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Validation of NEXUS Chest Criteria in Chest Trauma Patients - A Prospective Observational Study

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Abstract: ***Background: Traumatic injuries significantly impact morbidity, mortality, and healthcare costs, particularly in developing countries like India. Thoracic injuries contribute to 20-50% of trauma-related deaths. The NEXUS chest criteria aim to reduce unnecessary radiological imaging, thereby saving time, reducing costs, and minimizing radiation exposure. Aim: To determine the diagnostic accuracy of NEXUS chest criteria in predicting traumatic thoracic injuries in an Indian context. Objective: To evaluate the sensitivity, specificity, negative predictive value, and positive predictive value of NEXUS chest criteria. Design, Setting, and Participants: A prospective observational study was conducted at KIMSHEALTH Thiruvananthapuram from March 2021 to July 2022, involving 122 trauma patients aged over 18 years. Physicians recorded the presence of NEXUS Chest 7 clinical criteria before viewing radiographic results. Method: The NEXUS chest criteria were applied to the study population, and results were compared with chest x-ray findings to determine sensitivity. Results: Among 122 patients (mean age 42.90 years, 63.1% male), 53.3% injuries were due to RTA. Chest x-ray was indicated in 53 patients, revealing thoracic injuries in 43. The NEXUS chest criteria showed a sensitivity of 90.7%, specificity of 97.5%, positive predictive value of 50%, and negative predictive value of 100%. The diagnostic accuracy was 97.5%. Conclusion: NEXUS Chest criteria effectively reduce the need for chest imaging in blunt trauma patients over 18 years old.***

Keywords: NEXUS Chest criteria, Chest trauma, Chest X-Ray

1. Introduction

Traumatic injuries are one of the most common causes of morbidity and mortality, thereby inflicting a big financial and social burden to the health care system, especially in a developing country like India. Thoracic injury accounts for 20-50% of mortality. Avoiding unwanted radiological imaging gain time for the emergency physician as well reduce financial burden and radiation exposure to the patient. A diagnostic tool namely the NEXUS chest has been identified for this purpose. This rule that pays more attention to clinical findings can significantly reduce unnecessary chest radiography for trauma patients.1-6

NEXUS chest is 7 item scoring system which includes the age of more than 60-year-old, rapid deceleration mechanism (falling from a height of more than 20 ft or a motor vehicle accident with a speed of more than 40 mph), chest pain, intoxication, altered mental status, distracting painful injury and tenderness to chest wall palpation as factor predictive of thoracic trauma. The presence of anyone is an indication for chest radiography as per the NEXUS chest model.7-9

X-ray findings showing any hemothorax, pneumothorax, ruptured diaphragm, rib fracture, sternal fracture, scapula, and clavicle fracture, mediastinal widening, and pulmonary contusion were considered positive.7 Radiology plays a major role in evaluation of the trauma patient. Previously, the Advanced Trauma Life Support (ATLS) course recommended performing the plain film radiography of the chest, abdomen, and cervical spine in all the blunt trauma patients. However, well-validated clinical decision rules, such as the NEXUS and Canadian cervical spine rules, have demonstrated that selective cervical spine imaging can be implemented in blunt trauma patients without compromising safety. This has led to the removal of routine cervical spine imaging recommendations from the most recent ATLS guidelines and widespread adoption of selective cervical spine imaging practice.10-14

The ATLS still recommends chest radiography in all trauma patients1. Recently, several studies have shown that also chest radiography has limited value in initial assessment of the blunt trauma patients who are hemodynamically stable or have negative physical examination result.8

However, before commonly using this model in routine practice there is still a need for further studies to determine its strong and weak points. Therefore, the current study is designed to find the sensitivity of NEXUS chest criteria

predicting the risk ofthoracic injuries that can be detected via chest x-ray.

2. Literature Survey

Chest trauma still continues to be a significant source of morbidity, mortality and hospitalization despite advances in trauma management and critical care especially in otherwise healthy young adults.15-17

Chest trauma directly accounts for 20%-25% of all trauma related deaths and is recognized as a major contributor in another25% of trauma related deaths in developed countries. Severity of chest injury, condition of the underlying lungs, associated extra-thoracic injuries especially to head, abdomen and long bones are the major factors that affect the mortality and morbidity.18

The causative mechanisms involved in chest trauma are Road traffic accidents (RTAs), fire arm injuries (FAIs), falls from heights, blasts, stabs and other acts of violence.15,18-19 RTAs, falls from heights and accidents at construction sites are the most common mechanism in urban areas. Stabs and FAIs are relatively more common in rural set ups. The more frequent involvement of the relatively young males amplifies the grave implications of this serious problem. The clinical presentationvaries from case to case.15, 20-22

Relevant Anatomy and Physiology

Chest trauma implies trauma to different structures of the chest wall and the chest cavity. Arbitrarily chest is divided into four components including chest wall, pleural space, lung parenchyma and mediastinum. Bony thorax and associated musculature form the chest wall. Between visceral and parietal pleura lies the pleural space and can become filled with blood or air following chest trauma. The lung parenchyma includes the lungs and associated airways and may sustain contusions, lacerations, hematoma and pneumatocele. The mediastinum includes the heart, aorta/ great vessels of chest, tracheobronchial tree and esophagus.18,19

The chest is responsible for the vital cardiopulmonary physiology of delivering oxygenated blood to the metabolically active tissues of the body. The pathologic consequences of chest injury are due to derangements in the flow of air or blood, either alone or in combination. Clinical consequences of chest trauma depend on factors such as the extent and location of injury, mechanism of injury, associated injuries and underlying co-morbidities. Patients with chest trauma are likely to deteriorate due to effects on respiratory function with secondary associated cardiac dysfunction. Treatment in chest trauma aims to restore cardiorespiratory function to normal, control of bleeding and prevention of sepsis.23-25

Mechanism of Injury:

Blunt or penetrating mechanisms causes chest trauma.18

Blunt Chest Trauma: 75%-80% of all chest trauma cases are due to blunt mechanisms and significant percentage of the patients have associated extra-thoracic injuries as well. RTAs are the leading cause in our country. Assaults, falls from heights, and blast injuries are the other causative mechanisms.

The three mechanisms by which blunt trauma to the chest causes injury are;

- Direct blow to the chest.
- Deceleration injury.
- Compression injury.

Penetrating chest trauma: The common causative mechanisms of penetrating chest trauma are stab injuries, firearm injuriesand blasts. On the basis of the velocities of the penetrating missiles these are further classified into: 18

a) Low velocity injuries include knife cuts and impalements.
b) medium velocity injuries resulting from handgun and air gun.
c) High velocity injuries typically caused by rifles and military weapons.
d) Very high velocity injuries are caused by weapons of antipersonnel effects e.g., mines, blast fragments, grenades andbombs.

Initial Resuscitation: Like any other trauma patients the initial management of chest trauma patients includes ABCDE i.e. A: Airway patency with care of cervical spine, B: Breathing adequacy, C: Circulatory support, D: Disability assessment and E: Exposure without causing hypothermia.1,26

Primary chest survey with thorough examination of the chest should be undertaken to identify and treat any immediately life- threatening conditions including airway obstruction, tracheobronchial injury, tension pneumothorax, open pneumothorax, massive hemothorax, and pericardial tamponade.27-29 Once the immediately life-threatening conditions have been addressed, a detailed head to toe examination along with secondary chest survey is undertaken. The secondary survey would focus on detection of following conditions: Simple pneumothorax, Hemothorax, Flail chest, Pulmonary contusion, Blunt cardiac injury, Traumatic aortic disruption, Traumatic diaphragmatic injury, Blunt oesophageal rupture.1,30-32

The leading indications for emergency endotracheal intubation in chest trauma patients are apnoea, profound shock and inadequate ventilation. The cornerstone of treating hemorrhagic shock is intravenous fluid resuscitation. Effective pain control in chest trauma patients is one of the most crucial measures. In patients with significant hypoxemia, hypercarbia and tachypnoea or impending respiratory failure, ventilatory support should be instituted. It is also indicated in patients with hemothorax or pneumothorax, severe lung contusion, and flail chest accompanied by hemodynamic compromise.18,23

Patients with tension pneumothorax should undergo immediate chest decompression with needle thoracocentesis and subsequently with tube thoracostomy. To prevent the development of open tension pneumothorax a sucking chest wound must be adequately covered with an occlusive dressing.33-37

Essential Diagnostic Work: The initial radiographic study of choice is Chest X-ray.38-40 Haemoglobin, haematocrit value, and arterial blood gases (ABGs) determination offer the most useful information for treating these patients. In patients with blood loss blood grouping and cross matching is also important. Other basic essential tests such as renal, liver function tests and blood sugar help to rule out underlying medical conditions especially renal and hepatic insufficiency and diabetes mellitus. The need for such specialized investigations such as cervical spine X-rays, CT scans of chest head and abdomen, extended focused assessment with sonography in trauma (eFAST) and angiography, will be dictated by the special circumstances of individual patients. 41

Common chest conditions are elucidated in the following:

Pneumothorax and Tension Pneumothorax: Simple pneumothorax refers to collection of air in the pleural cavity without mediastinal shift. Tension pneumothorax occurs when a flap valve leak allows air accumulation in the pleural space and intrapleural pressure rises above atmospheric pressure. There will be progressive air accumulation as with each inspiration air enters into the pleural space with no escape during expiration. This causes circulatory collapse and mediastinal shift.

Respiratory distress, shock, hyper-expanded hemithorax, engorged neck veins, tracheal shift to the opposite side absent breath sounds and hyper-resonant percussion notes etc. indicate tension pneumothorax. The diagnosis is clinical without chest X-ray. Rapid decompression with needle thoracocentesis followed by expeditious tube thoracostomy is done.42

Needle thoracocentesis is performed by inserting a wide bore needle (14-16 G) with a syringe partially filled with 0.9%saline 5th intercostal space anterior to midclavicular line in adults on the affected side. The plunger is removed to allow escape of the trapped air that bubbles through the syringe with saline as water seal, until tube thoracostomy is done.

Alternatively, a wide bore venflon can be inserted in the same location.43,44

Massive Hemothorax: It is characterized by accumulation of >1500 cc of blood in the pleural space. It is often associated with hemodynamic instability. The sources of the bleeding include internal mammary vessels, intercostals vessels, lung parenchyma and major vessels. Initial treatment includes a tube thoracostomy. Tube thoracostomy will re-expands the lung and serves to tamponade bleeding by bringing the lung surface up against the thoracic wall. Initial output (i.e.,>1500cc) and continued high hourly output (i.e., > 200cc / hr for consecutive 3 or more hours) are frequently associated with thoracic vascular injuries that require thoracotomy.1,18,19 Large clotted hemothorax results in dense fibrothorax with the possibility of added empyema. This can be managed with thoracoscopy or open approach.45

Pericardial Tamponade: It is most commonly seen in penetrating thoracic trauma but occasionally it is observed in blunt thoracic trauma from myocardial rupture, coronary arterial laceration or ascending dissection of an aortic tear. As little as 150 cc blood in pericardial cavity is sufficient to cause cardiac tamponade. 18,46

The classic Beck's triad of hypotension, venous distension and muffled heart sounds is documented only in 10-30 % of patients with proven cardiac tamponade. There may be associated pulses paradoxus as well. Diagnosis can be confirmed in stable patients by echocardiography, needle pericardiocentesis or subxiphoid pericardial window. [18] Definitive management is thoracotomy and opening of pericardial sac. Small lacerations can be repaired using pledgeted sutures on the beating heart, while large or complex be repaired on cardiopulmonary bypass. [46,47]

Open Pneumothorax: It is most commonly seen in penetrating thoracic trauma but may rarely occur in association with blunt trauma as well. A chest wall defect provides a direct communication of the pleural space with the environment. A wound more than 2/3rd of the laryngeal cross-sectional area provides an alternative air pathway with less resistance than that of the normal tracheobronchial tree. Small wounds can thus form a one-way valve, allowing air to be sucked into chest with inspiration leading to pneumothorax. The treatment consists of covering the wound with occlusive dressing and taping the dressing on three sides so it can act as a valve allowing air to exit the chest with expiration but preventing sucking in during inspiration. A tube thoracostomy is performed at another place and the wound is managed with debridement and closure.

Reconstruction and closure with prosthetic devices such as Mesh or tissue flaps is done for large chest wall defects. [18]

Injuries to Great Vessels and Tracheobronchial Tree: Patients rarely survive such injuries hence are relatively rarely seenin hospital. The prevalence of great vessel injuries is 0.3-10 %. Penetrating injury accounts for more than 90% of these.10- 15% of automobile crash fatalities are due to traumatic aortic rupture. Up to 90 %of these victims die within minutes at the scene or when en-route to the hospital. Rapid deceleration is the most common mechanism causing major blunt bronchial injuries. Emergency thoracotomy for rapid descending aortic cross-clamping and manual control of bleeding is required in patients who arrive alive to hospital. Specific operative measures are instituted according to the individual needs of the patients. [18]

Tube Thoracostomy: Tube thoracostomy is the most frequent intervention undertaken among chest trauma patients. It effectively drains the pleural space and provides the definitive treatment in the great majority of patients. It is effective for obtaining rapid re-expansion of injured the lung, complete evacuation of the pleural space and monitoring injured chest for any continued heavy blood loss following insertion. It as a safe procedure, however there is 2%-10 % reported incidence of complications which often result from poor technique.48-52 Thoracotomy: Thoracotomy has a role in certain emergency situations as well as in some late complications of chest trauma. It may be

indicated in emergency room or on urgent basis orin chronic basis. Internationally the rate of thoracotomy is approximately 10% in blunt and 30% in penetrating thoracic trauma.53-56

3. Materials and Methods

The research was carried out in the department of Emergency Medicine, KIMS HEALTH, Trivandrum during March 2021 to July 2022.Induviduals admitted with traumatic injuries in the Emergency Department of KIMSHEALTH, Thiruvananthapuram above the age of 18 years and had given consent are included in the study. Patients presenting with penetrating trauma or whose imaging had already done from outside hospital were excluded from the study. Accordingly, 122 patients were included in the study.

Methods of Measurement of Outcomes

Patient's demographical data, mechanism of injury, hemodynamic variables (blood pressure, heart rate, respiratory rate, oxygen saturation); the level of consciousness (based on GCS), presence of distracting pain, intoxication, chest pain, and chest wall tenderness were obtained from the EMR. As per the hospital protocol, chest x-ray was done for all patients withblunt injury which is the first-line of investigation in diagnosing the thoracic injury. NEXUS chest was applied on every patient based on their details obtained from EMR. Everything was recorded on the proforma. Results of the NEXUS chest was compared with the results of the chest x-ray (The report was obtained from the medical records) to determine the sensitivity of the NEXUS chest in predicting thoracic injury. This was the primary outcome of the study.

4. Result

NEXUS criteria in study population

Age >60 years-number (%)	
Yes	19(15.6)
No	103(84.4)
Rapid decelerating mechanism-number (%)	
Yes	30(24.6)
No	92(75.4)
Chest pain-number (%)	
Yes	32(26.2)
No	90(73.8)
Intoxication-number (%)	
Yes	7(5.7)
No	115(94.3)
Altered mental status-number (%)	
Yes	13(10.7)
No	109(89.3)
Distracting painful injury-number (%)	
Yes	19(15.6)
No	103(84.4)
Tenderness to chest wall-number (%)	
Yes	42(34.4)
No	80(65.6)

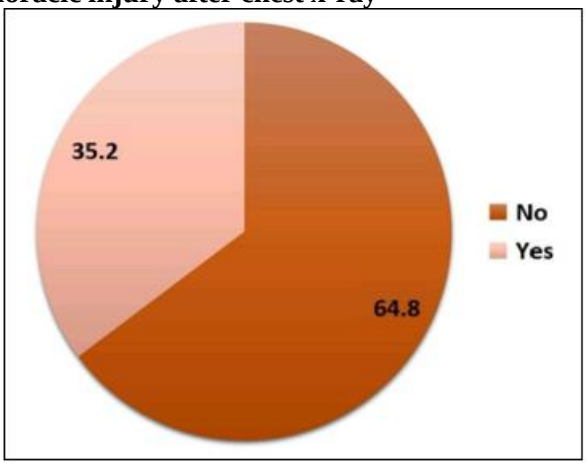
Chest X-ray indicated in study population

Chest X-ray indicated-number (%)	
Yes	53(43.3)
No	69(56.6)

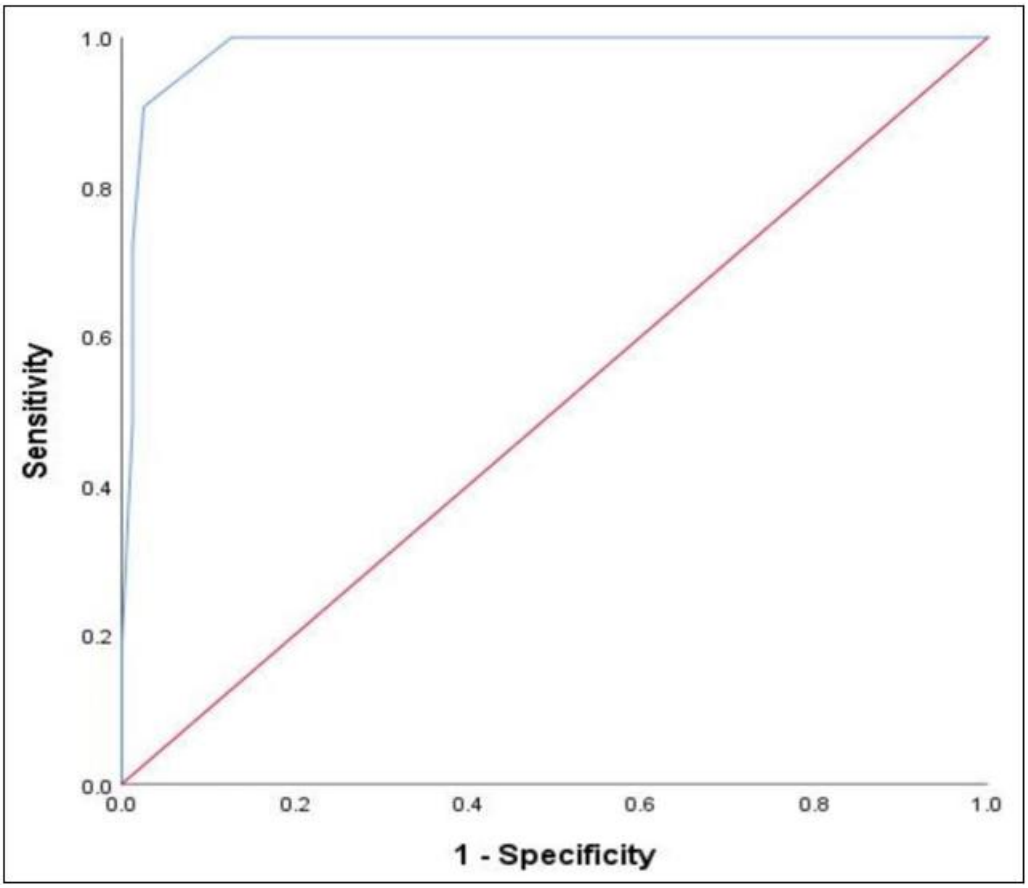
Chest X-ray findings

Hemothorax-number (%)	
Yes	11(9)
No	111(91)
Pneumothorax-number (%)	
Yes	16(13.1)
No	106(86.9)
Rib fracture-number (%)	
Yes	38(31.1)
No	84(68.9)
Sternal fracture-number (%)	
Yes	7(5.7)
No	115(94.3)
Scapula fracture-number (%)	
Yes	1(0.8)
No	121(99.2)
Clavicle fracture-number (%)	
Yes	22(18)
No	100(82)
Aortic or great vessel injury-number (%)	
Yes	7(5.7)
No	115(94.3)
Pulmonary contusion-number (%)	
Yes	21(17.2)
No	101(82.8)
Diaphragmatic injury-number (%)	
Yes	3(2.5)
No	119(97.5)

Thoracic injury after chest x-ray



ROC Curve of NEXUS chest criteria in predicting chest trauma



Area under the ROC curve of NEXUS chest criteria in predicting chest trauma

Area	95% confidence interval	P value
0.985	0.966 - 1.00	<0.001*

Outcome

Cut of score	Sensitivity	Specificity	PPV	NPV	Accuracy
≥ 1.5	90.70%	97.50%	50%	100%	97.50%

5. Discussion

In our study, 122 patients in the age group of 19-89 years with mean age of 42.90 and median age 41 years was studied compared to study conducted by Robert M Rodriguez et al7 and Safari et al2 in which mean age was 46 years and 37.4 years respectively which was comparable to our study. In our study group, 77(63.1%) patients were male and 45 (36.9 %) patients were female compared to study conducted by Robert M Rodriguez et al7 and Safari et al2 in which 62.8 % and 57.4% were males respectively. In our study, 53.3 % injuries were due to RTA, 27 % were due to slip and fall, 16.4 % were due to fall from height and 3.3 % were due to other causes compared to study conducted by Robert M Rodriguez et al7 (60.9% RTA, 27.5 % fall and 5.8% struck by blunt objects) and Safari et al2 (91.5 % RTA and 8.5% fall) and it was found that RTA were the most common mechanism in all these studies which was comparable to our study. In the study population 17.2 % patientshad associated long bone injuries, 5.7 % patients had traumatic brain injury, 2.5 % patients had spinal injuries, 2.5 % patients had facial bone injuries and 3.3 % patients had other (liver spleen or other intra abdominal injuries) injuries.

While evaluating our study population with NEXUS chest criteria 19 (15.6 %) patients were in the age group of more than 60 years, Rapid decelerating mechanism is present in 30 (24.6%) patients, 32 (26.2%) patients have chest pain, 7 (5.6%) patients were intoxicated, altered mental status is seen in 13 (10.7%) patients, distracting painful injury is seen in 19 (15.6%) patients and tenderness to chest wall is seen in 42 (34.4%) patients compared to study conducted by Raja A S et al57 in which % were above 60 years old, Rapid decelerating mechanism is present in 6.3% patients, 1.2% patients have chest pain, 1.8% patients were intoxicated, altered mental status is seen in 1.8% patients, distracting painful injury is seen in 6.9% patients and tenderness to chest wall is seen in 1.6 % patients. In study conducted by Safari et al2 altered mental status (17.7%), distracting pain (16.4%), rapid deceleration mechanism (13.6%), abrasion (11.8%), age over 60 years (11.5%), chest tenderness (10.7%) and chest pain (8.7%) were the indicators for chest imaging.

Chest x-ray done in our study population showed hemothorax in 9% patients, pneumothorax in 13.1% patients, rib fracture in 31.1% patients, sternal fracture in 5.7% patients, scapular fracture in 0.8% patients, clavicle fracture in 18% patients, aortic and great vessel injury in 5.7% patients, pulmonary contusion in 17.2% patients and, diaphragmatic injury is seen in 2.5% patients. In study conducted by Robert M Rodriguez et al7 hemothorax is seen in 2.1% patients, pneumothorax in 5.3% patients, rib fracture in 10.1% patients, sternal fracture in 2.1% patients, clavicle fracture in 18% patients, aortic and great vessel injury in 5.7% patients, pulmonary contusion in 6% patients and, diaphragmatic injury in 2.5% population, pulmonary contusion in 17.2% patients and diaphragmatic injury is

present in 0.1 % patients. In similar study conducted by Safari et al2 hemothorax is seen in 1.4 % patients, pneumothorax in 2.6% patients, rib fracture in 10.1% patients, clavicle fracture in 6.7% patients, pulmonary contusion in 1.4% patients and subcutaneous emphysema in 6.7% patients. According to above studies rib fracture and clavicle fracture were the most common injuries, which was comparable to our study. Primary and secondary outcome measures.

On evaluating NEXUS chest criteria in our study population chest x-ray was indicated in 53 (43.4 %) patients and after chest imaging thoracic injuries were seen in 43 (35.2 %) patients. In Robert M Rodriguez et al7 study chest imaging was indicated in 88.49% patients and thoracic injury seen on chest imaging was seen in 14.9% patients and in Safari S et al2 study chest imaging was indicated in 45.4% patients and thoracic injury was seen in 9.07% patients after imaging. The difference in value between these studies may be due to difference in demographical and mechanism of injury The Sensitivity, Specificity, Positive predictive value and Negative predictive value NEXUS chest criteria in predicting thoracic injury in our study population are 90.7%, 97.5 % 50 %, 100% respectively. The diagnostic accuracy of NEXUS chest criteria in predicting thoracic injury in our study population is 97.5 %. The similar study conducted by Safari et al2 sensitivity specificity positive predictive value and negative predictive value are 98.60% 59.94% 19.97% and 99.76% respectively and in Robert M Rodriguez et al7 study 98.8%,13.3%,16.7% and 98.5% were the sensitivity specificity, positive predictive value and negative predictive value respectively. The difference in value between these studies may be due to difference in study population and sample size.

6. Conclusion

Male sex and younger age group were predominant in the study population. RTA was the most common mechanism of injury. Long bone injuries were the most common associated injury The most common chest x-ray finding in our study population was rib fracture We have concluded that use of NEXUS Chest criteria in blunt trauma patients have safely reduce the need for chest imaging (Chest x-ray) in patients older than 18 years of age.

7. Future Scopes

One of the primary limitations in our study population was small sample size as larger sample size could have better validated the criteria. Our study was conducted in a single centre. A multicentre study will be necessary for conclusive results. In our study we have used chest x-ray as modality of chest imaging, though CT chest is considered as gold standard investigation in chest trauma.

References

[1] American College of Surgeons. Advanced trauma life support. 10th edition. Chicago: American College of Surgeons,Committee on Trauma; 2018;60-81.
[2] Safari S, Radfar F, Baratloo A. Thoracic Injury Rule Out Criteria and NEXUS Chest in predicting the risk of traumatic intra-thoracic injuries. Injury. 2018 May; 49(5): 959–962.
[3] Fazel R, Krumholz HM, Wang Y, Ross JS, Chen J, Ting HH, et al. Exposure to low-dose ionizing radiation from medical imaging procedures. N Engl J Med. 2009;361(9):849-857.
[4] Amis ES Jr, Butler PF, Applegate KE, Birnbaum SB, Brateman LF, Hevezi JM, et al. American College of Radiology. American College of Radiology white paper on radiation dose in medicine.J Am Coll Radiol. 2007;4(5):272-284.
[5] Sierink JC, Saltzherr TP, Beenen LF, Russchen MJ, Luitse JS, Dijkgraaf MG, et al. A case-matched series of immediate total-body CT scanning versus the standard radiological work-up in trauma patients. World J Surg 2014;38:795–802.
[6] Davis KL, Joshi AV, Tortella BJ, Candrilli SD. The direct economic burden of blunt and penetrating trauma in amanaged care population. J Trauma 2007; 62:622–30.
[7] Rodriguez RM, Anglin D, Langdorf MI, Baumann BM, Hendey GW, Bradley RN et al. NEXUS Chest: Validation of a decision instrument for selective chest imaging in blunt trauma. JAMA Surg. 2013 Aug; 148 (10): 940–946.
[8] Rodriguez RM, Hendey GW, Marek G, Dery RA, Bjoring A. A pilot study to derive clinical variables for selective chest radiography in blunt trauma patients. Ann Emerg Med. 2006;47(5):415-418.
[9] Rodriguez RM, Hendey GW, Mower W, Kea B, Fortman J, Merchant G. Derivation of a decision instrument for selective chest radiography in blunt trauma. J Trauma. 2011;71(3):549-553.
[10] American College of Surgeons. Advanced Trauma Life Support for Doctors: Student Course Manual. 4th ed.Chicago, IL: American College of Surgeons; 1985.
[11] Kool DR, Blickman JG. Advanced Trauma Life Support: ABCDE from a radiologic point of view. Emerg Radiol.2007;14(3):135-141.
[12] Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker MI. National Emergency X-Radiography Utilization Study Group. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. N Engl J Med. 2000;343(2):94-99.
[13] Stiell IG, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, De Maio VJ, et al. The Canadian C-spine rule forradiography in alert and stable trauma patients. JAMA. 2001;286(15):1841- 1848.
[14] Wisbach GG, Sise MJ, Sack DI, Swanson SM, Sundquist SM, Paci GM, et al. What is the role of chest X-ray in the initial assessment of stable trauma patients? J Trauma. 2007;62(1):74-79.
[15] Saaiq M, Shah SA. Thoracic trauma: Presentation and management outcome. J Coll Physician Surg Pak 2007; 18:230-3.
[16] Farooq U, Raza W, Zia N, Hanif M, Khan MM. Classification and management of chest trauma. J Coll PhysicianSurg Pak 2006; 16: 101-3.
[17] Hanif F, Mirza SM, Chaudhary AM. Reappraisal of thoracic trauma. Pak J Surg 2000; 16: 25-8.
[18] Ullah I, Shah SA. Chest trauma; significant source of morbidity and mortality. Ann. Pak. Inst. Med. Sci.

2010;6(3):172-7.
[19] Hoyt DB, Coimbra R, Engelhardt S, Hansbrough JF, Mikulaschek A, Moosa AR, et al. Chest Trauma. In: CuschieriA, Steele RJC, Moosa AR, editors. Essential surgical practice. 4th ed. London: Arnold; 2002; 5-15.
[20] Bhopal FG, Khan MJS, Iqbal M. Penetrating chest injuries. Pak Armed Forces Med J 2000; 50: 29-31.
[21] Khan MS, Bilal A. A prospective study of penetrating chest trauma with evaluation of the role of thoracotomy. JPostgrad Med Inst 2004; 18: 33-9.
[22] Khan K, Rehman G, Khan MY, Waheed T. Management of thoracic injuries in children. J Postgrad Med Inst 2004;18: 18-23.
[23] Pettiford BL, Luketich JD, Landreneau RJ. The management of flail chest. Thorac Surg Clin 2007;17(1):25-33.
[24] Feliciano DV, Rozycki GS. Advances in the diagnosis and treatment of thoracic trauma. Surg Clin North Am 1999;79(6):1417-29.
[25] Seamon MJ, Fisher CA, Gaughan J, Lloyd M, Bradley KM, Santora TA, et al. Pre-hospital procedures before emergency department thoracotomy: "scoop and run" saves lives. J Trauma 2007; 63: 113-20.
[26] American College of Surgeons Committee on Trauma. Thoracic trauma. In: Advanced Trauma Life Support. Student course manual. 7th ed. Chicago: American College of Surgeons; 2005;103-29.
[27] Friend KD. Prehospital recognition of tension pneumothorax. Prehosp Emerg Care 2000;4(1):75-7.
[28] Champion HR, Copes WS, Sacco WJ. The Major Trauma Outcome Study: establishing national norms for traumacare. J Trauma 1990;30(11):1356-65.
[29] McPherson JJ, Feigin DS, Bellamy RF. Prevalence of tension pneumothorax in fatally wounded combat casualties. JTrauma 2006;60(3):573-8.
[30] Parker MS, Matheson TL, Rao AV. Making the transition: the role of helical CT in the evaluation of potentially acute thoracic aortic injuries. AJR Am J Roentgenol 2001;176(5):1267-72.
[31] Peytel E, Menegaux F, Cluzel P. Initial imaging assessment of severe blunt trauma. Intensive Care Med2001;27(11):1756-61.
[32] Rubikas R. Diaphragmatic injuries. Eur J Cardiothorac Surg 2001;20(1):53-7.
[33] Zengerink I, Brink PR, Laupland KB. Needle thoracostomy in the treatment of a tension pneumothorax in trauma patients: what size needle? J Trauma 2008;64(1):111-4.
[34] Marinaro JL, Kenny CV, Smith SR. Needle thoracostomy in trauma patients: what catheter length is adequate? AcadEmerg Med 03 ;10(5):495.
[35] Leigh-Smith S, Harris T. Tension pneumothorax—time for a rethink? Emerg Med J 2005;22(1):8-16.
[36] Jones R, Hollingsworth J. Tension pneumothoraxes not responding to needle thoracocentesis. Emerg Med J2002;19(2):176-7
[37] Ahmed T, Ahmed SW, Hussain N, Khan MI. Role of urgent. Thoracotomy in improving the survival of patients with severe chest trauma. J Coll Physician Surg Pak 2009; 19: 575-8.
[38] Wintermark M, Wicky S, Schnyder P. Imaging of acute traumatic injuries of the thoracic aorta. Eur Radiol2002;12(2):431-42.
[39] Vignon P, Boncoeur MP, Francois B, Rambaud G, Maubon A, Gastinne H. Comparison of multiplane transesophageal echocardiography and contrast-enhanced helical CT in the diagnosis of blunt traumatic cardiovascular injuries. Anesthesiology. 2001;94(4):615-22.
[40] Scaglione M, Pinto A, Pinto F. Role of contrast-enhanced helical CT in the evaluation of acute thoracic aortic injuries after blunt chest trauma. Eur Radiol 2001;11(12):2444-8.
[41] Chen MY, Regan JD, D'Amore MJ, Routh WD, Meredith JW, Dyer RB. Role of angiography in the detection of aortic branch vessel injury after blunt thoracic trauma. J Trauma 2001;51(6):1166-71.
[42] Longmore M, Wilkinson I, Torok E. Oxford handbook of clinical medicine.5th ed. Oxford university pressInc, NewYark 2003: 796.
[43] Netto FA, Shulman H, Rizoli SB. Are needle decompressions for tension pneumothoraxes being performed appropriately for appropriate indications? Am J Emerg Med 2008;26(5):597-602
[44] Vinson ED. Improvised chest tube drain for decompression of an acute tension pneumothorax. Mil Med2004;169(5):403-5
[45] Ahmed T, Ahmed SW. Role of video assisted thoracoscopy in the management of clotted hemothorax. J Surg Pak2006; 11: 134-7.
[46] Spodick DH. Pathophysiology of cardiac tamponade. Chest 1998; 113: 1372-78.
[47] Dunsire MF, Field J, Valentine S. Delayed diagnosis of cardiac tamponade following isolated blunt abdominaltrauma. Br J Anaesth 2001;87(2):309-12.
[48] Keel M, Meier C. Chest injuries-what is new? Curr Opin Crit Care 2007;13(6):674-9.
[49] Muslim M, Bilal A, Salin M, Kan MA, Baseer A, Ahmed M. Tube thoracostomy: Management and outcome in patients with penetrating chest trauma. J Ayub Med Coll Abbottabad 2008; 20: 108-11.
[50] Deneuville M. Morbidity of percutaneous tube thoracostomy in trauma patients. Eur J cardiothoracic Surg 2002; 22:673-8.
[51] Bailey RC. Complications of tube thoracostomy in trauma. J Accid Emerg Med 2000; 17: 111-14.
[52] Khanzada TW, Samad A. Indications and complications of tube thoracostomy performed by general surgeons. J PakMed Assosc 2008;58: 39-40.
[53] Karmy-Jones R, Jurkovich GJ, Nathens AB, Shatz DV, Brundage S, Wall MJ Jr, Engelhardt S, Hoyt DB, Holcroft J, Knudson MM. Timing of urgent thoracotomy for hemorrhage after trauma: a multicentre study. Arch Surg 2001; 136(5): 513-8.
[54] Demetriades D, Velmahos GC. Penetrating injuries of the chest: indications for operation. Scand J Surg 2002; 91 (1):41-5.
[55] Wall MJ, Hirschberg A, LeMaire SA. Thoracic aorta and thoracic vascular injuries. Surg Clin North Am 2001; 81:1375-93.
[56] Rhee PM, Acosta J, Bridgeman A, Wang D, Jordan M, Rich N. Survival after emergency department thoracotomy: Review of published data from the past 25 years. J Am Coll Surg 2000; 190: 288-98.
[57] Raja AS, Lanning J, Gower A, Langdorf MI, Nishijima DK, Baumann BM et al. Prevalence of

chest injury with thepresence of Nexus Chest criteria: data to inform shared decision making about imaging use. Ann Emerg Med. 2016;68 (2): 222–226.
[58] Acar E, Demir A, Yıldırım B, Kaya G, Alataş OD, Kilinc RM et al. Evaluation of the Nexus X-ray rules in blunt thorax trauma. Ulus Travma Acil Cerrahi Derg. 2020 Nov;26(6):920-926.
[59] Agladioglu K, Serinken M, Dal O, Beydilli H, Eken C, Karcioglu O et al. Chest X-Ray in detecting injuries causedby blunt trauma. World J. Emerg Med. 2016; 7 (1): 55–58.
[60] Safari S, Yousefifard M, Baikpour M, Rahimi-Movaghar V, Abiri S, Falaki M, et al. Validation of thoracic injury rule out criteria as a decision instrument for screening of chest radiography in blunt thoracic trauma. J Clin Orthop Trauma. 2016 Apr 1;7(2):95-100.
[61] Paydar S, Johari HG, Ghaffarpasand F, Shahidian D, Dehbozorgi A, Ziaeian B, et al. The role of routine chest radiography in initial evaluation of stable blunt trauma patients. Am J Emerg Med. 2012 Jan 1;30(1):1-4.
[62] Ahmadi A, Paydar S, Dalfardi B, Shakibafard A, Abbasi H, Bolandparvaz S. Clinical and economic effects of selective radiological evaluation of high-energy trauma patients: a prospective experience of a level 1 busy trauma centre. Emerg Med J. 2015 Jul 1;32(7):535-8.
[63] Myint KS, French S, Williams-Johnson J, Williams E, Johnson P, Reid MO, et al. Role of routine chest radiographs in the evaluation of patients with stable blunt chest trauma: a prospective analysis. West Indian med J. 2012:64-72.
[64] Sears BW, Luchette FA, Esposito TJ, Dickson EL, Grant M, Santaniello JM, et al. Old fashion clinical judgment inthe era of protocols: is mandatory chest X-ray necessary in injured patients? J Trauma. 2005 Aug 1;59(2):324-32.
[65] Bokhari F, Brakenridge S, Nagy K, Roberts R, Smith R, Joseph K, et al. Prospective evaluation of the sensitivity of physical examination in chest trauma. J Trauma. 2002 Dec 1;53(6):1135-8.

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