Traumatic Injuries of the Diaphragm

Aaron S. Estrera, M.D.;** Melvin R. Platt, M.D., F.C.C.P.;† Lawrence J. Mills, M.D.**

Traumatic injury of the diaphragm is not an infrequent occurrence. With the rise in violence and increasing use of automobiles, more diaphragmatic injuries may be seen, especially in inner-city hospitals. Sixty-six cases from our institution within the last five years were reviewed. Of these there were 41 penetrating injuries and 23 secondary to blunt trauma. Two cases were surgically induced following a difficult decortication for pleuropulmonary tuberculosis. There were ten deaths (15 percent mortality). All deaths were related to the severity of associated injuries. In addition, we analyzed 307 patients with multiple injuries who were dead on arrival and were autopsied by the county medical examiners in a 24-month period. Of the 307 autopsied cases, 16 (5.2 percent) had ruptured diaphragms. Interestingly, all but one of these cases were associated with thoracic aortic injuries. Diagnoses of penetrating diaphragmatic injuries were made during exploration of other injuries. In blunt diaphragmatic rupture, a high index of suspicion is most important in the diagnosis. In 10 of 23 blunt injuries, visceral herniation was noted on initial x-ray films. In four, follow-up films several hours to a day later showed loops of bowel in the chest. In nine cases, there were no apparent visceral herniations on initial films, and in these, the diagnosis was made during surgery for other indications. The surgical approach to diaphragmatic injuries is individualized. Acute left-sided injuries are best approached through the abdomen. Acute right-sided injuries and all chronic injuries should be approached through the chest.

The first recorded injury of the diaphragm was as early as 1541 and was credited to Sennertus, (quoted by Reid"). In 1578, Ambrose Paré (quoted by Hamby*) described the autopsy findings of a French captain of artillery who died with loops of colon in the left chest that had herniated through a small diaphragmatic tear. Only in 1940 did multiple reports of this entity appear, although Bowditch,* in 1853, reported the first antemortem diagnosis of traumatic diaphragmatic hernia. The majority of those reports pertained to traumatic diaphragmatic “hernia”--not to all diaphragmatic “injuries.”* Traumatic diaphragmatic hernia is relatively rare.5-11

Traumatic injury (versus hernia) of the diaphragm, however, is not uncommon, especially in inner-city hospitals dealing with a large volume of trauma cases.12-18 Parkland Memorial Hospital is one of the recognized centers for treatment of trauma in the southwestern United States. It primarily serves Dallas County with a population of about 1.5 million. In addition, it is also one of the referral trauma centers for the surrounding counties. Statistically, the incidence of a particular traumatic event from this center should be representative of the actual incidence.

We reviewed traumatic diaphragmatic injuries we had seen in the past five years, which included 66 cases. The majority were secondary to penetrating wounds, and most of these were discovered during exploration for associated abdominal or thoracic injuries. Factors leading to the diagnosis, therapy and the postoperative course of patients were reviewed. We also reviewed all persons with multiple trauma who were dead on arrival and had autopsies performed by the Dallas County medical examiners in a 24-month period (1975-1976). The problems in the diagnosis, management and care of patients with diaphragmatic ruptures are illustrated in the following case presentations.

Case Reports

Case 1

A 24-year-old white man was brought to the emergency room at Parkland Memorial Hospital on July 6, 1975, a few hours following an auto accident when he was knocked unconscious momentarily. He regained consciousness in the emergency room, was tachypneic and anxious. Vital signs were: blood pressure 117/76; pulse, 124; respirations, 26. On examination, the significant findings were confined to his right chest. There was a contusion on the right lower chest and palpable evidence of rib fractures. Breath sounds were diminished over the right chest, and dullness to percussion was noted up to the 4th intercostal space anteriorly. The abdomen was unremarkable except for slightly hypoactive bowel sounds.

Laboratory results were normal except for WBC of 13,700...
cu mm. Chest x-ray film (Fig 1) was interpreted as either an elevated right diaphragm or large pleural effusion or hemothorax. Follow-up chest x-ray findings remained unchanged, so a ruptured diaphragm was then suspected. Fluoroscopic examination for diaphragmatic activity was performed and revealed only limited motion of the right hemidiaphragm with no paradox. Pneumoperitoneum was induced with a total of 600 ml of air, but the air could not be localized. No right pneumothorax occurred, although the chest tube was already inserted and was not clamped during the air injection. Peritoneal lavage was negative.

The patient was taken to the operating room and a right posterolateral thoracotomy was performed. Exploration revealed the presence of a 12 cm tear of the diaphragm posterolaterally. The entire liver had herniated through this defect, with even the gallbladder visible. In attempting to reduce the herniated liver, massive hemorrhage occurred from a laceration in the suprarenal inferior vena cava and an avulsed middle hepatic vein, which was sealed by the herniated liver before its reduction. These were repaired and the diaphragm primarily closed with nonabsorbable sutures. The patient did well and was discharged 14 days postoperation. Subsequent follow-up in the clinic has been satisfactory.

CASE 2

An 18-year old white girl was admitted to Parkland Memorial Hospital following an automobile accident. She was one of the passengers in the back seat when the car hit a guardrail.

On admission, her blood pressure was 80/0 mm Hg. She responded to instillation of 2 L of lactated Ringer's solution and the blood pressure rose to 90/20 mm Hg. The patient remained fully conscious and awake, but was anxious and tachypneic.

On physical examination, the remarkable findings were confined to the left chest, where breath sounds were diminished at the left base. Marked tenderness was noted over the left lower thorax and left upper quadrant of the abdomen. Bowel sounds were hypoactive but no guarding was noted.

Chest x-ray film (Fig 2) was interpreted as showing left hemothorax with elevated left hemidiaphragm; ruptured left hemidiaphragm was suspected. A nasogastric tube appeared to be in normal position in the stomach. Pelvic x-ray film revealed a fracture of the left acetabulum. A chest tube was inserted on the left, with drainage of 500 ml of bloody effusion. Peritoneal lavage was negative. Repeat chest x-ray examination was done 45 minutes later (Fig 3), which showed evidence of bowel loops in the left thoracic cavity. The patient was brought to the operating room, where exploratory laparotomy was performed. The upper half of the stomach, spleen, splenic flexure of colon, and loops of small bowel had herniated through a tear on the posterolateral aspect of the left hemidiaphragm (Fig 4). The spleen had multiple lacerations and had to be removed. All viscera were reduced and the diaphragm repaired primarily with non-absorbable sutures. The patient did well and was discharged 3 weeks postoperation. Subsequent follow-up in the clinic has been satisfactory.

FIGURE 1. Initial film shows an abnormally elevated right hemidiaphragm or a large pleural effusion or hemothorax.

FIGURE 2. Initial chest x-ray film shows evidence of hemothorax and raises the question of an elevated diaphragm. Nasogastric tube appears to be in normal position in the stomach.

FIGURE 3. Repeat chest x-ray film about 30 minutes later, after another chest tube was inserted, shows evidence of loops of bowel in the left chest.

FIGURE 4. Repeat chest x-ray film on same patient, 30 minutes later, shows herniation of loops of bowel in the left chest, and demonstrates the defect in the diaphragm.
absorbable sutures. The postoperative course was unremarkable.

**Case 3**

A 53-year old white man weighing 330 lbs was admitted to the Veterans Administration Hospital at Dallas on June 10, 1976 with the chief complaint of increasing shortness of breath. His medical history revealed that four months prior to admission he was involved in an automobile accident and sustained multiple injuries, including multiple rib fractures with pulmonary contusion, which necessitated tracheostomy and ventilatory therapy. He was hospitalized for four weeks at Parkland Memorial Hospital at that time. From the record, there was no mention of any possible diaphragmatic rupture. The patient was discharged and was doing fairly well until about two weeks prior to admission, when he started having right-sided chest pain and shortness of breath.

On admission his vital signs were blood pressure 140/90; pulse 88; and respirations 24. Physical examination revealed an obese white man in moderate distress and slightly tachypneic. Chest findings revealed diminution of breath sounds on the right side with normal breath sounds on the left. Also, peristaltic sounds were heard over the right chest. An epigastric ventral hernia was present. Laboratory results were within normal limits except for the arterial blood gas levels which were pH, 7.34; Pco₂, 30.4; and Po₂, 52.

Chest x-ray film showed loops of bowel in the right chest. The patient was operated upon through an abdominal approach. The diagnosis of ruptured right hemidiaphragm with herniation of the hepatic flexure of transverse colon to the right chest cavity was confirmed. Reduction from below was unsuccessful, so a right anterolateral thoracotomy incision was made and adhesions of the colon to the lung were dissected. Reduction of the loops of bowel and repair of the diaphragmatic defect were performed with the use of a Marlex prosthesis (Fig 5).

The patient's postoperative course was complicated by pulmonary insufficiency, which required ventilatory support for about five days. Subsequently, he did well and was discharged from the hospital three weeks later.

**Figure 4.** Operative findings show the margin of the laceration (on the clamp) with fundus of stomach and spleen herniating through the defect. Loops of colon and small bowel have also herniated through.

**Figure 5.** Repair of a chronic diaphragmatic rupture with the use of Marlex mesh.

**Autopsy Series**

With the hope of understanding better the mechanism and determining the incidence of diaphragmatic rupture in patients with multiple injuries, we reviewed a total of 307 autopsy reports of victims of multiple trauma in a 24-month period from 1975 through 1976. The majority had died at the scene of the accident. Of these 307 cases, 16 (5.2 percent) had ruptured diaphragm. There were six bilateral, five on the right side, and five on the left side. A typical case in this group revealed multiple organ injuries probably incompatible with survival (Table 1). Despite the degree of injuries, only 5.2 percent sustained rupture of the diaphragm. This indicates how well-protected this organ is.

Another interesting finding in our autopsy series was the high incidence of associated thoracic aortic injuries. Fifteen of 16 victims had some form of thoracic aortic injuries, from total transection to incomplete intimal tear. Almost all had multiple aortic tears, most commonly involving both the ascending aorta and the aortic isthmus. One such combination was seen in one patient from our institution who sur-

<table>
<thead>
<tr>
<th>Table 1—Autopsy Findings in Cases with Ruptured Diaphragm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skull fractures (8)</td>
</tr>
<tr>
<td>Fracture of long bones, facial bones and pelvis (16)</td>
</tr>
<tr>
<td>Rib fractures (13)</td>
</tr>
<tr>
<td>Thoracic aortic rupture (15)</td>
</tr>
<tr>
<td>(L) Ventricular contusion (7)</td>
</tr>
<tr>
<td>Pulmonary contusion or laceration (10)</td>
</tr>
<tr>
<td>Laceration of liver (14)</td>
</tr>
<tr>
<td>Laceration of spleen (12)</td>
</tr>
<tr>
<td>Other visceral injuries (kidney, bowel, mesentery) (8)</td>
</tr>
</tbody>
</table>
The two surgically produced diaphragmatic injuries occurred following difficult decortication of old pleuropulmonary tuberculosis.

**RESULTS**

In the past five years, we have seen 66 cases of traumatic diaphragmatic injuries (Table 2). There were 41 penetrating injuries, 32 secondary to gunshot wounds and nine due to stab wounds. Blunt diaphragmatic injuries accounted for 23 cases, and two were iatrogenic following difficult decortication for old pleuropulmonary tuberculosis. There were ten hospital deaths (15 percent), six with penetrating injuries (gunshot wounds) and four secondary to blunt trauma. The six deaths following penetrating wounds were due to the severity of associated injuries. Four were admitted in shock with no palpable or audible blood pressure and were rushed to the operating room. The other two cases had rather prolonged hospital courses and succumbed to generalized sepsis. In the blunt trauma group, the four deaths were related to the severity of associated injuries, primarily head injuries.

All patients with penetrating diaphragmatic injuries were seen within a few hours following the injury. Similarly, almost all patients with blunt diaphragmatic injuries were seen in the acute stage except in three, who were seen in their chronic phase.

Among the penetrating gunshot injuries, 16 were on the right side, 13 on the left, one bilateral and in two patients with multiple gunshot wounds, definite localization was not recorded. In those with stab wounds, seven were on the left and two were on the right. Of the 23 blunt diaphragmatic injuries, the left hemidiaphragm was involved in 14 and the right in nine, an unusually high incidence of right-sided injuries. No bilateral injuries were noted.

In all but two cases of blunt diaphragmatic injuries the victims were either the driver or a passenger in a motor vehicle accident. In the two exceptions, one was run over by a tractor and the other by a car. There were no cases following cave-in or mining accidents, following a fall or so called "spontaneous" rupture.19,20

**DISCUSSION**

In this review, penetrating wounds represent the most common cause of diaphragmatic tear. A similar pattern was noted in other recent reports.12,13,18 Part of the reason for the large number of penetrating injuries of the diaphragm in our series is the frequent exploration of the abdomen with penetrating injuries, where the diaphragmatic tear is found somewhat incidentally. There were possibly many other unrecognized injuries among patients who

**Table 2—Traumatic Diaphragmatic Injuries at Parkland Memorial Hospital (1972-1976)**

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Penetrating Injuries</th>
<th>Blunt Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>Gunshot wounds</td>
<td>9</td>
<td>*Iatrogenic (surgically produced)</td>
</tr>
<tr>
<td>Stab</td>
<td></td>
<td>Total</td>
</tr>
</tbody>
</table>

*The two surgically produced diaphragmatic injuries occurred following difficult decortication of old pleuropulmonary tuberculosis.

Among those with penetrating injuries, only two had herniation, both containing only omentum and both secondary to stab wounds penetrating the left hemidiaphragm. In blunt diaphragmatic injuries, 14 of 23 had visceral herniation. In ten, visceral herniations were noted on initial films. In four, follow-up films subsequently showed bowel herniation. In the three chronic cases, admission chest x-ray films showed loops of bowel in the chest. In nine, there were no visceral herniations, and the injuries were found on exploration for other indications, although in the majority it was suspected. As expected, with injuries on the right, the liver herniated most often, while on the left, the stomach, spleen and splenic flexure of colon herniated (Table 3).

**Table 3—Herniated Viscera in Blunt Diaphragmatic Injury**

<table>
<thead>
<tr>
<th>Viscerum</th>
<th>Right-Sided</th>
<th>Left-Sided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Gallbladder</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Spleen</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Stomach</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Colon</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Small bowel</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>No herniation</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

**Table 4—Other Associated Injuries**

<table>
<thead>
<tr>
<th>Organ Involved</th>
<th>Gunshot Wound</th>
<th>Stab Wound</th>
<th>Blunt Trauma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>21</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Spleen</td>
<td>6</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Stomach</td>
<td>8</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Colon</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Small Bowel</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Kidney</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pancreas</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gallbladder</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cardiac</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>IVC</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Aorta</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 3**

*Ranges from mild contusion to actual rupture.*

**Table 4**

*Based on plain films of the chest and on clinical findings; no detailed rib films done.*
were not explored but managed only by tube thoracostomy or observation.

The importance of repair of penetrating injuries of the diaphragm cannot be overemphasized. However small or benign-appearing the diaphragmatic tear, it should be repaired. Gravier and Freark7 reported a missed diagnosis with a fatal outcome. Ebert6 pointed out that careful initial exploration of the diaphragm in suspected injuries should be performed to avoid future fatal complication of bowel herniation and incarceration or strangulation. It has been mentioned by Nelson and associates27,28 that lacerations of the diaphragm tend to remain open because of the pressure differential between the chest and abdomen. However, we are still convinced that many penetrating diaphragmatic injuries go unrecognized (Table 4).

Grimes13 reported 127 cases of penetrating injuries in a ten-year period, and during that period observed only six diaphragmatic hernias secondary to direct penetrating trauma. Gravier and Freark7 reported only 19 cases of traumatic diaphragmatic hernias in an 11-year period; 11 were due to stab wounds. In our series, only three cases of incarcerated chronic diaphragmatic hernias were documented in the last five years. None was secondary to penetrating injury. One possible explanation for this observation is the difficulty in obtaining long-term follow-up of these patients. The other explanation, which is more plausible, is that unrecognized diaphragmatic wounds probably heal spontaneously, contrary to what others believe.22 However, the smaller defects (penetrating stab wounds and gunshot wounds) account for a significant number of chronic strangulated diaphragmatic hernias. We wish to emphasize that diaphragmatic lacerations should be closed at the initial exploration to avoid the significant mortality and morbidity of a strangulated or incarcerated diaphragmatic hernia.23-26

In blunt diaphragmatic injuries, there are controversies regarding the diagnosis, surgical approach, and even the mechanism of diaphragmatic rupture. We have managed 23 such patients, nine involving the right side and 14 the left side. We are unable to explain this ratio, although Mansour and associates27 also reported a relatively higher incidence of right-sided injuries compared to the more commonly reported left-to-right ratio of 26:1.7,8 Harrington,38 in his review of 72 cases of diaphragmatic hernias, found only two cases involving the right; 55 of his cases were secondary to trauma. The rarity of the right-sided blunt diaphragmatic injuries is explained on the basis of the buffering effect of the liver.

Several concepts are advanced to explain the mechanism of blunt diaphragmatic rupture. One of the concepts proposed is that of the diaphragm likened to a membrane stretched tightly over a hoop, and if too much distortion of the hoop occurs, the membrane ruptures.29 However, the laxity and stretchability of the diaphragm makes this unlikely. Somewhere the diaphragm is avulsed from the chest wall which may be on this basis; we have not seen such a case in our series.

Another concept was proposed by Probert and Havard,29 primarily based upon their patients who were involved in mining accidents. They believed that rupture or tearing of the diaphragm occurs as a result of violent respiratory efforts during a period of compression, when the diaphragm is fixed by the crushing force. This concept is probably true among this group of patients.

The most attractive explanation of diaphragmatic rupture is proposed by Desforges et al30 and supported by Andrus and associates.31 These authors reported that it is the transmission of force through the abdominal viscera to the diaphragm which results in rupture. This would explain the common involvement of the left hemidiaphragm which is unprotected, as compared to the right which is protected by the liver. The blow of the precipitating force applied to the abdomen or flank should be distributed equally in all directions throughout the abdominal visceral contents. This force is distributed perpendicularly to all points in the peritoneal cavity (Pascal's law), and the left diaphragm, which is buffered only by the less bulky stomach, spleen and kidney, ruptures when enough pressure is applied. It appears, then, that all three mechanisms of diaphragmatic rupture proposed can occur.

There is no uniformity of opinion as to the sites of injuries (whether thoracic or abdominal) that result in diaphragmatic rupture. Wise and associates18 showed that in blunt diaphragmatic injuries, the impact of trauma was located twice as commonly in the abdomen as in the chest. Ebert and associates,6 on the other hand, suggested that diaphragmatic rupture occurs more often after thoracic trauma than after abdominal trauma. In our own series, as far as we can determine, the precipitating force was primarily confined to the abdomen in the majority of cases. However, when severe thoracic trauma occurs, the possibility of diaphragmatic rupture should always be considered.32,33

The association of diaphragmatic rupture with aortic injury has been noted by several investigators.30,31,34 In our review of autopsy cases, we found 16 diaphragmatic ruptures in 307 people who died with severe thoraco-abdominal injuries in
a two-year period. All but one of these had an associated thoracic aortic injury, again emphasizing that in any severe thoracic trauma, rupture of both the aorta and diaphragm can occur. It is interesting to note that the incidence of ruptured diaphragm in this autopsy series is only 5.2 percent. Rodkey,35 in his review of 177 patients with blunt abdominal injuries admitted to the hospital, found eight cases of diaphragmatic rupture, (4.5 percent). In the majority, these injuries were minimal compared to our autopsy series, but the similar incidence emphasized that more forceful (and lethal) injuries do not necessarily lead to an increase in diaphragmatic rupture. It seems that the point of impact of precipitating force and, perhaps, its timing in relation to the respiratory cycle are important factors. Recent reports by Bekassy and co-workers19 of five cases of "spontaneous" rupture of the diaphragm further support the above observation. The diaphragm can be ruptured even without external force; just the mere interplay of pressures from within 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.36

In this series there was no particular area of the diaphragm that was prone to rupture. Ebert and associates6 found that the posterocentral portion of the diaphragm is the most common site of rupture secondary to blunt trauma.14 On the other hand, others have shown that the anterolateral and paracardiac portion are the more common areas of tear.10,11 As mentioned, in our own series there was no particular pattern of rupture that could be identified. Similar observation has been noted by others.5,37 We have seen one case of rupture of the diaphragm into the pericardium. Moore38 collected five such cases with herniation of the abdominal viscer to the pericardium, with subsequent cardiac compression.

The diagnosis of penetrating injuries of the diaphragm is usually made as an incidental finding during exploration for other suspected injuries. This tear, no matter how small or benign appearing, must be repaired. In injuries secondary to blunt trauma, the diagnosis is not always clearcut. The single most important factor in the diagnosis is probably the \textit{high index of suspicion} when examining acutely injured patients. Twenty of our 23 patients were diagnosed during the acute phase, one during the interval phase and two during the late (incarcerated) phase.

The most useful tool in the diagnosis of blunt diaphragmatic rupture is serial chest roentgenograms. All of our cases demonstrated some abnormality on the initial chest x-ray film, the most common being the interpretation of an elevated diaphragm and/or significant hemothorax. This should lead to further evaluation and confirmation of the diagnosis. Four of our patients appeared to have only small hemothoraces or slightly elevated diaphragms on the original film, but on subsequent x-ray films, loops of bowel were easily visualized in the chest cavity (Case 2). There are several preoperative diagnostic procedures that are of value in suspected cases of diaphragmatic rupture. Among these are fluoroscopic evaluation of the diaphragm, contrast medium and air insufflation through a nasogastric tube to definitely outline the stomach, and in those suspected to have chronic herniation, a barium enema, gastrointestinal series and intravenous pyelography may be helpful. For injuries on the right, liver or liver-lung scans and celiac angiography can be helpful. Induced pneumoperitoneum has been utilized but is not without danger. Pneumothorax can be precipitated with the introduction of air into the abdominal cavity and in these groups of injured patients it can be dangerous. Salahi and co-workers39 have recommended that pneumoperitoneum should be done with portable x-ray guidance to allow rapid confirmation of the diagnosis along with immediate reintroduction of chest suction to avoid prolonged pneumothorax. Interpretation of the results of induced pneumoperitoneum can be difficult, especially in injuries on the right. In Peck's40 series of diaphragmatic injuries on the right, pneumothorax was not noted in instances where pneumoperitoneum was diagnostic. Rabin41 states that incomplete delineation of the undersurface of the right hemidiaphragm in a properly performed pneumoperitoneum procedure suggests liver herniation. It should also be known that the failure of inducing pneumothorax following pneumoperitoneum in patients with diaphragmatic rupture may simply imply that the diaphragmatic pleura remains intact. Also, adhesions may exclude air through the defect. In our series, pneumoperitoneum was utilized in four subsequently proven cases. In two, it was diagnostic, but in the other two it was unrevealing.

In the differential diagnosis of blunt diaphragmatic rupture with visceral herniation, congenital hernias (Morgagni and Bochdalek hernias) should always be considered. We have seen cases which would have been diagnosed easily as traumatic rupture if they had been admitted following a traumatic incident—two adults (21 and 65 years of age) with bowel herniating through the posterolateral pleuropitoneal defect of Bochdalek into the left chest.
and two other patients (55 and 63 years of age) with bowel herniating into the right chest through a Morgagni hernia defect. Aside from the history, the normal position of the stomach in a patient with Bochdalek hernia will aid in the diagnosis. Eventration or paralysis of the diaphragm and tumor mass arising from the diaphragm or its adjacent structures can usually be ruled out by fluoroscopic examination and, if necessary, by induced pneumoperitoneum.

**Management**

Once the diagnosis of diaphragmatic injury is established, surgical intervention should be instituted. Gastric decompression in this situation 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.

Penetrating injuries can be approached either by transthoracic or transabdominal routes, depending upon the trajectory of the missile(s) and upon the expected associated injuries. In acute blunt diaphragmatic injuries, the choice of approach is still controversial. Some surgeons prefer a thoracotomy approach⁴³,⁴⁴ while others prefer an abdominal route.²²,²⁷

In our institution, we have utilized an individualized approach according to the injured side. In acute blunt traumatic injuries on the left, we believe that the best approach is abdominal unless other compelling reasons force us to use thoracotomy, such as suspected cardiac or serious pulmonary injuries. We have not had any problems in terms of exposure and repair of left diaphragmatic rupture from the abdominal route. Other associated injuries in the abdomen have been easily accessible which would have been difficult through the thoracotomy incision.⁴⁵ In our series, 17 of the 20 with acute blunt diaphragmatic injuries had associated significant visceral injuries (Table 3).

In blunt injuries on the right, our own experience has shown the transthoracic route is the ideal approach as has been supported by many investigators.²⁴,³¹,⁴⁰,⁴⁴,⁴⁵ Exposure of the right hemidiaphragm and its reconstruction is made easy through this approach. Another important reason is the accessibility for repair of a particularly common associated injury which we have seen in three of our cases, a tear in the suprahepatic vena cava or hepatic vein (Case 1). We do not hesitate to explore the abdomen with another incision, if indicated.

In chronic injuries, transthoracic approach is the best choice without much controversy. Extensive adhesions between the herniated viscera and the lung are extremely difficult to take down or dissect through the abdominal approach, as we have experienced in one of our cases (Case 3). The use of Marlex mesh prostheses⁴² or Dacron patches⁴⁶ in chronic rupture should be considered if primary repair cannot be done without tension.

**References**

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41 Rabin CB: X-ray Diagnosis of Chest Disease. Baltimore, Williams & Wilkins, 1952, p 192
44 Epstein LI, Lempke RE: Rupture of the right hemidiaphragm due to blunt trauma. J Trauma 8:19, 1968

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