

REVIEW ARTICLE

Role of radiology in diagnosis and management of chest trauma: a brief review

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ABSTRACT

A substantial source of death and morbidity in chest trauma patients is damage to the chest wall. The radiologists' accurate diagnosis and 1 description of any damage to the chest wall can help direct the right care for the patient. The improvement in patient treatment results from catastrophic intra-thoracic injuries being diagnosed quickly. The imaging method used in an emergency situation must arrive at the right diagnosis as soon as feasible. Imaging is a crucial component of post-chest trauma care for both the initial diagnostic evaluation and the follow-up evaluation of prospective treatments. The anterior-posterior chest radiograph continued to be the first step in the imaging work-up despite its well-known limitations. Computed tomography (CT) with adjunctive imaging, which is now more frequently done on multi-detector computed tomography equipment, provides important information that is not immediately available on the traditional radiograph. This enables a clearer description of thoracic injuries linked to trauma. This review aimed to examine and explain the radiological models connected with the diagnosis of chest trauma, as well as to explore the consequences of care.

Keywords: Chest trauma, radiography, multidetector computed tomography, X-ray, diagnosis.

Introduction

In nonintentional trauma, chest trauma has swiftly become the second most frequent traumatic injury. Chest trauma is characterized as either blunt or penetrating. Blunt trauma accounts for the vast majority of thoracic injuries (90%). The fundamental distinction between penetrating trauma and blunt chest trauma is the absence of an entrance to the interior thorax in penetrating trauma caused by stabbing or gunshot wounds [1].

Following head and limb injuries, blunt thoracic injuries are the third most frequent injury among poly trauma patients [2]. Although 33% of thoracic injuries necessitate hospitalization, 50% of them are mild [3]. Overall, blunt chest trauma is a key factor in another 50% of trauma-related deaths and is directly responsible for 25% of all trauma deaths [3].

In addition, chest trauma is by far the most frequent cause of mortality in the young age range between 15 and 44 years, ranked second only to head trauma [4]. Motor vehicle collisions (63%-78%) accounted for the majority of blunt thoracic injuries, whereas falls from heights (10%-17%) and impacts from blunt items or explosive devices (10%) accounted for the balance [5]. However,

mortality approaches 50% in more severe situations, including blunt poly trauma with bilateral pulmonary contusions and a hemothorax.

The prognosis is significantly worse for individuals who have trachea-bronchial injuries, with up to 80% pre-hospital death. The existence and severity of pulmonary injuries have a substantial impact on the post traumatic course of trauma patients, with contusions being independently linked to the onset of acute respiratory distress syndrome [6].

Imaging methods are crucial in managing these patients in this aspect. Even if certain thoracic injuries are treated based on the patient's clinical findings before any imaging

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Received: 26 December 2023 | **Accepted:** 03 January 2024



examinations, it is often required to use several imaging modalities including computed tomography (CT) scan, plain chest X-ray (CXR), and ultrasonography.

The CT scan is the gold standard among these modalities for locating intra thoracic injuries after trauma and has a very high diagnostic value for occult and soft tissue injuries. The researchers had to hunt for other diagnostic methods due to the restricted availability of CT scans in all medical centers, restrictions on patient transfer to the radiology department, and radiation exposure.

CXR is the first diagnostic tool for thoracic trauma screening; however, several investigations have demonstrated the limits of supine radiography in specific traumatic injuries, such as pneumothorax. In addition, the researchers were inspired to look at alternative imaging approaches by the low diagnostic yield of standard chest radiography in patients with thoracic injuries. To lessen the burden of pointless imaging investigations, scoring methods like the thoracic injury rule-out criteria and the national emergency X-radiography utilization study (NEXUS) have been established recently [7].

Ultrasonography has received a lot of interest recently as a rapid screening method with a few problems. Compared to chest radiography, it has demonstrated higher diagnostic usefulness in the identification of thoracic traumatic injuries. Ultrasonography is typically unreliable in detecting injuries without bleeding or free fluid, and diagnostic accuracy is greatly dependent on the operator's abilities [7].

The CT scan is the gold standard for evaluating lung parenchymal damage. However, it takes a long time, costs a lot of money, and radiation exposure and patient hemodynamic instability during transfer are worries [8]. In these circumstances, CT scans are frequently performed on multiple trauma patients in trauma centers; although, the use of extended focused assessment with sonography in trauma (E-FAST) bedside examinations and avoiding torso CT scans are required due to the presence of clinical injuries that call for urgent surgical management in unstable patients, such as brain lateralizing signs. This might still be the case for the stable and carefully chosen set of individuals who have high-risk damage mechanisms to lessen radiation exposure.

The Advanced Trauma Life Support (ATLS) guidelines have been revised to include E-FAST in the evaluation of high-energy trauma patients in light of the potential for US diagnosis of potentially life-threatening disorders in traumatic injuries [9]. This study was created to assess the diagnostic utility of various forms of radiography in the diagnosis of trauma, considering local, national, and international statistics on trauma, particularly chest trauma and its high frequency in the population.

Mechanisms of Chest Wall Injuries

At least one of the following four basic modes of injury including direct contact, thoracic compression, fast deceleration, and blast injury can result in damage to the chest wall. Findings can be found more easily if one is aware of the predicted harms linked to specific causes [10].

At the point of impact, direct impact injuries often result in focused damage. Numerous variables, including the object's density, the area of impact, and the object's velocity, affect the precise harm. The superficial soft tissues of the chest wall are usually injured in low-energy direct contact injuries, leading to contusions, abrasions, lacerations, and hematomas. The sternum, scapula, and ribs are just a few examples of underlying bones that might fracture as a result of high-energy direct-impact injuries [10].

Thoracic compression injuries happen when the chest wall is squeezed between external objects or up against organ structures. Contusions, lacerations, rib or sternal fractures, solid organ damage, and overpressure injuries (such as pneumothorax) can all be caused by compression of the chest wall [10].

Injury caused by sudden deceleration can result in shear stresses that can shred semi-mobile bodily components

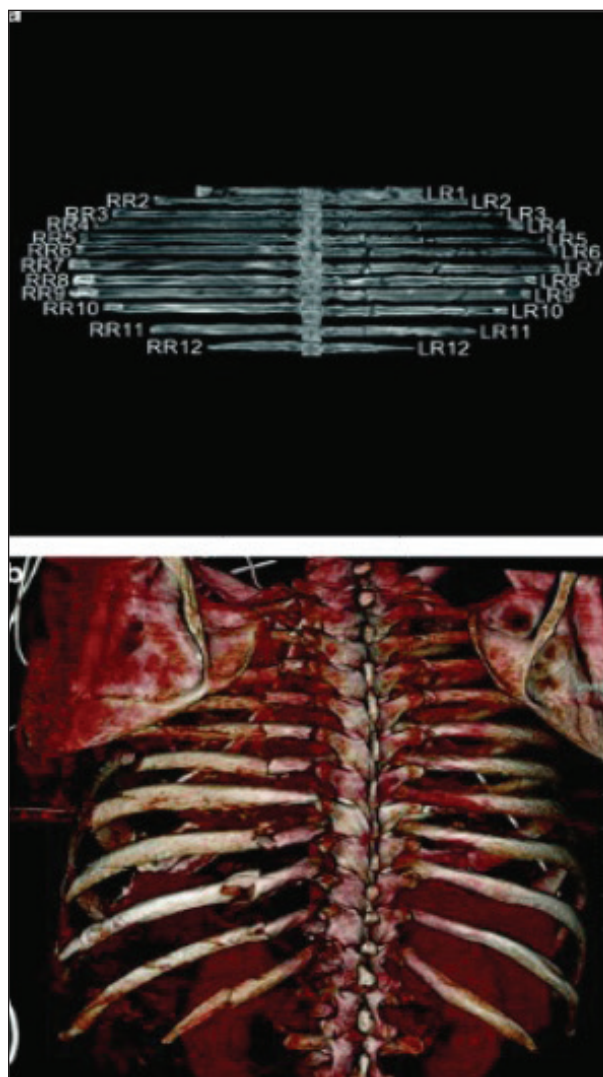


Figure 1. (a) A CT of the chest taken from a trauma patient shows many rib fractures, including segmental rib fractures on the left side involving more than three contiguous ribs. (b) The same patient's three-dimensional reconstruction reveals several segmental rib fractures in the left posterior chest wall [29].

at the point of connection. The ligamentum arteriosum level shearing damage to the thoracic aorta is a typical illustration of this [11]. These wounds frequently have accompanying compression wounds brought on by the chest wall rapidly decelerating against an object. Shearing forces are less likely to result in chest wall injuries, although the presence of compression chest wall injuries might point to internal chest injuries caused by fast deceleration [12].

Blast injuries are caused by the great energy that is released when explosives detonate, turning solid or liquid material into a gas. Combinations of compression, shear, and direct impact forces result in blast injuries. A blast wave is originally produced by the high-energy release, which raises air pressure. This blast wave induces barotrauma, which leads to alveolar hemorrhage and ruptures when it reaches the chest wall. Vascular emboli caused by severe pulmonary damage might result in ischemic consequences. Secondary explosion injuries are caused by the high-velocity evacuation of adjacent debris and shrapnel. Tertiary injuries result from a person being physically displaced by the explosion force and then hitting nearby items as a result. Numerous blunt and piercing injuries can result from secondary and tertiary blast injuries. Both soft tissue and skeletal chest wall injuries can result from secondary and tertiary blast injuries [13].

Diagnostic Methods

Imaging of the patient is included in the thorough secondary survey, once the patient has been clinically stabilized. Antero-posterior chest, pelvic, and cross-table lateral cervical spine radiographs are all part of the patient's first imaging, or "trauma series." A portable chest radiograph might be taken quickly, which makes it an important component in the first assessment of the traumatized patient since it gives vital information on the scope and severity of chest injuries.

The choice of doing additional imaging procedures must then be made. In traumatized individuals, the decision threshold for CT imaging is often quite low. Chest CT is more effective than traditional chest radiography at detecting lung contusions, pneumothoraxes, and hemato-thoraxes while being very sensitive for the diagnosis of thoracic injuries. Early chest CT has also been demonstrated to have a major influence on many patients' therapeutic treatments. Multi-detector computed tomography (MDCT) has significantly improved CT technology in recent years. Better longitudinal and temporal resolution, which are necessary for the imaging of highly traumatized individuals are offered by MDCT.

A significant improvement in scanning speed makes it possible to scan the same amount of interest, or perhaps more, in a lot less time. Rapid acquisition periods also enhance scan quality by lowering motion artifacts. Due to the smaller "secondary raw data," MDCT can also provide higher quality sagittal and coronal reformatted pictures, in addition to improved quality of axial images. The soft-tissue, lung, and bone window settings should always be used to view chest CT images in trauma patients. The aorta, tracheobronchial tree, and thoracic

skeleton should all be routinely assessed using sagittal and coronal reformations [14].

Radiological Modalities

Chest injuries can cause a variety of clinical symptoms, many of which do not match the severity of the injury. This is the rationale behind why diagnostic imaging should be one of the initial procedures carried out upon admission to a hospital. The simplest and most practical techniques are ultrasonography and chest radiography.

The existence of major injuries needing an immediate intervention, such as tension pneumothorax, massive hemothorax, hemopericardium, hemoperitoneum, and damage to the abdominal organs behind the diaphragm, might be shown by them, especially in unstable individuals. These techniques are not definitive because they are less sensitive to particular forms of damage, notably high-energy wounds.

Chest radiography is carried out in the supine position in cases of serious injuries, significantly diminishing its value. Finding a pulmonary parenchymal contusion and laceration, as well as a minor hemothorax and pneumothorax, is another problem. It is also quite unreliable for identifying heart and large vascular damage. Its limited specificity is an issue, in addition to its low sensitivity to some traumas [15].

An example would be the symptom of an enlarged mediastinum, which might indicate damage to the heart and major blood arteries. This only applies to 20% of situations, though. The remaining findings are either due to nontraumatic reasons such as mediastinal lipomatosis, congenital anomalies, enlarged lymphatic nodes, or tumors, or they are due to bleeding without damage to the major blood arteries [16]. In contrast to this, MDCT reveals alterations that cannot be picked up by other techniques and permits a sufficiently precise evaluation of all compartments of the chest. In MDCT, additional discoveries are highly prevalent (up to 83% of cases), but only a few of them can really alter the course of treatment (7%-41%) [17].

Computed Tomography

Due to its speed, accessibility, and sensitivity, CT is the industry standard for imaging evaluation of trauma patients. Over 50% of patients with initial chest radiographs that were normal had numerous chest injuries on the CT scan, according to a research paper by Exadaktylos et al. [18]. MDCT has recently improved in speed to the point that it can now photograph the whole chest in a single breath hold and significantly minimize motion artifacts in patients who are unable to follow breath-holding instructions. In addition, this quick imaging at lower radiation doses is made possible by more recent versions of CT scanners and interactive reconstruction methods [18].

Depending on the CT hardware available at a particular institution, the ideal scanner settings for identifying traumatic chest wall injuries would change. Using 0.6-1.2 mm collimation, the images should be taken from the

level of L1 to the apex of the lung in a cranial-caudal orientation [19].

The identification of vascular and soft tissue damage frequently involves the administration of intravenous contrast. The aorta and arterial vessels are best opacified by injecting 80-100 ml of iodinated contrast at a flow rate of 3-4 ml/second with a latency of 25-40 seconds. If a whole-body scan is conducted, contrast timing might need to be altered to account for abdominal solid organ opacification. The coronal and sagittal axes can be reformatted using the axial thin slices. Every reformatted picture should be evaluated at the soft tissue, lung, and bone windows on a regular basis [20].

Although CT imaging detects chest wall injuries more accurately than radiography, 43% of initial CT scan results inaccurately identified the number and location of rib fractures. The quantity and location of rib fractures give insight into the severity of the injury and any possible sequelae. To address problems in characterizing rib fractures, various reformatting methods have been devised [21].

High-quality multi-detector row CT data might be used to recreate three-dimensional volume rendering. These 3D reconstructions maintain the 3D interdependence of data, in contrast to maximum intensity projection imaging [22]. In particular, fractures that are transversely orientated might benefit from 3D reconstructions in difficult rib and sternal fractures. For the examination of complicated sternal fractures and sternoclavicular dislocations, they are the most accurate procedure [23]. For the assessment of aortic damage brought on by blunt chest trauma, 3D reconstructions might also be helpful. 3D reconstructions, like in-plane rib reformats, increase accuracy and time efficiency in the detection of rib fractures [22].

Although 3D renderings can help improve accuracy and time efficiency in patients with rib fractures, the renderings are based on thresholding, which might not be optimal for segmentation in some circumstances [23]. Adaptive filtering techniques might be advantageous for bone edge enhancement in the presence of fractures in comparison to thresholding.

To regulate the out-of-plane-in-plane voxel ratio, adaptive filtering techniques enable the creation of filters on grids with changing spatial resolutions in various orientations [23]. There are two primary parts to this method. First, a filter set made up of six directed quadrature filters is applied to the data to create a description of a local structure. Second, the data is filtered using a basis filter set made up of six directed high-pass filters and one low-pass filter [24]. This filtering enables smoothing and sharpening of edges along structures [25].

Geometric diffusion and anisotropic diffusion are other techniques for edge enhancement [26]. On petrous bone fractures, Turski et al. [27] describe target reconstruction by reducing pixel size and using several convolutional filters. These techniques increase the segmentation and separation of spatially near bones to highlight important bony elements. The gold standard imaging modality for identifying thoracic injuries is CT chest, according to

the most recent ACR appropriateness recommendations. Patients with high-energy mechanisms, aberrant radiographs, changed mental status, distracting injuries, and those in whom there is a clinical suspicion of thoracic wall injury should all have a chest CT scan highly evaluated [28] (Figure 1).

Chest Radiography

Due to its quickness and extensive availability, conventional radiography continues to be a crucial first-line imaging modality for the assessment of chest injuries in the context of trauma. Prior to surgical intervention, chest radiography is frequently the sole imaging technique utilized in hemo-dynamically unstable patients (although focused ultrasound in the trauma bay is expanding in availability).

Chest radiographs should be taken in the postero-anterior (PA) and lateral views with the patient upright and in full inspiration to maximize the identification of direct and indirect evidence of chest wall injuries; however, in experience, this is seldom, if ever, attainable. Due to the extensive multisystem injuries in trauma patients, often only an antero-posterior (AP) supine radiograph is practical.

Poor patient placement, insufficient inspiratory effort, superimposed equipment artifact, and the lack of a lateral view frequently restricts the ability to detect chest wall lesions on a single-view supine radiograph. However, a thorough review of the portable supine radiograph can reveal displaced rib fractures and localized pleural thickening that, in the event of trauma, might indicate the existence of nondisplaced rib fractures [29].

Chest X-ray

Physical examination and a CXR can be used to evaluate the majority of thoracic injuries. A CXR is quick, simple, affordable, and frequently available. To ensure the effectiveness of any intervention performed in the trauma bay, a second CXR should be taken of the patient. Any patient who has blunt thoracic trauma should have an initial CXR, but it is not necessary if the damage is small and the patient shows no outward symptoms that would indicate an underlying injury.

According to the NEXUS chest decision standards, individuals younger than 60 years with no chest discomfort or soreness, no distracting injuries or drunkenness, and whose mechanism did not entail fast deceleration do not require a regular CXR. With a 99% negative predictive value, there is a limited possibility of clinically severe intra-thoracic damage even if all criteria are satisfied. Chest radiography, however, needs to be done if the patient satisfies any particular requirement.

In contrast, it has not been demonstrated that a physical examination by itself can accurately diagnose a patient with penetrating trauma, particularly when it comes to pneumothorax. All patients who have penetrating wounds must be evaluated with a CXR since up to 20% of patients with unfavorable physical signs would really have a hemothorax or pneumothorax [30].

Ultrasound

In the earliest stages of the trauma assessment, focused assessment using sonography in trauma (FAST) examinations of the abdomen and thorax are crucial. According to ATLS recommendations, it is best carried out during the initial survey's section on circulation to enable the quick identification of pathologic intra-peritoneal, intra-cardiac, or intra-thoracic free fluid. The most reliable areas of the pleural spaces might be scanned utilizing the usual flank views, which can be used to detect hemothorax.

Additional chest views are used in the extended FAST (E-FAST) assessment to check for pneumothorax. Instead of the more common curvilinear probe (2.5-5 MHz), a linear ultrasonic transducer probe (5-10 MHz) is used, since it allows for better visualization of the pleural space.

Examination assessment is based on the presence or absence of lung sliding, the parietal and visceral pleura moving past one another, in the third or fourth intercostal region at the midclavicular line. Lung sliding is absent, which points to the presence of a pneumothorax. In order to help with the diagnosis, a number of indicators have also been identified, the most significant of which is the lung point sign, which shows both lung sliding and the lack of lung sliding in the same sonographic frame. The lung point sign is 100% specific for pneumothorax and has a sensitivity of over 66% [31].

Magnetic Resonance Imaging

As of now, chest wall injuries are not best diagnosed by magnetic resonance imaging (MRI). Its use in the context of trauma is constrained by its lengthy scanning time, scarcity of resources, and potential safety concerns. Once the first trauma evaluation is over, an MRI could be helpful. According to research costal cartilage damage can be found using fat-saturated T2-weighted or STIR sequence MRI. Differentiating between a cardiac contusion and an acute peri-traumatic myocardial infarct, two lesions linked with chest wall trauma that might be characterized by MRI and have therapeutic consequences [29].

Esophagography, Esophagoscopy, and Bronchoscopy

Due to the absence of distinct symptoms, esophageal injuries are frequently challenging to detect. It is uncommon in blunt trauma and frequently happens in conjunction with severe poly-trauma, further complicating the diagnosis. Patients might have bloody aspirate from a stomach tube, neck hematoma, or cervical subcutaneous emphysema, none of which are particular. A CXR might show pneumomediastinum or pleural effusion, requiring a CT scan, although an esophagram or endoscopy is needed for a certain diagnosis. Usually, a water-soluble esophagram is performed first, and if there is still cause for suspicion, a barium esophagram.

Due to concerns about worsening an already existing damage, endoscopy is typically less preferred in the acute environment. Less than 1% of patients who experience blunt trauma also have tracheobronchial damage, which

is more common in cases of severe high-risk mechanisms. Injuries are more likely in the right main stem bronchus, which is less flexible, and occurs within 1 cm of the carina.

Due to closeness, esophageal damage in penetrating trauma frequently coexists with a tracheal injury, therefore these patients need to be evaluated for both. Flexible bronchoscopy should be performed as soon as possible on patients who have persistent pneumothorax following tube thoracostomy, a significant air leak following, trouble breathing, and transmediastinal penetrating trauma [32].

Electrocardiography

Electrocardiogram (ECG) findings for a left-sided pneumothorax include a rightward shift of the frontal QRS axis, a drop in precordial R voltage, a reduction in QRS amplitude, and a precordial T-wave inversion. When there is a right pneumothorax, the ECG might exhibit right axis deviation, a pronounced R wave in V2, and a decrease of S wave voltage that mimics a posterior myocardial infarction. All of these alterations are not indicative of myocardial ischemia or infarction and are assumed to be the result of mechanical causes [33].

Emergency Room Trauma Life Support

Information on the probable degree of thoracic damage would be provided by repeating the clinical examination from the initial survey together with anamnestic data on the mechanism of thoracic trauma. It is advised to undergo a contrast-enhanced CT scan when the severity of the trauma cannot be determined. As a CXR at the emergency room has a sensitivity of just 58.3%.

When a CT scan is not required, a thoracic ultrasound examination is valid. When compared to a CXR, it has equal sensitivity and specificity for the diagnosis of pneumothorax. In the emergency department, ultrasonography is another trustworthy way to rule out pleural/pericardial effusion. While pneumothorax is present, progressing, or while the patient is being mechanically ventilated, chest tube drainage is required. When treating individuals who have suffered serious injuries, larger chest tubes provide no advantages over smaller ones [34].

Conclusion

Imaging techniques are a crucial component of the diagnostic process for chest injuries. Understanding the causes of chest wall injuries is crucial for better identifying, describing, and classifying these injuries and for improving patient care. Adjunctive imaging using CT, which is now more frequently carried out utilizing MDCT, adds crucial information that is not immediately available on traditional radiographs. The primary component is MDCT. It enables the rapid, accurate, and clear display of traumatic alterations as well as their categorization. As a result, a trauma radiologist plays a key role in the team that decides how to proceed with the healing process. The chest radiograph continues to provide the required foundation for imaging patients with chest injuries despite its well-known limitations. Although the function

of Ultrasound has not yet been fully understood, recent research has shown promise. To assess severe thoracic wall injuries, MRI is seldom employed. This article's content aimed to increase knowledge of the crucial role that imaging plays in both the initial diagnosis process and the follow-up evaluation of prospective treatments.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this study.

Funding

None.

Consent to participate

Not required.

Ethical approval

Not required.

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