

## TRAUMATIC DIAPHRAGMATIC HERNIAS: DIAGNOSIS AND MANAGEMENT

## Travmatik diyafragmatik herniler: Teşhis ve tedavi

Yiğit Akçalı<sup>1</sup>, Fahri Oğuzkaya<sup>2</sup>, Berkant Özpolat<sup>2</sup>

**Summary:** Traumatic diaphragmatic hernias are produced either by blunt thoracoabdominal trauma or penetrating wounds of the diaphragm. In this study, 30 patients were managed surgically for diaphragmatic injury. Twentyone patients sustained blunt trauma and 9 patients sustained penetrating trauma. Diaphragmatic perforations were localized 90 % on the left and 10 % on the right. All patients had associated injuries, most commonly herniating a intraabdominal viscus. Eighteen patients underwent a thoracotomy with repair of diaphragm, 3 patients were intervened with thorcoabdominal approach, and 9 patients received a celiotomy following tube thoracostomy at the beginning due to hemothorax and/or hemopneumothorax. There were 4 deaths, unrelated to the diaphragmatic injury. All survivors recovered without sequelae. Diaphragmatic injury with visceral herniation must be considered in any patient suffering penetrating or blunt thoracoabdominal injury. Morbidity and mortality can be minimized by a high index of suspicion, urgent recognition, and surgical repair of even the smallest diaphragmatic tear.

**Key Words:** Traumatic diaphragmatic rupture, Hernia.

**Özet:** Travmatik diyafragmatik herniler ya künt torakoabdominal travma ya da diyafragmanın penetran yaralanmalarından oluşur. Bu çalışmada, diyafragma yaralanması dolayısıyla 30 hasta cerrahî olarak tedavi edildi. Yirmibir hasta künt travmadan ve dokuz hasta penetran travmadan yaralanmıştı. Diyafragmatik perforasyonlar solda % 90 ve sağda % 10 lokalizeydi. Tüm hastalarda çoğunluğu herniye intraabdominal organlardan olan yaralanmalar mevcuttu. Onsekiz hastaya diyafragma onarımlı torakotomi uygulandı, 3 hastaya torakoabdominal bir yaklaşımla müdahale edildi ve 9 hastaya hemotoraks ve/veya hemopnömotoraksa bağlı olarak başlangıçtaki tüp torakostomisini takiben çelyotomi yapıldı. Diyafragmatik yaralanmaya bağlı olmayan 4 ölüm vardı. Sağ kalanların tümü herhangi bir sekel olmaksızın iyileşti. Visseral herniasyonlu diyafragmatik yaralanma, penetran veya künt torakoabdominal yaralanmalı herhangi bir hastada düşünülmelidir. Morbidite ve mortalite, kuşkulama, ivedi tanı ve çok küçük diyafragma tik yırtıkların bile cerrahî onarımıyla azaltılabilir.

**Anahtar Kelimeler:** Travmatik diyafragma rüptürü, Herni.

**T**raumatic diaphragmatic hernia, which was first reported by Sennertus in 1541, may be caused by penetrating (10-15 % of patients with penetrating injury to the lower thorax) or blunt trauma (3-5 % of patients with blunt injury to the abdomen) (6,11,23). Traumatic diaphragmatic rupture with visceral herniation have three clinical stages (1); The acute phase (immediate or traumatic phase)

Erciyes University Faculty of Medicine, 38039 Kayseri-TÜRKİYE  
Department of Thoracic and Cardiovascular Surgery. Assist.  
Assoc.Prof.<sup>1</sup>, Resident<sup>2</sup>.

during which the signs and symptoms reflect injury to the intrathoracic and intra-abdominal contents and mediastinal shift. This injury may be masked by sign referable to the pleural cavity or gastrointestinal tract (2). The interval phase (latent phase) is generally silent. After recovering from the original injury, which may have occurred days or even years before, the patients with vague upper abdominal or thoracic symptoms which may be variously attributed to the cardiac, gastrointestinal or biliary systems. The latent phase also includes those cases discovered on

routine chest roentgenography (3); In the late stage (the phase of obstruction or strangulation) complications of the herniated intra-abdominal viscera develops, such as bowel obstruction, gangrene, gastric stasis with bleeding, and cardiorespiratory compression with chest pain, dyspnoea or a pleural effusion (6, 21).

Traumatic diaphragmatic hernia is relatively rare (11). The purpose of our study is to review the experience of thirty cases of traumatic diaphragmatic rupture at the Department of Thoracic and Cardiovascular Surgery during a 13-year period and to identify those clinical elements that may permit earlier diagnosis and urgent management.

## METHODS

There were thirty patients with diaphragmatic rupture. Nineteen were male (63.3 %) and 11 were female (36.6 %). Their ages ranged from 3 to 74 years, with a mean age of 32 years. Blunt trauma was responsible for the injury in 70 % and penetrating trauma in 30 %. Third of the penetrating injuries were caused by gunshot or shotgun (Figure 1). Twelve patients (40.0 %) were diagnosed in the acute (traumatic) phase and 18 patients (60.0 %) in the interval (delayed) phase. The clinical data are summarized in table 1.

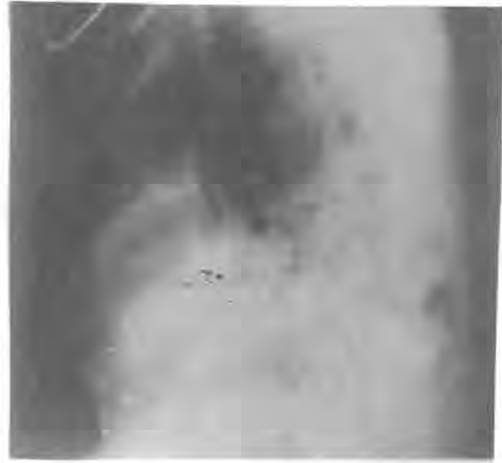


Figure 1. Thoracoabdominal radiograph of the patient with penetrating injury which was caused by gunshot.

Nine patients were admitted to the emergency department with a systolic BP of less than 90 mmHg, and two of them had a profound shock.

The correct diagnosis was made within 24 hours of admission in 12 patients. Diagnostic delay of more than 24 hours occurred in 18 patients.

Traumatic diaphragmatic hernia through the left hemidiaphragm occurred in 25 patients. Hernias

Table 1. Type of injury and time of presentation

	D i a g n o s i s	
	Traumatic (acute)	Interval (delayed)
Mechanism of injury		
Blunt	26.7	43.3
Automobile accident or collision	20.0	40.0
Falling from a high place	6.7	3.3
Penetrating	13.3	16.7
Stab wound	3.3	16.7
Gunshot/shotgun wound	10.0	0.0
Site of herniation		
Right hernidiaphragm	13.3	0.0
Left hemidiaphragm	26.7	60.0



Figure 2. Chest radiograph shows loss of left hemidiaphragm contour and a large gas collection at left lung base.

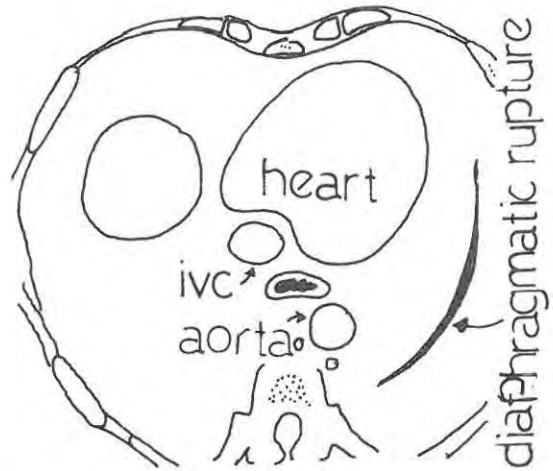


Figure 4. Schematic cross section of abdomen at the diaphragmatic level

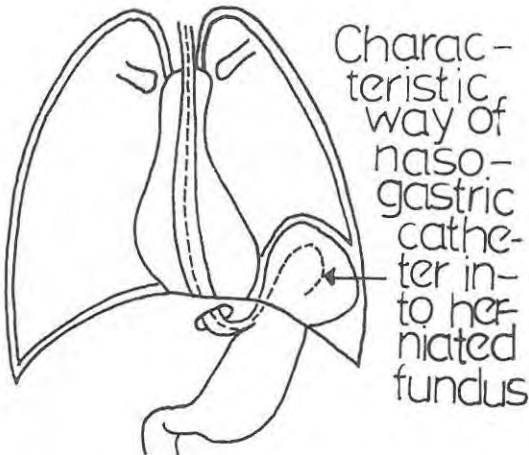


Figure 3. Contrast study with barium in a patient with diaphragmatic hernia.



Figure 5. Schematic representations of intrathoracic stomach herniating through diaphragmatic tear. Note the gastroesophageal junction that occupies its normal anatomic position.

through the right hemidiaphragm did not occur in any patient.

All but 5 of the patients had an injury the fifth intercostal space or above the umbilicus. Thoracic and/or abdominal pain, and/or dyspnea were noted in each acutely traumatized patient.

Physical examination revealed bowel sounds in the chest in four of 25 patients with herniated viscus. This auscultatory finding was considered as pathognomonic of diaphragmatic hernia. Dullness of tympany on thoracic percussion and decreased breath sounds were found in three fifth of the cases with hermitated viscus. Chest aspiration diagnosis

was facilitated by an awareness of the possibility of traumatic diaphragmatic hernia and confirmed by radiological examination. Plain chest radiograms were abnormal in four fifth of all cases (Figure 2). Recognition of lacerated diaphragm was obtained by passing a nasogastric tube and observing its location above the diaphragm or, if the colon was herniated, by performing a barium sulfate enema (Figure 3). The clinical and radiological findings are depicted in table 2.

Celiotomy was considered preferable in the acute phase because of the high incidence of intraperitoneal injury, and this approach via the abdomen was used in 30 % of our cases. The peritoneal and thoracic cavities were thoroughly irrigated with warm saline and the diaphragm was repaired with interrupted heavy nonabsorbable sutures. Surgical exploration was performed via a thoracotomy incision in 18 patients. Nonabsorbable suture was also used to repair the hernia in all cases.

Table 2. Diagnostic clinical and radiological findings

Findings	n	%
Clinical		
History		
Pericostal trauma	30	100.0
Dyspnea	21	70.0
Chest pain	22	73.3
Abdominal pain	11	36.6
Physical examination		
Decreased breath sounds*	23	76.6
Abnormal thoracic percussion*	23	76.6
Intercostal tenderness	19	63.6
Abdominal tenderness	10	33.3
Bowel sounds in thorax	8	26.6
Drainage of gastric contents or peritoneal lavage fluid from chest drainage tubes***	2	6.6
Radiologic		
Ruptured right hemidiaphragm		
Raised right hemidiaphragm **	1	3.3
Obscured right hemidiaphragm **	1	3.3
Ipsilateral costal fracture	3	10.0
Diagnostic pneumoperitoneum	1	3.3
Ruptured left hemidiaphragm		
Raised apparent hemidiaphragm	25	83.3
Air-containing viscus/viscera in thorax i.e., gas bubbles in chest ***	15	50.0
Obscured or discontinuous diaphragm contour	26	86.6
Mediastinal shift	18	60.0
raised tip of nasogastric catheter (" nasogastric tube sign ") ***	9	36.0
Fractured ribs	17	56.6
Positive barium study ***	11	36.6
Pleural finding (collapse, air and/or fluid in thorax) **	12	40.0
Normal chest film (misleading)	3	10.0
Normal barium study	1	3.3
Diagnostic pneumoperitoneum	5	16.6

\* = nonspecific, \*\* = associated, \*\*\* = pathognomonic.

Table 3. Surgical treatment

Incision	D i a g n o s i s	
	Acute (immediate)	Interval (delayed)
Thoracotomy	0	18
Celiotomy	9	0
Combined	3	0
Total	12	18

Table 4. Thoracic, abdominal and other system complications associated with diaphragmatic rupture

Complication	n	%
<b>Thoracic</b>		
Chest wall injury-open pneumothorax	1	3.3
Subcutaneous emphysema	4	13.3
Multiple costal fracture	14	46.6
Hemothorax and/or hemopneumothorax*	21	70.0
Cardiac compression (enteropericardium)*	1	3.3
Myocardial injury	1	3.3
<b>Abdominal</b>		
Hepatic laceration	2	6.6
Interrupted renal hilus	1	3.3
Gastric rupture	1	3.3
Splenic laceration	3	10.0
Herniated viscus	26	86.6
stomach	9	30.3
colon	6	20.0
spleen**	3	10.0
others (great omentum, jejunum, liver, kidney)	8	26.6
<b>Others</b>		
Ischion pubis and acetabular fractures	1	3.3
Cranial (occipital) injury, cerebral contusion	1	3.3
<b>Systemic</b>		
Profound shock***	2	6.6

\* In this patient who occurred both diaphragmatic and pericardial rupture with blunt chest injury, the colon which herniated through ruptured pericardium caused the cardiac tamponade

\*\* One patient with penetrating diaphragmatic injury due to stab wound had an isolated splenic herniation, and the spleen had been attached to atelectatic lower lobe of the left lung.

\*\*\* These patient who were complicated with hemopneumothoraces as a result of blunt chest injury were undergone the urgent thoracotomy because the blood over 1500 mL was drained immediately from drains of thoracostomy which they were inserted within the pleural space in emergency room. In fact that the origin of blood in pleural cavity of both the patients was from the injury of subdiaphragmatic viscera, and the blood had been oozed within pleural cavity through ruptured diaphragm. It surprised that peritoneal lavage which were performed in both patients was negative (i.e., false-negative).

Table 5. The causes for the death of diaphragmatic injury

Cause	n	%
Respiratory insufficiency	2	6.6
Exsanguination	1	3.3
Cerebral contusion	1	3.3
Total	4	13.3

and the thoracic cavity was routinely drained. Management modalities are listed in Table 3.

## RESULTS

The three patients who had urgently a thoracotomy had repair of two heart ("enteropericardium" with subsequent cardiac compression, and cardiac injury with extensive myocardial defect). All of these patients survived. Various thoracic and abdominal complications were together with diaphragmatic rupture. Table 4 outlines these complications associated with diaphragmatic rupture.

The average hospital stay was eleven days. Postoperative complications such as empyema developed in four patients. The mortality rate was 16.6 per cent. The causes for the deaths are shown in Table 5.

## DISCUSSION

It has been reported that diaphragmatic injuries occur seven times more frequently in the male population (3). In our own series, there were 19 male and 11 female patients.

In a series (19), the authors reported that all patients with diaphragmatic hernias had some suggestion of injury on physical examination. By contrast, in two different series, it has been reported that 55 % of blunt trauma and 44 % of penetrating trauma were not recognized on physical examination (3), and that 30 % of stab wound patients and 20 % patients with gunshot/shotgun wounds to the lower chest and upper abdomen had negative clinical findings (17).

If a patient with thoracoabdominal trauma has some clinical findings such as pericostal injury, fracture of pelvis or lumbar spine reflecting a major compression of the torso, dyspnea, pain in the lower chest or upper abdomen, particularly if referred to the shoulder, dullness or tympany over the lower thorax, mediastinal shift or bowel sounds in the chest, it should be suspected from traumatic hernia and performed prompt further diagnostic investigation (17).

Crush injuries secondary to automobile accidents or collisions and penetrating trauma are the primary causes of traumatic diaphragmatic hernias. In literature (17, 19), 15-21 % of patients with lower-thoracic and/or abdominal stab wounds and 46-59 % of patients with lower thoracic and/or abdominal gunshot wounds had diaphragmatic injuries.

The quickness of the diagnosis are affected by the mechanism of injury. When the hernias are due to blunt trauma, major force is required to disrupt the diaphragm, and other visceral injury usually occurs, being an indication for celiotomy. Accordingly, most hernias due to blunt trauma are promptly identified and repaired (13). Left-sided blunt hemidiaphragmatic injury predominates, probably because of the protective effect of the liver on the right and the heart in the center, and a particular weakness in the posterolateral aspect of the left hemidiaphragm (10,16). In all reported series traumatic diaphragmatic hernia occurs in the rate of 77-97 percent on the left side (3, 5, 6, 15, 19). This rate was 83.3 percent in our cases.

Regardless of whether the forces exerted on the chest

occur in the anteroposterior or lateral direction, the diaphragmatic rupture usually is centrally located and spares the esophageal hiatus (Figure 4.) Eighty-four percent of traumatic ruptures due to penetrating injury have a defect shorter than 2 cm, whereas diaphragmatic tears due to blunt trauma are more than 2 cm long with the majority being over 10 cm long (15, 20). The cardia of the stomach therefore lies in its normal anatomic position. The most frequently herniated segments are the fundus and greater curvature of the stomach. In such cases, the nasogastric tube will extend inferiorly below the normal gastroesophageal junction and then form an upward curve into the herniated part of the stomach within the left hemithorax (20) (Figure 5).

Thoracic or abdominal blunt injuries produce a marked increase in intrathoracic or intraabdominal pressure, usually resulting in a tear in the posterior central section of the diaphragm. The initial diaphragmatic defect may be quite small, but an actual herniation was occurred much later by pleuroperitoneal pressure gradients (\*) which serve to draw or "suck" abdominal viscera into the thorax (19). We do not identify a particular pattern of site of diaphragmatic rupture, usually occurs centrally and spares esophageal hiatus, in our own series.

Most diaphragmatic injuries due to stab wounds occur to the left hemidiaphragm and may reflect the way of attack by predominantly right-handed assailant, whereas diaphragmatic injuries due to gunshot are equally distributed between both sides (19).

That missed diaphragmatic injury from stab wounds causes the majority of chronic hernias is born out by others (6,19). In our series, 83.3 percent of diaphragmatic injuries due to stab wound occurred in the interval (delayed) phase (1 to 5 days).

Traumatic diaphragmatic hernias also can be caused by iatrogenic injuries such as Smithwick's sympathectomy, truncal vago tomy, or Allison's hiatal hernia repair (9, 16). In this series, there was no iatrogenic diaphragmatic injury.

(\*) Pleuroperitoneal pressure gradients have 7 to 20 cm H<sub>2</sub>O at rest and over 100 cm H<sub>2</sub>O on deep inspiration.

In cases of traumatic diaphragmatic rupture, associated injuries are more commonly found in patients with injuries to the left side. Traumatic diaphragmatic ruptures may associate with an aortic injury (11). In review of our cases with diaphragmatic injury, we did not found any aortic injury.

We have found one case with herniation of the colon to the pericardium, with subsequent cardiac compression. In literature, traumatic pericardial diaphragmatic hernia is rare (10,17,18).

The diaphragm can be ruptured even without external force ("spontaneous" rupture); just the mere interplay of pressures within thorax can tear it. The creation of a significant pressure gradient across the diaphragm is the main mechanism for rupture. A similar mechanism appears to apply to traumatic rupture of the trachea, bronchus, or esophagus (11).

Regardless of the mechanism of injury, the early recognition of an occult hernia usually depends on a high index of suspicion (3,11,17). In our series, eighty-six percent of the patients were correctly diagnosed prior to surgery. The preoperative diagnosis of traumatic diaphragmatic rupture due to blunt trauma is difficult (3). The injury may be initially overlooked because of other more immediate life-threatening conditions in the patient with multiple injuries. In 16.6 percent of our patients, the early thoracotomy had been performed because of other more urgent life-threatening conditions such as enteropericardium, large hemothoraces, or myocardial injury.

The serial chest radiograph remains the primary, easiest, and most reliable diagnostic procedure in the diagnosis of blunt diaphragmatic rupture, although various radiologic methods have been proposed for establishing the preoperative diagnosis after blunt thoracic trauma (3,19,20). All of our cases demonstrated some abnormality on the initial chest roentgenogram, the most common being interpretation of an elevated diaphragm and/or significant hemothorax and/or hemopneumothorax (70 %), as compared with 34 % of hemothorax and 31 % of hemopneumothorax in a series (3).

No evidence of injury can be detected in these roentgenograms. In a series (3), 17 % of patients with blunt trauma and 42 % of patients with penetrating trauma had normal films. The following roentgenographic findings may be suggestive or diagnostic of traumatic diaphragmatic rupture; an elevated hemidiaphragm; pleural effusion in associated with strangulated bowel; platelike atelectasis above an indistinct diaphragm (if a herniated viscus does not contain gas, it may appear as a diffuse haze at the base of the hemithorax); mediastinal shift away from the injured side; loss of the normal contour of the diaphragm (the wall of the stomach or colon may lie beneath the lung and mimic the contour of the diaphragm, forming a "pseudodiaphragm"); gas bubbles, air-fluid levels, or other unusual shadows above the diaphragm; bowel above the diaphragm (pathognomonic) (1,7,19).

A simple and valuable diagnostic clue is afforded by passage of a nasogastric tube to stomach demonstrated by radiography. The nasogastric tube placement in establishing the preoperative diagnosis of acute traumatic rupture is mandatory and may easily identify the stomach above the diaphragm (19,20). The patient's clinical status may limit the use of the accessory radiologic procedures such as barium instillation or diagnostic pneumoperitoneum. It may not be feasible and may even be contraindicated to transport these patients for such procedures. Only the simplest of techniques, i.e., placement of a nasogastric tube, should be undertaken immediately after acute trauma. It may allow confirmation of the presence of the stomach within the left hemithorax in addition to its ameliorative decompressive effect.

If the clinical findings suggest a diaphragmatic hernia and chest X-ray is either normal or obscure, appropriate contrast gastrointestinal studies should be performed; but if there is evidence of a perforated viscus, these studies should not be performed because contrast media leaking from a perforated viscus will cause severe peritonitis and increase mortality. The entire gastrointestinal tract must be visualized to ensure accurate diagnosis.

Positive results of diagnostic peritoneal lavage, which has been rarely employed in some series (19),

may be helpful in suggesting the diagnosis of diaphragmatic injury, but this findings is nonpesific for site or severity of injury, and indiscriminate exploratory celiotomy based solely on the presence of a positive diagnostic peritoneal lavage results in an excessively high nontherapeutic celiotomy rate of up to twenty-five percent (14). Peritoneal lavage in itself is usually not very helpful. In a series (3), false-negative lavage was noted in 20 percent of ten patients. Isolated diaphragmatic injuries are often associated with low red blood cell counts in peritoneal lavage fluid. However, if a chest tube is in place, appearance of the peritoneal lauge fluid in the chest tube drainage is virtually diagnostic (24).

Diagnostic pneumoperitoneum has been employed to demonstrate a diaphragmatic defect (3, 8). However, omentum or other viscera may occlude the diaphragmatic defect and prevent passage of the gas into the chest (19). Up to 20 % of defects may be missed (8). Air embolism can occur if air is used as the test gas, but carbon dioxide may reduce the risk (19). Pneumoperitoneum should be done with portable X-ray guidance to allow rapid confirmation of the diagnosis along with immediate reinstitution of chest suction to avoid prolonged pneumothorax, which can be precipitated with the introduction of air into the abdominal cavity.

Intravenous pyelography may be helpful (11). We should have made this procedure in one of our patients with traumatic diaphragmatic hernia. The kidney of this patients had been found in the left chest cavity because her left kidney had dissected from its hilum "renothorax" (A new word created by me) Hepatic or hepatic-pulmonary scans, liver spleen scintigraphy, and celiac angiography can be helpful (11), but we did not perform these procedures in our patients.

We did not use ultrasonography because it is limited by subcutaneous emphysema, thoracic wall and abdominal pain, the presence of gastric and splenic flexural gas, and the performance of operator-dependent (15). Nevertheless, in patients with suspected traumatic rupture, use of real-time sonography that is inexpensive and widely available are recommended (1).



Suspected acute traumatic diaphragmatic ruptures are definitively diagnosed by magnetic resonance imaging which may be the ancillary diagnostic procedure of following equivocal chest radiographs (4).

Laparoscopy and thoracoscopy which is likely to be hazardous have been used to visualize the ruptured diaphragm in acute-phase diagnosis (17,19).

Once the diagnosis of immediate or delayed traumatic diaphragmatic hernia is made, surgical repair is indicated. In the traumatic (acute) phase, most surgeons advocate a laparotomy (6,16,17). This permits coincident repair of associated visceral injuries, reduction of the hernia, and repair of the diaphragmatic defect.

Congenital diaphragmatic hernias such as Morgagni and Bochdalek hernias should always be kept in mind in the differential diagnosis of blunt traumatic diaphragmatic hernia. Aside from the history, the normal gastric position in a patient with Bochdalek hernia will aid in the diagnosis. Eventration or unilateral paralysis of the diaphragm and tumor mass arising from the diaphragm or its adjacent structures can usually be ruled out by fluoroscopic examination and by pneumoperitoneum (11).

Once the diagnosis of immediate or delayed traumatic hernia is made, surgical repair is indicated. Gastric decompression with a nasogastric tube is essential prior to anesthetic induction.

The preferred approach in the repair of diaphragmatic injury is dependent on the type of trauma, the side of the diaphragm involved, and the time of injury (11). In the traumatic (acute) phase, if there is presenting trauma, diaphragmatic injury can be approached either by transthoracic or transabdominal routes, depending upon the trajectory of the missile and upon the expected associated injuries. If there is blunt diaphragmatic injury, the choice of approach is still controversial, i.e., some

surgeons prefer a thoracostomy while others prefer a celiotomy. However, in the early stage, most surgeons advocate a laparotomy that permits coincident repair of associated visceral injuries, reduction of the hernia, and repair of the diaphragmatic defect (6,16,17,19,22). In 75 percent of our cases in the acute phase, celiotomy was utilized. In blunt diaphragmatic injuries on the right, the ideal approach is the transthoracic route because exposure of the right hemidiaphragm and its reconstruction is made easily through this approach (2,11).

Transthoracic route-either anterolateral thoracotomy if the patient's BP is low or unstable, or posterolateral thoracotomy to provide better exposure for most intrathoracic viscerais the preferable incision for treatment of a delayed hernia without much controversy. It provides excellent exposure to enable reduction of the hernia, the freeing of abdominal viscera that may be densely adherent to the chest, and the repair of the hernia defect. Adhesions in the chest between abdominal viscera and intrathoracic organs may be so extensive that dissection via a transabdominal approach will lead to excessive hemorrhage and viscera injury, increasing the likelihood of empyema (11,19,22, 24).

Primary repair of the diaphragmatic defect with nonabsorbable suture is recommended (11,19,22) and only rarely will a prosthetic patch such as Marlex mesh or Dacron patches be required, if patches be primary repair cannot be done without tension (12).

The prompt identification of traumatic diaphragmatic hernia depends on a high index of suspicion when examining acutely injured patients, and careful attention to physical findings and chest roentgenograms. Early diagnosis and repair of the defect will reduce the numbers of delayed hernias. Celiotomy provides optimum surgical exposure for acute hernias, whereas the majority of delayed hernias are best approached via a thoracotomy.

## KAYNAKLAR

1. Amman AM, Brewer WH, Maul KI, et al: Traumatic rupture of the diaphragm: Real-time sonographic diagnosis. *AJR* 140: 915-916, 1983.
2. Andrus CH, Morton JH: Rupture of the diaphragm after blunt trauma. *Am J Surg* 119: 686-691, 1971.
3. Aranoff RJ, Reynolds J, Thal ER: Evaluation of diaphragmatic injuries. *Am J Surg* 144: 671-675, 1982.
4. Boulanger BR, Mirvis SE, Rodriguez A: Magnetic resonance imaging in traumatic rupture: Case reports. *J Trauma* 32: 89-93, 1992.
5. Brandt ML, Luks FI, Spigland NA et al: Diaphragmatic injury in children. *J Trauma* 32: 298-301, 1992.
6. Bryer JV, Hegarty MM, Howe C, et al: Traumatic diaphragmatic hernia. *Br J Surg* 65: 69-73, 1973.
7. Carter BN, Ginseffi J, Felson B: Traumatic diaphragmatic hernia. *AJR* 65: 56-72, 1951.
8. Clay RC, Hanlon CR: Pneumoperitoneum in the differential diagnosis of diaphragmatic hernia. *J Thorac Surg* 21: 57-69, 1951.
9. Coppinger WR: Rupture of diaphragm following repair of hiatal hernia: Report of two cases. *Arch Surg* 80: 998-1004, 1960.
10. Estrera AS, Landay MJ, McClelland RN: Blunt traumatic rupture of the right hemidiaphragm: Experience in 12 patients. *Ann Thorac Surg* 39: 525-530, 1985.
11. Estrera AS, Platt MR, Mills LJ: Traumatic injuries of the diaphragm. *Chest* 75: 306-313, 1979.
12. Feigenberg A, Salomon J, Levy MJ: Traumatic rupture of the diaphragm: Surgical reconstruction with special reference to delayed closure. *J Thorac Cardiovasc Surg* 74: 249-257, 1977.
13. Feliciano DV, Cruse DA, Mattox KL, et al: Delayed diagnosis of injuries of the diaphragm after penetrating wounds. *J Trauma* 28:1135-1139, 1988.
14. Freeman T, Fischer RP: The inadequacy of peritoneal lavage in diagnosing acute diaphragmatic rupture. *J Trauma* 16: 538-542, 1976.
15. Gelman R, Mirvis SE, Gens D: Diaphragmatic rupture due to blunt trauma: Sensitivity of plain chest radiographs. *AJR* 156: 51-57, 1991.
16. Lucido JL, Wall CA: Rupture of the diaphragm due to blunt trauma. *Arch Surg* 86: 989-999, 1963.
17. Moore JB, Moore EE, Thompson JS: Abdominal injuries associated with penetrating trauma in the lower chest. *Am J Surg* 140: 724-730, 1980.
18. Moore TC: Traumatic pericardial hernia. *Arch Surg* 79: 827-836, 1959.
19. Payne JH, Yellin AE: Traumatic diaphragmatic hernia. *Arch Surg* 117: 18-24, 1982.
20. Perlman SJ, Rogers LF, Mintzer RA, et al: Abnormal course of nasogastric tube in traumatic rupture of left hemidiaphragm. *AJR* 142: 85-88, 1984.
21. Sutton JP, Carlisle RB, Stephenson SE Jr: Traumatic diaphragmatic hernia: A review of 25 cases. *Ann Thorac Surg* 3: 136-142, 1967.
22. Trinkle JK: Management of blunt thoracic injuries. In Jackson JW, Copper DKC (eds), *Rob & Smith's Operative Surgery*, Butterworths, London, 1986, pp 22-38.
23. Ward RE, Flynn TC, Claid WP: Diaphragmatic disruption secondary to blunt abdominal trauma. *J Trauma* 21: 35-40, 1981.
24. Wiencek RG Jr, Wilsor RF, Steiger Z: Acute injuries of the diaphragm. *J Thorac Cardiovasc Surg* 92: 989-993, 1986.