

Diaphragmatic injury

A clinical review

Maha S. Abdel Hadi, MBBS, FRCSI, Abdulmohsen A. Al-Mulhim, MBBS, FRCSI, Naif I. Al-Awad, MBBS, CABS, Hazem M. Zakaria, MBBS, PhD, Majed S. Al-Awami, MD, FACS.

ABSTRACT

Objective: Recent experience at King Fahad Hospital of the University, Al-Khobar University, Kingdom of Saudi Arabia was reviewed to identify the pitfalls in the diagnosis of diaphragmatic injuries, and attempt to develop a scheme by which early diagnosis is achieved in order to avoid the sequelae of delayed presentations.

Methods: A retrospective chart review of patients admitted to the surgical service, with the diagnosis of diaphragmatic injury was undertaken during the period June 1994 through to June 1999.

Results: The total number was 8 patients, and the age ranged between 6-71 years. Of these patients 5 were diagnosed immediately post-traumatic, 2 with delayed presentation, and one with recurrent post-traumatic repair. This case was excluded. Six patients presented following

blunt and one after penetrating trauma. Rupture occurred mainly on the left dome of the diaphragm in 5 patients and on the right in 2. Complications ranged from mild chest symptoms to severe respiratory and multi-system involvement.

Conclusion: Diaphragmatic injuries occurred in 2%-5% of multiple trauma victims. It is considered a predictor of serious associated injuries. However, as many as 10%-30% are missed during the initial evaluation. A high index of suspicion is required, and judicious use of diagnostic aids should be employed to reach early diagnosis to avoid the sequelae of missed injuries.

Keywords: Diaphragm, injury, trauma.

Saudi Med J 2001; Vol. 22 (10): 890-894

Traumatic diaphragmatic tears remain a challenge to the treating surgeon. It is considered an accurate marker of severe associated injuries, occurring in up to 5% of blunt and 15% of penetrating trauma.¹⁻³ Sennertus in 1541 described an autopsy finding of a stomach herniating through the diaphragm 7 months prior to death.⁴ Bowditch in 1853 reported the first antemortum diagnosis,⁵ and the first repair was performed by Riolfi in 1886.⁶ The first prompt diagnosis and repair was reported by Walker in 1900, who treated a patient crushed by a falling tree.⁷ Despite the limited facilities surgeons in the past encountered almost 3 centuries ago, many attempts were made to achieve early diagnosis and

repair of diaphragmatic injuries. Prompt diagnosis is based on a high index of suspicion and judicious use of available diagnostic aids, to reach early diagnosis and avoid the sequelae of missed injuries. Recent experience at King Fahad Hospital of the University (KFHU) prompted this study to identify the pitfalls in the diagnosis and management of such injuries, and to outline the best possible scheme for early and successful treatment.

Methods. A review of all patients admitted to KFHU with the diagnosis of traumatic diaphragmatic hernia was undertaken during the period of June

From the Department of Surgery, King Fahad University, Dammam, Kingdom of Saudi Arabia.

Received 18th October 2000. Accepted for publication in final form 17th April 2001.

Address correspondence and reprint request to: Dr. Maha S. Abdel Hadi, Department of Surgery, King Fahad Hospital of the University, PO Box 2208, Al Khobar 31952, Kingdom of Saudi Arabia. Fax: +966 (3) 8823720. E-mail: abdelhadi_m@hotmail.com

Table 1 - Clinical summary.

n	Age	Site & type of injury	Time of diagnosis	Pre-operative findings	Operative findings and treatment	Complications and outcome
1	6	Left penetrating trauma	Immediate	Left hemothorax	Lacerated left dome and lung. Surgical repair	Recovery
2	32	Left blunt trauma	Immediate	Left sided herniated stomach	Lacerated left, dome repaired	Recovery
3	71	Right blunt trauma	Immediate	Pneumothorax, pneumoperitonium, cardiac contusion and fractured ribs	None	Respiratory complications, slow recovery
4	23	Left blunt trauma	Immediate	Hemopneumothorax, scalp lacerations, fractured femur	Surgical repair and internal fixation of the femur	Recovery
5	36	Left blunt trauma	Immediate	Pneumothorax fracture ribs and scapula retropertitoneal hematoma	Surgical repair	Recovery
6	43	Right blunt trauma	Delayed 19 years	Multiple injuries	Multiple adhesions between lung, liver, diaphragm surgically repaired.	Lobar pneumonia, slow recovery
7	47	Right blunt trauma	Delayed 15 years	Multiple injures	Multiple adhesions with herniated liver and large bowel repaired.	Persistent lower lobe atelectasis, slow recovery
n=number						

1994 through to June 1999. King Fahad Hospital of the University is a general hospital with level III trauma center facilities that admits approximately 1300 trauma cases per year. Both the emergency room admitting records as well as patients medical charts were reviewed. Patients reported dead on arrival were excluded.

Results. During the specified period, 8 patients were admitted with the diagnosis of traumatic diaphragmatic hernia. They were divided into 2 groups, early and delayed presentations. Two patients presented 15 years and 19 years after the accident, one with recurrent hernia 30 months after post-traumatic repair and was excluded, and 5 immediately after trauma. With the exception of one, all patients sustained blunt trauma. The anatomical distribution of the diaphragmatic injury was 5 early diagnosed with left traumatic tears, while the remaining 3 were diagnosed at different stages of management as right diaphragmatic injuries. In the early post traumatic group the diagnosis was made pre-operatively in 2 patients, one patient based on the plain chest x-ray finding and one on computerized tomography (CT) scan after initiation of ventilation, the remaining 4 were discovered at laparotomy. Details of the patients presentation, management, complications and outcome are summarized in Table 1. The first patient was a 6-year-old male who sustained a penetrating lower left chest injury by

falling on broken glass. Plain chest films showed a hemopneumothorax. Intra-operatively and through a thoracoabdominal approach a 2 inch stab wound was visualized in the left dome of the diaphragm associated with left lower lobe laceration and no visceral herniation or other associated injuries, he underwent repair and recovered without complications. The 2nd patient was admitted after a motor vehicle accident. The patient was a back seat passenger in a mini-bus with no seat belts on. He presented with lower chest pain and minimal abdominal signs. The striking symptom was his inability to lie down and assumed the sitting position throughout the physical examination. Chest x-ray demonstrated the stomach herniating into the left thoracic cavity (Figure 1). No associated injuries were discovered at laparotomy, he also recovered without complications. The 3rd patient was a 71-year-old male driver with no seat belt on, involved in a head-on collision sustaining multiple rib fractures, lung and cardiac contusion, and multiple lacerations. Initial films were non-conclusive, he was ventilated and the positive pressure ventilation demonstrated the air from the lacerated lung traversing the diaphragm through a visible rent on CT scan into the peritoneal cavity (Figure 2a and 2b), due to his unstable condition, he was not explored. He developed a series of respiratory complications and multi-system involvement which mandated prolonged intensive care treatment. The diaphragmatic defect could not be demonstrated after

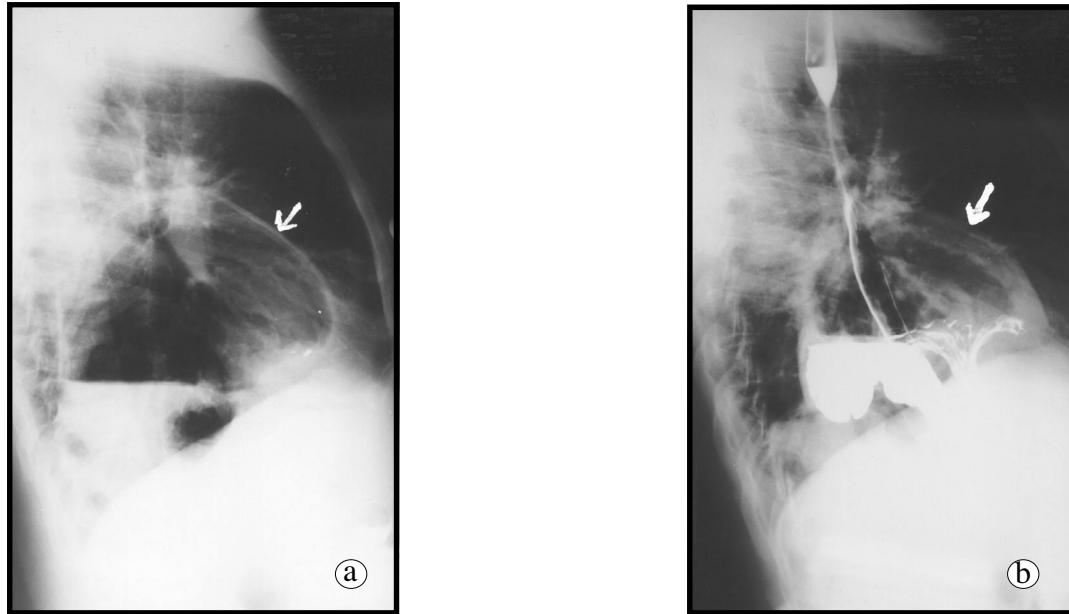


Figure 1 (a) - A lateral view of a plain chest roentgenogram demonstrating the stomach occupying the left lower chest. (b) - A lateral view of a barium swallow and meal showing the whole folded stomach occupying the left lower chest.

recovery. The remaining 2 patients sustained multiple rib and long bone fractures, hemopneumothorax, and positive peritoneal lavage. They were diagnosed at laparotomy as left diaphragmatic hernia with stomach and intact spleen, into the thoracic cavity, both recovered with minimal complications. The 2 who presented 15 years and 19 years after trauma were

diagnosed radiologically as right sided missed traumatic injuries and both underwent thoracotomy and reduction of herniated liver and large bowel and repair. The last 2 patients showed marked adhesions between the lung and diaphragm. Two of the 3 patients developed lobar pneumonia, which however, responded to antibiotic therapy.

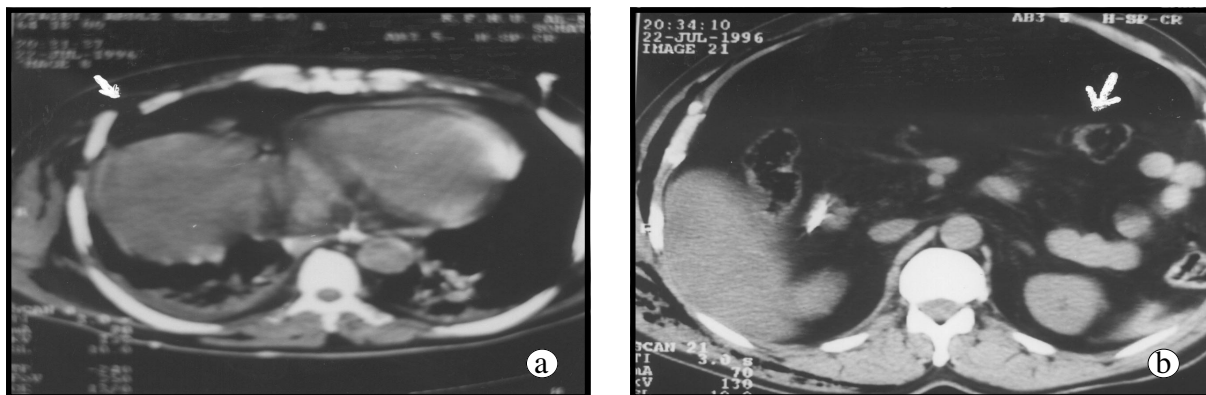


Figure 2 (a) - Computerized tomography scan of the lower chest demonstrating the fracture of the ribs and the avulsed right border of the diaphragm with air traversing the rent into the peritoneal cavity. (b) - Computerized tomography scan of the upper abdomen demonstrating the pneumoperitoneum created, and the marked compression effect on the abdominal viscera.

Discussion. Traumatic diaphragmatic rupture is frequently overlooked especially when associated with other more obvious injuries. It is seen in 3%-5% of major blunt trauma and 10% of penetrating trauma.⁸ Although thoracic injuries are common, the mechanism is thought to be due to abdominal compression.⁹ It occurs more commonly on the left side. This may be due to the plugging effect of the liver, or the more associated fetal injuries with right diaphragmatic ruptures. Recent reports have indicated an apparent increase in the diagnosis of the right hemi-diaphragm involvement to approximately one 3rd of the total trauma cases,¹⁰ and 20%-50% in another reported series.¹¹ In our limited experience none of the right-sided injuries were diagnosed at the initial evaluation. Patients with blunt diaphragmatic ruptures often have major associated injuries and thus the reported mortality ranges from 20.5% to 40.5%.¹² The diagnosis of traumatic rupture is seldom made at the initial clinical and radiological evaluation. In our series, only 2 patients were diagnosed pre-operatively, one after a plain chest roentgenogram and the other, contrary to what had been stated in many reports that the positive intra-thoracic pressure in ventilated patients obscures the diagnosis, our patient was diagnosed pre-operatively by CT-scan after initiation of positive pressure ventilation, which demonstrated the air traversing the right hemi-diaphragmatic rent creating a pneumoperitoneum. Diaphragmatic tears should be approached surgically since there is no documented evidence of spontaneous closure of injury to the diaphragm regardless of its size. In fact many authors consider the smaller lacerations to be more hazardous and having a higher potential to strangulate. In addition the collection of blood and bile in the pleural cavity may lead to lung entrapment and emphysema.^{13,14} Injuries of the diaphragm often challenge the surgeon by the subtle presentation in the face of other more obvious injuries. The lack of reliable diagnostic aids and the potential life-threatening sequelae of untreated patients compound the problem.¹⁵ Initial chest radiograms are helpful in the diagnosis of specific thoracic injuries, but has its limitations in the diagnosis of diaphragmatic trauma. Abnormal chest radiograms may reveal elevation of the hemidiaphragm, blunting of the costophrenic angle, absence of the sharp line of the hemidiaphragm, or hemothorax. Only 25%-30% of initial chest radiograms are diagnostic of diaphragmatic injury.¹⁶⁻¹⁸ Ultra-sonography is a valuable tool in the emergency room when available especially when the initial radiographic chest findings are equivocal, it may demonstrate intra-abdominal, thoracic and pericardial collections. Of course the capture rate and accuracy depends on the expertise and technical skills of the operator.¹⁹ On the other hand, the accuracy of the CT scan in the diagnosis of diaphragmatic rupture is

reported by some authors as 100% following blunt trauma,²⁰ while others reported the high benefits of CT-scan in detection of associated injuries, but up to 30% limitation in the diagnosis of diaphragmatic injuries especially when isolated.²¹⁻²³ The use of peritoneal lavage to detect diaphragmatic injuries resulted in 25%-34% false negative rates although the egress of the lavage fluid through the chest drainage tube may be diagnostic.^{1,3,15} A recent case report described the successful use of intra-peritoneal technetium to diagnose a suspected right-sided diaphragmatic tear.²⁴ Oral contrasts, radio-opaque naso-gastric tubes, and fluoroscopy may confirm the radiological suspicion of diaphragmatic injuries on plain chest radiogram in stable patients.⁸ The high rate of morbidity associated with missed diaphragmatic injuries has prompted recommendations of mandatory abdominal exploration in certain patients with penetrating lower thoracic wounds despite a 20%-30% incidence of non-therapeutic laparotomy,²⁵ and expected incidence of post operative complications. However, the advent of laparoscopic surgery has led to a resurgence of interest in the use of diagnostic laparoscopy in abdominal trauma and thoracoscopy in thoracic trauma offering the possibility of lowering the rate of non-therapeutic laparotomies while at the same time improving the diagnostic yield for diaphragmatic injuries.²⁶⁻²⁸ They provide excellent visualization of the entire diaphragm by video-scopic equipment and with the confidence gained in the procedure, are considered as acceptable alternatives to observation and exploration.²⁹ Few reported pitfalls of laparoscopy raised some concerns, these include difficulty in examining the small bowel in its entirety, as well as assessing the degree of active bleeding.^{30,31} However, it remains a reliable tool in evaluating the diaphragm for thoracoabdominal trauma, in addition, it provides minimally invasive, accurate and safe operative therapy to evacuate retained thoracic collections,³² and repair of diaphragmatic defects,³³⁻³⁴ thereby, shortens patients hospitalization and minimizes the complications and cost.

In conclusion the prompt diagnosis of diaphragmatic injury in the initial evaluation of the multiple trauma patients cannot be over emphasized, the presence of multiple injuries should alert the surgeon. When the body is subjected to a large force of energy, marked internal damage is expected and the possibility of diaphragmatic injury becomes a reality. As isolated diaphragmatic injuries provide few helpful clinical clues in aiding the diagnosis, appropriate investigations and good follow-up are of paramount importance in preventing the late presentation of traumatic diaphragmatic rupture. Therefore, a high index of suspicion and judicious use of specific diagnostic aids are to be employed as deemed necessary.

Acknowledgment. Sincere appreciation to our Professors: T. Tamimi and S. Kawaja for their valuable contribution to this article.

References

- Freeman T, Fischer RP. The inadequacy of peritoneal lavage in diagnosing acute diaphragmatic rupture. *J Trauma* 1976; 16: 538-542.
- Rodriguez-Morales G, Rodriguez A, Shatney CH. Acute rupture of the diaphragm in blunt trauma: analysis of 60 patients. *J Trauma* 1986; 26: 438-444.
- Voeller GR, Reisser JR, Fabian TC, Kudsk , Mangiante EC. Blunt diaphragm injuries: a five years experience. *Am J Surg* 1990; 56: 28-32.
- Reid J. Diaphragmatic hernia. *Edin Med Surg J* 1840; 53: 104-107.
- Bowditch HI. Diaphragmatic hernia. *Buff Med J* 1853; 9: 65-94.
- Hedblom CA. Diaphragmatic hernia. *JAMA* 1925; 85: 947-953.
- Walker EW. Diaphragmatic hernia, with report of a case. *Int J Surg* 1900; 13: 257-260.
- Meyers BF, McCabe CJ. Traumatic Diaphragmatic hernia: occult marker of serious injury. *Ann Surg* 1993; 218: 783-790.
- Lorimer WH, Reid RK, Raymond F. Blunt extraperitoneal rupture of the right hemidiaphragm: case report. *J Trauma* 1994; 36: 414-416.
- Estrera AS, Landay MJ, McClelland RN. Blunt traumatic rupture of the right hemidiaphragm. *Ann Thoracic Surg* 1985; 93: 525-530.
- Sukul DM, Kats E, Johannes EJ. Sixty-three cases of traumatic injury of the diaphragm. *Injury* 1991; 22: 303-306.
- Van Vugt AB, Schoots FJ. Acute diaphragmatic rupture due to blunt trauma: a retrospective analysis. *J Trauma* 1989; 29: 683-686.
- Riswold FW, Warden HE, Gardner RJ. Acute diaphragmatic rupture caused by blunt trauma. *Am J Surg* 1972; 124: 359-362.
- Hood RM. Trauma to the chest. In: Sabiston DC Jr, Spencer FC, editors. *Surgery of the chest*. 5th ed. Philadelphia (PA): WB Saunders; 1990. p. 383-417.
- Waldschmidt ML, Laws HL. Injuries of the diaphragm. *J Trauma* 1980; 20: 587-592.
- Aronoff RJ, Reynolds J, Thal E. Evaluation of diaphragmatic injuries. *Am J Surg* 1982; 144: 671-675.
- Johnson CD. Blunt injuries of the diaphragm. *Br J Surg* 1988; 75: 226-230.
- Morgan AS, Flancbaum L, Esposito T, Cox EF. Blunt injury of the diaphragm: an analysis of 44 patients. *J Trauma* 1986; 26: 565-568.
- Ammann AM, Brewer WH, Maull KI, Walsh JW. Traumatic rupture to the diaphragm: real-time sonographic diagnosis. *AJR* 1983; 140: 915-916.
- Johnson CD. Blunt injuries of the diaphragm *Br J Surg* 1988; 75: 226.
- Sola JE, Mattei P, Pegoli W, Paidas CN. Rupture of the right diaphragm following blunt trauma in an infant: case report. *J Trauma* 1994; 36: 417-420.
- Leaman P. Rupture of the right hemidiaphragm due to blunt trauma. *Ann Emerg Med* 1983; 12: 351-357.
- Madden MR, Paull DE, Finkelstein JL, Goodwin CW, Marzulli V, Shires GT. Occult diaphragmatic injury from stab wounds to the lower chest and abdomen. *J Trauma* 1989; 29: 292-298.
- Halldorsson A, Esser MJ, Rappaport W. A new method of diagnosing diaphragmatic injury using intraperitoneal technetium: case report. *J Trauma* 1992; 33: 140-142.
- Miller L, Bennett EV, Root HD, Tinkle JK, Grover FL. Management of penetrating and blunt diaphragmatic injury. *J Trauma* 1984; 24: 403-409.
- Merlotti GJ, Dillon BC, Lange DA, Robin AP, Barrett JA. Peritoneal lavage in penetrating thoracoabdominal trauma. *J Trauma* 1988; 28: 17-23.
- Ivatury RR, Simon RJ, Weksler B, Bayard V, Stahl WM. Laparoscopy in the evaluation of the intrathoracic abdomen after penetrating trauma. *J Trauma* 1992; 33: 101-109.
- Berci G, Sackier JM, Paz-Partlow M. Emergency laparoscopy. *Am J Surg* 1991; 161: 332-335.
- Ochsner MG, USNR CM, Rozycki GS, Lucente F, Wherry DC, Champion HR. Prospective evaluation of thoracoscopy for diagnosing diaphragmatic injury in thoracoabdominal trauma: A preliminary report. *J Trauma* 1993; 34: 704-710.
- Livingston DH, Tortella BJ, Blackwood J, Machiedo GW, Rush BF. The role of laparoscopy in abdominal trauma. *J Trauma* 1992; 33: 471-475.
- Sosa JL, Sims D, Martin L, Zeppa R. Laparoscopic evaluation of tangential abdominal gunshot wounds. *Arch Surg* 1992; 127: 109-110.
- Heniford BT, Carrillo EH, Spain DA, Sosa JL, Fulton RL, Richardson JD. The role of thoracoscopy in the management of retained thoracic collections after trauma. *Ann Thorac Surg* 1997; 63: 940-943.
- Mouroux J, Padovani B, Poirier NC, Benchmol D, Bourgeon A, Deslauriers J et al. Technique for the repair of diaphragmatic eventration. *Ann Thorac Surg* 1996; 62: 905-907.
- Kocher TM, Gurke L, Kuhrmeier A, Martinoli S. Misleading symptoms after a minor blunt chest trauma: case report. *Surg Endosc* 1998; 12: 879-881.