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Helical CT examination in blunt chest trauma

Injuries to the chest play a major role in one third to one half of all fatalities related to traffic accidents. In view of the scope of the problem and the conservative trend in management of blunt and penetrating injuries, rapid, accurate assessment is of paramount importance in planning therapy (5). Proper management of chest injuries is predicated upon clinical and radiographic assessment. However, significant injuries are frequently overlooked, while, conversely, a substantial number of invasive procedures, including thoracotomy and arteriography, are performed on normal patients because of the nonspecific appearance of many injuries. Significant trauma such as rupture of the great vessels, trachea, bronchi, or diaphragm may not be apparent clinically or radiographically in up to 90% of patients. While four or five years ago, all open, penetrating injuries were treated surgically, recently there has been a shift toward more conservative management (1, 5). Chest injuries directly cause 25% of all trauma-related deaths and contribute markedly to another 25%. Computed tomography (CT) is being used with increasing frequency in the evaluation of blunt chest trauma and is indicated primarily in the assessment of traumatic aortic injury. CT has also proved useful in the assessment of other acute injuries including tracheobronchial disruption, diaphragmatic tears, and bone fractures. In addition, CT of different patients demonstrates an obvious aortic tear in the proximal descending aorta (arrow). Note the periaortic hematonu has been shown to be superior to chest radiography in detecting pulmonary lacerations and pneumothoraces. Although CT may allow identification of aortic, bronchial, and diaphragmatic tears, it has important limitations that must be considered. In this article, we illustrate characteristic CT findings in blunt chest trauma, including traumatic injury of the thoracic aorta, pulmonary and bronchial injuries, skeletal trauma, and diaphragmatic injury. In addition, we review the main indications for and limitations of CT as well as the specific advantages of volumetric data acquisition in spiral CT in blunt chest trauma (6).

The aim of the study is to present the use of spiral CT in evaluation of patients after blunt chest trauma.

MATERIAL AND METHODS

Material comprises a group of 23 patients after blunt chest trauma. In all of them PA chest radiogram and CT examination were performed. CT examination was performed with helical CT scanner Somatom Emotion by Siemens, before and after administering of 100 ml contrast agent intravenously. Both unenhanced and enhanced axial CT section was assessed, as well as MPR reconstructions in sagittal and coronal planes and VRT and SSD image of bone structures. The results were compared to plain chest radiograms.

RESULTS

In 15 patients on CT sections irregular hiperdense areas of lung contusions were seen, invisible on plain radiograms (Fig. 1). In 8 patients broken ribs were seen, clearly demonstrated on both radiographs (Fig. 2) and CT images (Fig. 3AB).

Fig. 1. Hiperdense area of lung contusion on axial CT section (arrowheads), and small pneumothorax, invisible on radiogram (arrow)

Fig. 2. Rib fracture on plain chest radiogram (arrow)

Pneumothorax was seen in 5 of them on CT examination. On plain radiographs very small pneumothorax was not seen in one of them (Fig. 1,4). The hemothorax was seen in 7 patients; CT enables precise assessment on MPR reconstructions (Fig. 5AB). In one patient rupture of the diaphragm was seen on chest radiograms (Fig. 6). CT performed without oral contrast administration was unable to precisely diagnose diaphragmatic rupture. The postraumatic aortic dissection was seen in one patient, in enhanced CT sections (Fig. 7). Posttraumatic hemopericardium without cardiac tamponade was seen in 2 patients on CT examination.

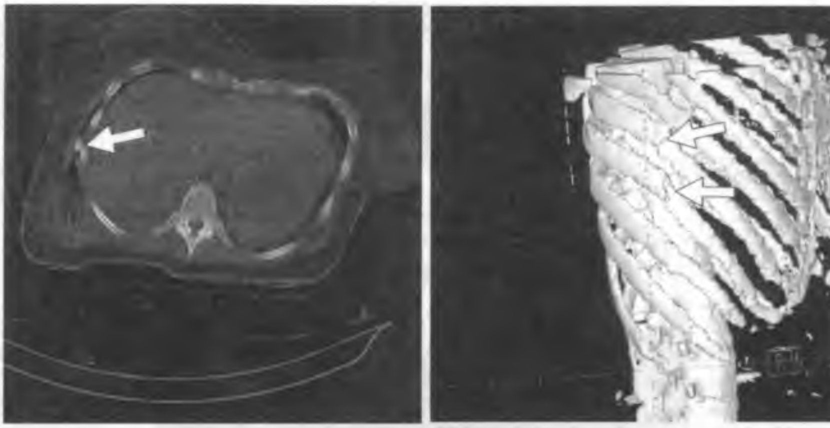

Fig. 3. Rib fractures (arrow) on axial CT section – A, and on 3D SSD reconstruction (arrows) – B

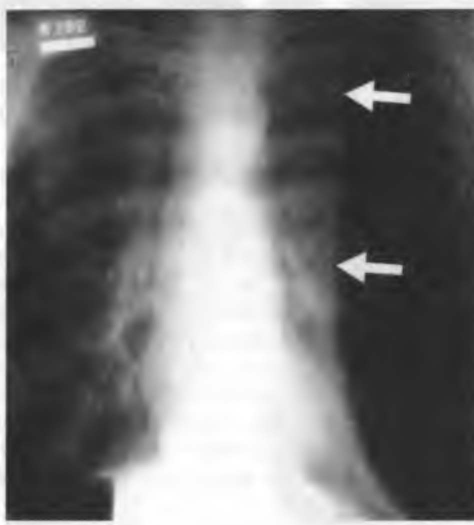

Fig. 4. Pneumothorax on plain radiogram (arrows)

Fig. 5. Hemothorax on plain radiogram (arrow) – A and axial CT section (arrow) – B

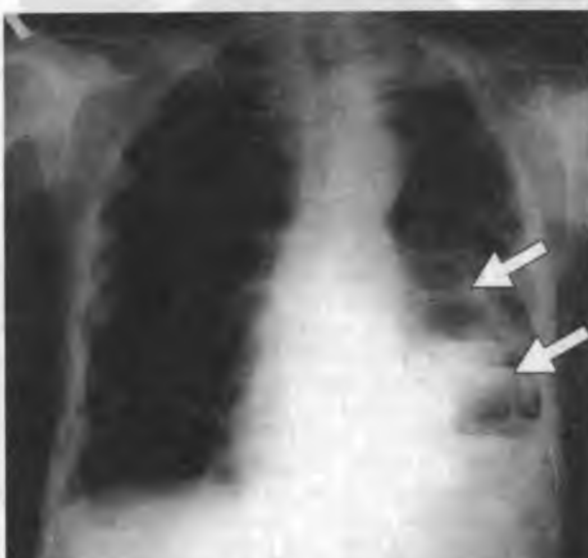

Fig. 6. Diaphragmatic rupture on plain chest radiogram; air-fluid levels in the intestinal loops above the left hemi-diaphragm (arrows)

Fig. 7. Posttraumatic aortic dissection visible on axial CT section

DISCUSSION

Imaging studies are an essential part of trauma care after the patient's vital signs have been stabilized. Although special studies (head or abdomen computed tomography ECTI, angiography, etc) may be indispensable in the management of a given case, chest radiography is indicated in virtually every trauma patient. Injuries that pose the most significant immediate threat to the patient's survival should be systematically searched for, and their presence or absence should be specifically noted. These include malpositioned lines and tubes, tension pneumothorax, hemopericardium with cardiac tamponade, simple pneumothorax, hemothorax, aortic rupture, and thoracic spine fracture. Technical limitations that make it difficult or impossible to exclude their presence must be mentioned and alternate studies should be suggested. Malpositioned lines and tubes after the technical adequacy of a chest radiograph of a trauma patient have been evaluated, one must determine what and where are all of the lines and tubes seen on the image. Inadequate or inappropriate placement of intravenous catheters, nasogastric tubes, chest tubes, and endotracheal tubes understandably occurs during the stress and confusion of emergency room resuscitations, particularly if the patient cannot cooperate or is combative during instrument placement (1).

Helical examinations of the chest should be performed with 5-mm collimation, and pitch 1.5, and 5 mm image spacing. Images are obtained from the pulmonary apices through the lung bases and are reviewed at lung and soft-tissue window settings. If trauma is under consideration, then all sections are also reviewed at bone window settings, to better identify bone injuries. Contrast agent should be injected IV. Scanning during a single breath hold permits imaging at maximum contrast material enhancement. The images are reconstructed at 3-mm spacing, and coronal, sagittal and oblique MPR and 3D reformations are performed (3).

Pulmonary contusion is seen in 30%–70% of patients with blunt chest trauma. A contusion is a focal parenchymal injury consisting of edema and interstitial and alveolar hemorrhage. Contusions are detected more frequently at CT than at chest radiography. At CT, a contusion appears as a poorly defined local area of consolidation, usually in the lung periphery adjacent to the area of trauma. Pulmonary laceration refers to a traumatic disruption of alveolar spaces with formation of a cavity filled with blood or air. Small lacerations are visible at CT in the majority of patients in whom only contusion is evident at radiography. Acute pulmonary laceration is characterized at CT by the presence of localized air collections in an area of consolidation. Lacerations can be single or multiple and unilateral or bilateral. A pulmonary hematoma is a traumatic, blood-filled lung cyst and appears as a well-circumscribed, round area of increased attenuation at CT. Pulmonary laceration can persist and result in a traumatic pneumatocele as the hemorrhage resolves (6, 7).

Pulmonary injuries are frequently seen following chest trauma, with or without rib fractures. Most of those demonstrated radiographically following trauma represent contusions, but lacerations and atelectasis are also seen. Contusion frequently occurs after blunt trauma, accounting for 30–75 % of all pulmonary injuries; however, it is seen less commonly after penetrating trauma. Outpouring of blood and fluid into the interstitial and alveolar spaces accounts for the densities observed on both CT and conventional radiographs. By definition, contusion appears on chest radiographs within six hours of trauma and begins to improve 48–72 h later. As three fourths of the parenchymal lesions in our study were visible only on CT, and since follow-up CT was not routinely performed, one cannot strictly apply previously established criteria for the diagnosis of pulmonary contusion to most current cases. However, the CT appearance of patchy parenchymal densities (both focal and diffuse) seemed to correlate well with published pathological findings, in which interstitial and alveolar fluid collections predominate. Even more frequent than contusion were small, focal, triangular peripheral consolidations which were frequently bilateral and located posteroinferiorly, near the diaphragm. Clinical symptoms were generally minimal, with only mild reductions in blood oxygenation when not associated with contusion. The CT appearance of these abnormalities was much more in keeping with subsegmental atelectasis than contusion. Atelectasis is a little-mentioned manifestation of pulmonary injury which has been thought to be related to bronchial compression from adjacent hemorrhage or endobronchial obstruction by blood or aspirated material. Pulmonary laceration is primarily associated with penetrating injuries and is seen less commonly in blunt trauma. Most lacerations are filled with blood (pulmonary hematoma), although they may contain air instead (traumatic air cysts). These lesions resolve more slowly than simple contusions and may be a source of hemopneumothorax and hemoptysis. The ability of CT to define the extent of injury. may help in the decision to perform surgery (5).

Mediastinal manifestations of trauma were seen infrequently in this series and were somewhat nonspecific. Pericardial effusion is common in both blunt and penetrating trauma. In blunt trauma, hemopericardium occurs frequently and is generally insignificant. It can also be accompanied by serous effusion and may develop insidiously over a period of two to three weeks. When associated with tamponade, it is usually acute, related to penetrating trauma, and frequently associated with severe cardiac and noncardiac injuries. While CT is not the method of choice for diagnosis of pericardial fluid collections, the pericardial space should be closely examined in every traumatized patient who undergoes CT. Mediastinal air collections frequently herald serious underlying injuries such as esophageal or bronchial rupture (4, 5). Ultrasound (US), CT, and magnetic resonance (MR) imaging can all demonstrate pericardial effusions and hemopericardium, but, as indicated above, they are rarely if ever indicated in a patient suspected of having acute traumatic cardiac tamponade (1, 4).

Mediastinal hematomas may occur in a variety of circumstances, ranging from laceration of small mediastinal veins to complete transection of the aorta (1). Early diagnosis of traumatic injury of the thoracic aorta is critical because the majority of patients will die unless they undergo appropriate surgical treatment. With the development of spiral CT, evaluation of the thoracic aorta has improved, and contrast-enhanced spiral CT now allows detection of subtle aortic tears as well as more obvious rupture of the aorta. A precise point of extravasation from a pseudoaneurysm may occasionally be detected. Although the majority of aortic tears involve the region of the aortic isthmus in the proximal descending aorta, it is also important to evaluate the distal thoracic aorta because traumatic aortic injuries occasionally occur at the level of the diaphragm (4, 6).

Simple pneumothorax occurs in 15%–38% of patients with blunt chest trauma and 18%–19% of patients with penetrating chest injuries (5, 4). Studies have documented the superior ability of CT scans to demonstrate pneumothoraces in patients with a wide variety of thoracic and nonthoracic injuries. Two significant advantages of CT scans are that patients are usually imaged supine and may be kept on a backboard if necessary and since CT images are obtained in the axial plane, abnormalities of overlying tissues such as subcutaneous emphysema-which might mask a pneumothorax on conven-tional chest radiographs-are easily detected and separated from the underlying pneumothorax (1, 2, 8). CT has greater sensitivity than radiography in the detection of pneumothorax, particularly in the supine trauma patient. Despite this increased sensitivity, CT is seldom performed solely for the purpose of detecting pneumothorax (6, 8). Hemothorax is seen in 23.2%–51.0% of patients with blunt chest trauma. Bleeding usually arises from lacerated or torn low-pressure pulmonary vessels and either subsides spontaneously or responds to treatment with simple tube thoracostomy. Although radiologic imaging and interventional procedures play little role in the diagnosis or treatment of significant hemothorax, when a supine chest radiograph reveals a "veiling" opacity projected over one or both hemithoraces, a homogeneous curvilinear or crescentic opacity interposed between the inner margin of the ribs and the lung, or an apical "cap," the possibility of an intrapleural fluid collection (eg, a hemothorax) should be considered (1).

Thoracic spine injuries are reasonably common, are frequently clinically devastating, and are often difficult to diagnose. Although plain radiographs of the spine demonstrate most (70%–90%) spine fractures, occasionally other imaging studies are indicated. Axial CT images demonstrate fractures of the vertebral bodies with great accuracy and can readily show the relationship of fracture fragments and displaced disk material to the spinal cord, particularly if intrathecal contrast material is used. Images reformatted in the sagittal and coronal planes provide additional information about the relative position of adjacent vertebral bodies and make conventional tomograms superfluous (1, 6).

Sternal fractures are usually not evident at anteroposterior chest radiography. The fracture is usually obvious at CT, often with an associated retrosternal mediastinal hematoma. The presence of a fat plane between the hematoma and the aorta implies that the hematoma is not aortic in origin (6). After the patient's condition has been stabilized and the life-threatening conditions discussed above have either been diagnosed and treated or excluded from further consideration, the chest radiograph should be reviewed for evidence of other less imminently dangerous but nonetheless important conditions including rupture of the diaphragm, pulmonary contusion or laceration, aspiration, rib fractures, tracheobronchial rupture, and esophageal perforation (1). Diaphragmatic ruptures are an unusual manifestation of blunt chest trauma, occurring in only 0.008–3 % of all chest injuries. One fourth of all patients with penetrating chest wounds will have diaphragmatic lacerations. The other diaphragmatic laceration presented a less clear-cut appearance, since it was continuous with the pulmonary laceration and located on the right side, unassociated with intra-abdominal herniation (5, 6). Chest radiographs obtained during this period are often abnormal, but, as in the acute period, the abnormalities are nonspecific and are frequently ascribed to other diseases. Diagnosis at this time is usually serendipitous (1).

Diaphragm rupture with intrathoracic herniation and incarceration of abdominal viscera is usually not suspected because the episode of trauma is now so remote that it is either not recalled or is not considered relevant. Radiologic findings of basilar opacity, pleural effusion, or an elevated hemidiaphragm are, once again, usually nonspecific and mimic the radiographic changes associated either with lower lobe atelectasis or pneumonia or with pulmonary infarction. Early diagnosis and treatment of diaphragm rupture are desirable, since surgical repair is easier when there is less fibrosis at the site of injury and since the morbidity and mortality associated with the latent and obstructive stages can be avoided. Clinical findings are usually not helpful, unless bowel sounds are heard over the thorax; even results of diagnostic peritoneal lavage are negative in 14%–40% of patients. The diagnosis is usually suggested on the basis of abnormalities on the chest radiograph or is made incidentally at the time of an exploratory laparotomy. Although laparotomy is the best test currently available for diagnosing diaphragm laceration, even it is not 100% sensitive; small rents in the diaphragm can be missed, particularly if they are not actively and meticulously searched for. Diaphragm rupture should not be assumed to have been excluded simply because a laparotomy has been performed; if radiographic findings suggest the diagnosis, the surgeon and the radiologist must confer and decide whether further evaluation, including a repeat laparotomy, should be considered (1). CT scans rarely show actual lacerations in the diaphragm because thoraco-abdominal CT images are obtained in the axial plane only. The CT findings associated with diaphragm rupture such as superior displacement of abdominal structures and visualization of abdominal organs lateral, instead of medial, to the diaphragm are usually only suggestive, not diagnostic. Sonography, with a virtually infinite number of available imaging planes, can be used to visualize the diaphragm directly and can demonstrate actual disruptions. It is particularly useful for evaluating patients with suspected rupture of the right hemidiaphragm, since the liver affords an excellent acoustic window (1).

CONCLUSIONS

CT is the imaging modality of choice in the assessment of patients with clinical or radiographic findings suggestive of aortic injury, thoracic spine fracture, or diaphragmatic tear following blunt chest trauma. CT may occasionally be indicated and helpful in the assessment of other thoracic injuries. CT has been found to be an effective, sensitive method of detecting thoracic injuries. Pleural, pulmonary, mediastinal, and diaphragmatic injuries were demonstrated, many of them not seen or underestimated on conventional supine chest radiographs. Usually, pleural fluid collections can easily be separated into hydro-and hemothorax. Several pulmonary lesions were encountered, including a surprising number of small areas of atelectasis. Mediastinal manifestations of trauma, including fluid or air collections, are also seen on CT.

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SUMMARY

Material comprises a group of 23 patients after blunt chest trauma. In all of them PA chest radiogram and CT examination were performed. CT examination was performed with helical CT scanner Somatom Emotion by Siemens, before and after administering of 100 ml contrast agent intravenously. Both unenhanced and enhanced axial CT section was assessed, as well as MPR reconstructions in sagittal and coronal planes and VRT and SSD image of bone structures. The results were compared to plain chest radiograms. In 15 patients on CT sections irregular hiperdense areas of lung contusions were seen, invisible on plain radiograms. In 8 patients broken

ribs were seen, clearly demonstrated on both radiographs and CT images. Pneumothorax was seen in 5 of them on CT examination. On plain radiographs very small pneumothorax was not seen in one of them. The hemothorax was seen in 7 patients; CT enables precise assessment on MPR reconstructions. In one patient rupture of the diaphragm was seen on chest radiograms. CT performed without oral contrast administration was unable to precisely diagnose diaphragmatic rupture. The postraumatic aortic dissection was seen in one patient, on enhanced CT sections. Posttraumatic hemopericardium without cardiac tamponade was seen in 2 patients on CT examination. CT is the imaging modality of choice in the assessment of patients with clinical or radiographic findings suggestive of aortic injury, thoracic spine fracture, or diaphragmatic tear following blunt chest trauma. CT may occasionally be indicated and helpful in the assessment of other thoracic injuries. CT has been found to be an effective, sensitive method of detecting thoracic injuries. Pleural, pulmonary, mediastinal, and diaphragmatic injuries were demonstrated, many of them not seen or underestimated on conventional supine chest radiographs. Usually, pleural fluid collections can easily be separated into hydro-and hemothorax. Several pulmonary lesions were encountered, including a surprising number of small areas of atelectasis. Mediastinal manifestations of trauma, including fluid or air collections, are also seen on CT.

Spiralna tomografia komputerowa u pacjentów po tępych urazach klp

Celem pracy jest przedstawienie zastosowania spiralnej tomografii komputerowej w diagnostyce pacjentów po tępych urazach klp. Materiał stanowi grupa 23 pacjentów po tępych urazach klp. U wszystkich pacjentów wykonane były zdjęcie PA klp oraz badanie TK spiralnym tomografem komputerowym Somatom Emotion firmy Siemens. Badanie wykonywane było przed i po podaniu iv bolusa 100 środka kontrastowego. Oceniano przekroje osiowe przed i po podaniu kontrastu oraz rekonstrukcje MPR, VRT i SSD. Porównywano uzyskane wyniki ze zdjęciami klp. U 15 pacjentów stwierdzono nieregularne hiperedensyjne zagęszczenia miąższowe widoczne jedynie na przekrojach TK, odpowiadające ogniskom stłuczenia miąższu płuca. U ośmiu pacjentów stwierdzono złamanie żeber, widoczne zarówno na zdjęciach rtg, jak i w badaniu TK. Odma opłucnowa była widoczna u pięciu z nich w badaniu TK, u jednego pacjenta mała odma opłucnowa widoczna w badaniu TK nie była widoczna na zdjęciu RTG. Płyn w jamie opłucnowej widoczny był u siedmiu pacjentów. U jednego pacjenta stwierdzono perforację przepony na zdjęciu RTG; badanie TK bez doustnego podania środka kontrastowego nie umożliwiało jednoznacznej diagnozy. U jednego pacjenta stwierdzono pourazowe rozwarstwienie aorty, a u dwóch pacjentów płyn w worku osierdziowym, bez objawów tamponady. Spiralna tomografia komputerowa jest metodą z wyboru w ocenie pacjentów po tępych urazach klp. Umożliwia ona precyzyjną ocenę zmian pourazowych miąższu płuc, ściany klp, obecności odmy i minimalnych ilości płynu w jamie opłucnowej, niewidocznych na zdjęciach klp. Ponadto umożliwia precyzyjną ocenę struktur śródpiersia, niedostępnych ocenie na zdjęciu klp.