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Evaluation of intrapleural contrast-enhanced abdominal pelvic CT-scan in detecting diaphragm injury in stable patients with thoraco-abdominal stab wound: A preliminary study

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ABSTRACT

Background: Many of the patients with thoraco-abdominal stab wound remain asymptomatic; in this regard, previous studies reported that 7–48% of asymptomatic patients had diaphragm injury (DI). Thoracoscopy or multidetector computed tomography (MDCT) scan is the best method to detect DI. We aimed to evaluate the role of CT scan with intrapleural contrast to rule out DI in stable thoraco-abdominal stab wounds.

Method: In a prospective study, we evaluated all haemodynamically stable patients with thoraco-abdominal stab wound, from October 2009 to 2010. Exclusion criteria included patients who needed emergency thoracotomy or laparotomy, those who were haemodynamically unstable and those with blunt trauma or gunshot injury. In the CT-scan department, 500 cc of diluted meglumine diatrozate was transfused into the pleural space via a chest tube and the CT scan was performed from the dome of the diaphragm to the pelvic cavity. In the second step, all patients were taken for thoracoscopy within 24 h after admission. The CT-scan slide was considered positive if one of the following signs was found: (1) the diaphragm was obviously injured as seen in CT-scan slides and (2) contrast agent was seen in the peritoneal cavity. Sensitivity and specificity were calculated for CT scan and thoracoscopy.

Results: Four out of 40 patients had DI according to thoracoscopy. CT scan with intrapleural contrast predicted diaphragmatic injury correctly in all four patients. Considering thoracoscopy as the gold-standard method, the CT scan had two false-positive cases. The sensitivity of the intrapleural-contrast CT scan was 100% and its specificity was 94.4%.

Conclusion: Our study showed that CT scan with intrapleural contrast can be an acceptable approach to rule out DI and limit the use of thoracoscopy for final diagnosis and repair of DI in cases with suspicious or positive CT-scan results, especially in trauma centres with high load of trauma patients and little accessible equipment.

Diaphragm injury (DI) may result from blunt trauma or penetrating thoraco-abdominal injury.[1] If diagnosis of DI is missed, it might result in the strangulation of the abdominal organs through diaphragm defect into the chest cavity, which is associated with gangrene of organs and, consequently, 30–60% mortality rate.[2,3] Although the first report of DI goes back to 1941,[4] diagnosis of DI has remained a controversial aspect of surgery.[1] Up to 1980, all patients with penetrating thoraco-abdominal injury underwent diagnostic laparotomy or thoracotomy,[5,6] procedures associated with 70% negative results.[7,8] Therefore, efforts focussed on testing noninvasive methods of diagnosis of DI. Nowadays, haemodynamically unstable patients with penetrating thoraco-abdominal stab wound (TASW) should be taken for either laparotomy or thoracotomy.[9,10] However, many of the patients with TASW remain asymptomatic; previous studies reported that 7–48% of asymptomatic patients might have DI.[9,11] Different types of protocols were suggested to diagnose DI in asymptomatic patients in trauma centres.

Nowadays, clinicians consider thoracoscopy or multidetector computed tomography (MDCT) scan as the standard method to diagnose DI.[6] However, they are not accessible in many of the trauma centres in our country and other developing trauma centres. This made us to consider a method compatible with our

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resources, accessible in our centres and, more importantly, sensitive enough to rule out DI in asymptomatic patients. Having a sensitive and practical method in our centre will decrease duration of hospital admission and therefore the cost imposed on the system.

Our hypothesis was based on the idea that a water-soluble contrast agent transfused into the pleural space will enter the peritoneal cavity through diaphragm defect, if it exists. We evaluated the accuracy of an intrapleural CT scan to rule out DI in asymptomatic TASWs. After extensive search in English journals, it appears that it is the first time that transfusion of a soluble contrast agent through a chest tube has been used to detect DIs.

Method

In a prospective study, we evaluated all haemodynamically stable patients with TASW from October 2009 to October 2010. The thoraco-abdominal area was defined as inferior to the thoracic cavity (below the nipple in front, below the sixth intercostal space laterally and the eighth intercostal space at the back) and superior quadrants of the abdomen. Exclusion criteria included patients who needed emergency thoracotomy or laparotomy, haemodynamically unstable patients, patients for whom chest tube was not needed and blunt-trauma patients. As in our hospital, the protocol of management of gunshot wounds is surgical exploration, these patients were also excluded.The protocol was approved by our university ethics committee. The method of the study, objectives and complications were completely described for the patients, and they signed the consent form.

All the patients were examined by a senior general-surgery resident to detect pleural injury by digital-wound exploration. Reaction to iodine-containing contrast was not reported by any of our patients. The chest tube was clamped and the patients were transferred to the CT-scan department. There, 500 cc of diluted meglumine diatrozate (including 100 cc meglumin and 400 cc of normal saline 0.9%) was transfused into the pleural space via a chest tube. During injection, vital signs of the patients were repeatedly checked, and they were requested to report any symptoms, such as dyspnoea, sweating and chills, to detect reaction to contrast agent. No intravenous or oral contrast agent was used. During injection of the contrast, we asked the patients to either cough or perform the Valsalva manoeuvre. A CT scan was performed from the dome of diaphragm to the pelvic cavity (General Electric Medical System Milwaukee, WI, USA). The slide thickness was 3 mm in the dome of the diaphragm and 7 mm in the abdomen and pelvic cavities. After the CT scan was finished, the clamp of the chest tube was opened and nearly the entire contrast agent was drained into the chest bottle through the chest tube.

In the second step, all the patients were taken for thoracoscopy within 24 h after admission. It was performed under general anaesthesia by a trauma surgeon with at least 10 years of experience. The radiologist and trauma surgeon were unaware of the thoracoscopy or radiology results, respectively. CT scans were reviewed by an attending radiologist. CT-scan slides were considered positive if one of the following signs was found: (1) the diaphragm was obviously injured in CT-scan images or (2) the contrast agent was seen in the peritoneal cavity. Due to the importance of negative predictive value (NPV) in our subjects (DI), all positive or equivalent reports were considered positive. Sensitivity, specificity, positive predictive value (PPV) and NPV were calculated for CT scan and thoracoscopy.

Results

From October 2009 to October 2010, 42 patients met our inclusion criteria to enter the study. Two patients refused to be taken for thoracoscopy; therefore, they were excluded from our study. Our patients included one female and 39 males, with the mean age of 23.2 years (range: 18–37 years). The site of the stab wound was right sided in 31 patients and left sided in nine patients. During injection of the contrast agent, none of our patients developed reaction to the agent.

Thoracoscopy reports confirmed DI in four patients. Wound characteristics, size and site of DI are summarised. In the case 1, the CT scan showed a 5-mm partial tearing in the left diaphragm (Fig. 1(a)). Thoracoscopy confirmed partial tearing of the diaphragm; however, it was not repaired due to intact peritoneum. In the case 2, the CT scan showed extravasation of the contrast agent anterior to the left crus of the diaphragm and around the spleen (Fig. 1(b)). The thoracoscopy report showed 1 cm left DI, which was not repaired due to the small size of the injury.

The CT scan showed focal extension of the contrast agent beneath the right crus of the diaphragm in the case 3. In this case, the trauma surgeon reported a 1-cm injury of the dome of the right diaphragm (Fig. 1(c)), which was not repaired. All the above patients were followed up in clinic, and they were asymptomatic with normal chest X-ray. It was only in the 4th case that, due to existence of a 3-cm injury in the lateral side of the right hemidiaphragm, thoracoscopy shifted to thoracotomy to repair the diaphragm. Minimal amount of contrast extravasation was seen in the suprahepatic area, anterior and parallel to the right crus of the diaphragm (Fig. 1(d)).

Thoracoscopy reports were negative in the rest of the 36 patients; however, the CT scan was positive in two further cases. The first case was a 23-year-old man with left-side TASW injury. The CT scan showed minimal amount of contrast agent in the left subdiaphragmatic and splenorenal areas (Fig. 2(a)). The second case was a 28-year-old man with left TASW. The radiologist reported extravasation of contrast agent in the left subdiaphragmatic area and just in the upper stomach area (Fig. 2(b)).

After comparing the results of the CT scan with thoracoscopy, sensitivity and NPV of the CT scan were reported 100%; however, its specificity and PPV were 94.4% and 66.6%, respectively. Specificity, sensitivity, PPV and NPV of the thoracoscopy were 100%.

In our study, two patients (5%) developed air leak in the bottle of the chest tube after thoracoscopy, which resolved during 7 days. Associated injuries seen in the CT scan were rib fracture ($n = 2$), soft-tissue haematoma ($n = 20$) and subcutaneous emphysema ($n = 35$). Extravasation of the contrast agent from the site of the chest tube was seen in three cases in the CT scan. None of these patients developed skin inflammation of the site of the chest tube.

Discussion

Our study showed that sensitivity and specificity of the intrapleural-contrast CT scan were 100% and 94.4%, respectively, considering thoracoscopy as the gold standard. Our study showed that CT scan with intrapleural contrast can be one of the approaches to rule out DI, and limit the use of thoracoscopy for final diagnosis and for repair of DI in cases with suspicious or positive CT-scan results, especially in trauma centres with high load of trauma patients and limited accessible equipment.

Considering the fact that many of the patients with penetrating TASW remain asymptomatic, having a practical and accessible method to diagnose DI in both developing and developed trauma centres is desirable. Recent investigations have discussed different methods, including conservative approach, digital-wound exploration, deep peritoneal large (DPL), MDCT scan and, finally, thoracoscopy to diagnose DI in haemodynamically stable patients with TASW.

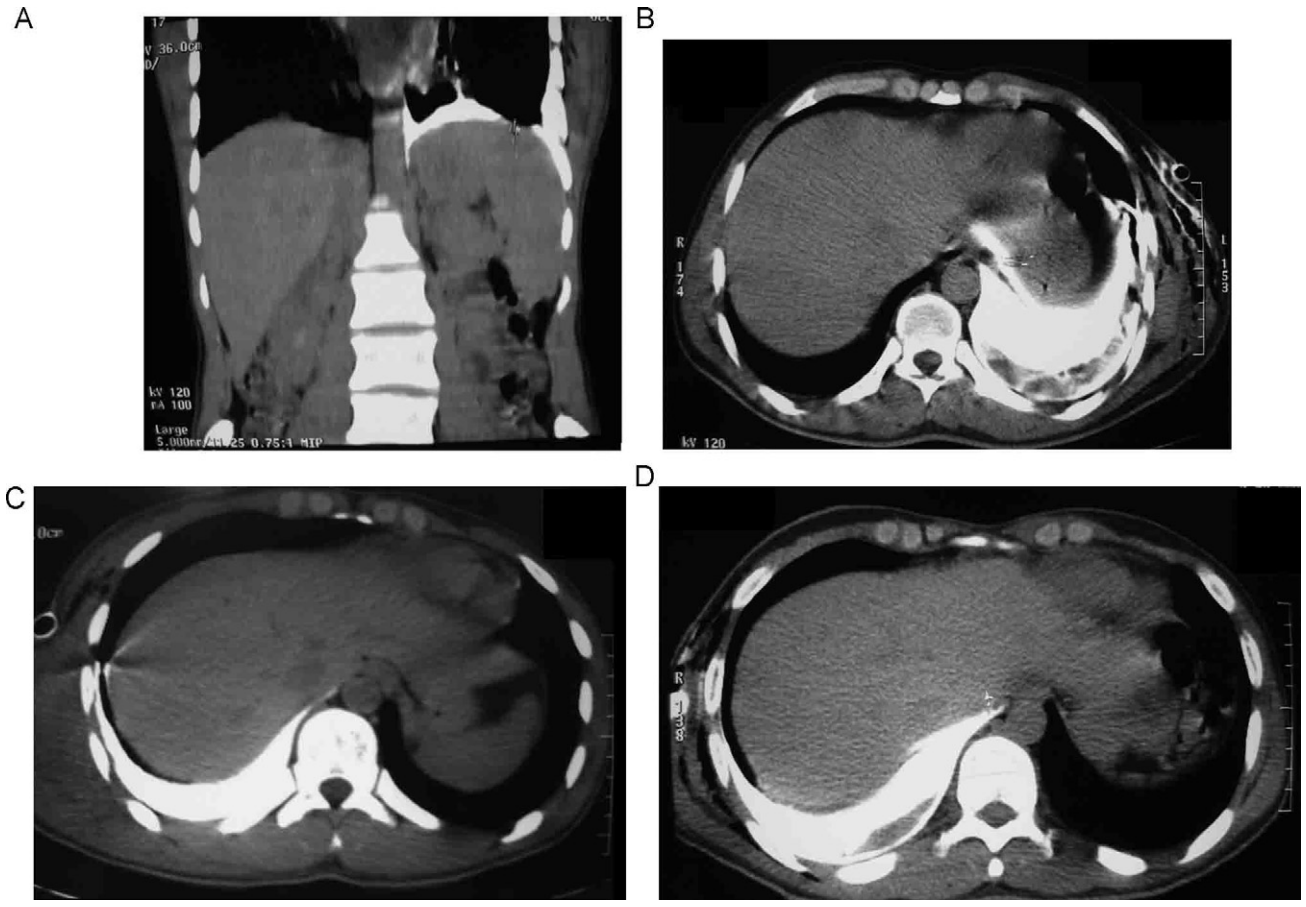

Fig. 1. Intrapleural contrast CT-scan in 4 cases with diaphragm injury. (A) CT-scan showed a 5 mm partial tearing in the left diaphragm, (B) CT-scan showed extravasation of the contrast agent anterior to the left crus of the diaphragm and around the spleen, (C) CT-scan showed focal extention of contrast agent beneath the right crus of the diaphragm, (D) Minimal amount of contrast extravasation was seen in the suprahepatic area, anterior and parallel to the right crus of the diaphragm.

The conservative approach and the serial physical examination failed to diagnose DI in 20–45% of the cases.[9,11] Ultrasonography was not accurate in the diagnosis of DI.[6] More et al. used DPL to detect DI. It had a high accuracy (90%) in the detection of DI;[12,13] however, it was not sensitive enough to reliably rule out DI (sensitivity: 87.5%, specificity: 96.6%).[14,15] Local wound exploration was not a useful method in the cases of thoraco-abdominal wounds.[16] Chest X-ray (CXR), the most common first radiologic investigation, failed to detect DIs in 12–66% of the patients.[17,18] Magnetic resonance imaging (MRI) was a good method to visualise the entire area of the diaphragm; however, it was not a suitable method in acute settings.[17] Conventional CT scan had a sensitivity of 14–61% and specificity of 76–99% to detect DI. Moreover, it was not able to differentiate between DI and adjacent pulmonary injuries.[19,20] Previous studies showed that spiral CT scan was not reliable to detect DIs resulting from TASW[21,22] because this type of

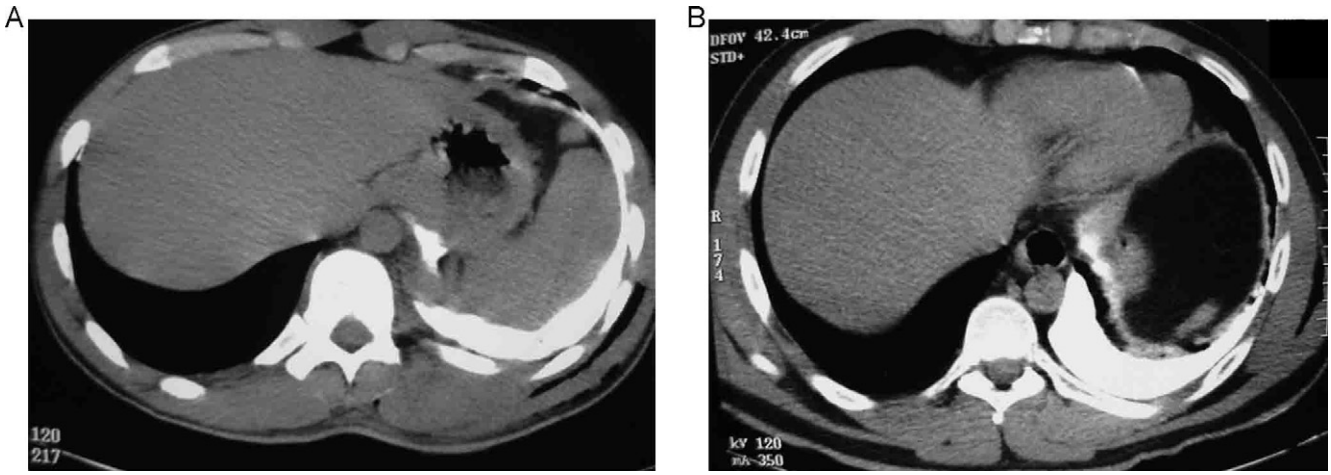

Fig. 2. Intrapleural contrast CT-scan in the 2 false positive cases. (A) CT-scan showed minimal amount of contrast agent in the left subdiaphragmatic and splenorenal areas. (B) Extravasation of contrast agent in left subdiaphragmatic area and just upper stomach area were noted.

DI is very small in size and is not associated with herniation of the abdominal organs despite DI resulting from blunt trauma.[23]

Few studies have evaluated the accuracy of CT scan with contrast agent in the diagnosis of DI. Bodanapally et al. compared the results of MDCT scan with surgical techniques. The sensitivity and specificity of MDCT in detecting DI in TASW were 90% and 68%, respectively. The signs of DI resulting from blunt trauma were not as sensitive for the diagnosis of the typically small-sized DI resulting from TASW (collar sign: 4%, herniation of viscera: 17%, discontinuity of diaphragm: 40%).[24] In our study, considering thoracoscopy results as gold standard, the CT scan was true positive in four cases and false positive in two cases. In the case 1, partial tearing of the diaphragm was detected by CT scan, which was evident as a focal accumulation of contrast in the site of tearing (Fig. 1(a)). In the cases 2, 3 and 4, the contrast agent was seen beneath the diaphragm and also around the abdominal organs.

In this study, we evaluated a new CT-scan sign of DI (focal accumulation of contrast along the diaphragmatic surface), which has not already been described (to the best of our knowledge, no one has used intrapleural water-soluble contrast material to evaluate DI). In our limited number of patients, focal subpleural accumulation of the contrast and existence of contrast beneath the diaphragm were sensitive enough indicators to detect DIs as a screening test. The intrapleural contrast CT scan had two false-positive results.

Undiagnosed cases of DI remain asymptomatic until they return with life-threatening complications, such as gangrene of the abdominal organs associated with 30–60% mortality rate.[2,3] However, previous studies failed to propose a sensitive noninvasive method to rule out DI. Some researchers have declared that[12] there should be a standard method to rule out DI in the stable patients. Stein et al.[9,25] showed that the sensitivity and sensitivity of MDCT scan to exclude DI in TASW were 94% and 95.9%, respectively. Unfortunately, they are not widely available yet.[9,25] Although we support the idea proposed in recent articles that MDCT scan[25] or thoracoscopy is the best method to diagnose DI, because of having an overcrowded trauma centre, we think it is not practical in our centre to evaluate all the stable patients with TASW with thoracoscopy. Moreover, MDCT scan was not available in our centre at the time of study as in many of other developing trauma centres. In our centre, thoracoscopy is usually limited either to stable patients who become symptomatic during the observation period or to patients with prolonged air leak in the chest tube. It is recommended that trauma protocols should be adjusted based on the availability of medical personnel, modern medical equipment and load of trauma patients, although the advanced protocols in developed trauma centres should be considered.[26] Consequently, it seems that it is logical to have a sensitive and practical method in our centre to rule out DI in stable patients and use thoracoscopy for final diagnosis of DI. Considering our preliminary study, this approach was sensitive enough to rule out DI, although its specificity was low. If continued in larger studies, this approach can decrease the duration of hospital admission and therefore the cost imposed on the system.

There were some limitations to our study. Contrast was injected only in patients with established indications for chest-tube insertion, due to ethical concerns. Moreover, at the time of this study, we did not possess a side scope for thoracoscopy, which can also limit the study's accuracy.

Conclusion

Our study showed that CT scan with intrapleural contrast can be one of the approaches to rule out DI and limit the use of thoracoscopy for final diagnosis and repair of DI in cases with suspicious or positive CT-scan results, especially in trauma centres with high load of trauma patients and little accessible equipment.

Conflict of interest statement

No conflict of interest.

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