting from early surgery, supporting our findings regarding the importance of the timing of the surgery[13]. The initial ASIA score was the strongest predictor of neurological outcome (aOR 6.75, p < 0.001), as supported by Aarabi et al., who have established intramedullary lesion length on postoperative MRI to be an excellent predictor of ASIA impairment scale grade change following decompressive surgery in cervical spinal cord injury[14]. Multivariable analysis identified predictors of favorable AIS improvement as initial AIS C-D (< 0.001), central cord syndrome (p = 0.016), and C0–C3 injury (p = 0.017) and corroborates our earlier results by Schoenfeld et al., in the prognostic value of the initial neurological status[15]. Complications analysis determined pressure ulcers to be much more common with the use of halo vest and cervical traction (20% each) than surgical stabilization (4%, p = 0.041). This result contradicts conventional strategies for prolonged external immobilization and concurs with current trends toward early surgical stabilization as indicated. A study by Pandor et al. indicates that cervical collar use can increase intracranial pressure or cerebrospinal fluid pressure, cause skin breakdown, and risk aspiration in older adults, concordant with our complication profile results[16]. The association with poor outcome (aOR 3.12, p = 0.003) and high-energy mechanism illustrates the extensive tissue destruction and multi-organ involvement typical of such injuries. This concurs with a more recent multicenter study by Hasler et al., who showed that patients with lowered GCS or systolic blood pressure, facial fractures of severity, dangerous mechanism of injury, male gender, and/or age ≥ 35 years are at higher risk[17]. The age-adjusted prognostic risk factor (aOR 2.45 for > 60 years) is in favor of the requirement of age-adjusted prognostic counseling and potentially adjusted management strategies in elderly patients. Our study contributes to the mounting evidence supporting early surgical treatment and selective immobilization policies in the management of cervical spine trauma. The relatively high rate of recovery (55% to ASIA D or E) suggests that early treatment and judiciously selected patient population can lead to substantial neurological recovery in a high percentage of patients.

Limitations of the Study

This single-center, small sample size study may potentially restrict the generalizability of findings to larger populations. The 24-month study period may not capture seasonal variations in trauma patterns or neurological outcomes beyond 6 months. The study also did not control for variations in surgical technique, surgeon experience, and rehabilitation protocols that influence outcome.

CONCLUSION

This study demonstrates that surgery performed early within 72 hours is linked to improved neurological outcomes for patients with cervical spine trauma. The ASIA score on admission was most predictive of improvement, while delayed surgery after 72 hours significantly increases the risk of poor neurological outcomes. These findings confirm the "time is spine" concept and justify early surgical intervention where clinically appropriate. The results emphasize the importance of detailed patient assessment and early decision-making in optimizing recovery outcomes in cervical spine trauma patients.

RECOMMENDATIONS

Future studies must be prospective multicenter studies with larger sample sizes to validate these findings in diverse populations and healthcare settings. The investigation of the optimal timing of surgery within the first 24 hours, particularly the role of ultra-early surgery within 8 hours, must be further studied. Predictive modeling based on advanced imaging biomarkers and molecular markers can enhance prognostic accuracy and guide personalized treatment strategies. Long-term follow-up studies that examine neurological recovery patterns at 6 months would provide valuable data concerning the long-term stability of early intervention benefits.

Funding: No funding sources
Conflict of interest: None declared

REFERENCES

1. *Jug M, Kejžar N, Vesel M, Al Mawed S, Dobravec M, Herman S, Bajrovic F. Neurological recovery after traumatic cervical spinal cord injury is superior if surgical decompression and instrumented fusion are performed within 8 h versus 8–24 h after injury: a single centre experience. Global Spine Journal. 2016 Apr;6(1_suppl):s-0036.*
2. *Breeding T, Nasef H, Amin Q, Wright DD, Zito T, Elkbuli A. Practices of Adult Spine Immobilization During Trauma Resuscitation: Proposal for Improved Guidelines. The American Surgeon™. 2024 Jun;90(6):1638-47.*
3. *Pandor A, Essat M, Sutton A, Fuller G, Reid S, Smith JE, Fothergill R, Surendra Kumar D, Kolias A, Hutchinson P, Perkins GD. Cervical spine immobilisation following blunt trauma in pre-hospital and emergency care: A systematic review. PloS one. 2024 Apr 25;19(4):e0302127.*
4. *Badhiwala JH, Ahuja CS, Fehlings MG. Time is spine: a review of translational advances in spinal cord injury: JNSPG 75th Anniversary Invited Review Article. Journal of Neurosurgery: Spine. 2018 Dec 20;30(1):1-8.*
5. *Fehlings MG, Vaccaro A, Wilson JR, Singh A, W. Cadotte D, Harrop JS, Aarabi B, Shaffrey C, Dvorak M, Fisher C, Arnold P. Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS). PloS one. 2012 Feb 23;7(2):e32037.*

6. *Hsieh YL, Tay J, Hsu SH, Chen WT, Fang YD, Liew CQ, Chou EH, Wolfshohl J, d'Etienne J, Wang CH, Tsuang FY. Early versus late surgical decompression for traumatic spinal cord injury on neurological recovery: a systematic review and meta-analysis. Journal of neurotrauma. 2021 Nov 1;38(21):2927-36.*
7. *Kirshblum SC, Burns SP, Biering-Sorensen F, Donovan W, Graves DE, Jha A, Johansen M, Jones L, Krassioukov A, Mulcahey MJ, Schmidt-Read M. International standards for neurological classification of spinal cord injury (revised 2011). The journal of spinal cord medicine. 2011 Nov 1;34(6):535-46.*
8. *Childs BR, Moore TA, Como JJ, Vallier HA. American spinal injury association impairment scale predicts the need for tracheostomy after cervical spinal cord injury. Spine. 2015 Sep 15;40(18):1407-13.*
9. *Wilson JR, Tetreault LA, Kwon BK, Arnold PM, Mroz TE, Shaffrey C, Harrop JS, Chapman JR, Casha S, Skelly AC, Holmer HK. Timing of decompression in patients with acute spinal cord injury: a systematic review. Global spine journal. 2017 Sep;7(3_suppl):95S-115S.*
10. *Jain NB, Ayers GD, Peterson EN, Harris MB, Morse L, O'Connor KC, Garshick E. Traumatic spinal cord injury in the United States, 1993-2012. Jama. 2015 Jun 9;313(22):2236-43.*
11. *Ahuja CS, Wilson JR, Nori S, Kotter M, Druschel C, Curt A, Fehlings MG. Traumatic spinal cord injury. Nature reviews Disease primers. 2017 Apr 27;3(1):1-21.*
12. *Yousefifard M, Hashemi B, Forouzanfar MM, Oskooi RK, Neishaboori AM, Khoshnoud RJ. Ultra-early spinal decompression surgery can improve neurological outcome of complete cervical spinal cord injury; a systematic review and meta-analysis. Archives of Academic Emergency Medicine. 2022 Jan 31;10(1):e11.*
13. *Tanaka C, Tagami T, Kaneko J, Fukuda R, Nakayama F, Sato S, Takehara A, Kudo S, Kuno M, Kondo M, Unemoto K. Early versus late surgery after cervical spinal cord injury: a Japanese nationwide trauma database study. Journal of orthopaedic surgery and research. 2019 Sep 5;14(1):302.*
14. *Aarabi B, Sansur CA, Ibrahimi DM, Simard JM, Hersh DS, Le E, Diaz C, Massetti J, Akhtar-Danesh N. Intramedullary lesion length on postoperative magnetic resonance imaging is a strong predictor of ASIA impairment scale grade conversion following decompressive surgery in cervical spinal cord injury. Neurosurgery. 2017 Apr 1;80(4):610-20.*
15. *Schoenfeld AJ, Bono CM, McGuire KJ, Warholic N, Harris MB. Computed tomography alone versus computed tomography and magnetic resonance imaging in the identification of occult injuries to the cervical spine: a meta-analysis. Journal of Trauma and Acute Care Surgery. 2010 Jan 1;68(1):109-14.*
16. *Pandor A, Essat M, Sutton A, Fuller G, Reid S, Smith JE, Fothergill R, Surendra Kumar D, Kolias A, Hutchinson P, Perkins GD. Cervical spine immobilisation following blunt trauma in pre-hospital and emergency care: A systematic review. PloS one. 2024 Apr 25;19(4):e0302127.*
17. *Hasler RM, Exadaktylos AK, Bouamra O, Benneker LM, Clancy M, Sieber R, Zimmermann H, Lecky F. Epidemiology and predictors of cervical spine injury in adult major trauma patients: a multicenter cohort study. Journal of trauma and acute care surgery. 2012 Apr 1;72(4):975-81.*