0022-5282/92/3201-0089$03.00/0
THE JOURNAL OF TRAUMA

Vol. 32, No. 1
Printed in U.S.A.

Magnetic Resonance Imaging in Traumatic Diaphragmatic Rupture: Case Reports

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Acute traumatic diaphragmatic rupture is usually diagnosed by plain chest x-ray studies or at laparotomy. On occasion, ancillary diagnostic procedures such as computed tomography (CT) and fluoroscopy are necessary for diagnosis. Suspected acute traumatic diaphragmatic rupture was definitively diagnosed by magnetic resonance (MR) imaging in two patients. In another three patients, MR imaging was used to rule out diaphragmatic rupture. Magnetic resonance imaging may be the ancillary diagnostic procedure of choice following equivocal chest radiographs.

Traumatic diaphragmatic rupture may be caused by blunt or penetrating trauma. This injury may be discovered at the time of urgent laparotomy or thoracotomy for associated injuries. Plain chest x-ray films may clearly demonstrate diaphragmatic rupture with visceral herniation. In a previous report from our level-I trauma center, the incidence of diaphragmatic rupture subsequent to blunt trauma was 0.8%.[1]

A dilemma arises in the management of two patient populations: patients with equivocal chest films on admission and no indication for urgent laparotomy/thoracotomy, and those with normal initial chest films but whose subsequent films are suggestive of a diaphragmatic rupture. We report our preliminary experience with the use of magnetic resonance (MR) imaging in suspected diaphragmatic rupture. In two cases, MR imaging was used to definitively diagnose diaphragmatic rupture, and in three cases, MR imaging was used to exclude suspected diaphragmatic rupture.

CASE REPORTS

Case 1. A 29-year-old man was an unbelted driver in a single-car crash. On arrival at our facility, he was alert, hemodynamically stable, and complaining of left elbow pain. He had a nontender chest wall with good air entry bilaterally and no adventitious sounds. Abdominal and rectal examinations were normal, as were the results of admission blood work. Chest x-ray films revealed apparent elevation of the left hemidiaphragm (Fig. 1). A computed tomographic (CT) scan of the lower thorax and abdomen was interpreted initially as showing no clear evidence of diaphragmatic rupture. Subsequent chest films were suggestive but not diagnostic of a traumatic rupture of the left hemidiaphragm. A MR study revealed avulsion of the lateral left hemidiaphragm from the chest wall, with herniation of omentum, contralateral mediastinal shift, and left lower lobe atelectasis (Fig. 1).

The patient was taken to the operating room and underwent left thoracotomy, which demonstrated a posterolateral avulsion of the left hemidiaphragm from the chest wall. The omentum and spleen were herniated through the diaphragmatic defect. Diaphragmatic repair required the use of a polytetrafluoroethylene (Gore-Tex, Flagstaff, AZ) patch. The postoperative course was unremarkable.

Case 2. A 28-year-old man was a belted driver in a motor vehicle crash in which his vehicle was hit broadside on the driver's side. On admission, he was in mild respiratory distress and hemodynamically stable. Chest auscultation revealed adventitious sounds at the left base. Abdominal examination revealed diffuse tenderness. Pelvic films demonstrated a fractured left pubic ramus. Plain chest x-ray films showed opacification of the lower two thirds of the left hemithorax, elevation of the splenic flexure, and a small contralateral mediastinal shift (Fig. 2). Diagnostic peritoneal lavage revealed 2,950 RBCs per mm^3 and 80 WBCs per mm^3. A CT scan of the abdomen demonstrated consolidation of the left lower lobe with an air–fluid level in the left hemithorax consistent with bowel or a traumatic lung cyst (Fig. 2). A MR study showed definite herniation of the colon through a ruptured left hemidiaphragm (Fig. 2).

The patient underwent exploratory laparotomy, with repair of a central rupture of the left hemidiaphragm and reduction of herniated colon and omentum.

Case 3. Falling 20 feet from a scaffold, a 48-year-old man landed on his left side. On admission he was alert and oriented, in no respiratory distress, and complaining of left shoulder pain. His vital signs were normal and an abdominal examination was unremarkable. The findings of his admission blood work were within normal limits. Plain chest films revealed an apparent elevation of the left hemidiaphragm without evidence of atelectasis at the left base. A CT scan of the lower thorax and abdomen revealed bibasilar atelectasis but was otherwise unremarkable. A ruptured left hemidiaphragm was suspected. Magnetic resonance imaging of the left hemidiaphragm demonstrated clearly that the left diaphragm was intact.

Case 4. A 65-year-old woman was transferred to our tertiary care facility from a local hospital following a motor vehicle collision. On admission, she was alert and hemodynamically

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stable, with air entry diminished at the left base. Cervical spine roentgenograms showed a stable C-2 fracture. A chest x-ray film revealed elevation of the left hemidiaphragm with contralateral mediastinal shift (Fig. 3). Magnetic resonance imaging of the left hemidiaphragm produced normal results (Fig. 3).

Case 5. A 37-year-old man was an unbelted driver in a vehicular crash. The steering wheel of his car was reportedly broken. On admission he was alert and hemodynamically stable. There was tenderness over the right chest wall with sternal tenderness and crepitus. Admission chest x-ray films demonstrated apparent mild elevation of the right hemidiaphragm with minimal right pleural effusion. Seven days after admission, the patient developed a right hemothorax that required chest tube drainage. Chest films showed apparent marked elevation of the right hemidiaphragm versus atelectasis and a right pleural effusion (Fig. 4). A MR scan revealed a normal right hemidiaphragm (Fig. 4).

DISCUSSION

Traumatic diaphragmatic rupture as a result of blunt or penetrating trauma may become apparent immediately or early or late in the clinical course. Early diagnosis of a traumatic diaphragmatic rupture is essential to prevent acute strangulation of intra-abdominal contents, which has high rates of morbidity and mortality.[2] In both blunt and penetrating injuries, the left hemidiaphragm is more commonly ruptured than the right.[3]

Diaphragmatic rupture secondary to blunt trauma is thought to be the result of a sudden pleuroperitoneal pressure differential during impact. Although the classic diaphragmatic tear is radial, tears may be seen at any location in the diaphragm, including avulsion from the chest wall. The organs most commonly herniated with left-sided ruptures are the stomach, colon, spleen, and small bowel.

Of interest is the herniation of fat only (e.g., greater omentum) through a large or small diaphragmatic defect. As reported by Gurney et al.,[4] a CT scan may detect this herniation of adipose tissue. As evidenced by our first case report, MR imaging is also useful in demonstrating intrapleural omental fat.

A diaphragmatic laceration secondary to penetrating abdominal, chest, or flank wounds may be discovered at laparotomy or thoracotomy. These diaphragmatic lacerations are notoriously difficult to diagnose preoperatively unless there is an isolated abdominal wound with evidence of intrathoracic injury or vice versa.[5] With the evolution of selective operative management of penetrating wounds, radiologic diagnosis of these lacerations may be increasingly important.

An isolated right-sided diaphragmatic rupture may be difficult to diagnose. Right-sided ruptures may be associated with severe liver injuries requiring early laparotomy. A recent report[6] noted an increased proportion of right-sided ruptures, possibly because of improved transport, resuscitation, and imaging. Magnetic resonance imaging has been used to diagnose right-sided congenital diaphragmatic hernia.[7] We found no reports of the use of MRI in right-sided traumatic diaphragmatic rupture.

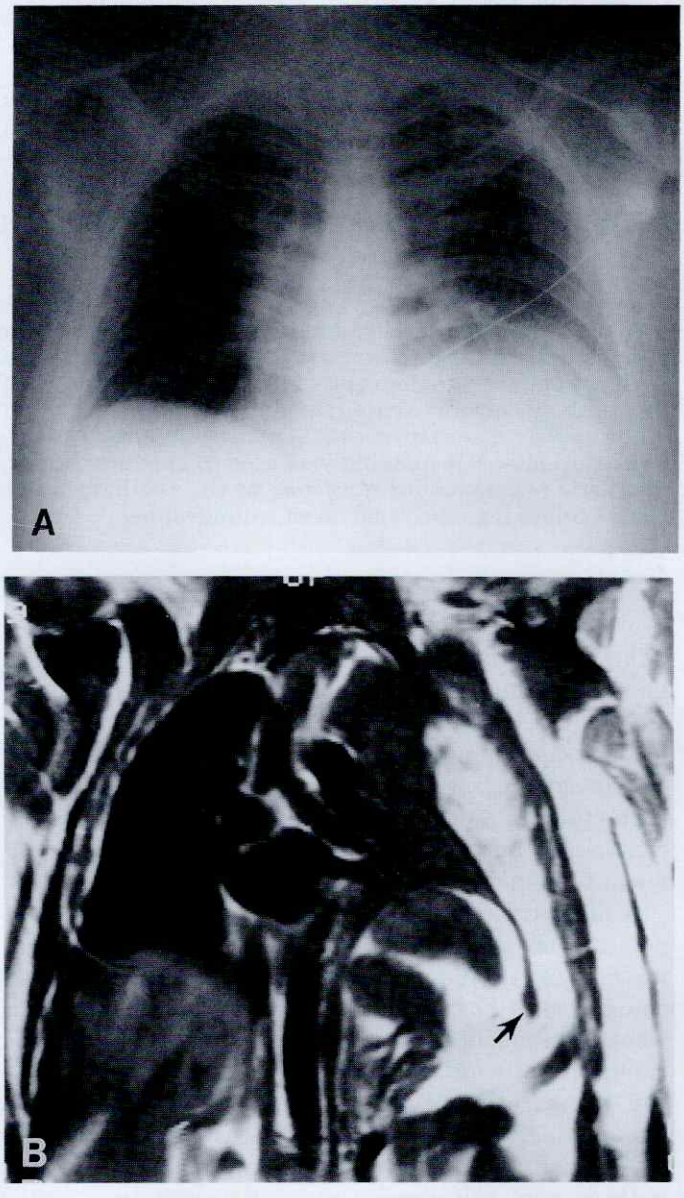

FIG. 1. Magnetic resonance images of diaphragmatic rupture: (A) The admission x-ray film of a 29-year-old man after a motor vehicle crash showed a poorly defined and apparently elevated left hemidiaphragm with evidence of some mediastinal shift. Numerous left posterior rib fractures are evident. The study was regarded as suggestive of a left hemidiaphragm injury. (B) A coronal T_1-weighted MRI revealed avulsion of the left hemidiaphragm from the chest wall (arrow), herniation of omental fat (bright tissue) into the left hemithorax, and atelectasis of the left lung. (Reprinted with permission from Gelman R, Mirvis SE, Gens R: Diaphragmatic rupture due to blunt chest trauma: Sensitivity of plain chest radiographs. *AJR* 156:51, 1991.)

Chest roentgenography remains the initial screening diagnostic test of choice. In a recent study by one of the authors (S.M.), plain chest x-ray films were diagnostic in 20 of 44 patients with left-sided ruptures.[8] Findings on plain chest films suggestive of diaphragmatic rupture are mediastinal shift to the contralateral side, apparent elevation of the hemidiaphragm, abdominal gas shadows or air–fluid levels above the usual diaphragmatic level, and obliteration or distortion of the diaphragmatic outline. On initial chest films, diaphragmatic rupture may

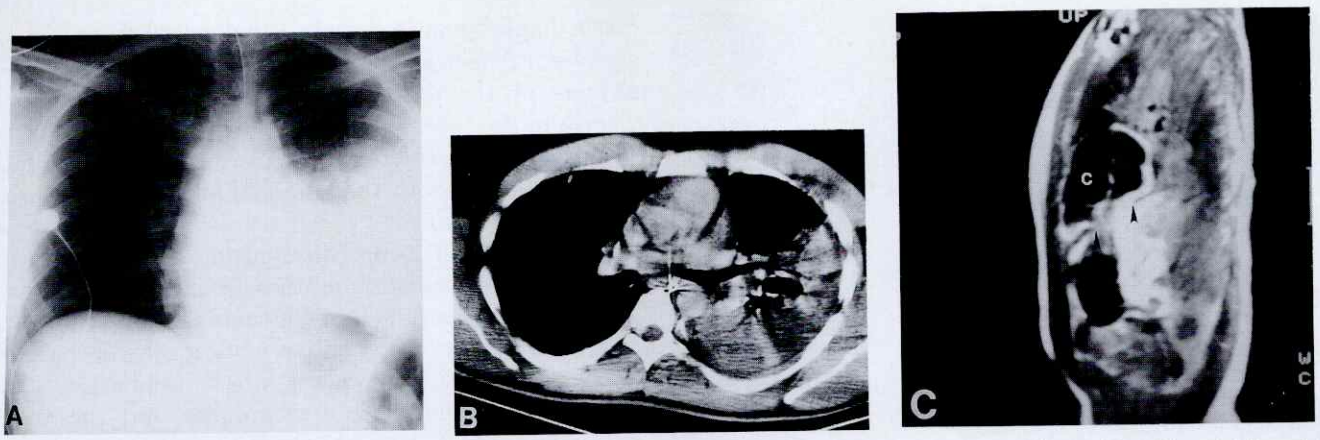

FIG. 2. Magnetic resonance images of diaphragmatic rupture: (A) Admission chest x-ray film in a 28-year-old man injured in a left broadside car collision revealed apparent elevation and poor definition of the left hemidiaphragm and increased density in the left lower hemithorax. (B) A CT image through the lower thorax demonstrated an air–fluid level with surrounding consolidation at the left base. The finding was considered consistent with herniated bowel or a traumatic lung cyst with surrounding consolidation. (C) A parasagittal T_2-weighted MRI scan through the left hemidiaphragm showed unequivocal herniation of colon (c) through a tear in the hemidiaphragm (arrowheads). (Reprinted with permission from Mirvis SE, Keramati B, Buckman R, et al: MR imaging of traumatic diaphragmatic rupture: Report of a case. *J Comput Assist Tomogr* 12: 147, 1988.)

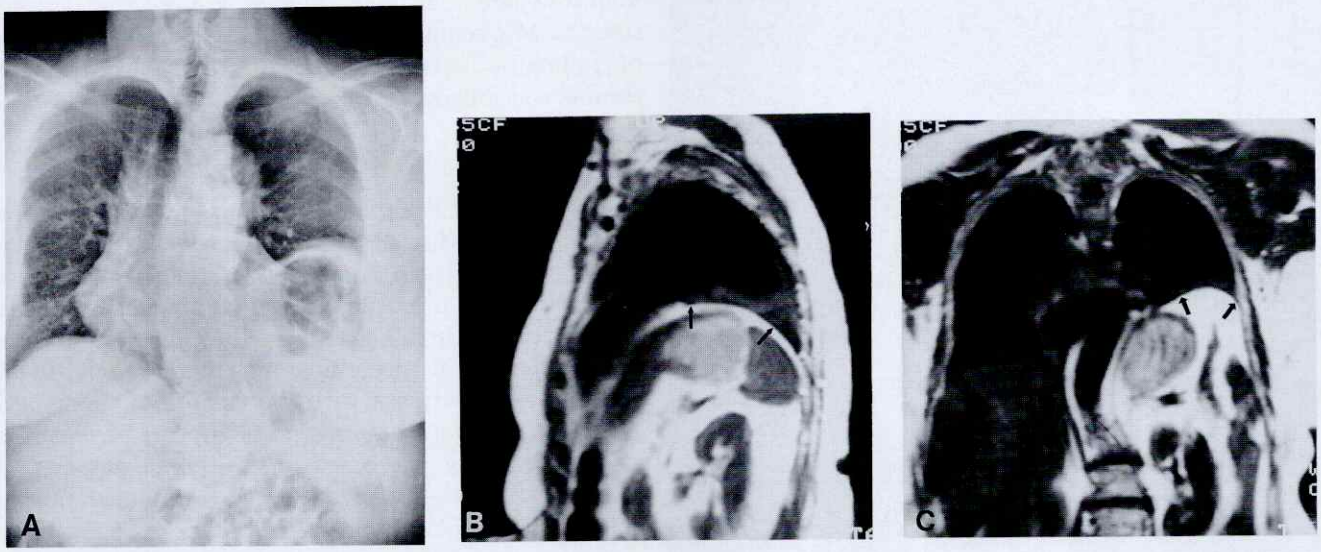

FIG. 3. Magnetic resonance images excluding diaphragmatic injury: (A) Admission chest x-ray film in a 65-year-old woman revealed focal elevation of the apparent left hemidiaphragm and mediastinal shift to the right. Sagittal (B) and coronal (C) MR images, T_1-weighted, show an intact low-signal left hemidiaphragm (arrows) and left basal atelectasis excluding rupture of the left hemidiaphragm.

be obscured or mimicked by atelectasis, hemothorax, pneumothorax, gastric dilatation, pulmonary contusion, intra-abdominal fluid, traumatic pneumatocele, or congenital eventration. Herniation of viscera through a diaphragmatic defect may be prevented or lessened by positive pressure ventilation, delaying radiologic diagnosis. When the initial chest film is equivocal or subsequent films are suggestive of diaphragmatic rupture, further diagnostic procedures are necessary.

Insertion of a gastric tube with or without water-soluble upper gastrointestinal contrast medium may demonstrate gastric herniation.[9] Diagnostic peritoneal lavage, using traditional criteria of positivity (RBC > 100,000/mm^3, WBC > 500/mm^3), is often negative in patients with isolated diaphragmatic rupture.[10] However, the drainage of lavage fluid from a thoracostomy tube is virtually pathognomonic of a diaphragmatic laceration. Computed tomography, despite the use of sagittal reconstructions, has been disappointing in our experience, as exemplified by the cases presented. In a recent review of documented traumatic diaphragmatic rupture,[8] CT scans were diagnostic in only one of seven cases. Fluoroscopy may be helpful, especially in evaluating a nonventilated patient. Nuclear scintigraphy, specifically liver–spleen scans, require organ herniation or constriction to be diagnostic.[11] Liver–spleen scans can be done in combination with perfusion lung scans to detect diaphragmatic rupture. At our institution we have little experience with this technique. Pneumoperitoneum and subsequent pneumothorax ipsilateral to the diaphragmatic rupture require free communication between the pleural and peritoneal cavities, which may not exist with herniated

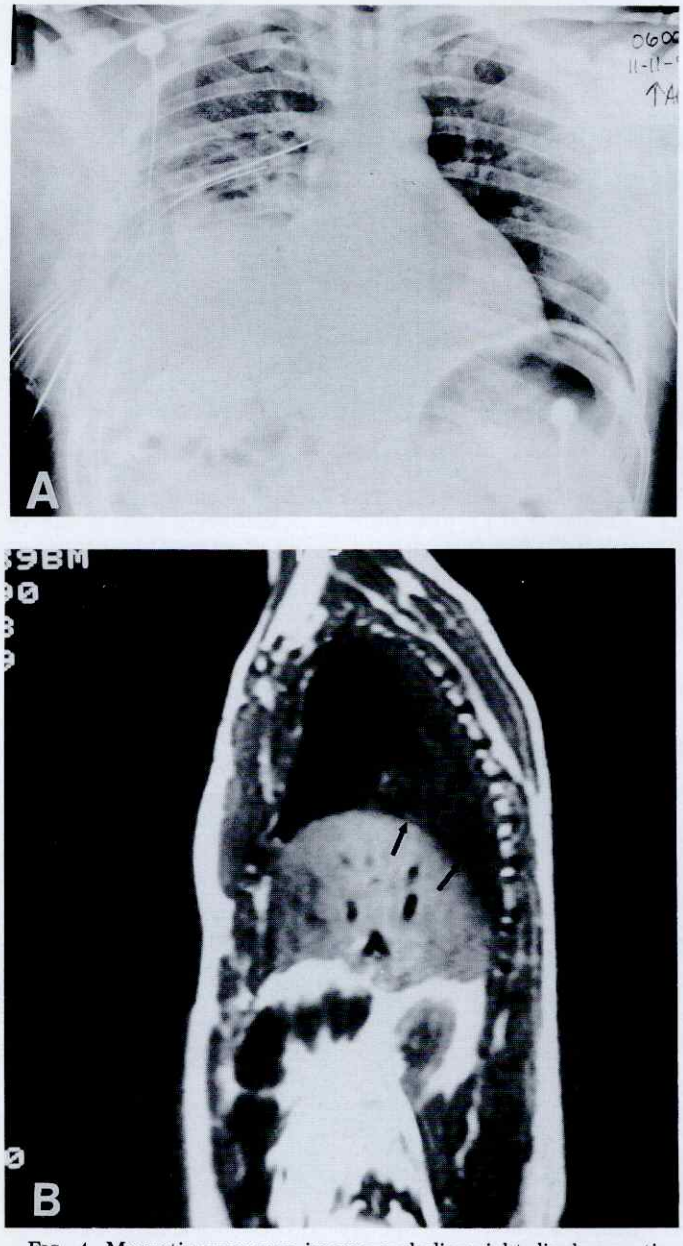

FIG. 4. Magnetic resonance images excluding right diaphragmatic rupture: (A) Erect chest x-ray film of a 37-year-old man after blunt chest trauma revealed apparent elevation of the right hemidiaphragm with poor definition of the diaphragm contour. (B) Sagittal MR image, T_1-weighted, shows an intact thin low-signal line representing the right hemidiaphragm (arrows), with right posterior lung atelectasis most likely accounting for diaphragm elevation.

viscera. Ultrasonography of the diaphragm may be limited by gas in hollow viscera or soft tissues and supradiaphragmatic pathologic conditions.[12] Clearly, the ideal ancillary diagnostic procedure for suspected acute traumatic diaphragmatic rupture has not been identified.

The use of magnetic resonance imaging in spinal and head trauma has been extensively reported.[13–15] There are few reports of its use in torso trauma.[16] Unlike CT, ultrasonography, and fluoroscopy, MR imaging is able to produce images in the axial, coronal, and sagittal planes. This property makes MR imaging uniquely suited to the detection of diaphragmatic pathologic states.[17] Traumatic diaphragmatic rupture is diagnosed from MR images by a defect in the low-signal intensity of the diaphragm or the demonstration of bowel, fat, or solid viscera in the thorax. Unlike CT, MR scanning does not require ionizing radiation. The use of MR imaging in the investigation of both thoracic and abdominal disease is certainly increasing.[18–20]

Two pitfalls of using MR imaging in a patient with suspected diaphragmatic rupture are motion artifact and monitoring/support equipment that is incompatible with MRI. Respiratory and cardiac motion may obscure the image. This motion artifact can be minimized by respiratory and cardiac gating techniques and the use of relatively rapid T-1 weighted sequences. Our technique of performing MR scans on invasively monitored and supported patients was previously reported.[21] The usual contraindications to MR imaging such as aneurysm clips, cardiac pacemakers, and prosthetic heart valves are observed. In our institution, intracranial pressure monitors, orthopedic instrumentation, invasive hemodynamic monitors, and ventilatory support are not contraindications to MR scanning. As familiarity with MR imaging of trauma patients increases, so will its selective use by trauma specialists.

SUMMARY

Acute traumatic diaphragmatic rupture can be difficult to diagnose. In the past, many procedures such as fluoroscopy, GI contrast studies, ultrasound, and CT scanning were used to obtain images of the suspected diaphragmatic rupture. The use of MR scanning is increasing in all surgical specialties, including trauma. In our preliminary experience with the use of MR imaging in suspected traumatic diaphragmatic rupture, two patients were definitively diagnosed and in three patients the diagnosis was excluded. Magnetic resonance imaging may be the ancillary diagnostic procedure of choice following equivocal chest roentgenograms.

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