Injuries to the Diaphragm

1. Introduction

Diaphragmatic injuries (DI)-a frequent accompaniment of thoraco abdominal trauma - remains a diagnostic challenge to surgeons and radiologists. (1-4) Case reports and case series describe myriad ways in which this condition can present early, or in a delayed fashion following either blunt or penetrating trauma (5-9). However it is important to recognize DI early because of the serious morbidity and mortality associated with missed DI. For example, Degiannis reported 3% mortality for diaphragmatic injury diagnosed on a first admission, and 25% mortality for diaphragmatic injury diagnosed in a delayed fashion on the second admission after penetrating trauma in an African setting (10). Following blunt trauma, delayed treatment of diaphragmatic injury carried a 10% mortality and a 30% major operative morbidity rate in a small series of ten patients (11)

This review will focus on the diagnosis and optimal management of this condition and offer recommendations for improved management in Africa. Diaphragmatic injuries are common in African surgical practice because of the mixture of road traffic injury and penetrating injury seen at busy trauma centres (12).

2. Epidemiology

The population incidence of DI is difficult to assess from the literature as most series are hospital based. A textbook estimate of diaphragmatic injury among patients suffering blunt or penetrating thoracoabdominal trauma ranges from 0.8 to 5.8% (13)

Romaldas (1) examined 2540 patients treated for thoracoabdominal trauma over a 12-year period (1987-1998). He found 43 cases of penetrating and 22 cases of blunt DI together comprising 2.56% prevalence. Adegboye (14) reviewed 1778 chest trauma patients and found a DI prevalence of 6.5% in the study population. This comprised 84 (6.8%) of 1230 blunt chest trauma and 32 (5.8%) of 548 penetrating chest injury.

3. The Challenge of Diagnosis

The diagnosis of traumatic diaphragmatic rupture (TDR) is commonly missed following thoracic and abdominal injuries because the manifestations are varied, non specific, subtle and in the setting of polytrauma may be masked by other injuries. (8,15,16)

No gold standard currently exists in the diagnosis of TDR. (17) A high index of suspicion holds the key to diagnosis. (18) This has become even more important with the trend towards non-operative management of blunt abdominal injuries.

HISTORY
Recognition of the kinematics of trauma in the pre hospital setting could be of value in diagnosis. The majority of TDR follow motor vehicle crashes (MVCs). (1,2, 13,14,19)The magnitude and direction of occupant compartment intrusion and change in velocity are important predictors of diaphragmatic rupture. Patients with TDR are more likely to have sustained a lateral intrusion. (2,20) Falls from heights or direct impacts in the thoracoabdominal region such as in the case of pedestrian hit by a car should draw attention to the possibility of TDR.

An association has been drawn between increased BMI and TDR. Donald (21) found that for near side crashes occupants with a BMI $\geq$ 25kg/m2 were twice as likely to sustain a diaphragmatic injury compared to those with a BMI $\leq$ 25kg/m2 The reason adduced for this is the increased intra abdominal pressure (IAP) at rest associated with increased BMI. In blunt abdominal trauma TDR results from a further increase in IAP.

ASSOCIATED INJURIES
TDR is a marker of severe injury. Patients with TDR on the average have significantly higher mean ISS scores when compared to those without TDR. (2)Pulmonary contusion, hepatic injury, splenic injury, rib and pelvic fractures are all positively associated with TDR. (2)

Penetrating trauma to the thoracoabdominal area (basically lower chest and upper abdomen) should prompt suspicion of DI. Murray studied 107 patients with penetrating left thoracoabdominal trauma. He found 45 (42%) DI.Stab wounds were 32% (22 of 68) and gunshot wounds 59% (23 of 39). (22)

CLINICAL FINDINGS
The clinical picture upon presentation in the ED would depend on the severity of associated injuries and whether herniation of abdominal viscera into the thoracic cavity has occurred. In general symptoms may be thoracic or abdominal. The thoracic symptoms depend on the volume of pleural space occupied by the herniating abdominal viscera and also whether the stomach is distended. Dyspnoea, orthopnoea are frequent accompaniment. A tension pneumothorax like picture may be evident. (23) Chest pains may be diaphragmatic referred to the area of the scapular or may be related to rib fractures. Abdominal symptoms vary from mild to severe depending on the severity of associated intra abdominal injuries or obstruction and strangulation of viscera. Gastric outlet obstruction with vomiting may occur. (13)

Physical signs in the chest include decreased breath sounds in the affected hemithorax, associated rib fractures, flail chest, presence of bowel sounds in the chest and evidence of haemothorax or pneumothorax. In the abdomen the signs could vary from localized or generalized tenderness with guarding and rebound to progressive abdominal distension from intra abdominal haemorrhage. (13)

4. Investigations

4.1. Chest X-rays

Initial chest radiographs are normal or non specific in 20-50% of patients with DI.Two chest radiographic findings are diagnostic of DI: focal constriction of a herniated hollow viscus at the site of tear in the diaphragm from circumferential compression (collar sign) and demonstration of the nasogastric tube or abdominal viscus in the thorax. (24) Findings that are

suggestive of DI include obliteration of the diaphragm outline or distortion of its contour,elevation of the hemi diaphragm, pleural effusion or air-fluid level in the lower thorax as well as contralateral shift of the mediastinum. These signs are however not specific as they could be mimicked by pathology in the lung bases such as atelectasis, pulmonary contusion, loculated pneumothorax, post traumatic pneumatocele, congenital eventration of the diaphragm, gastric dilatation and subphrenic fluid collections. (24-26)

Pikoulis (16) in a study of 18 patients achieved a preoperative diagnosis of BDR in 16 (89%) using initial chest radiographs and a high index of suspicion and concluded that these should be the cornerstone of diagnosis of BDR. Matsevych (27) reached a similar conclusion in a study of 12 patients.

The value of serial chest radiographs especially in ventilated patients has been documented. (17) In ventilated patients positive pressure support overcomes the natural negative pressure gradient (7-20cm H2O) between the pleural and peritoneal cavities that normally facilitates herniation of abdominal contents into the chest via the diaphraghmatic defect. (25) Diagnosis of TDR may therefore be facilitated by extubation. (17)

4.2. CT

CT evaluation is increasingly the mainstay of investigations in blunt thoracic and abdominal trauma in the stable patient. On conventional CT a defect in the continuity of the hemidiaphragm is the most sensitive sign while the collar sign is 100% specific. The dependent viscera sign occurs when upper abdominal viscera abut directly on the posterior chest wall in the supine patient-a situation normally prevented by an intact diaphragm. (28)
Limitations of conventional CT include difficulty in visualizing the entire dome shaped diaphragm and difficulty in differentiating the diaphragm from adjacent pulmonary pathology or normal tissue structures. (26) Other diagnostic pitfalls are failure to appreciate normal variations, subtle signs of injury and scanning artefacts. (25)

Helical CT and multidetector CT (MDCT) technique have improved the sensitivity of diagnosing DI. Multiplanar reconstructions have added more value to diagnosis. (28) Killeen studied the role of spiral CT in DI and found the collar sign to be the most common abnormal finding of diaphragmatic rupture (DR). In this study the sensitivity was 63% and specificity 100 %. (29) Scaglione in a study of 35 patients concluded that CT is a reliable tool in the diagnosis of DI in the acute trauma setting. (30)

In penetrating trauma the CT signs are more subtle owing to the small size of the defects although omental herniation may occur. However a wound tract caused by a knife, bullet etc that extends to both sides of the diaphragm is specific. Triple-contrast helical CT has been found to accurately demonstrate peritoneal violation and visceral injury in patients with penetrating torso wounds. (31) Also in a study of 803 patients with penetrating injuries in the torso MDCT was found to be an accurate test to detect DI. (32)

4.3. Ultrasound Scan

Ultrasonographic findings supportive of DI include diaphragmatic disruption, non visualization of the diaphragm, floating diaphragm and herniation of abdominal viscera into the thorax. Kim found ultrasonography very useful in the diagnosis of TDR. (33)

4.4 Gastrointestinal Contrast studies and Nuclear Scintigraphy

Administration of barium contrast through a nasogastric or rectal tube may be useful in the diagnosis of intrathoracic herniation of a hollow viscus while contrast studies of the stomach or colon using technetium-99m sulfur colloid scintigraphy may aid in the evaluation of TDR.

4.5 Magnetic Resonance Imaging

In a review of MR imaging of thoracic trauma Mirvis found it a useful ancillary study to confirm or exclude DI especially in situations where CT scan or thoracic angiography fails to clarify the diagnosis. (34) However, despite the benefits its use in polytrauma patients in the acute phase is limited because its strong magnetic field may interfere with monitoring devices, poor access to the patient may hinder treatment of haemodynamic instability coupled with staffing issues in some centres. (25)
Besides, MRI is not readily available in many parts of Africa and this limits its recommendation in the subregion.

4.6 Laparoscopy

The role of laparoscopy in the diagnosis and repair of DI is well documented. (3,6,13,22,35-38) Laparoscopy is an excellent diagnostic tool when suspicion exists for a DI.Randall (37) assessed 34 haemodynamically normal asymptomatic patients with laparoscopy and achieved specificity of 100% and sensitivity of 87.5%. He concluded that in haemodynamically normal patients with penetrating thoracoabdominal injury laparoscopy alone is sufficient to exclude DI.
Laparoscopy helps reduce negative and non-therapeutic laparotomy rates and length of hospital stay. (36)

4.7 Digital Exploration

Morales studied 82 consecutive patients with stab wounds in the left thoracoabdominal region. For the detection of DI digital exploration yielded a sensitivity of 96%, a specificity of 83.3%, a positive predictive value of 91% and a negative predictive value of 93.7%. They concluded that digital exploration is a reliable method for the detection of injuries to the left side of the diaphragm caused by stab wounds. (39) Konobu while reporting a case also recommended initial wound exploration for similar injuries. (40)

4.8 Thorascopy and Video Assisted Thorascopic Surgery (VATS)

The reliability of thoracoscopy in evaluating the diaphragm was reported by Nel in their study of 55 patients. (41) The use of fibre-optic thoracoscopy for DI in children was also reported by Pitcher. (42)

VATS found its first clinical application in the diagnosis of DI after penetrating thoracoabdominal trauma while the criteria for performing VATS in blunt chest trauma are less clear. (43) Freeman analyzed 171 patients who underwent VATS assessment of a hemidiaphragm following penetrating chest trauma and identified five independent risk factors for DI. (44) These are abnormal chest radiograph, associated intra abdominal injuries, high velocity mechanism of injury, entrance wound inferior to the nipple line or scapula and right sided entrance wound. They concluded that those patients without clear cut indications for thoracotomy or laparotomy should be considered for VATS if they had two or more predictors of DI.

5. Treatment of Diaphragmatic Injuries

DI should always be treated early because of the attendant morbidity and mortality that may follow delayed recognition and repair. Since the diaphragm is in a constant state of motion its wounds are unlikely to heal spontaneously.

Options for repair include laparotomy, laparoscopy, thoracotomy and VATS. The choice would be influenced by a variety of factors such as the cavity with severe associated injuries or significant haemorrhage, expertise and equipment availability. At times thoracoabdominal injuries may require surgical intervention in both chest and abdomen. The cavity to open first, thorax or abdomen is often a challenge in such cases. (45)

It is important to recall misleading situations in the presence of DI such as intra abdominal bleeding giving rise to massive chest tube output or urohaemothorax in the case of ruptured urinary bladder. These situations may lead to the wrong cavity being opened first.

It has been suggested that the trans abdominal route be used in acute DI. (18) Some situations however mandate a thoracotomy: involvement of the thoracic aorta (46,47), thoracoabdominal impalement (48), pericardiodiaphragmatic ruptures (49) and in severe contamination of the thoracic cavity to enable proper irrigation. TDI is often repaired as an emergency. However in the absence of associated injuries in blunt ruptures (a rarity) repair could be planned (50) Repair should be done with non absorbable sutures in a continuous or interrupted fashion in single or double layer closure.

A tube thoracostomy is usually needed for haemothorax, or for evacuation of contamination from rupture of hollow abdominal viscera. Contamination mandates irrigation of the pleural cavity

6. Diaphragmatic Injuries in Children

BDR occurs in children with a frequency and severity commensurate with that observed in adults. (51) Clinical presentation and management is similar to adults. Post operative intussusceptions may occur. (52)

7. Diaphragmatic Injuries in Africa

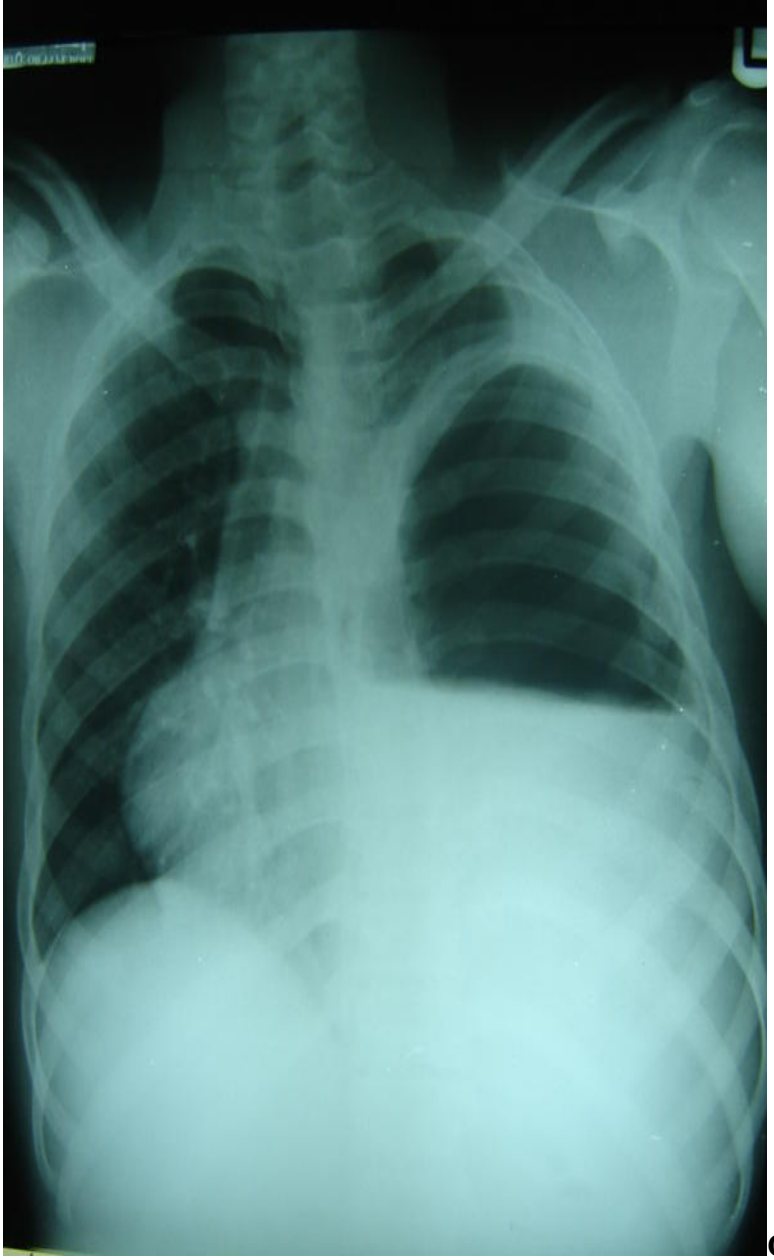
Adegboye (14) in his report on 116 DI (84 from blunt and 32 from penetrating chest injuries) observed that motor vehicle accidents was the commonest cause of blunt ruptures while gunshot injuries was the commonest cause of penetrating DI. The left to right prevalence of DI was 4:1while the mortality in the series was 34.5%.Matsevych (27) reported on nine 9 patients with acute DI in which all were recognized pre operatively using plain chest radiographs and a high index of suspicion and 3 patients with delayed presentation. Their mortality was 25%. Degiannis studied 45 patients with DI and noted the danger of missed DI and subsequent delayed presentation. The mortality rate in the early presentation group was 3% compared with 25% in the delayed group. (10)
Matsevych's patients all had laparotomy. However laparoscopy (35), thoracoscopy (41,42) and VATS are being practiced in selected centres.

8. Conclusions

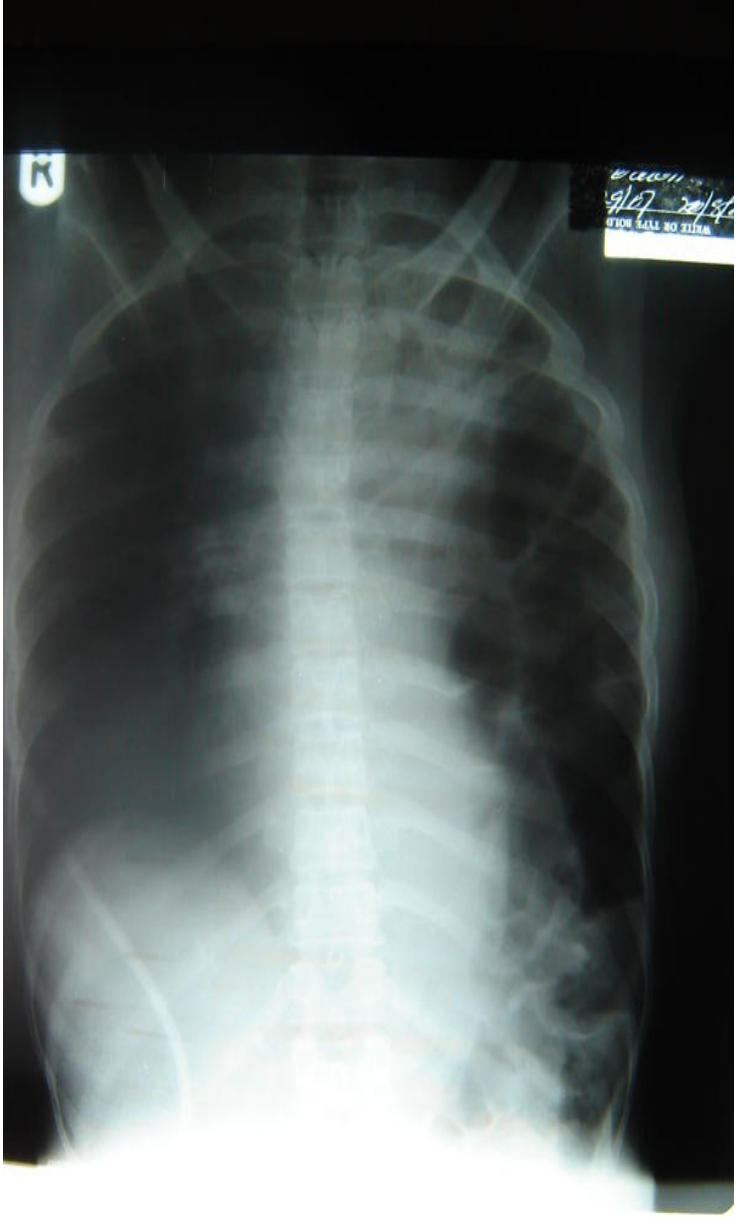
Diaphragmatic injuries remain a diagnostic challenge for surgeons and radiologists worldwide. While improved diagnosis is being achieved with multi detector CT scans, laparoscopy, thoracoscopy and videoassisted thoracoscopic surgeries the same cannot be said of Africa where these facilities and expertise are hardly available. Motor vehicle crashes-the recognized major cause of blunt diaphragmatic ruptures remains endemic in the Low and Medium income countries that span Africa where penetrating thoracoabdominal trauma is also high. However absence of Emergency Medical Systems, trauma systems and poor preventive strategies is the situation in most countries. With these facts it is obvious that missed diaphragmatic injuries and the attendant morbidity and mortality of traumatic diaphragmatic hernias will continue to feature in Africa for some time yet.

9. Recommendations

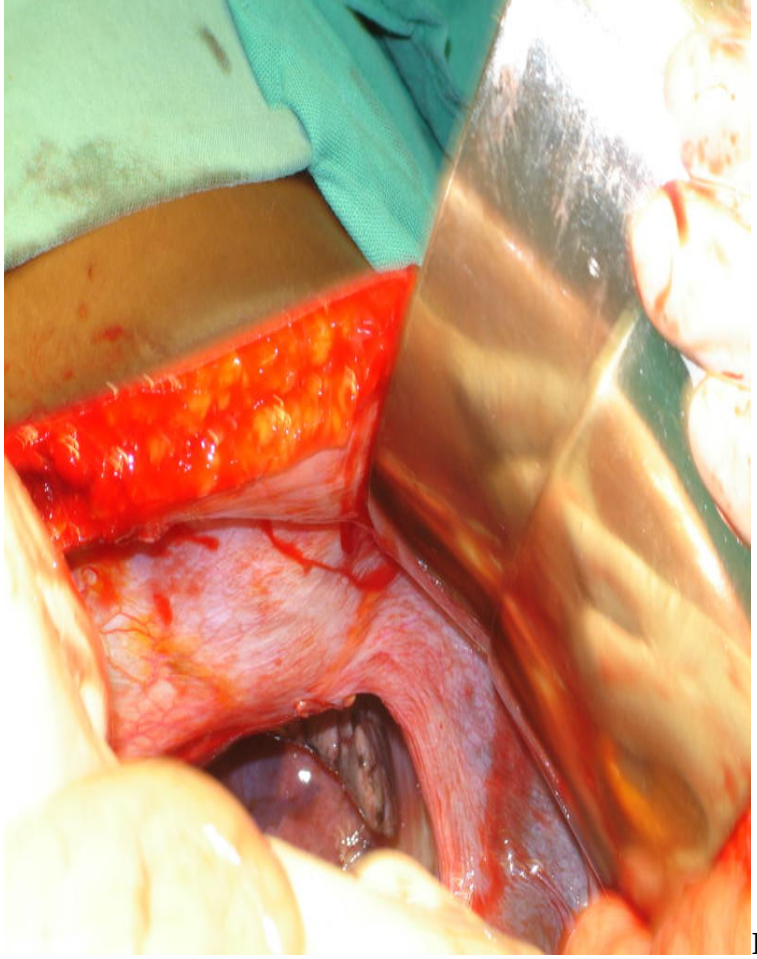
1. African governments must respond to the challenge posed by trauma and design trauma systems encompassing both treatment and preventive strategies.
2. Efforts must be made to acquire modern equipment such as mentioned above at least in specialized centres.
3. Surgeons and radiologists dealing with trauma in Africa must maintain a high index of suspicion for diaphragmatic injuries.
4. Serial plain chest radiographs and conventional CT scanners (which are becoming more readily available) are the appropriate investigations to reduce the incidence of missed diaphragmatic injuries in Africa.
5. Digital wound exploration has a high sensitivity and specificity for diaphragmatic injury in the case of penetrating trauma.
6. African surgeons practicing in resource challenged settings should consider laparotomy in cases in which a high chance of diaphragmatic injury is present.



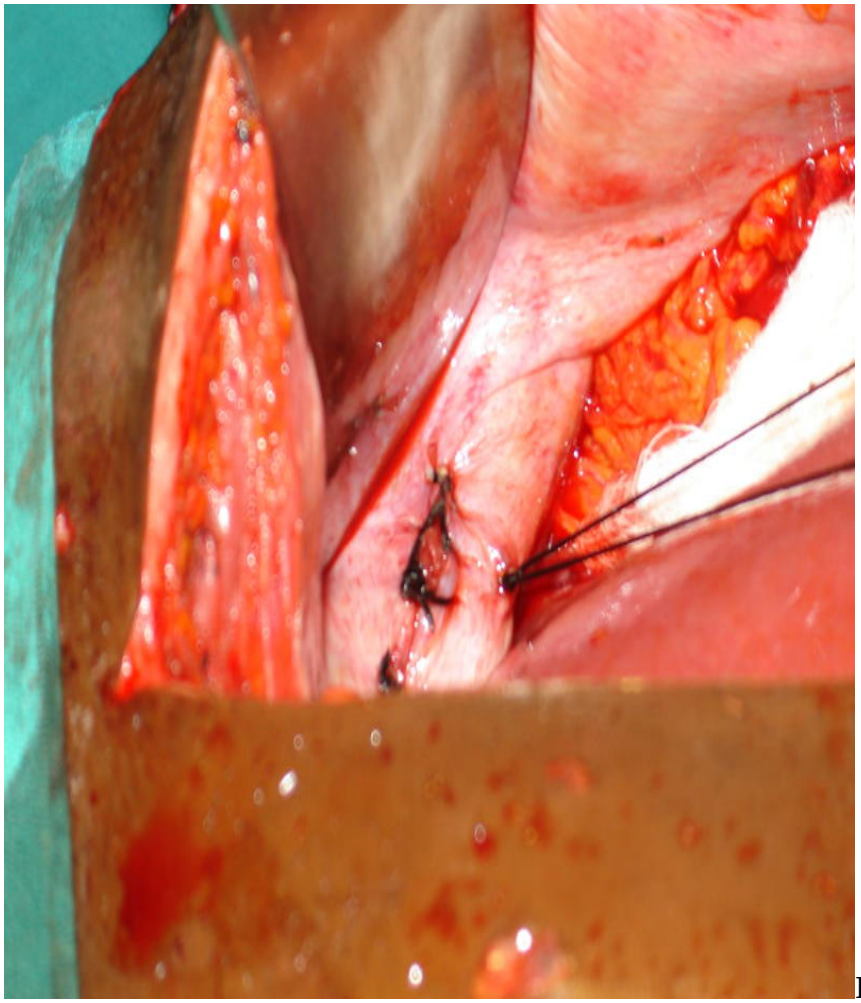
Gastrothorax



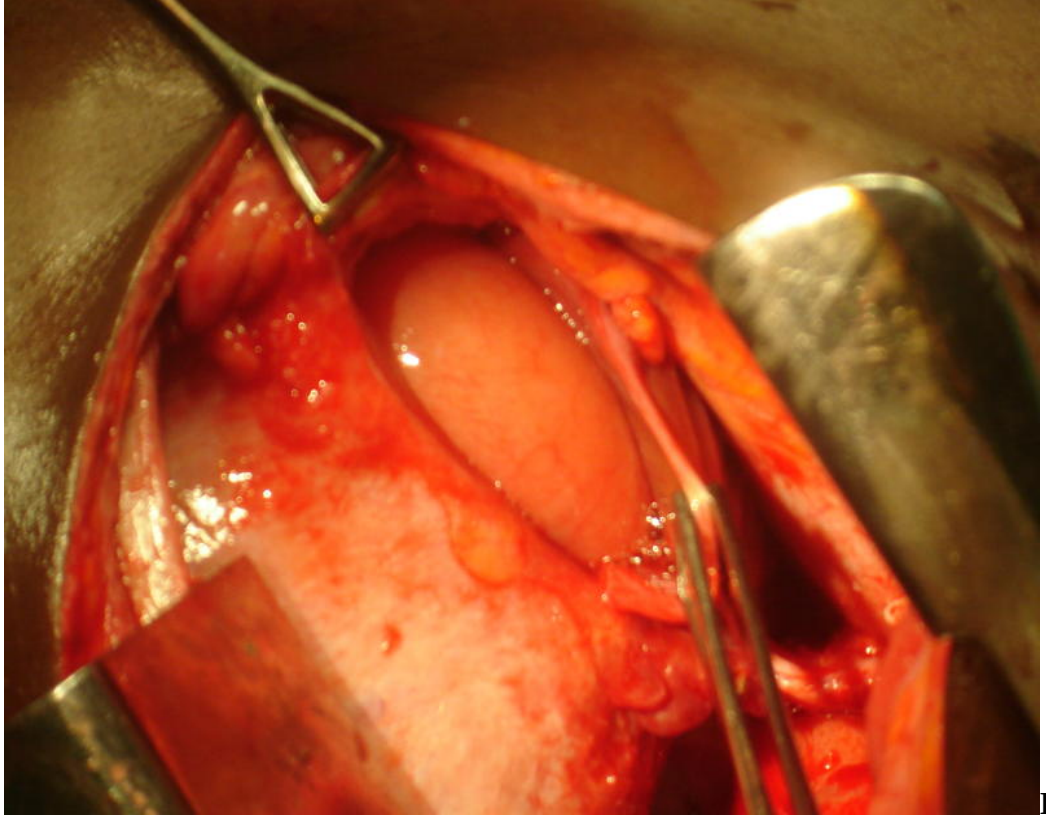
Nasogastric tube in the chest with colonic loops



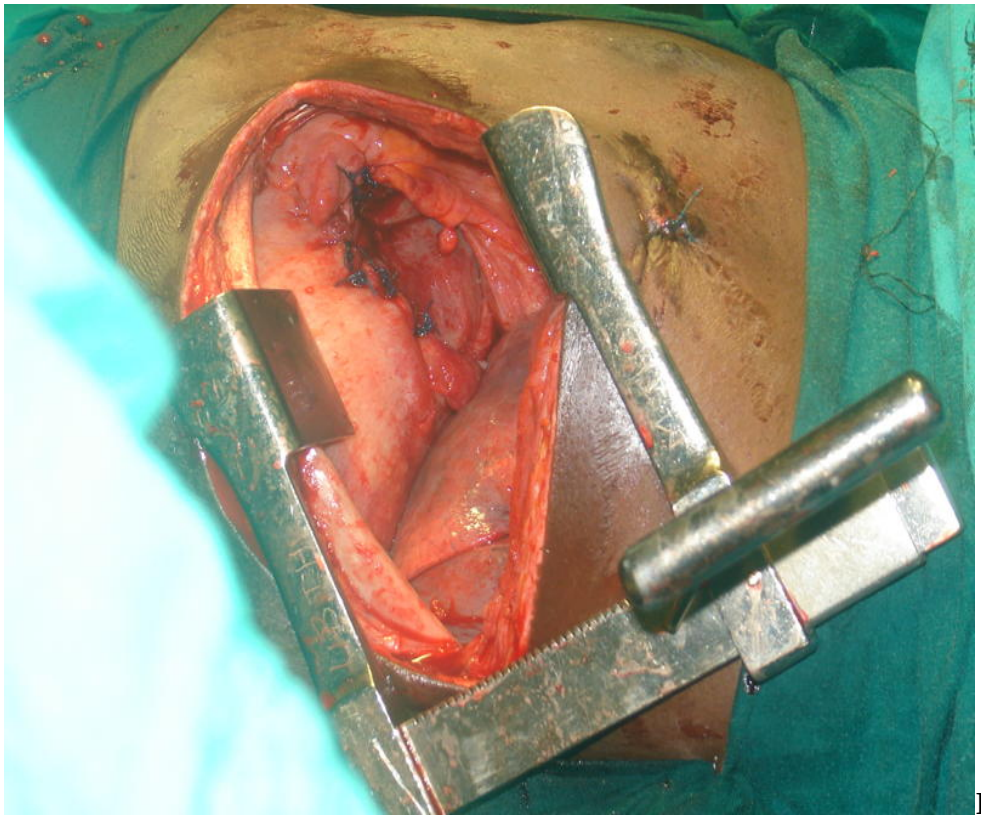
Blunt diaphragmatic rupture viewed from the abdomen



Diaphragmatic rupture repair via laparotomy



Blunt diaphragmatic rupture viewed from the chest



Diaphragmatic rupture repaired via laparotomy

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10. References

(1) Rubikas R. Diaphragmatic injuries. Eur.J.Cardiothorac.Surg. 2001 Jul;20(1):53-57 .http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96250

(2) Reiff DA, McGwin G,Jr, Metzger J, Windham ST, Doss M, Rue LW,3rd. Identifying injuries and motor vehicle collision characteristics that together are suggestive of diaphragmatic rupture. J.Trauma 2002 Dec;53(6):1139-1145.

(3) Savoie PH, Bonnet PM, Avaro JP, Peycru T, Bertani A, Farthouat P. Recent injuries to the left diaphragm: value of laparoscopy in Africa and Europe. Med.Trop.(Mars) 2008 Oct;68(5):529-532. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96254

(4) Cupitt JM, Smith MB. Missed diaphragm rupture following blunt trauma. Anaesthesia & Intensive Care 2001 Jun;29(3):292-296. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96255

(5) Montresor E, Procacci V, Guarise A, Minniti S, Bortolasi L, Nifosi F, et al. Strangulated traumatic hernia of the diaphragm. A report of two cases. Chirurgia Ialiana 1999(51):471-476. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96256

(6) Ahmad J, Beattie GC, Kennedy R, Clements WDB, Kennedy JA. Penetrating trauma to the junctional zone needs aggressive management. BMJ 2007;334:257-258. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96257

(7) Montresor E, Bortolasi L, Ragni E, Attino M, Margiante M, Puchetti V. Delayed traumatic hernia of the diaphragm presenting with hypertensive pneumothorax. Giornale di Chirurgia 1997;18:295-296. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96259

(8) Tsang J, Ryan F. Delayed diaphragmatic herniation masquerading as a complicated parapneumonic effusion. Canadian Respiratory Journal 1999 Jul-Aug;6(4):361-366**.** http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96260

(9) Leoncini G, Lurilli L, Lupi P, Catrabone U. Intrathoracic perforation of the gastric fundus as a late complication of an unknown post traumatic rupture of the diaphragm. Giornale di Chirurgia 1998;19:235-238. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96261

(10) Degiannis E, Levy RD, Sofianos C, Potokar T, Florizoone MG, Saadia R. Diaphragmatic herniation after penetrating trauma. Br.J.Surg. 1996 Jan;83(1):88-91. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96262

(11) Reber PU, Schmied B, Seiler CA, Baer HU, Patel AG, Buchler MW. Missed diaphragmatic injuries and their long-term sequelae. J.Trauma 1998 Jan;44(1):183-188. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96263

(12) Clarke DL, Greatorex B, Oosthuizen GV, Muckart DJ. The spectrum of diaphragmatic injury in a busy metropolitan surgical service. Injury 2009 200909;40(9):932-937.

(13) Feliciano D, Mattox K, Moore E. Trauma 5th Edition ; 2004.

(14) Adegboye VO, Ladipo JK, Adebo OA, Brimmo AI. Diaphragmatic injuries. African Journal of Medicine & Medical Sciences 2002 Jun;31(2):149-153.

(15) Steinau G, Bosman D, Dreuw B, Schumpelick V. [Diaphragmatic injuries--classification, diagnosis and therapy]. Chirurg 1997 May;68(5):509-512. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96264

(16) Pikoulis E, Delis S, Scandalakis P, Leppainiemi AK, Derlopas K, Geranios A, et al. Reliability of initial chest radiographs in the diagnosis of blunt diaphragmatic rupture. Ann.Chir.Gynaecol. 2000;89(1):10-13. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96265

(17) Shapiro MJ, Heiberg E, Durham RM, Luchtefeld W, Mazuski JE. The unreliability of CT scans and initial chest radiographs in evaluating blunt trauma induced diaphragmatic rupture. Clinical Radiology 1996;51:27-30. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96267

(18) Mansour KA. Trauma to the diaphragm. Chest Surgery Clinics of North America 1997;7:373-383. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96270

(19) Wael CH, Lorenzo EF, Paola F, Tarek R, David SM. The current status of traumatic diaphragmatic injury: lessons learned from 105 patients over 13 years. Ann Thorac Surg 2008;85:1044-1048. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96271

(20) Kearny PA, Rouhana SW, Burney RE. Blunt rupture of the diaphragm: mechanism, diagnosis and treatment. Ann Emerg Med 1989;18:1328-1330. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96272

(21) Reiff DA, Davis RP, MacLennan PA, McGwin G,Jr, Clements R, Rue LW,3rd. The association between body mass index and diaphragm injury among motor vehicle collision occupants. J.Trauma 2004 Dec;57(6):1324-8; discussion 1328. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96273

(22) Murray JA, Demetriades D, Cornwell EE,3rd, Asensio JA, Velmahos G, Belzberg H, et al. Penetrating left thoracoabdominal trauma: the incidence and clinical presentation of diaphragm injuries. Journal of Trauma-Injury Infection & Critical Care 1997 Oct;43(4):624-626. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96274

(23) Luc JM, Mortel M, Guido CYJ, Luc C. Acute post-traumatic gastrothorax, a tension pneumothorax-like injury. European Journal of Emergency Medicine 2003;10:344-346. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96276

(24) Shanmuganathan K, Killeen K, Mirvis SE, White CS. Imaging of diaphragmatic injuries. J.Thorac.Imaging 2000 Apr;15(2):104-111.

(25) Clint WS. Imaging of diaphragmatic injuries. Radiol Clin N Am 2006;44:199-211.

(26) Stuart EM. Imaging hemidiaphragmatic injury. Eur Radiol 2007;17:1411-1421. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96279

(27) Matsevych OY. Blunt diaphragmatic rupture: four year's experience. Hernia 2008 Feb;12(1):73-78. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96280

(28) Bergin D, Ennis R, Keogh C, Fenlon HM, Murray JG. The "dependent viscera" sign in CT diagnosis of blunt traumatic diaphragmatic rupture. AJR Am.J.Roentgenol. 2001 Nov;177(5):1137-1140. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96281

(29) Killeen KL, Mirvis SE, Shanmuganathan K. Helical CT of diaphragmatic rupture caused by blunt trauma. AJR.American Journal of Roentgenology 1999;173(6):1611-1616. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96282

(30) Scaglione M, Pinto F, Grassi R, Romano S, Giovine S, Sacco M, et al. [Diagnostic sensitivity of computerized tomography in closed trauma of the diaphragm. Retrospective study of 35 consecutive cases]. Radiol.Med. 2000 Jan-Feb;99(1-2):46-50. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96283

(31) Shanmuganathan K, Mirvis SE, Chiu WC, Killeen KL, Hogan GJ, Scalea TM. Penetrating torso trauma: triple-contrast helical CT in peritoneal violation and organ injury--a prospective study in 200 patients. Radiology 2004 Jun;231(3):775-784. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96284

(32) Stein MS, York GBB,S., Shamuganathan K, Haan JM, Scalea TM. Accuracy of Computed tomography scans in the detection of penetrating diaphragm injury. J Trauma 2007;63:538-543.

(33) Kim HH, Shin YR, Kim KJ, Hwang SS, Ha HK, Byun JY, et al. Blunt traumatic rupture of the diaphragm: sonographic diagnosis. J.Ultrasound Med. 1997 Sep;16(9):593-598. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96473

(34) Mirvis SE, Shamuganathan K. Imaging of thoracic trauma. Magnetic Resonance Imaging Clinics of North America 2000;8:91-104. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96474

(35) Shaw JMN,P.H. Laparoscopy-assisted repair of diaphragm injuries. World J Surg 2003;27:671-674. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96475

(36) Simon RJ, Rabin J, Kuhis D. Impact of increased use of laparoscopy on negative laparotomy rates after penetrating trauma. J Trauma 2002;53:297-302. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96476

(37) Friese RS, Coln CE, Gentilello LM. Laparoscopy is sufficient to exclude occult diaphragm injury after penetrating abdominal trauma. Journal of Trauma-Injury Infection & Critical Care 2005 Apr;58(4):789-792. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96477

(38) Martin I, O'Rourke N, Gotley D, Smithers M. Laparoscopy in the management of diaphragmatic rupture due to blunt trauma. ANZ J Surgery 1998;68:584-586. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96478

(39) Morales CH, Villegras MI, Angel W, Vasquez JJ. Value of digital exploration for diagnosing injuries to the left side of the diaphragm caused by stab wounds. Archives of Surgery 2001;136:1131-1135. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96479

(40) Konobu T, Hata M, Imanishi M, Inada Y, Murao Y, Okuchi K, et al. [Penetrating lung and diaphragmatic injuries with no abnormal finding of chest X-ray: a case report]. Kyobu Geka - Japanese Journal of Thoracic Surgery 2000 Nov;53(12):1049-1051. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96480

(41) Nel JH, Warren BL. Thoracoscopic evaluation of the diaphragm in patients with knife wounds of the left lower chest. Br J Surg 1994;81:713-714. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96481

(42) Pitcher G. Fiber-endoscopic thoracoscopy for diaphragmatic injury in children. Semin.Pediatr.Surg. 2001 Feb;10(1):17-19. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96482

(43) Cass SR, Richardson JD. Role of thoracoscopy in acute management of chest injury. Curr Opin Crit Care 2006;12:584-589. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96484

(44) Freeman RK, Al-Dossari G, Hutcheson KA, Huber L, Jessen ME, Meyer DM, et al. Indications for using video-assisted thoracoscopic surgery to diagnose diaphragmatic injuries after penetrating chest trauma. Ann.Thorac.Surg. 2001 Aug;72(2):342-347. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96485

(45) Hirschberg A, Wall MJ, Allen MK, Mattox KL. Double jeopardy: Thoracoabdominal injuries requiring surgical intervention in chest and abdomen. J Trauma 1995;39:225-231.

(46) Philip JF, Raleigh BK. Combined blunt thoracic aortic and abdominal trauma: diadnostic and treatment priorities. Southern Medical Journal 2000;93:865-867.

(47) Charalambros Z, Sokratis F, Ioannis K, Panayiotis D, Konstantinos B, Ion B. Right diaphragm rupture with extended traumatic dissection of the descending aorta. Ann Thorac Surg 2006;82:e1-e2. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96486

(48) Benjamin NJT, Simon RK. Bilateral thoracoabdominal impalement: Avoiding pitfalls in the management of impalement injuries. J Trauma 2000;49:1135-1137. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96487

(49) Sharma OP. Pericardio-diaphragmatic rupture: five new cases and literature review. J Emerg Med 1999;17(963-968). http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96488

(50) Eric B, David C, Sebastien R, Gills B, Ronald D, David E, et al. Impact of deferred treatment of blunt diaphragmatic rupture: a 15-year experience in six trauma centres in Quebec. J Trauma 2000;52:633-640.

(51) Barsness KA, Bensard DD, Ciesla D, Partrick DA, Hendrickson R, Karrer FM. Blunt diaphragmatic rupture in children. Journal of Trauma-Injury Infection & Critical Care 2004 Jan;56(1):80-82. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96489

(52) Karnak I, Senocak ME, Tanyel FC, Buyukpamukcu N. Diaphragmatic injuries in childhood. Surg.Today 2001;31(1):5-11. http://simplelink.library.utoronto.ca.myaccess.library.utoronto.ca/url.cfm/96490

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