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Routine CT- Chest in Primary Evaluation of the Major Blunt Trauma Patients; Pros and Cons

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1. Introduction

Trauma is a major worldwide public health problem, and it is one of the leading causes of death in both industrialized and developing countries. Injuries of the thorax are a major cause of morbidity and mortality in blunt trauma patients. Approximately 20% of trauma- related deaths are attributable to chest injuries (LoCicero and Mattox, 1989).
In trauma patients, a clear history is rarely available as most patients are confused, unconscious or even anesthetized and the clinical findings have been shown to be equivocal or misleading in 20–50% of victims of blunt polytrauma (Poletti et al., 2002).
Consequently, radiology plays a major role in evaluation of the trauma patient.
The Advanced Trauma Life Support (ATLS 2004) course recommended performing the plain film radiography of the chest, abdomen, and cervical spine in all the blunt trauma patients. Nowadays, Chest computed tomography (CCT) is being used with increasing frequency in the evaluation of blunt chest trauma. CCT frequently detects injuries not seen on routine initial chest x-ray (CxR) (occult findings). However, in the vast majority of patients the impact of these findings on patient management is debatable (Blostein et al., 1997, Hamad and regal, 2010).
CT is used primarily to assess for traumatic aortic injuries but also has been shown to be useful in the evaluation of skeletal, pulmonary, airway, and diaphragmatic injuries.

2. Chest wall injuries

Rib fractures are the most common finding after blunt chest trauma with an incidence reported up to 40%. Chest radiography is routinely used to assist in the diagnosis of rib fractures, even though it has limited sensitivity. it is even more insensitive in showing costochondral fractures. CT is the most sensitive technique for imaging rib fractures, since it can help to determine the site and number of fractures and, more importantly, provide information regarding any associated injuries (Primak and Collins, 2002).
Sternal fractures are found in 8–10% of blunt chest traumas and it is a marker of a high- energy trauma. The most common site of the sternal fractures is approximately 2 cm down from the manubrium-sternal joint. Sternal fracture usually cannot be diagnosed on frontal chest radiographs, whereas the lateral projections can detect it with high sensitivity. Spiral

CT, with sagittal and coronal reformations, should be the examination of choice in the suspicion of sternal fracture, as it identifies with high accuracy both the fracture, especially that with minimal dislocation, and the associated lesions.
Thoracic spine fractures account for 16% to 30% of all spine fractures. These fractures are usually difficult to detect on routine chest radiographs, especially those located in the upper portion. CT is much more sensitive for diagnosing thoracic spine fractures and is the imaging modality of choice. In addition to soft tissue and lung windows, chest CT scans in the trauma patient also should be viewed in bone windows for skeletal injuries. The most common fractures of the thoracic spine are anterior wedge compression fractures and burst fractures, most of which occur near the thoracolumbar junction (Meyer, 1992). If a thoracic spine fracture is suspected on either plain radiographs or chest CT, a dedicated thoracic spine CT at the level in question should be obtained with sagittal and coronal reconstructions to determine the type of fracture and to assess its stability.

3. Pleural space injuries

Pneumothorax, an air collection in the pleural space occurs in approximately 30% to 40% of cases of blunt trauma (Sariego et al., 1993). The diagnosis of pneumothorax is important whatever it is small because they may enlarge and progress to tension pneumothorax particularly if the patient undergoes mechanical ventilation or general anesthesia (Enderson et al., 1993). In supine position, pleural air will rise to the most nondependent portion of the thorax, which is the anterior, caudal aspect of the pleural space in the supine patient. Radiographic signs of pneumothorax in the supine trauma patient include 1) the deepsulcus sign, which is a deep, lucent costophrenic sulcus, 2) a relative increase in lucency at the affected lung base, and 3) the double diaphragm sign, which is created by the interfaces between the ventral and dorsal portions of the pneumothorax with the anterior and posterior aspects of the hemidiaphragm. CT is more sensitive for detecting pneumothorax than radiography, particularly in the supine patient. Pneumothoraxes that are not apparent on the supine chest radiograph have been shown on CT in 10% to 50% of patients with head and blunt abdominal trauma (Wolfman et al., 1993).
It is generally safe to observe a stable patient with an occult pneumothorax, the situation is more controversial when the patient undergoes PPV. In a randomized study of treatment of occult pneumothorax with or without tube thoracostomy regardless of presence or absence of PPV, there was no difference in the incidence of respiratory distress or the need for emergent tube thoracostomy in either group suggesting that size progression of occultpneumothorax is unrelated to PPV (Brazel et al., 1999).
Pneumomediastinum in blunt trauma, the most common cause of pneumomediastinum is from rupture of the alveoli caused by a sudden increase in intra-alveolar pressure. The air then tracks centripetally through the pulmonary interstitium into the mediastinum ("Macklin effect"). On plain radiographs and CT, pneumomediastinum is diagnosed when air is seen outlining mediastinal soft tissue structures and the parietal pleura. The continuous diaphragm sign may be seen when air is present between the pericardium and the diaphragm.

4. Lung parenchymal injuries

Pulmonary contusion is defined as focal parenchymal injury with edema and alveolar and interstitial hemorrhage. It is reported in 17%–70% of blunt traumas cases, it is usually seen adjacent to solid structures like vertebrae, ribs, the liver, and the heart (Gavelli et al., 2002). In chest radiographs, lung contusion appears within the first 6-8 hours following trauma as non-segmental, non-lobar, peripheral, and in the form of increased density (Kerns et al., 1990). It is more likely to detect contusions with thoracic CT than with chest radiography (Schild et al., 1989).

Pulmonary laceration is defined as the disruption of alveolar spaces with formation of a cavity filled with blood or air and may occur from penetrating trauma or from shearing forces associated with blunt trauma. It is difficult to detect lacerations with chest radiography as they usually overlap accompanying contusion areas. On CT, pulmonary laceration is characterized by air collections within an area of consolidation. CT detects far more lacerations; in one study of 85 patients with pulmonary laceration, 99 lacerations were present on CT, but only 5 were seen radiographically (Wagner et al., 1988). Pulmonary hematoma results from complete filling of a laceration cavity with blood. Hematomas are seen as well-defined, spherical or oval, homogenous increased densities, both with thoracic CT and chest radiography. A traumatic pneumatocele is a completely air-filled cystic space after either acute laceration or complete resolution of a pulmonary hematoma. The radiographic sequelae of pulmonary laceration may persist for months or years (Mirvis et al., 1992).

5. Tracheobronchial injury

Tracheobronchial ruptures due to thoracic trauma are relatively rare, reported in 0.4–1.5% of patients in clinical series of major blunt thoracic trauma. More than 80% of bronchial injuries occur in the main bronchi within 2.5 cm of the carina, with the right side more commonly than the left side (Euathrongchit et al., 2006). Common but nonspecific radiographic findings of tracheobronchial injury are pneumothorax, pneumomediastinum, and subcutaneous emphysema. More specific findings of tracheobronchial injury include persistent pneumothorax after adequate chest tube placement, collapse of the lung away from the hilum ("fallen lung sign"), and overdistension or herniation of the endotracheal balloon. Helical CT with sagittal and coronal reconstructions is more sensitive and specific than radiography (Unger et al., 1989; Wintermark et al., 2001).

6. Esophageal injury

Esophageal rupture is extremely rare as a complication of blunt trauma (1/1000 cases of blunt chest trauma). However it must be excluded in any case of mediastinal penetrating trauma. Radiographic signs are not specific and include persistent cervical and mediastinal emphysema, pleural fluid, and abnormal mediastinal contour caused by leakage of fluids, hematoma, or mediastinitis (Rivas et al., 2003). CT findings include the radiographic findings, as well as mediastinal fluid and extraluminal enteric contrast.

7. Diaphragmatic injury

Diaphragmatic injuries occur in approximately 1% to 8% of blunt trauma cases (Boulanger et al., 1993). Most injuries occur in the posterolateral portion of the left hemidiaphragm (Worthy et al., 1995). Chest radiographic findings of diaphragmatic injury depend mainly onherniation of hollow viscus into the thorax, and abnormal course of the nasogastric tube.The most common finding of diaphragmatic injury on CT is abrupt discontinuity of the diaphragm. Other CT findings include herniation of abdominal contents into the thorax and constriction of bowel at the herniation site ("collar sign"). The sensitivity of axial CT for diaphragmatic tears ranges between 70% and 90%, and the specificity is approximately 90% (Murray et al., 1996). Pitfalls in diagnosing diaphragmatic tears on CT occur when intraabdominal blood or hemothorax obscures the diaphragm. Also, small incidental diaphragmatic defects are often identified, particularly in older patients.

8. Aortic injury

Diagnosis of acute aortic injury is critical. The frontal chest radiograph is the initial study for the evaluation of aortic injury. The greatest utility of chest radiography is not in diagnosing aortic injury, however, but in excluding it. Normal chest radiograph has a 98% negative predictive value (Pretre et al., 1997). Radiographic findings that may indicate mediastinal hematoma include mediastinal widening, abnormal contour or indistinctness of the aortic knob, apical pleural cap, rightward deviation of the nasogastric tube within the esophagus, rightward deviation of the trachea, downward displacement of the left main stem bronchus, and thickening of the right paratracheal stripe. However, mediastinal widening due to mediastinal hematoma is not specific for aortic injury and can be caused by other injuries such as sternal fractures, thoracic spine fractures, venous injury, or great vessel injury.

According to initial chest radiograph findings, and level of clinical suspicion, further workup for aortic injury may be necessary. For a long-time aortography has been consideredthe gold standard for diagnosing aortic injury. More recently several studies have evaluated the use of contrast-enhanced helical CT as a screening and diagnostic modality and recommended CT for routine evaluation (Mirvis and Shanmuganathan 2007). The chest CT scan performed for possible aortic injury is evaluated for direct evidence of a tear, including abnormal aortic contour, pseudoaneurysm, intimal flap, active extravasation of contrast, or abrupt tapering of the descending aorta relative to the ascending aorta ("pseudocoarctation"). Prospective studies with helical CCT for the evaluation of bluntaortic injury (BAI) shows comparable sensitivity (100% vs. 92%) and negative predictive value (NPV) (100% vs. 97%) when compared to aortography but performed poorly by comparison in regard to specificity (83% vs. 99%) (Fabian et al., 1998).

9. Comment

While conventional X-rays still play an important role as the primary screening method, CT imaging has become an integral part of the trauma screening and resuscitation phase.

In general, The CCT is superior to routine screening CxR with regard to sternal, rib and spine fractures, lung lacerations and contusions, pneumothorax, hemothorax, heart, pericardium, aorta and diaphragm (Guerrero-Lopez et al., 2000, Rivas et al., 2003). However,it is not clear whether CT chest should be used in the general blunt trauma population routinely or on selective basis.

Several authors reported the detection of clinically significant findings more frequently on CCT in 'high risk' blunt trauma admissions, These patients included but were not limited to high-speed motor vehicle collisions, >15-foot falls, pedestrian versus motor vehicle collisions, patients with any sign of thoracic trauma on physical examination or any mediastinal abnormalities on CxR (Demetriades et al., 1998; Exadaktylos et al., 2001). A

significant number of these patients (14–65%) can have a completely normal CxR (Trupka et al., 1997; Demetriades et al., 1998; Exadaktylos et al., 2001; Plurad et al., 2007).
The lethality of the occult injury defines the urgency and pertinence of subsequent clinical action. For example, the finding of an aortic or great vessel injury or spine fracture would mandate critical management or diagnostic manoeuvres, while the diagnosis of an occult pneumothorax may not (Brazel et al., 1999).
Therefore, use of CCT in Selected patients can lead to significant changes in patient management (18– 41%) (Trupka et al., 1997; Guerrero-Lopez et al., 2000; Renton, 2003; Salim et al., 2006; Deunk et al., 2007) while application of CCT more liberally results in little consequential intervention overall (Blostein and Hodgeman, 1997; Plurad et al., 2007; Wisbach et al., 2007) based on these occult diagnoses.
On the other hand, others argue that the higher discovery of injuries with CT is of questionable clinical significance at great costs. For example, it has previously been shown that occult pneumothoraces can be treated expectantly, even with positive pressure ventilation (Guerrero-Lopez et al., 2000; Brazel et al., 1999). Also, The significance of occult rib fractures, hemothorax, or contusion is also questionable because hemothoraces may resolve without intervention (Poole et al., 1993) and there is no treatment for the vastmajority of rib fractures other than pain management. The increased use of CCT for blunt trauma, presumably for the diagnosis BAI, has not resulted in a significant increase in detection overall. It can also be questioned as to whether all occult BAIs needs to be treated, because this probably was the case before the evolution of the CCT (Plurad et al., 2007).
The question is, when should CT be used in the general blunt trauma population? Should we scan selectively if clinical examination or plain radiography is abnormal, or should we use a lower threshold and scan on a routine basis?
On trying to answer this question, Brink et al., tested a number of risk factors (age ≥55 years, abnormal chest PE, altered sensorium, abnormal thoracic spine PE, abnormal chest and thoracic spine CR, abnormal abdominal US or pelvic CR, Hb<6 and BE < −3 mmol/l.) as independent predictors of positive findings on chest CT in high-energy blunt trauma patients. Presence of any of these criteria can predict presence of chest injuries on CT with a sensitivity of 95%. However, they reported that if these positive predictors were implemented as scanning indications, 5% of all patients with chest injuries on CT would not be identified. This implies that the chance of missing injuries of the chest remains 13% in the low-risk patients if these patients do not undergo chest CT (Brink et al., 2010).
The liberal use of CT scanning is not without concerns; in addition to the cost issue, radiation exposure, time loss and isolation of patient from medical care are important drawbacks.
There is a general consensus that the current levels of CT radiation may be associated with an increased risk of cancer. The effective radiation dose to all organs from a single full-body CT examination is 12 to 16 milli-Sieverts (mSv). Considering that studies of Japanese atomic bomb survivors who received only 5–150 mSv dose have increased risk of cancer, it is reasonable to assume that the risk of cancer from CCT exposure is small but real. Even the lowest dose in the exposed atomic-bomb survivor population (range, 5-50 mSv; mean, 20 mSv) is associated with an increased cancer mortality risk. This risk is more important in children (Kalra et al., 2004; Brenner et al., 2007; Huda 2007).
In most trauma centers, the CT scanner is located outside of the trauma resuscitation bay, even in a different department of the hospital. This requires patient transportation and isolation from the ER team; this potentially influences the decision to perform CT imaging on a patient-to-patient basis.

In Amsterdam, the Academic Medical Center recently introduced a moveable CT scanner in the trauma room itself (Fung Kon Jin et al., 2008). The aim of this concept is the elimination of patient transfer for CT imaging with subsequent shorter time(79 min. in comparison to105 min before) until completion of diagnostic imaging in patients requiring CT imaging. Moreover patients in Amsterdam can be treated during CT imaging this progress can encourage ER team to incorporate CT imaging during the initial trauma evaluation thus favoring the decision to go for diagnostic accuracy over immediately performing emergency surgery with Less-than-optimal insights in the potential injuries of the trauma patient.

On the extreme side, some institutions in Europe have reported their experience with full body CT imaging prior to physical examination by the trauma team in their effort to reduce time (Weninger et al., 2007).

Multiple trauma presentations at the same moment undoubtedly influence the overall time needed for complete radiological evaluation, especially when CT imaging is required. Fung Kon Jin et al in a high-volume level-1 trauma center, reported that complete radiological workup, including CT scanning, of a stable trauma patient is completed in a median of 114 min. Patients that are more severely injured (ISS > 15) were transported faster to CT, resulting in faster diagnostic imaging (Fung Kon Jin et al., 2008).

10. References

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