Traumatic diaphragmatic rupture in children

Mehmet Hanifi Okur a,⁎, Ibrahim Uyguna, Mehmet Serif Arslana, Bahattin Aydogdua, Ahmet Turkoğlua, Cemil Goya b, Mustafa Icen c, Murat Kemal Cigdem a, Abdurrahman Onen a, Selçuk Otcua

a Dicle University Faculty of Medicine, Department of Pediatric Surgery, 21280, Diyarbakir, Turkey
b Dicle University Faculty of Medicine, Department of Radiology, 21280, Diyarbakir, Turkey
c Dicle University Faculty of Medicine, Department of Emergency Medicine, 21280, Diyarbakir, Turkey
d Dicle University Faculty of Medicine, Department of General Surgery, 21280, Diyarbakir, Turkey

⁎ Corresponding author. Tel.: +90 412 248 8001, +90 507 607 4662 (GSM); fax: +90 412 248 8523.
E-mail address: m.hanifi-okur@hotmail.com (M.H. Okur).

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Abstract

Background: The purpose of this study was to describe our experience with traumatic diaphragmatic rupture (TDR). Very little has been written about this condition in the pediatric age group. Between January 2000 and December 2011, data on twenty-two patients with TDR were analyzed, and clinical data were recorded. The patients were divided into subgroups based on injury type and ISS values.

Methods: Patients and methods

Results: Four patients were female, and eighteen were male. Mean age was 9.4 years (range 2–15 years). TDR was left-sided in twenty (91%) patients and right-sided in two (9%). The mean ISS (Injury Severity Score) was 19 (range 11–29). No significant difference in morbidity was noted between firearm and other injuries (p = 0.565) or between ISS values below and above 16 (p = 0.565). Seven patients (32%) had isolated diaphragmatic injury, while the other fifteen cases had additional associated injuries. Diagnoses were determined via a chest radiograph alone in the majority of cases, while suspected cases were confirmed by multidetector computed tomography if the patients were hemodynamically stable. Herniation was observed in twenty patients. Primary suture of the diaphragm and tube thoracostomy were performed in all patients. Postoperative complications included ileus (two cases), intussusception (one case), empyema (one case), and one patient succumbed during the operation.

Conclusions: TDR, while uncommon, should be considered in cases of thoracoabdominal injury. All patients should undergo meticulous examination preoperatively. When the chest radiograph does not provide a definitive diagnosis, multidetector computed tomography, including multiplanar reconstruction or volume rendering, may be beneficial for confirming suspicion of diaphragmatic rupture.
Between 2000 and 2011, approximately 15,000 pediatric trauma patients were admitted to the emergency clinic at Dicle University; twenty-two were diagnosed with TDR. The mean patient age was 9 years (range 2–15 years). Ten patients (45%) presented with blunt trauma. The remaining twelve (55%) had penetrating trauma: seven firearm injuries and five stab wounds. Diaphragmatic rupture was left-sided in 20 (91%) patients and right-sided in two (9%) patients. Twenty patients presented with herniation (displacement of an organ into the thorax), primarily of the stomach and the transverse colon. Other clinical features are presented in Table 1. Among these patients, seventeen were diagnosed preoperatively. Diagnoses were based on CXR for fourteen patients. MDCT was performed on twelve patients, nine of whom were diagnosed via CXR, while the remaining three had suspicious CXRs and required MDCT for definitive diagnosis. The other five patients were diagnosed intraoperatively as they were hemodynamically unstable and required immediate surgical intervention. All five patients had ISS values greater than 16; four of the five cases were firearm injuries.

All patients underwent primary diaphragmatic repair and tube thoracostomy. The seven patients with isolated injuries needed no further procedures. Among the remaining patients, fourteen were treated for additional injuries and one patient was treated for an iatrogenic organ injury. The additional injuries and the performed procedures are presented in Table 1. In the single patient with an iatrogenic injury, the stomach was injured after having herniated into the thorax. The patient’s history revealed that a chest tube had been inserted at an outside hospital owing to suspected pneumothorax. Diaphragmatic rupture was left-sided in 20 (91%) patients and right-sided in two (9%) patients. Twenty patients presented with herniation (displacement of an organ into the thorax), primarily of the stomach and the transverse colon. Other clinical features are presented in Table 1. Among these patients, seventeen were diagnosed preoperatively. Diagnoses were based on CXR for fourteen patients. MDCT was performed on twelve patients, nine of whom were diagnosed via CXR, while the remaining three had suspicious CXRs and required MDCT for definitive diagnosis. The other five patients were diagnosed intraoperatively as they were hemodynamically unstable and required immediate surgical intervention. All five patients had ISS values greater than 16; four of the five cases were firearm injuries.

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While 19 patients underwent laparotomy alone, three patients required both thoracic and abdominal interventions. One of these patients underwent a laparotomy through a median incision and a right thoracotomy owing to multiple injuries caused by gunshots. A grade III liver injury, vena cava injury, and small intestinal injury observed during the laparotomy were repaired primarily. In addition, a lung injury was repaired through the right thoracotomy, and a bleeding intercostal artery was ligated. The patient, who could not be stabilized despite blood and fluid resuscitation, succumbed during the surgery. This patient was one of the seven patients who had sustained firearm injuries. The patient’s ISS was greater than 16 (ISS = 29). In another patient who underwent both thoracic and abdominal interventions, a left thoracotomy was performed after more than 1400 cc of blood had been drained via chest tube. Following the ligation of a bleeding intercostal artery, a diaphragm injury was detected and repaired. Subsequently, an exploratory laparotomy was performed through a median incision, and no additional pathologies were observed. In the third patient who underwent both thoracic and abdominal interventions, a liver laceration was observed during the repair of the diaphragmatic hernia through a right thoracotomy. A laparotomy was additionally performed to repair the liver laceration.

Four patients had postoperative complications. Empyema developed in the patient with the iatrogenic stomach injury; and, decortications were performed on the 10th day, and he was discharged on the 20th day. The remaining three patients presented to our clinic owing to ileus and two of them were conservatively treated. The third patient did not respond to conservative treatment, and an intussusception 20 cm distal to the ligament of Treitz was observed on abdominal ultrasonography. The patient underwent a relaparotomy, and the intussusception was manually reduced.

Complications were observed in two of seven patients with firearm injury. Complications were also observed in two out of the other 15 patients, but no significant difference between the complication rates was determined (p = 0.565). The two firearm injury patients had ISS values below 16, and the two non-firearm injury patients had ISS values above 16; no significant difference between ISS values above and below 16 was determined (p = 0.565).

### 3. Discussion

TDR may originate from blunt or penetrating thoracoabdominal trauma. The main causes of blunt trauma observed in our study were falls from heights and motor vehicle accidents, while penetrating trauma resulted from gunshot and stab wounds. One collective review previously suggested that 75% of observed TDR were owing to blunt trauma, and 25% owing to penetrating trauma [8]. The incidence of penetrating injuries of 55% (12/22) in the pediatric age group in this report is much different from what is reported in most of the literature, whether coming from developed or developing countries. This high percentage of violence among children may reflect a form of child battering. In a large series of 20,500 trauma patients seen over a 21-year period, Ramos et al. reported only 15 children (0.07%) with TDR [1]. Brandt et al. reported 13 children with TDR seen over a period of 18 years [2], and Shehata et al. reported 10 children with TDR over a period of six years [9]. Our study included 15,000 trauma patients over a period of 11 years, 22 of whom were children presenting with TDR. The male incidence rate (81%) in our study was similar to that of other studies [9,10]. TDR commonly affects the left side [1]. Left diaphragmatic rupture is more frequent following trauma owing to the weaker structure of that side. The right hemidiaphragm is congenitally stronger than the left side, and the liver serves as extra protection
A higher rate of left-sided (91%) diaphragmatic injury was encountered in our series.

The diagnosis of a ruptured diaphragm is frequently missed in the first post-traumatic assessment owing to the presence of associated injuries. CXR is the most important diagnostic study; however, a high index of suspicion is required [10,11]. In various studies, CXR has been reported to provide a diagnosis of TDR in 46–87% of cases [9,12]. In our study, 64% of patients were diagnosed by primary CXR alone (Fig. 1). For patients for whom a definitive diagnosis cannot be established by CXR, or who have suspicious findings (including indistinct or elevated hemidiaphragm, rib fractures, pneumothoraces, hemothoraces, and pleural effusions), MDCT is recommended [13,14]. In our study, in three patients TDR was diagnosed using MDCT (Fig. 2). MDCT clearly depicts the anatomy via three-dimensional reconstructions, and it highlights other associated organ injuries. In scientific visualization and computer graphics, volume rendering (VR) is a set of techniques used to display a two-dimensional (2D) projection of a three-dimensional (3D), discretely-sampled dataset. Multiplanar reconstruction (MPR) is a term used in medical imaging that refers to the reconstruction of images in the coronal and sagittal planes in conjunction with the original axial dataset (Fig. 3A and B). Patients should be hemodynamically stable for MDCT examinations [15,16]. In our study, accurate and detailed visualization of the size, location, and extension of diaphragmatic rupture and associated organ injury was revealed using 3D VR images generated from a 64-slice MDCT in twelve (55%) patients. In a study by Karnak et al., a diagnosis of diaphragmatic rupture was determined preoperatively in 87% of 15 patients [12]. Our preoperative diagnosis rate was quite similar (82%).

Laparotomy alone was performed on 19 patients, while thoracotomy plus laparotomy were performed on the remaining three cases. Recently, laparoscopy and thoracoscopy were reported to be helpful in both the diagnosis and treatment of TDR [17,18]. In our opinion, although the surgical approach depends on the localization, size, and stability of the trauma, as well as associated injuries, the abdominal approach should be the procedure of choice for patients with severe trauma, as it provides better exposure. In this study, thoracotomy and laparotomy were applied together in three patients. One of these patients was exposed to multiple traumas. The other two patients were not preoperatively evaluated in detail because they were in shock when taken to the operating room. Therefore, we performed thoracotomy and laparotomy. However it would also have been possible to begin with a thoracoabdominal incision.

Associated abdominal injuries are common. The liver (38%) and spleen (34%) are the most often reported associated injuries in the literature [8]. In our study, gastric (40%), splenic (26%), and hepatic (13%) injuries were most common. Renal, pancreatic and esophageal injuries were also noted, but less commonly, encountered. While Ramos et al. reported a gastrointestinal perforation rate of 33% in their series comprising 15 patients with two penetrating and 13 blunt traumas, we observed a rate of 45% (10 cases) in our study consisting of 22 patients with 12 penetrating and 10 blunt traumas [1]. In our study, eight perforations (36%) were caused by penetrating trauma, while two (9%) were owing to blunt trauma. Stomach perforations, which are the most commonly reported type of rarely-occurring iatrogenic complications in the literature [11,19], were observed in two patients. The diameter of the diaphragmatic defect was 5 cm
who have undergone intra-abdominal surgery and who show evidence of early intestinal obstruction or ileus, postoperative intussusception should be considered.

The mean ISS for our patients was 19 (range 11–29). Children with TDR have lower ISS values compared to adults whose scores average 21 (range 9–50) in the literature [20]. In our study, the patient who died had an ISS value of 29; however, high ISS values do not always correspond to high mortality. The patient had a major firearm-related vascular injury, and the presence of major vascular and/or head injuries has a direct impact on mortality. None of the 15 patients with nonfirearm injuries died. In our study, the diaphragmatic defect size did not affect mortality. We reported one fatality (4.5%), a mortality rate lower than in most of the pediatric series in the literature [1,19].

TDR, while uncommon, should be considered in cases of thoracoabdominal injuries. In the majority of these patients, this is the result of severe trauma and so patients may have other associated injuries. Although the chest radiograph may be diagnostic, multi-detector computed tomography, including multiplanar reconstruction or volume rendering, can be helpful to verify the diagnosis and detect associated injuries. Operative strategies should be planned based on the localization, size of the defect, associated injuries and stability of the patient.

References