

TRAUMATIC RUPTURE OF THE DIAPHRAGM*

*Ünal Zorludemir MD**, Işık Olcay MD***, Selçuk Yücesan MD*****

Key words: trauma, rupture of the diaphragm, diaphragmatic hernia.

Traumatic rupture of the diaphragm is a rare surgical problem which was first reported in the literature by Ambrose Pare in 1541¹. The pediatric series^{2,3} and the children in the reports are limited in number⁴⁻⁹. In the past nine years we have treated 20 children with diaphragmatic rupture. The purpose of this article is to discuss these cases within the framework of several parameters.

Material and Methods

Twenty patients with traumatic rupture of the diaphragm were admitted and treated in the Department of Pediatric Surgery at Çukurova University Hospital during 1977-1986. The following parameters were used in the review of the patients: age and sex, etiology, clinical findings, diagnostic methods, localization and length of rupture, abdominal organs in the thorax, additional injuries, surgical approach and mortality.

Results

There were 11 boys (55%) and nine girls (45%) in the study group (Table I). The youngest patient in the series was one year-old and the oldest was fifteen. The mean age was found to be 6.2 years. There were no newborns in the group. Diaphragmatic ruptures were the result of blunt trauma in 16 (80%) and penetrating trauma in four (20%) children (Table II). In the blunt trauma group traffic accidents were the most common etiologic factor while falls from heights placed second. Three children in the penetrating trauma group were injured by shotguns.

* From the Department of Pediatric Surgery, Çukurova University Faculty of Medicine, Adana.

** Associate Professor of Pediatric Surgery, Çukurova University Faculty of Medicine.

*** Professor of Pediatric Surgery, Çukurova University Faculty of Medicine.

**** Professor of Pediatric Surgery, Ankara University Faculty of Medicine, Ankara.

TABLE I: Age and Sex Distribution of 20 Patients with Traumatic Rupture of the Diaphragm

Age	Female	Male	Total
Newborn	—	—	—
Infant	—	—	—
1- 6 years	7	5	12
7-15 years	2	6	8
Total	9	11	20

TABLE II: Etiologic Factors in 20 Patients with Traumatic Rupture of the Diaphragm

Type of trauma	Number of patients
Blunt trauma	16 (80%)
Motor vehicle accident	11
Falls from heights	4
Collapse of a wall	1
Penetrating trauma	4 (20%)
Gunshot	3
Plow	1
Total	20 (100%)

TABLE III: Signs and Symptoms in 20 Patients with Traumatic Rupture of the Diaphragm

Signs and symptoms	Number of patients
Diminishing or loss of breath sounds	13 (65%)
Abdominal tenderness	12 (60%)
Dyspnea	8 (40%)
Cyanosis	5 (25%)
Abdominal distention	4 (20%)
Abdominal muscular defense	4 (20%)
Intestinal sounds in the thorax	2 (10%)
Abdominal pain	1 (5%)
Abdominal rebound	1 (5%)

The patients with diaphragmatic rupture were admitted to our clinic within 48 hours of the injury. The recorded symptoms at admission were: diminished or loss of breath sounds in 13 (65%) patients, abdominal tenderness in 12 (60%) patients, dyspnea in eight (40%) patients and cyanosis in five (25%) patients (Table III). The patients did not present with coughing, hiccupping, vomiting, hematemesis nor chest pain.

The diagnosis of diaphragmatic rupture in ten children was made by chest x-ray. In one patient this finding was confirmed by ultrasonographic study. In four children, a barium study of the gastrointestinal tract was also performed. Six children were taken directly to surgery because of acute abdomen or penetrating abdominal wound and the diagnosis was established during the laparotomy.

The localization of the ruptures is shown in Table IV. Twelve (60%) of the ruptures were on the left, six (30%) on the right and one (5%) was bilateral. In one patient, the rupture was localized to the esophageal hiatus. In the blunt traumatized children, most of the ruptures were on the left side and this incidence was also found in the penetrating trauma group. The lengths of the ruptures ranged from one to fifteen centimeters; a dimension of two to four centimeters in the penetrating, and one to fifteen centimeters in the blunt trauma group.

In 11 (55%) children abdominal organs were found in the thoracic cavity (Table V). In all of the patients the length of the ruptures were five centimeters or larger. When localization in the thoracic cavity is considered, the liver and gallbladder were the most common herniated organs on the right side while stomach, colon and intestines were found on the left side. In one patient the spleen was found to be necrotized due to torsion of the hilus.

All patients but three (85%) had additional organ injuries. The gastrointestinal tract and the liver were most commonly injured (Table VI). Rupture of the pericardium was observed in two children. In one patient, temporary obstruction of the superior vena cava was clinically demonstrated.

In all twenty children, a laparotomy was performed. In each case interrupted 2-0 silk sutures were used to repair the rupture. No prosthetic material was used. Eighteen (90%) children survived and two (10%) died. One patient, who did not survive, was brought to the hospital 24 hours after the trauma. In addition to the diaphragmatic rupture, perforation of the colon and generalized peritonitis were also found. He died on the seventh postoperative day due to septicemia. The second child was admitted soon after a blunt abdominal trauma. Multiple organ and system injuries were found during the course of the operation. The cause of death was due to bile peritonitis.

Eleven of the patients who survived have been followed for a period of one to eight years. Neither clinical nor radiological pathology was demonstrated during the follow-up period.

TABLE IV: Localization of Rupture

Localization	Blunt	Penetrating	Total
Left	10	2	12
Right	4	2	6
Bilateral	1	—	1
Esophageal hiatus	1	—	1
Total	16	4	20

TABLE V: Herniated Abdominal Organs in 11 Patients with Traumatic Rupture of the Diaphragm

Herniated Organ	Right	Left	Bilateral	Hiatus	Total
Stomach	—	4	—	1	5
Colon	1	4	—	—	5
Small bowel	1	3	1	—	5
Liver	2	—	1	—	3
Gallbladder	2	—	—	—	2
Spleen	—	2	—	—	2
Total	6	13	2	1	22

TABLE VI: Additional Organ Injuries in 17 Patients

Involved Organ	Number of cases
A- Intraabdominal	
1. Gastrointestinal tract	8
2. Liver	7
3. Retroperitoneal hematoma	3
4. Spleen	2
5. Kidney	1
6. Adrenal	1
7. Inferior vena cava	1
B- Extraabdominal	
1. Chest wall	3
2. Lung(s)	3
3. Extremity	3
4. Pericardium	2
5. Superior vena cava	1
6. Clavicle	1
7. Pubis	1

Discussion

Series on diaphragmatic rupture is uncommon and the number of pediatric patients is rare^{2,3,5,8,10-13}. Boys outnumber girls^{5,8,10-14}. Our 20 patients were between the ages of one and fifteen and no predominance with regard to sex was found.

When the nature of the trauma is considered, different figures are obtained from reported series. The incidence has been found to be 63.4% for penetrating trauma and 36.6% for blunt trauma in 11 series which cover 665 patients^{6,10-12,15-21}. It has also been reported that the chance of diaphragmatic rupture is 1.6-3% in blunt trauma²⁰. In reported series^{5,8}, the most common etiologic cause of traumatic diaphragmatic ruptures are traffic accidents. In our study, falls from heights and accidents caused by tractors were the leading etiologic factors. These two types of trauma are very specific to the southern part of the country. The roofs of houses in small towns and villages of this part of the country are smooth and built of concrete and are used as sleeping areas on hot summer nights. On the other hand, tractors and trailers are also used for transportation from homes to farms in small towns and villages. Therefore, very specific types of trauma occur in the southern part of the country.

Clinical findings in traumatic diaphragmatic rupture differ from one patient to the other. Early symptoms seen most commonly are chest pain and dyspnea¹. While some patients have no pathologic findings, some present with diminishing or loss of breath sounds on the side of the lesion¹². Abdominal symptoms are related to the additional organ injuries. Apparent scaphoid abdomen (Gibson's sign) and intestinal peristaltic sounds at the thorax are unusual findings²⁰. The clinical signs and symptoms of the patients in this report correlate with those in the literature.

Preoperative diagnosis of the rupture is rather difficult and this is true especially for the right hemidiaphragm⁷. The most important step in the diagnosis is to suspect a diaphragmatic rupture in patients who have had a thoracic and/or abdominal trauma^{7,22}. Chest x-rays are still a great help in the diagnosis^{16,23}. A barium study of the gastrointestinal tract, sonography, computerized tomography, liver-spleen and lung-liver scintigraphic studies are various diagnostic methods^{4,6,7,12,13,15,16,20,23-28}. The most specific method for an accurate diagnosis is the demonstration of the passage of an opaque or radioactive material from one cavity to the other^{16,29}. There are reports of delayed diagnosis in the literature¹⁴. In one case the diagnosis was made 48 years following the occurrence of the trauma⁶. It was also reported that in some patients, even during surgical exploration, the diagnosis could not be made^{12,30,31}.

The mechanism by which a rupture of the diaphragm occurs as a result of blunt abdominal trauma is a subject for discussion. Some authors believe that during

severe abdominal trauma, pressure can increase ten-fold in the abdomen, transmitting a sudden blow of kinetic energy to the dome of both hemidiaphragms¹³. Desforbes et al³² is of the opinion that it is the transmission of force through the abdominal viscera to the diaphragm that results in the rupture. The blunt force applied to the abdomen is distributed perpendicularly to all points in the peritoneal cavity²². The right hemidiaphragm, being protected better by the liver, is less frequently injured⁶.

On the other hand, it is reported that the incidence of right hemidiaphragmatic ruptures is increased due to the presence of sophisticated diagnostic methods¹⁵. This ratio is 6.3-54.5 percent in various series^{6,9,13,15,16,20}. In the same series, which cover 187 patients, rupture of the right hemidiaphragm was found to be 24 percent due to blunt trauma. In our study the rupture was found on the right side in four of the 16 children who had blunt abdominal trauma. This figure is six out of 20 in both trauma types (Table IV).

In the literature bilateral diaphragmatic rupture is rare^{9,16,31,33}, and only one hiatal hernia in a patient has been reported following the trauma³⁴. In our series, we had one patient with bilateral diaphragmatic rupture and one patient with traumatic hiatal hernia.

In most of the series, it is reported that the liver (on the right) and stomach (on the left) are the most often herniated organs through the rupture^{8,13,15,20,35}. Mansour et al¹⁴ have found that the colon was mostly herniated to the thorax in their patients. The stomach, colon and intestines were mostly found in the thorax in our study (Table V).

In several studies, a predominating number of patients with diaphragmatic rupture had also additional organ injuries; the liver was found to be the main organ affected^{12,13,15,16}. Intrathoracic injuries placed second following intraabdominal organs^{12,16,20,23,31}. In our series, gastrointestinal organs were mostly affected and this was followed by liver and thoracic injuries. In two of the 20 patients, pericardial rupture was observed, which is a very rare type of injury reported in the literature^{2,16,36,37}.

Diaphragmatic ruptures are mostly treated by an abdominal approach^{10,12-14,20,22,33}. The high incidence of additional abdominal organ injuries is one of the important reasons for the performance of laparotomies in this surgical problem^{14,22,23}. Besides, in bilateral diaphragmatic ruptures, an abdominal approach is more convenient. In the presence of intrathoracic injuries, the incision can easily be elongated to maintain a thoraco-abdominal exposure^{14,33}. In delayed cases, intrathoracic adhesions may complicate the mobilization of the abdominal organs^{13,30}. In delayed or chronic cases, thoracotomy is accepted as the surgical approach^{10,12,13,20,22,23}. Since all the children in this series were admitted soon after the trauma, laparotomy was the choice of surgical approach.

The mortality rate regarding diaphragmatic ruptures ranges between 1-50 percent in other series^{10,12,15,16,18,20,23,31,37}. A large correlation between the mortality rate and additional organ injuries has been observed^{16,18,31}. It is also reported that this rate increases up to 66 percent in the presence of gastrointestinal necrosis in the thoracic cavity¹⁹. Although most of our patients had several additional organ injuries, our mortality rate was found to be 10 percent. We believe this final outcome is due to early and accurate diagnosis, and correct surgical approach and treatment.

Summary

Twenty children with traumatic diaphragmatic rupture were admitted to the Department of Pediatric Surgery at Çukurova University Hospital. There were eleven boys and nine girls. Their ages ranged between one and fifteen years. The etiology was penetrating trauma in four and blunt trauma in 16 of the children. Diagnosis was made by chest x-ray in ten, barium study of the gastrointestinal tract in four, and six children were taken directly to surgery. The ruptures were on the left in twelve patients, on the right in six, bilateral in one and hiatal in one. The length of the ruptures ranged between one and fifteen centimeters. The incidence of the placement in the thorax through the rupture of the organs is as follows: stomach five, colon five, intestines five, liver three, gallbladder two and spleen two. Seventeen children had also additional organ injuries. Eighteen of the patients survived the trauma but two died. The mortality rate was found to be 10 percent.

REFERENCES

1. Hagman J, Iguchi R, Kinsey J, et al. Diaphragmatic rupture following blunt trauma. *Ann Emerg Med* 13:49, 1984.
2. Melzig EP, Swank MS, Salzberg AM. Acute blunt traumatic rupture of the diaphragm in children. *Arch Surg* 111:1009, 1976.
3. Radhakrishna C, Dickinson SJ, Shaw A. Acute diaphragmatic hernia from blunt trauma in children. *J Pediatr Surg* 4:553, 1969.
4. Ammann AM, Brewer WH, Maull KI, Walsh JW. Traumatic rupture of the diaphragm: real-time sonographic diagnosis. *AJR* 140:915, 1983.
5. Andrus CH, Morton JH. Rupture of the diaphragm after blunt trauma. *Am J Surg* 119:686, 1970.
6. Arendrup HC, Jensen BS. Traumatic rupture of the diaphragm. *Surg Gynecol Obstet* 154:526, 1982.
7. Ball T, McCrory R, Smith JO, Clements JI Jr. Traumatic diaphragmatic hernia: errors in diagnosis. *AJR* 138:633, 1982.
8. Bengisu N, Sözüer E, Genç H, et al. Kliniğimizde görülen diafragma rüptürleri ve ilginç komplikasyonlar. *Erciyes Üniversitesi Tıp Fakültesi Dergisi* 7:207, 1985 (Eng. Abstr.) (Tur).
9. Lucido JL, Wall CA. Rupture of the diaphragm due to blunt trauma. *Arch Surg (Chicago)* 86:989, 1963.

10. Dajee A, Schepps D, Hurley EJ. Diaphragmatic Injuries. *Surg Gynecol Obstet* 153:31, 1981.
11. Drews JA, Mercer EC, Benfield JR. Acute diaphragmatic injuries. *Ann Thorac Surg* 16:67, 1973.
12. Miller L, Bennett EV Jr, Root HD, et al. Management of penetrating and blunt diaphragmatic injury. *J Trauma* 24:403, 1984.
13. de la Rocha AG, Creel RJ, Mulligan GW, Burns CM. Diaphragmatic rupture due to blunt abdominal trauma. *Surg Gynecol Obstet* 154:175, 1982.
14. Mansour KA, Clements JL, Hatcher CR, Waters DA. Diaphragmatic hernia caused by trauma: Experience with 35 cases. *Am Surg* 41:97, 1975.
15. Estrera AS, Landay MJ, McClelland RN. Blunt traumatic rupture of the right hemidiaphragm: experience in 12 patients. *Ann Thorac Surg* 39:525, 1985.
16. Flancbaum L, Morgan AS, Esposito T, Cox EF. Non-left sided diaphragmatic rupture due to blunt trauma. *Surg Gynecol Obstet* 161:266, 1985.
17. Brooks JM. Blunt traumatic rupture of the diaphragm. *Ann Thorac Surg* 26:199, 1978.
18. Estrera AS, Platt MR, Mills LJ. Traumatic injuries of the diaphragm. *Chest* 75:306, 1979.
19. Grimes OF. Traumatic injuries of the diaphragm. Diaphragmatic hernia. *Am J Surg* 128:175, 1974.
20. Ward RE, Flynn TC, Clark WP. Diaphragmatic disruption secondary to blunt abdominal trauma. *J Trauma* 21:35, 1981.
21. Wise L, Connors J, Hwang YH, et al. Traumatic injuries to the diaphragm. *J Trauma* 13:946, 1973.
22. Ittleman FP, Horrigan TP. Traumatic rupture of the right hemidiaphragm: case report of an unusual means of diagnosis. *J Truma* 23:350, 1983.
23. Leaman PL. Rupture of the right hemidiaphragm due to blunt trauma. *Ann Emerg Med* 12:351, 1983.
24. Blumenthal DH, Raghu G, Rudd TG, Herman CM. Diagnosis of right hemidiaphragmatic rupture by liver scintigraphy. *J Trauma* 24:536, 1984.
25. Harman PK, Mentzer RM Jr, Weinberg AC, et al. Early diagnosis by liver scan of a right-sided traumatic diaphragmatic hernia. *J Trauma* 21:489, 1981.
26. Heiberg E, Wolverson MK, Hurd RN, et al. CT recognition of traumatic rupture of the diaphragm. *AJR* 135:369, 1980.
27. Kim EE, McConnell BJ, McConnell RW, et al. Radionuclide diagnosis of diaphragmatic rupture with hepatic herniation. *Surgery* 94:36, 1983.
28. Peck WA. Right-sided diaphragmatic liver hernia following trauma. *Am J Roentgenol* 78:99, 1957.
29. Shea L, Graham AD, Fletcher JC, Watkins GM. Diaphragmatic injury: a method for early diagnosis. *J Trauma* 22:539, 1982.
30. Ebert PA, Gaertner RA, Zuldema GD. Traumatic diaphragmatic hernia. *Surg Gynecol Obstet* 125:59, 1967.
31. Hood RM. Traumatic diaphragmatic hernia. *Ann Thorac Surg* 12:311, 1971.
32. Desforges G, Strieder JW, Lynch JP, Madoff IM. Traumatic rupture of the diaphragm: clinical manifestations and surgical treatment. *J Thorac Surg* 34:779, 1957.
33. Wyffels PL, Kenny JN. Primary repair of bilateral diaphragmatic rupture with crural involvement. *Am J Surg* 147:414, 1984.
34. Friedman AI. Hiatus hernia and peptic esophagitis following trauma. *Am J Gastroenterol* 34:169, 1960.
35. Hill LD. Injuries of the diaphragm following blunt trauma. *Surg Clin North Am* 52:611, 1972.
36. Coats RR, Sakai K, Lam CR. Extensive diaphragmatic-pericardial rupture from blunt trauma. Report of a case, with a review. *J Thorac Cardiovasc Surg* 63:275, 1972.
37. Mattila S, Järvinen A, Mattila T, Ketonen P. Traumatic diaphragmatic hernia. Report of 50 cases. *Acta Chir Scand* 143:313, 1977.