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Comparison of the accuracy of plain radiography and CT scan in diagnosing cervical spine injuries in trauma patients referred to the emergency department of Imam Hussein (AS) Hospital, Shahroud

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Abstract

Background: *Trauma is the leading cause of death in developing countries. Head and neck trauma is one of the most common causes of referral to the emergency department following injuries resulting from motor vehicle accidents, sports, fights, and falls from heights. Cervical spine injuries account for 2-3% of trauma patients. This study was conducted to compare the accuracy of plain radiography and CT scan in diagnosing cervical spine injuries in trauma patients in Shahroud city.*

Methods: *This descriptive-analytical study was conducted using a cross-sectional method and convenient sampling on 115 cervical spine trauma victims referred to the emergency department of Imam Hossein (AS) Hospital in Shahroud in 2018-2019. Data were collected using a demographic information checklist. After collection, the data were entered into SPSS version 23, WinPepi version 11.65, and MEDCALC statistical software and analyzed using descriptive-analytical statistics.*

Results: *In this study, the results showed that out of 115 patients with cervical spine injury, 59.1% were male and 40.9% were female. The mean age of the patients was 39.8±15.3 years. Car accident, rollover and motorcycle accident were the most frequent mechanisms of injury to the patients with 39.1, 24.3 and 20.9% respectively. The sensitivity, specificity, positive and negative predictive value, positive and negative likelihood ratio and area under the Ruck curve for simple radiographs read by an emergency medicine specialist were 55.56, 97.17, 26.5, 96.62, 19.63, 0.46 and 76% respectively. Also, the sensitivity, specificity, positive and negative predictive value, positive and negative likelihood ratio, and area under the Rock curve for plain radiographs read by a radiologist were 0, 0.33, 66.67, 100, 100, 97.25, and 83 percent, respectively.*

Conclusions: *According to the results of the study, it can be stated that plain radiography cannot be considered an appropriate tool to rule out cervical vertebrae injuries caused by trauma. Also, taking radiography may be a waste of time for faster and better diagnosis, as well as a waste of money without achieving appropriate results, given the higher accuracy of CT scanning. Therefore, it is recommended to use CT scanning in case of clinical suspicion or if the radiography images do not meet the standards.*

Keywords: Trauma, Cervical Vertebrae, Plain radiography, CT scan.
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Introduction

Trauma is generally classified as penetrating (blow-in) and non-penetrating (slow-in). The energy transfer and damage generation are the same in both types of trauma. The only difference between these two types is the degree of penetration into the skin. In penetrating trauma, all the energy of an object is concentrated on a small area of the skin. In non-penetrating trauma, a large object whose energy is spread over a large area of the skin does not penetrate the body. As a result, the impact covers a large area of the body and the type of injury is less focused.[1,2] Trauma is now recognized as a major health problem in different societies with different health, economic, and social conditions. Iran ranks second in the world in terms of mortality due to trauma.[3] Head and neck trauma is one of the most common causes of emergency department visits following injuries from motor vehicle accidents, sports, fights, and falls from heights. Cervical spine injuries account for 2-3% of trauma patients. However, due to the high mortality rate and complications, most cervical spine fractures occur at two levels. About one-third of them occur at level 2C and half of the injuries occur at level 6C or 7C.[1, 4, 5] In addition to imposing direct and indirect social and economic costs on society, trauma causes temporary or permanent disabilities for individuals. This problem affects the family, community resources, and the systems involved, such that this issue has been introduced as one of the priorities of the World Health Organization.[6-8]

Due to the presence of major vessels, digestive nerve conduits such as the spinal cord and esophagus, and the carotid and vertebral arteries, the higher the level of injury, the greater the likelihood of disability, neurological damage, and events that may affect the person's entire life and future. The association of cervical spine fractures with spinal cord injuries can lead to neurological deficits and lead to many socio-

economic problems. Delay in diagnosing lesions can cause serious and irreversible damage to the patient, and timely treatment and diagnosis can reduce the burden of the disease and the resulting disabilities to some extent.[9, 10]

The lack of a consistent approach to assessing cervical spine injuries resulting from traumatic mechanisms that are highly damaging is a common problem. Although validated guidelines and strategies for assessing cervical spine injuries reduce the incidence of missed and unrecognized lesions in patients, they are not yet widely accepted and used by clinicians.[8, 11, 12] Currently, cervical spine injuries are assessed using one or a combination of radiological diagnostic tools, such as plain radiography, CT scan, and MRI,[13-15] CT scan and MRI are the main imaging modalities for evaluating spinal cord and spinal cord injuries; they are particularly useful for confirming the exact location of the injury, assessing spinal stability, and neurologic compromise. Imaging can describe all spinal injuries. Despite the disadvantage of plain radiography in diagnosing traumatic injuries due to the higher radiation dose and higher cost of CT scan compared to radiography, plain radiography is used in most cases in trauma patients. However, in cases where the treating physician has a high suspicion of cervical vertebrae injury and the radiography is normal or has no suspicious findings, a neck CT scan is prescribed at the discretion of the treating physician.[16, 17]

Methods of accident prevention and control in developing countries have been less evaluated; therefore, any effort that leads to the identification of deficiencies in related care and their correction is of great value. Plain radiography and CT scan are important tools available for the diagnosis of traumatic neck injuries. Despite the emphasis of some physicians on performing neck radiography for all trauma patients, the discussion of performing CT scan for symptomatic patients and the use of clinical decision-making systems to determine patients requiring neck radiography has long been raised. On the other hand, considering the high false negative rates in neck radiography, many recommendations have now been made to perform CT scan as the first diagnostic method, and in practice, plain radiography has been given a much lesser role.[18-20]

A significant number of cervical vertebrae fractures cannot be detected on plain radiographs, especially in patients with severe injuries and without surgery. As a result, CT scanning is used as an auxiliary method to better diagnose fractures and the extent of damage. Plain radiographs are unable to create a clear image of the cervical spine in about 72% of cases, which is why the need for CT scanning is felt in cervical trauma. Despite the disadvantage of plain radiographs in diagnosing traumatic injuries due to the higher radiation dose and higher cost of CT scanning compared to radiographs, plain radiographs are used in most cases in trauma patients. Of course, in cases where the treating physician has a high suspicion of cervical vertebrae injury and the radiograph is normal or has no suspicious findings, a neck CT scan is prescribed according to the treating physician's opinion. Also, according to the new guidelines of the Eastern Practice Trauma of Surgery Association, the best screening method for clarifying blunt neck injury is a CT scan of the occiput area up to 1T.[20-22] In addition, based on the results of various studies, plain radiography can detect about 60 to 80% of fractures, while CT scan, with its high sensitivity and specificity, can detect 97 to 100% of fractures.[23, 24] Therefore, the present study was conducted with the aim of comparing the accuracy of plain radiography and CT scan in diagnosing cervical vertebrae injury in trauma patients in Shahroud city.

Materials and Methods

This descriptive-analytical study was conducted using convenience sampling on trauma patients with neck injuries referred to Imam Hossein Shahroud Hospital in 2018-2019. The sample size was calculated based on the study of Breen et al.[25] and a confidence interval of 95%, accuracy of 7%, and sensitivity of 85.2% for simple radiography. Finally, 115 subjects were evaluated. At the beginning of the study, a series of inclusion and exclusion criteria were set. The inclusion criteria for the study were: 1- Trauma to the cervical vertebrae with midline tenderness according to the NEXUS criteria (NEXUS criteria are a tool that physicians use to decide whether adults are at risk of cervical spine injury or whether they need to use radiographic imaging); 2- Age over 16 years; 3- non-pregnancy; and 4- Consent to participate in the study and exclusion criteria. 1- The patient died before performing paraclinical procedures. 2- They had a desire to withdraw from the study at the time of imaging. A researcher-made checklist was used to collect information, which consisted of two sections. In the first part, the patient's demographic information, cause and type of trauma were collected by the emergency specialist (age, gender) and in the information section, the findings of the radiography and CT scan were recorded. Also, if the patient was conscious, consent was obtained from the patient himself and if he was unconscious, consent was obtained from the patient's companion or guardian. After receiving the informed consent form, the patients were referred to the radiology department for plain radiography and CT scan of the cervical vertebrae. The radiology results, including plain radiography and CT scan, were read by the emergency medicine specialist in terms of variables such as cervical fracture, cervical dislocation, associated lesion, cause of injury and recorded in the checklist. Also, the aforementioned images were reviewed and examined separately by a radiologist and the checklist was completed once by the radiologist without knowing the report completed by the emergency specialist. In this study, CT scan findings were considered as the gold standard. It should be noted that the location and type of imaging device were the same in all patients. In order to compare and examine the decision-making made by both specialists (emergency medicine and radiology specialists), their responses were compared for each individual and their agreement coefficient for each imaging was examined using the kappa statistic. The collected data were entered into SPSS version 23, WinPepi version 11.65 and MEDCALC statistical software for statistical analysis. Mean and standard deviation were used to describe quantitative variables and frequency and frequency percentage were used to describe qualitative variables. Sensitivity, specificity, positive and negative predictive values, positive and negative likelihood, and area under the Rock curve were used to determine the diagnostic value of simple imaging compared to CT scan. The

kappa agreement coefficient was also calculated and a significance level of less than 0.5 was considered.

Results

In this study, a total of 115 people were included in the study, most of the participants were male (59.1%), 25-34 years old (35%, 30.4%), self-employed (67%), education level below diploma (63%), Midline Tenderness (68.7%), car accident (39.1%) (Table 1), and the average age of the participants was 39.8±15.3 years.

Table 1. Frequency of subjects based on demographic variables, mechanism of injury

Variable	Subgroup	Frequency	Percentage
Gender	Man	68	59.1
	Woman	47	40.9
Age Group	24-18	16	13.9
	25-34	35	30.4
	35-44	29	25.2
	45-54	15	13
	55-64	12	10.4
	65 and above	8	7
Occupation	Housewife	35	31.3
	Freelance	75	67
	Employee	1	0.9
	Student	1	0.9
Education Level	Illiterate	19	17.6
	Undergraduate	68	63
	Bachelor's Degree	20	18.5
	Master's Degree and Doctorate	1	0.9
NEXUS Criteria	AMS	2	1.7
	Distracting Injury	34	29.6
	Midline Tenderness	79	68.7
Mechanism of Injury	Car accident	45	39.1
	Motorcycle accident	24	20.9
	Rollover	28	24.3
	Pedestrian	6	5.2
	Fall	10	8.7
	Conflict	2	1.7

Most of the radiographs were taken from the C1-C5 and C1-C6 vertebrae. According to other results, 93 and 94.8 percent of the people whose radiographs were evaluated by the emergency medicine specialist and the radiologist, respectively, were diagnosed as having no injury, and the frequency of injuries diagnosed by the emergency medicine specialist was 8 injuries and by the radiologist was 6 injuries. (Table 2), People without injury had the highest frequency (92.2 percent), which was completely equal between the emergency medicine specialist and the radiologist. On the other hand, the frequency of types of injuries was almost the same between the emergency medicine specialist and the radiologist, and the only difference was the diagnosis of Spinos Process FX injury by the emergency medicine specialist (Table 3).

Table 2. Frequency of injuries detected in plain radiography

Injury Type	Emergency medicine specialist		Radiology specialist	
	Frequency	Percentage	Frequency	Percentage
Compress FX	1	0.9	0	0
Spinous Process FX	1	0.9	0	0
Lamina FX	0	0	1	0.9
Odontoid FX	0	0	1	0.9
Other Injuries	6	5.2	4	3.5
No Injury	107	93	109	94.8

Table 3. Frequency of injuries detected on CT scan

Injury Type	Emergency medicine specialist	Radiology specialist

	Frequency	Percentage	Frequency	Percentage
Burst FX	1	0.9	1	0.9
Lamina FX	1	0.9	2	1.7
Spinous Process FX	1	0.9	0	0
Odontoid FX	1	0.9	1	0.9
Other Injuries	5	4.3	5	4.3
No Injuries	106	92.2	106	92.2

The number of images with cervical vertebra damage in simple radiography was 5 cases and 103 cases of damage-free radiography and 4 cases of false negatives (absence of damage in radiography and definite presence of damage in CT scan). Also, 3 cases of damage reported by radiography were detected in CT scan results without damage (false positive) and based on the calculated specificity for simple radiography (99.41-91.95) 97.17% has value and power to detect negative and undamaged individuals. However, due to the high false negative cases compared to the total number of patients, the calculated sensitivity for simple radiography (86.30-21.20) is 55.56%. The kappa index between simple radiography and CT scan was calculated to be 56%, which is an average degree of agreement (Table 4).

The number of images with cervical vertebra damage in plain radiography was 6 cases and correct radiography without damage was 106 cases, and false negatives were 3 cases (absence of damage in radiography and definite presence of damage in CT scan) and false positives (damage reported by radiography was detected in CT scan results without damage) were zero.Using the matching of the results of plain radiography against CT scan which were examined by a radiologist, the components of sensitivity, specificity, positive and negative predictive value, positive and negative likelihood ratio were calculated. Based on the results of the calculated specificity for plain radiography (100-96.58) 100% has value and power to detect negative and uninjured individuals. However, considering the presence of false negative cases against the total number of patients, the calculated sensitivity for plain radiography (92.51-29.93) was 66.67% and the kappa index between plain radiography and CT scan was calculated to be 79% (Table 5).

Table 4. Comparison of simple radiography screening with CT scan in diagnosing cervical spine injuries by emergency medicine specialists

Screening indicators	
False positive	**3**
True positive	**5**
False negative	**4**
True negative	**103**
Accuracy	**93.91 (87.86-97.52)**
Sensitivity	**55.56 (21.20-86.30)**
Specificity	**97.17 (91.95-99.41)**
Positive predictive value	**62.50 (32.12-85.45)**
Negative predictive value	**96.26 (92.53-98.17)**
Positive likelihood ratio	**19.63 (5.57-69.15)**
Negative likelihood ratio	**0.46 (0.22-0.95)**
Kappa index	**0.56**

Table 5. Comparison of simple radiography screening with CT scan in diagnosing cervical spine injuries by radiologists

Screening indicators	
False positive	**0**
True positive	**6**
False negative	**3**
True negative	**106**
Accuracy	**97.39 (92.57-99.46)**
Sensitivity	**66.67 (29.93-92.52)**
Specificity	**100 (96.58-100)**
Positive predictive value	**100**
Negative predictive value	**97.25 (93.34-98.89)**
Positive likelihood ratio	**0**
Negative likelihood ratio	**0.33 (0.13-0.84)**
Kappa index	**0.79**

According to Figure 1, the area under the Rock curve or the overall accuracy of plain radiography versus CT scan for an emergency medicine specialist was calculated to be 76.4%, which is classified as a good accuracy level for the Rock curve. The reported confidence interval is wide but is within the significant level range. (Figure 1). According to the results of Figure 2, the area under the Rock curve or the overall accuracy of plain radiography versus CT scan for a radiologist was calculated to be 83.3%, which is classified as a good accuracy level for the Rock curve. Therefore, radiography can be accepted for diagnosing injuries to the cervical vertebrae (Figure 2).

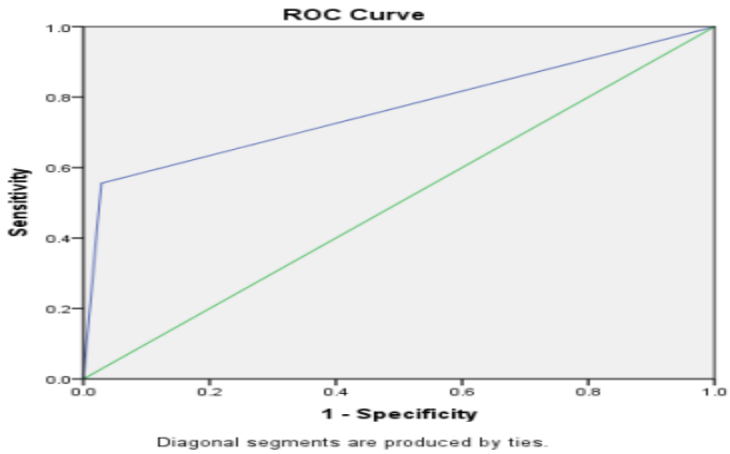

Figure 1. Area under the Rock curve in diagnosing injuries by emergency medicine specialists

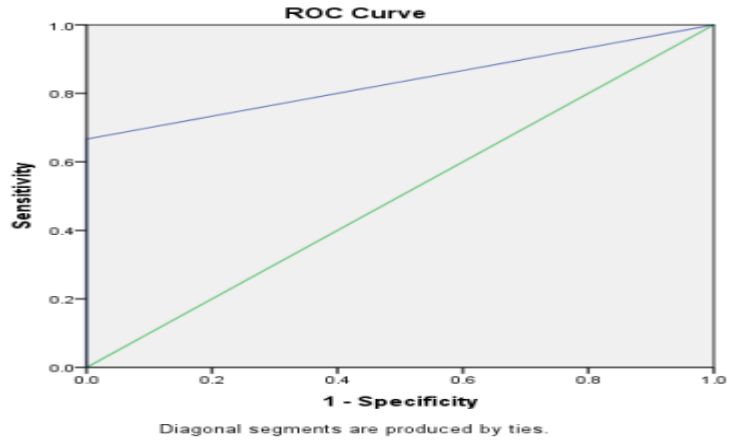

Figure 2. Area under the Rock curve in the diagnosis of injuries by radiologists

Regarding the Kappa score, both experts considered that there was no damage to the cervical vertebrae in 105 cases of plain radiography. However, in 6 cases, the opinions of the emergency medicine and radiology specialists were different. Therefore, the agreement between the two experts in diagnosing injuries using plain radiography is 55.1%, which indicates moderate to good agreement in the report of plain radiography by both experts. According to both experts, in the CT scan images, there was no damage to the cervical vertebrae in 106 cases, and in 7 cases, both experts reported the same damage. In only two cases did the two experts differ in diagnosing the damage. Therefore, the agreement between the two experts in diagnosing the damage using CT scan is 0.883,

which indicates excellent agreement in the CT scan report by both experts.

Discussion

The results of the present study showed that about 60% of the subjects were male. In the study of Sabzqabaei et al.[26] about 70%, in the study of Saadat et al.[27] more than 70%, Asadi et al.[1], Safaei et al.[28] most of the subjects were male. In this respect, the results obtained are consistent with other studies. It seems that given that the prevalence of accidents and incidents is higher in men, therefore the damage and injuries suffered by men are more than women[29], the average age of the subjects studied was 39.8±15.3 years and most of the patients were in the age group of 25 to 44 years. In the study of Sabzqabaei et al.[26] the average age was 32 years, in the study of Saadat et al.[27] it was 36 years, in the study of Asadi et al.[1] the average age was 39 years and the most involved age group was 30-59 years. In this respect, the findings are consistent with the results of other studies. In a study conducted in England[30], the findings showed that demographic and social factors are associated with the occurrence of consequences and injuries caused by head and neck trauma. Considering that in our study, as mentioned, most injuries were observed in the young age group, less than 40 years old and in men, this demographic pattern can be considered as a result of high-risk behaviors of young people. Also, considering the more active presence of men compared to women in society and the greater use of personal vehicles, it may be the reason for the higher prevalence of injuries in the cervical vertebrae in men.

In our study, the most common mechanism of injury leading to cervical spine trauma was traffic accidents and car accidents. In the study of Sabzeh Ghobayi et al.[26], the most common mechanism of injury was motor vehicle accidents (83.3%). In the study of Saadat et al.[27], traffic accidents and falls from heights were the most common mechanisms of injury. In the study of Bahadur Khan in Mashhad[31] and Heidari et al.[32], the most common mechanism of injury was reported to be vehicle accidents. In a study in Taiwan[33], California[34] and a study conducted in Scotland[35], the findings showed that the most common mechanism of injury in trauma patients was injuries caused by motor vehicles. Due to the rapid increase in mechanization of societies in different regions of the world, traffic injuries are considered the most important cause of trauma. Based on the results of the present study, it is seen that only in 14 cases (6.12%) of patients did the radiographs taken from the 1C to 7C cervical vertebrae completely display, which is of great importance for diagnosis. Various factors such as the patient's condition, patient weight, damage to other organs of the patient can affect the correct position for simple radiography and make it erroneous.

In our study, the sensitivity of plain radiography read by emergency medicine and radiology specialists was 55.56 and 67.66 percent, respectively. The specificity of plain radiography was 97.17 and 100 percent, respectively. All injuries were identified by CT scan as the standard and gold standard tools. This is while in the study conducted by Sabzeh Ghobai et al.[26] in hospitals under the auspices of Shahid Beheshti University of Medical Sciences in Tehran, the sensitivity was 33.09 and the specificity was 80.48 percent. In the study by Vigia et al.[36] in Austria, plain radiography had a sensitivity of 63 percent, and in the study by Badihiolu et al., the sensitivity and specificity of plain radiography were 39 and 98 percent, respectively[8]. In the study by Saba et al., the results showed that the sensitivity and specificity of CT scan in diagnosing traumatic lesions of the cervical vertebrae were between 70 and 90 percent[37]. A study by Cain et al. in California showed that CT scanning is more suitable for evaluating the cervical spine than plain radiography[20]. Koum et al. also showed that injuries to the cervical vertebrae that were not detected on plain radiography can be correctly identified on CT scanning[38]. The results of the study by Ramoz et al. indicated that CT scanning has a higher sensitivity and specificity in diagnosing traumatic neck injuries[39]. In a study by Bach et al., plain radiography was able to detect 79% of injuries to the cervical vertebrae[40]. In another study, researchers found that plain radiography detected 54% of cervical fractures. While CT scanning correctly detected 9% of injuries[41], in a study by Bern et al., the sensitivity of plain radiography was 60%[42]. Therefore, it seems that plain radiography cannot be used as an appropriate tool to rule out injuries to the cervical vertebrae caused by cervical trauma. To be considered.

According to the findings of our study and other studies, in order to better diagnose injuries to the cervical vertebrae due to trauma, it is better to reconsider the request for a CT scan of the neck for patients with trauma. The use of clinical decision-making methods such as the neck nexus can help in better diagnosing patients requiring imaging. Therefore, it is better to first evaluate all neck trauma patients using simple radiography. Considering the higher sensitivity and specificity observed in the examination of radiography and CT scan by a radiologist in this study and considering the skill and experience of radiologists, it is recommended that all radiographs be evaluated by a radiologist first, if possible. However, if this is not possible due to the patient's emergency conditions and the radiographs are reviewed by an emergency medicine specialist, and if the radiographs taken do not meet the required criteria for a standard image showing all cervical vertebrae, image resolution, etc., CT scans should be used directly in patients to examine trauma in the cervical vertebrae to minimize false negatives.

In the present study, the positive and negative predictive values of the radiographs read by the emergency medicine specialist were 62.50 and 96.26 percent, respectively. While the positive and negative predictive values of the radiographs read by the radiologist were 100 and 97.25 percent, respectively. This indicates that the radiologist was better able to distinguish between actual injured and healthy cases based on the radiographs. The kappa index obtained for radiography versus CT scan in the emergency medicine and radiology studies was 56 and 79 percent, respectively, which again indicates that the radiologist was more accurate in diagnosing injuries to individuals. The strengths of this study include the lack of such a study at the provincial and city levels, and the weaknesses of this study include the difficulty in requesting different positions and conditions for appropriate imaging using radiography, the lack of standardization of imaging using radiography for clarity

and number of cervical vertebrae, the lack of inclusion of patients with acute conditions in the study, and the high weight of the patients for CT scans and radiography.

Conclusion

According to the results obtained in our study, the accuracy of plain radiography is very low compared to CT scan in diagnosing injuries to the cervical vertebrae due to trauma. This is due to the very low sensitivity of plain radiography in diagnosing injuries. Also, taking radiography, given the higher accuracy of CT scan, may result in wasting time for faster and better diagnosis and also spending money without achieving appropriate results; therefore, it is recommended to use CT scan in case of clinical suspicion or if the radiography images do not meet the standards.

Ethical Considerations

This article is also part of the doctoral thesis in emergency medicine of Dr. Seyyedah Umm al-Baneen Seyyed Rezaei, which has been approved by the Ethics Committee of Shahroud University of Medical Sciences with the ethics code IR.SHMU.REC.1397.198.

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Conflict of Interest

There are no conflicts of interest among the authors of the article.

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References

1. Asadi P, Asadi K, Monsef-Kasmaei V, Zohrevandi B, Kazemnejad-leili E, Kouchakinejad Eramsadati L, et al. Evaluation of Frequency of Cervical Spine Injuries in Patients with Blunt Trauma. Journal of Guilan University of Medical Sciences. 2015;23.

2. Okonta KE. Traumatic chest injury in children: A single thoracic surgeon's experience in two Nigerian tertiary hospitals. African Journal of Paediatric Surgery. 2015;12(3):181-6. doi:10.4103/0189-6725.170193

3. Aghakhani N, Azami M, Jasemi M, Khoshsima M, Eghtedar S, Rahbar N. Epidemiology of traumatic brain injury in urmia, iran. Iranian Red Crescent Medical Journal. 2013;15(2):173. doi:10.5812/ircmj.2090

4. de Winter JC, Dodou D. The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. Journal of safety research. 2010;41(6):463-70. doi:10.1016/j.jsr.2010.10.007

5. Gupta P, Kumar A, Gamangatti S. Mechanism and patterns of cervical spine fractures-dislocations in vertebral artery injury. Journal of Craniovertebral Junction and Spine. 2012;3(1):11-5. doi:10.4103/0974-8237.110118

6. Zohoor A, Asadi F. Suggestion: A national trauma registry system for Iran. Journal of research in health sciences (2001). 2011;4(1):64-70.

7. Lin FC-F, Li R-Y, Tung Y-W, Jeng K-C, Tsai SC-S. Morbidity, mortality, associated injuries, and management of traumatic rib fractures. Journal of the Chinese Medical Association. 2016;79(6):329-34. doi:10.1016/j.jcma.2016.01.006

8. Badhiwala JH, Lai CK, Alhazzani W, Farrokhyar F, Nassiri F, Meade M, et al. Cervical spine clearance in obtunded patients after blunt traumatic injury: a systematic review. Annals of internal medicine. 2015;162(6):429-37. doi:10.7326/M14-2351

9. Saeidiborojeni HR, Fattahian R. A survey on the spine fracture epidemiology and risk factors among patients referred to a specialized trauma center in Iran during 1998-2000. Journal of injury and violence research. 2012;4(3 Suppl 1):33.

10. Poonnoose PM, Ravichandran G, McClelland MR. Missed and mismanaged injuries of the spinal cord. Journal of Trauma and Acute Care Surgery. 2002;53(2):314-20. doi:10.1097/00005373-200208000-00021

11. Oosterwold J. Spinal immobilization in patients after blunt trauma: a retrospective observational study, 2008-2010.2015(5)

12. Luna LM, Mendoza RdJA, Oropeza YM. Epidemiology of spine trauma in patients with polytrauma. Coluna/Columna. 2017;16(02):121-6. doi:10.1590/s1808-185120171602172288

13. Trumbower RD, Jayaraman A, Mitchell GS, Rymer WZ. Exposure to acute intermittent hypoxia augments somatic motor function in humans with incomplete spinal cord injury. Neurorehabilitation and neural repair. 2012;26(2):163-72. doi:10.1177/1545968311412055

14. Stiell IG, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, De Maio VJ, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. Jama. 2001;286(15):1841-8. doi:10.1001/jama.286.15.1841

15. Harris TJ, Blackmore CC, Mirza SK, Jurkovich GJ. Clearing the cervical spine in obtunded patients. Spine. 2008;33(14):1547-53. doi:10.1097/BRS.0b013e31817926c1

16. Shah LM, Ross JS. Imaging of spine trauma. Neurosurgery. 2016;79(5):626-42. doi:10.1227/NEU.0000000000001336

17. Davis B. Rosen's Emergency Medicine: Concepts and Clinical Practice. Prehospital Emergency Care. 2004;8(3):334-5. doi:10.1016/S1090-3127(03)00283-1

18. Park Y, Lee GJ, Lee MA, Choi KK, Gwak J, Hyun SY, et al. Major causes of preventable death in trauma patients. Journal of Trauma and Injury. 2021;34(4):225-32. doi:10.20408/jti.2020.0074

19. Kulvatunyou N, Lees J, Bender J, Bright B, Albrecht R. Decreased use of cervical spine clearance in blunt trauma: the implication of the injury mechanism and distracting injury. Accident Analysis & Prevention. 2010;42(4):151-55. doi:10.1016/j.aap.2009.12.029

20. Cain G, Shepherdson J, Elliott V, Svensson J, Brennan P. Imaging suspected cervical spine injury: plain radiography or computed tomography? Systematic review. Radiography. 2010;16(1):68-77. doi:10.1016/j.radi.2009.09.001

21. Theocharopoulos N, Chatzakis G, Karantanas A, Chlapoutakis K, Damilakis J. CT evaluation of the low severity cervical spine trauma: when is the scout view enough? European journal of radiology. 2010;75(1):82-6. doi:10.1016/j.ejrad.2009.03.024

22. Panczykowski DM, Tomycz ND, Okonkwo DO. Comparative effectiveness of using computed tomography alone to exclude cervical spine injuries in obtunded or intubated patients: meta-analysis of 14,327 patients with blunt trauma: A review. Journal of neurosurgery. 2011;115(3):541-9. doi:10.3171/2011.4.JNS101672

23. Cullinane DC, Schiller HJ, Zielinski MD, Bilaniuk JW, Collier BR, Como J, et al. Eastern Association for the Surgery of Trauma practice management guidelines for hemorrhage in pelvic fracture-update and systematic review. Journal of Trauma and Acute Care Surgery. 2011;71(6):1850-68. doi:10.1097/TA.0b013e31823dca9a

24. Walters BC, Hadley MN, Hurlbert RJ, Aarabi B, Dhall SS, Gelb DE, et al. Guidelines for the management of acute cervical spine and spinal cord injuries: 2013 update. Neurosurgery. 2013;60:82-91. doi:10.1227/01.neu.0000430319.32247.7f

25. Gerrelts BD, Petersen EU, Mabry J, Petersen SR. Delayed diagnosis of cervical spine injuries. Journal of Trauma and Acute Care Surgery. 1991;31(12):1622-6. doi:10.1097/00005373-199112000-00010

26. Sabzeghabaei A, Shojaei M, Hosseinzadeh A. Plain radiography Compared with Computed Tomography Scan in Detection of Traumatic Injuries of

Cervical Spine; a Diagnostic Accuracy Study. Iranian Journal of Emergency Medicine. 2016;5:6.

27. Saadat S, Nouralishah B, Khaji A. Epidemiology of Head and Neck Injuries in Tehran. The Neuroscience Journal of Shefaye Khatam. 2013;1(4):17-21. doi:10.18869/acadpub.shefa.1.4.17

28. Safaei M, Dehnadi Moghadam A, Kamali G. Spinal fractures in admitted patients in Poursina Hospital. Journal of Guilan University of Medical Sciences. 2008;17(66):38-43.

29. Saadat S, Soori H. Epidemiology of traffic injuries and motor vehicles utilization in the Capital of Iran: A population based study. BMC public health. 2011;11:1-6. doi:10.1186/1471-2458-11-488

30. Shivaji T, Lee A, Dougall N, McMillan T, Stark C. The epidemiology of hospital treated traumatic brain injury in Scotland. BMC neurology. 2014;14:1-7. doi:10.1186/1471-2377-14-2

31. Bahadorkhan G, Samini F, Ehsaei M. Evaluation of the Results of Cervical Spine & Spinal Cord Trauma in Children. 2009.

32. Heidari P, Zarei MR, Rasouli MR, Alexander RV, Rahimi-Movaghar V. Spinal fractures resulting from traumatic injuries. Chinese Journal of Traumatology. 2010;13(01):3-9.

33. Chen C-L, Howng S. The incidence and mortality rates of head injuries in Kaohsiung City, Taiwan (1991-1992). Gaoxiong yi xue ke xue za zhi= The Kaohsiung journal of medical sciences. 1995;11(9):537-45.

34. Pandrich MJ, Demetriades AK. Prevalence of concomitant traumatic cranio-spinal injury: a systematic review and meta-analysis. Neurosurgical review. 2020;43(1):69-77. doi:10.1007/s10143-018-0988-3

35. Goodall CA, MacFie F, Conway DI, McMahon AD. Assault-related sharp force injury among adults in Scotland 2001-2013: Incidence, socio-demographic determinants and relationship to violence reduction measures. Aggression and violent behavior. 2019;46:190-6. doi:10.1016/j.avb.2018.10.002

36. Veiga JRS, Mitchell K. Cervical spine clearance in the adult obtunded blunt trauma patient: A systematic review. Intensive and Critical Care Nursing. 2019;5(1).57-63. doi:10.1016/j.iccn.2018.11.001

37. Saba L. Computed tomography of carotid and vertebral arteries. Multi-detector CT imaging: principles, head, neck, and vascular systems CRC Press, London. 2013:383-4.

38. Como JJ, Diaz JJ, Dunham CM, Chiu WC, Duane TM, Capella JM, et al. Practice management guidelines for identification of cervical spine injuries following trauma: update from the eastern association for the surgery of trauma practice management guidelines committee. Journal of Trauma and Acute Care Surgery. 2009;67(3):651-9. doi:10.1097/TA.0b013e3181ae583b

39. Ramouz A, Hosseini M, Vahdati SS. Epidemiology of head and neck fractures caused by motorcycle accidents. Iranian journal of emergency medicine. 2016;3(1):23-7.

40. Bach C, Steingruber I, Peer S, Peer-Kühberger R, Jaschke W, Ogon M. Radiographic evaluation of cervical spine trauma: Plain radiography and conventional tomography versus computed tomography. Archives of orthopaedic and trauma surgery. 2001;121:385-7. doi:10.1007/s004020000257

41. Nyuon D. Test Performance of Cervical Spine Radiography as Compared to Computed Tomography in Diagnosing Traumatic Cervical Spine Injuries In adults With Head Injury at the Kenyatta National Hospital: University of Nairobi; 2023.

42. Lau BPH, Hey HWD, Lau ET-C, Nee PY, Tan K-A, Tan WT. The utility of magnetic resonance imaging in addition to computed tomography scans in the evaluation of cervical spine injuries: a study of obtunded blunt trauma patients. European Spine Journal. 2018;27:1028-33. doi:10.1007/s00586-017-5317-y