

Traumatic Diaphragmatic Rupture

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SUMMARY

The experience with traumatic diaphragmatic hernia at the Johannesburg General Hospital between 1959 and 1973 is described. The mechanisms responsible for producing diaphragmatic rupture by blunt trauma, are discussed. The radiological diagnosis is discussed and the importance of artificially-induced pneumoperitoneum as a diagnostic aid is stressed. The thoracic approach is advocated in all cases, except for the acute case often associated with other intra-abdominal injuries. Traumatic diaphragmatic hernia is a fairly rare condition, the diagnosis of which is often missed at the original presentation. It is a fairly benign condition; death usually only occurs when it is associated with multiple severe injuries.

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Traumatic diaphragmatic rupture is an uncommon occurrence, being found in about 3,4% of all patients requiring surgery for abdominal injuries.¹

Although a relatively rare condition, it extends far into the annals of medical history. Traumatic diaphragmatic herniation was first described in 1541 by Sennertus.² In 1579 Ambrose Pare described 2 cases of traumatic diaphragmatic hernia. One of his patients, an artillery captain, lived for 8 months after a gunshot wound through the chest. At autopsy he was found to have a transverse colon herniated through a thumb-sized rent in the diaphragm.³ The diagnosis of traumatic diaphragmatic hernia in a living person was first made by an American, H. I. Bowditch, in 1853. The first successful repair of a lacerated diaphragm produced by a penetrating injury was effected in 1886 by Riolfi. In 1899 Walker successfully reduced a diaphragmatic hernia and repaired the diaphragm in a patient who had been crushed beneath a falling tree.²

This article describes the experience with traumatic diaphragmatic rupture at the Johannesburg General Hospital from 1959 to 1973. Thirty patients have been traced, of whom 21 were males and 9 females. The average age was 34,3 years, with 80% of the patients between 20 and 40 years old.

AETIOLOGY

The vast majority of traumatic diaphragmatic hernias result from either blunt or penetrating trauma. There are also a few reports in the literature of iatrogenic penetration of the diaphragm during subdiaphragmatic surgical pro-

cedures, and occasionally from efforts to introduce a tube into the thoracic cavity.⁴ In our series 63,7% were due to blunt trauma, mainly motor vehicle accidents, and 37,3 were due to either bullet or stab wounds (Table I).

TABLE I. CAUSATIVE AGENTS

Blunt trauma	19	63,7%
Motor vehicle accident	17	
Assault	1	
Spontaneous	1	
Penetrating	11	37,3%
Stab	6	
Bullet	5	

There are 6 case reports in the literature of 'spontaneous' rupture of the diaphragm.^{5,6} The existence of this entity must be somewhat in doubt, and it is our belief that these cases most probably represent cases where previous trauma has been forgotten by the patient, possibly having occurred when the patient was a child. One of our cases would have fallen into this group of so-called 'spontaneous' rupture.

MECHANISMS

A number of mechanisms have been suggested as being responsible for diaphragmatic rupture after blunt trauma. Firstly, blunt trauma to the flanks or abdomen produces a raised intra-abdominal pressure.⁷ The force applied to the abdomen or flanks is, according to Pascal's law, distributed equally in all directions through the fluid abdominal contents. The portion of the left diaphragm that is not buffered by solid viscera or chest wall, being the weakest area to which the force is transmitted, tears.

The second mechanism commonly cited, is that the contracted diaphragm is distorted by opposing forces, leading to a tear in the membrane.⁸ Lucido and Wall⁹ attempted to explain the site of rupture as being most likely to occur in the posterior lateral left leaflet, as this is the embryological point of weakness—the anterior leaflet being derived from the rather strong septum transversum. Bekassy *et al.*⁵ showed that slightly lower pressures were required to rupture the left side of the diaphragm, when compared with the right side *in vitro* experiments.

Probert and Havard,¹⁰ in reviewing their cases caused by falls of coal and rock, or from crushing by trucks and pit cages among coalminers in South Wales, suggested that tearing most probably occurred in association with respiratory effort in a diaphragm fixed by a crushing force. In the final assessment it is most probably a

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combination of factors which causes the diaphragm to rupture from blunt trauma.

SIDE OF THE RUPTURE

The protective mechanism of the liver and an inherent weakness in the left diaphragm are put forward to explain why rupture of the right diaphragm occurs, on the average, in only 11% of cases (Table II). The lesion

TABLE II. SIDE OF DIAPHRAGMATIC RUPTURE AS REPORTED IN THE LITERATURE

	Total	% left	% right	Bilat.
Bekassy <i>et al.</i> ⁵	19	100,0	—	—
Desforges <i>et al.</i> ⁷	16	93,8	6,2	—
Bernatz <i>et al.</i> ¹³	112	92,8	7,2	—
Childress and Grimes ¹⁴	25	92,0	8,0	—
Schwindt and Gale ¹⁵	12	91,7	8,3	—
Ebert <i>et al.</i> ¹⁶	24	91,7	8,3	—
Lucido and Wall ⁹	47	91,6	6,3	2,1
Grage <i>et al.</i> ¹⁷	26	91,5	7,7	3,8
Griswold <i>et al.</i> ¹⁸	11	90,9	9,1	—
Carlson <i>et al.</i> ¹⁹	99	84,9	14,1	1,0
Noon <i>et al.</i> ³	22	81,9	18,1	—
Andrus and Morton ²⁰	32	81,4	15,5	3,1
Johannesburg General Hospital	30	80,1	16,6	3,3
Probert and Havard ¹⁰	15	80,0	20,0	—
Hardy ²¹	11	54,5	45,5	—
Total	524	87,8	11,0	1,2

is increasing in frequency, which is directly related to high-speed deceleration in traffic accidents.

In our series, 24 of the ruptures occurred on the left, 5 on the right and 1 was bilateral.

HERNIATION

Sixteen of our cases of ruptured diaphragm occurred without herniation, whereas 14 were associated with herniation. The organ to herniate most commonly through the diaphragm was the stomach. Other organs found in the chest were colon, small bowel, spleen, omentum and liver (Table III).

TABLE III. TRAUMATIC DIAPHRAGMATIC HERNIA—ORGANS EVISCERATED

	Left	Right
Stomach	9	—
Colon	5	—
Small bowel	4	—
Spleen	1	—
Omentum	1	—
Liver	—	1
None	12	4

CLINICAL PRESENTATION

The common types of clinical presentation of traumatic diaphragmatic rupture were classified by Carter and his associates¹¹ into an early or acute presentation, an interval phase when the patient is essentially asymptomatic, and a late phase, which presents with intestinal obstruction or strangulation. The vast majority of our patients presented in the early phase; 2 were seen in the interval phase and 6 in the phase of strangulation and obstruction. One of the cases presenting with postprandial discomfort, shoulder tip pain and vomiting 1 month after a motor vehicle accident, was shown at operation to have an eviscerated volved stomach.

In about a third of the patients there were no clinical signs or symptoms. The clinical symptoms and signs which were noted are given in Tables IV and V. The most common symptoms were dyspnoea and abdominal pain; the most common signs were dullness on the side of herniation and poor entry at the base.

TABLE IV. TRAUMATIC DIAPHRAGMATIC RUPTURE — SYMPTOMS

Thoracic	No.
Dyspnoea	9
Chest pain	4
Shoulder tip pain	2
Abdominal	
Pain:	10
Epigastric	8
Left hypochondrial	2
Vomiting	7
Constipation	3
None	10

TABLE V. TRAUMATIC DIAPHRAGMATIC HERNIA—SIGNS

Shock	11
Dullness at base	12
Poor air entry	7
Cyanosis	3
Mediastinal shift	3
Bowel sounds in chest	2
None	9

ASSOCIATED INJURIES

Traumatic diaphragmatic rupture is characteristically associated with multiple injuries. It is for this reason that a routine chest X-ray examination should be done in all cases of abdominal injuries, and fractures of the pelvis and lumbar spine. In our series 56,6% of patients had chest injuries, usually a haemo- or pneumothorax. Seventy-three per cent had abdominal injuries; lacerated liver occurred in 43,8%, and ruptured spleen in 33,3% of the cases. Perforation of an abdominal viscus was less common. Skeletal fractures were present in 53,3% and fractured ribs in 33,3%. In 2 patients there were no associated injuries (Table VI).

DIAPHRAGMATIC RUPTURE

TABLE VI. INJURIES ASSOCIATED WITH TRAUMATIC

	No. of patients	% of patients
Chest	17	56,6
Haemoperitoneum	12	
Flail chest	5	
Stab heart	1	
Abdomen	22	73,3
Lacerated liver	13	
Rupture of spleen	10	
Perforated stomach	6	
Perforated colon	4	
Perforated small bowel	2	
Skeletal fractures	16	53,3
Ribs	10	
Pelvis	5	
Other	12	
Concussion	10	33,3

Two patients had no associated injuries.

RADIOLOGY

Traumatic diaphragmatic rupture is often a radiological diagnosis. In our series of 14 cases with herniation, straight chest X-ray examination gave the clue to diagnosis in 12 cases. Either a barium or Gastrografin swallow was done in 2 cases and a barium enema was diagnostic in 1 case. Artificially-induced pneumoperitoneum gave the diagnosis in another. In 2 cases radiology was of no help. Fig. 1 shows an example of the radiological diagnosis of traumatic diaphragmatic rupture. Straight X-ray examination after artificially-induced pneumoperitoneum is one of the most useful diagnostic methods for traumatic diaphragmatic hernia. Six hundred to 1000 cm³ of air should be introduced into the peritoneum. The air in the erect radiograph is seen to lie beneath the diaphragm, outlining it so that organs eviscerated through the diaphragm are clearly seen lying above it. Besides outlining the diaphragm, pneumoperitoneum may produce a pneumothorax, if the hole in the diaphragm is not occluded by the herniated viscus. In our cases the hazard of pneumoperitoneum was shown in that at operation after pneumoperitoneum, air bubbles and blood were found in the mesentery. The only possible cause appeared to be iatrogenic.

DIFFERENTIAL DIAGNOSIS

Two conditions must be considered in the differential diagnosis of traumatic diaphragmatic rupture, viz. pneumothorax and phrenic nerve damage leading to paralysis of the diaphragm. Dyspnoea, absence of breath sounds, dullness and decreased air entry on the affected side can occur in both diaphragmatic rupture and pneumothorax. Diagnostic chest aspiration in cases of doubt carries the danger of injury to the herniated organ. Gastric contents have been aspirated through the chest wall in 2 cases,⁵ and Salomon *et al.*⁶ have reported a case of damage to the spleen during chest aspiration.

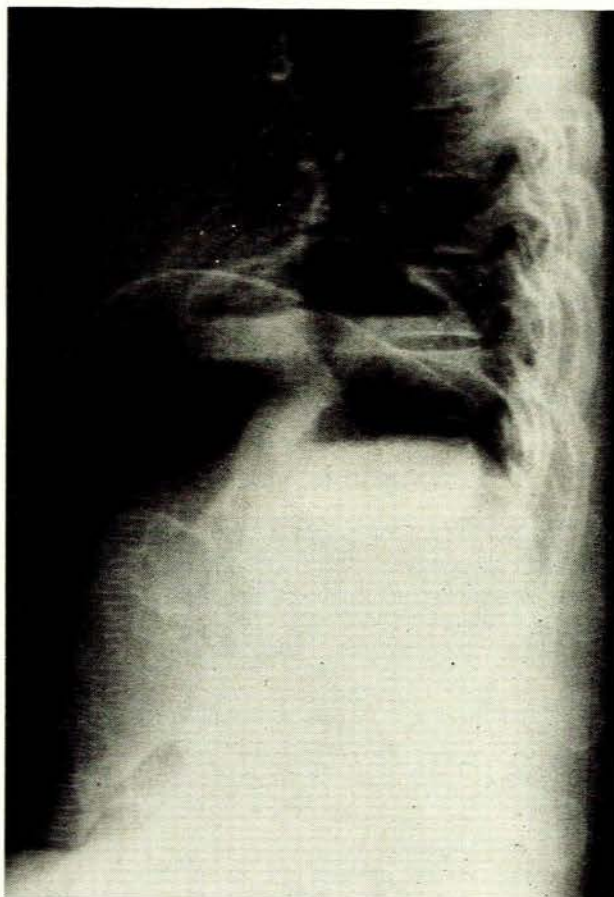


Fig. 1. Lateral chest X-ray film after pneumoperitoneum, clearly showing stomach above both diaphragms.

One case at the Johannesburg General Hospital was explored after phrenic nerve paralysis. On chest radiography the high diaphragm was missed and the stomach was thought to lie in the chest.

TREATMENT

In our series the majority of surgeons chose to approach the repair of a ruptured diaphragm from the abdomen (Table VII). This is in distinct contradiction to the literature, which virtually unanimously advocates the thoracic approach, except in acute cases associated with other abdominal injuries. The main reasons for choosing

TABLE VII. OPERATIVE APPROACH CHOSEN FOR TRAUMATIC DIAPHRAGMATIC RUPTURE REPAIRS

Abdominal	21
Thoracic	4
Thoraco-abdominal	4
None	1
	—
Total	30

the thoracic approach¹¹ are: it gives excellent exposure; bowel is often adherent to lung and thoracic wall and can be freed from the above under direct vision; access to the diaphragmatic orifice is easily gained; and when rupture is near the heart, sutures can be safely and accurately placed avoiding the heart, oesophagus and mediastinal structures.

If after an abdominal approach difficulty is experienced in returning the eviscerated organs through the diaphragmatic tear, an artificial pneumothorax may be induced. This equalises the pressures in thorax and abdomen. Marchand¹² found that the pressure gradient across the diaphragm varied between 7 and 20 cm water with quiet respiration, increasing to 100 cm water with deep respiration. This gradient alone may be sufficient to resist the surgeon's efforts to deliver the eviscerated organs.

COMPLICATIONS

Eleven of the patients had an uncomplicated postoperative course. The major postoperative complication was pleural effusion. Atelectasis, empyema, deep vein thrombosis, and pneumonia occurred less commonly. Stress ulceration, gas gangrene, renal failure, gangrenous bowel and abdo-

minal sinus occurred singly (Table VIII). Tracheostomy and artificial ventilation were required in 6 patients, 5 of whom died. Seven of our 30 patients died.

CONCLUSION

Traumatic diaphragmatic hernia is a fairly rare condition, the diagnosis of which is often missed at the original presentation. In addition, it is a fairly benign condition, death usually occurring only when it is associated with multiple severe injuries.

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TABLE VIII. COMPLICATIONS FOLLOWING TRAUMATIC DIAPHRAGMATIC RUPTURE

Death	7
Uncomplicated	...	...	...	...	11
Complications					
Pleural effusion	...	...	...	...	8
Atelectasis	...	...	...	...	3
Deep vein thrombosis	...	...	...	...	3
Empyema	...	...	...	...	3
Pneumonia	...	...	...	...	2
Miscellaneous	...	...	...	...	5