Blunt Diaphragmatic Injuries: Pericardial Ruptures

Tevrat Özalp¹ · Mustafa Küpeli² · Yaşar Sönmezoğlu³ · Abdülkadir Çakmak⁴ ·
Sıraç Akgül⁵ · Mithat Fazlıoğlu⁶ · Cevdet Tokat⁵

Received: 15 July 2015 / Accepted: 10 February 2016 / Published online: 17 February 2016
© Association of Surgeons of India 2016

Abstract Blunt traumatic diaphragmatic injuries (BTDIs) can be misdiagnosed. Careful evaluation of associated injuries in BTDI is important. In this study, we evaluated treatment options and difficulties in the diagnosis of patients with BTDI. We evaluated ten patients retrospectively with BTDI admitted to our departments, between January 2004 and 2015. Age, gender, trauma type, symptoms, radiological findings, diagnosis time, location and grade of the diaphragmatic injury, surgical type of repair, associated injuries and pericardial rupture, and morbidity and mortality rates were recorded. The mean age of the patients was 46.7 years, and all were males. Ninety percent of BTDI was left sided, and 10 % was on the right side. The diagnosis was confirmed with chest radiograph in 50 % and computed tomography in 70 %. Radiological examination revealed hemothorax in 80 %, the loss of diaphragmatic shadow in 60 %, and visceral organ herniation to the thorax in 60 %. Multiple organ injuries were present in 90 % of cases.

Pericardial rupture seen in 30 % was remarkable. Early surgery was performed for eight patients and late surgery for two patients. There were six patients with grade 4 or 5 central diaphragmatic injuries (CDIs). Multiorgan injury was present in all patients developing acute CDI. Multiple organ injury is much higher in patients with severe acute blunt trauma with CDI. Pericardial rupture rate is high in cases with acute BTDI and CDI. Proper diagnosis and early surgical management reduce morbidity and mortality.

Keywords Blunt traumatic diaphragmatic injuries · Pericardial injuries · Central diaphragmatic injury · Multiorgan injury

Introduction

Diaphragmatic rupture can be missed due to associated injury [1]. Rupture occurs in 1–8 % of abdominal injuries [2, 3]. The blunt injuries occur as a result of traffic accidents, falls from height, and industrial accidents [1].

The most important factor in the determination of blunt traumatic diaphragmatic injuries (BTDIs) is clinical suspicion and radiological examination [4]. Additional extra-abdominal organ injury in 80–100 % of diaphragmatic injury and intraabdominal organ injury in 50–80 % have been reported [5].

It was seen that the most likely cause of morbidity and mortality is the associated injuries and the delay in diagnosis [6]. In this study, our goals are to highlight the challenges of diagnosis, to specify the effect of early diagnosis on patient morbidity and mortality, and to re-evaluate the surgical treatment strategies.

✉ Mustafa Küpeli
mustafakupeli@yahoo.com

¹ Department of Thoracic Surgery, Amasya University, Amasya, Turkey

² Department of Thoracic Surgery, Gaziosmanpaşa University, 60100 Tokat, Turkey

³ Department of Thoracic Surgery, Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital, Istanbul, Turkey

⁴ Department of Cardiology, Amasya University, Amasya, Turkey

⁵ Department of General Surgery, Amasya University, Amasya, Turkey

⁶ Department of Thoracic Surgery, Kayseri Training and Research Hospital, Kayseri, Turkey

Patients and Methods

Between January 2004 and 2015, ten patients operated with the diagnosis of BTDI in our general surgery and thoracic surgery clinics were retrospectively reviewed. Age, gender, trauma type, symptoms, vital signs, diagnostic tests, radiographic findings, diagnosis time, location and grade of the diaphragmatic injury, type of surgical approach and repair, associated injuries and pericardial ruptures, organs herniated into the chest cavity, and morbidity and mortality rates were recorded (Tables 1 and 2).

Chest X-ray, chest and abdominal CT, and biochemical tests were performed on patients routinely. Firstly, tube thoracostomy was performed on the majority of patients with pneumothorax or hemothorax. Resuscitation was performed quickly on hemodynamically unstable patients (hypotension, bleeding more than 1200 ml, tachycardia). Bleeding was controlled by thoracotomy and/or laparotomy. The organs herniated to the thoracic cavity from the ruptured area were replaced into the abdomen. Additional organ injury was repaired. After pushing the herniated organs to the abdomen, nonabsorbable sutures or polypropylene nonabsorbable grafts were used to repair the diaphragm. It was classified as early (acute) if the duration of time is less than 24 h between the BTDI and surgery, and it was classified after 24 h as late.

BTDis were divided into five groups in accordance with the *American Association for the Surgery of Trauma Organ Injury Scoring Scale* [7]: grade 1, contusion; grade 2, laceration <2 cm; grade 3, laceration 2–10 cm; grade 4, laceration >10 cm with tissue loss <25 cm²; and grade 5, laceration with tissue loss >25 cm².

Results

The mean age of the patients was 46.7 years (range 23–60 years), and all patients were males. Seven of them were injured from traffic accident (70 %), two were injured falls from height (20 %), and one was injured under rubble (10 %). Nine cases of BTDI were on the left side (90 %), and one was on the right side (10 %). The most common symptoms were dyspnea in nine (90 %), chest pain in eight (80 %), and abdominal pain in eight (80 %) cases. Hypovolemic shock was diagnosed clinically in eight cases (80 %). In seven cases (70 %), the diagnosis of diaphragmatic rupture was estimated by radiological examinations, one patient (10 %) was diagnosed intraoperatively, and one patient (10 %) was diagnosed after repeated chest X-rays. The lesion was estimated by chest X-ray in five cases (50 %) and CT in seven cases (70 %). Three cases (30 %) were not estimated at the first time radiologically. Two cases were diagnosed at laparotomy,

Table 1 Demographic data of patients

Variables	Number	Percent
Age	46.7 (23–60)	
Gender		
Female	0	0
Male	10	100
Hypovolemic shock	8	80
Sign and symptoms		
Chest pain	8	80
Dyspnea	9	90
Abdominal pain	8	80
Radiologic signs		
Pneumothorax	3	30
Hemothorax	8	80
Diaphragmatic elevation	5	50
Loss of contour	6	60
Stomach and intestine herniation	6	60
Solid organ appearance	6	60
Lung contusion	3	30
Mediastinal shift	3	30
Associated injuries	9	90
Lung	2	20
Fractured ribs	9	90
Other fracture	8	80
Pericardium	3	30
Liver	4	40
Spleen	7	70
Aortic intramural hematoma	2	20
Intestines	1	10
Stomach	1	10
Ureters	1	10
Tail of the pancreas	1	10
Diagnosis time (h)		
<12	8	80
12–24	0	0
>24	2	20
Side of diaphragmatic injury		
Right	1	10
Left	8	80
Bilateral	1	10
Diagnostic tools		
Chest X-ray	5	50
CT scan	7	70
Laparotomy	2	20

and one case was diagnosed with follow-up chest X-ray series.

In the posterior-anterior and lateral chest X-rays taken for our patients, hemothorax in eight cases, the obliteration of the diaphragm contour in six cases, diaphragmatic elevation in

Table 2 Surgical procedures and results

Variables	Number	Percent
Surgical procedures		
Laparotomy	1	10
Thoracotomy	2	20
Laparotomy + thoracotomy	7	70
Surgery	10	100
Emergency surgical (<24 h)	8	80
Late surgical (>24 h)	2	20
Diaphragmatic rupture	11	100
Grade 1	1	9.1
Grade 2	0	0
Grade 3	1	9.1
Grade 4	7	63.6
Grade 5	2	18.2
Central diaphragmatic injury (CDI)	6	60
Pericardial rupture	3	30
Technique		
Direct suture	8	80
Mesh repair	2	20
Other surgical procedures		
Primary repair of the pancreas	1	10
Small intestine resection	1	10
Primary repair of the stomach	1	10
Primary repair of the pericardium	3	30
Urethra	1	10
Pneumoraphy	2	20
Mandibular stabilization	1	10
Primary repair of the liver	4	40
Splenectomy	6	60
Orthopedic procedures	8	80
Complication	5	50
Postoperative bleeding	1	10
Atelectasis	2	20
Pneumonia	2	20
Intraparenchymal hematoma of the lung	1	10
Hemopericardium	1	10
Mortality	1	10
Hospital stay (mean $\pm$ S.D.) (days)	14 (7–24)	

five cases, and pneumothorax in three cases were seen. In two cases, pneumothorax and hemothorax occurred at the same time. In thorax CT, a view of the gastrointestinal gas in the pleural cavity in six cases, abdominal solid organs in thorax in six cases, pulmonary contusion in three cases, and mediastinal shift in three cases were diagnosed (Fig. 1).

Early (emergency) surgery was done for eight cases, and all eight cases had symptoms of shock (hypotension, tachycardia, sweating). Chest tube drainage was performed in four patients in the acute phase. After chest tube insertion, two cases

Fig. 1 The thorax CT after blunt trauma. The right diaphragm eventration is seen, but fourth grade diaphragmatic injury could not be estimated. However, patchy hypodense areas on the right diaphragm are noted

underwent surgery immediately due to 1200 ml or more hemorrhagic drainage. In seven cases, thoracotomy with laparotomy was performed. Thoracotomy was performed in five cases and laparotomy in two. In one case, only laparotomy was performed. Primary diaphragmatic repair was performed in seven cases, and a synthetic patch graft was used in one case that had an extensive defect. Eight cases were in grades 4–5, and there was central diaphragmatic injury (CDI) in five of them. Mortality was recorded in this group.

There were two cases diagnosed late. BTDI was detected after 2 months and 15 years, and both patients underwent thoracotomy. One was in grade 3, and the other was in grade 5 in accordance with the injury scoring scale. Primary diaphragmatic repair was used in one case, and in another case, a synthetic patch graft was used. No additional injuries were detected except rib fracture. There was no morbidity and mortality.

There was one case of grade 1, no case of grade 2, one case of grade 3, seven cases of grade 4, and two cases of grade 5 diaphragmatic injury. In a patient with bilateral BTDI, grade 4 injury on the left and grade 1 injury on the right were seen.

The number of CDI cases was 6. Five of them were in the early (acute) group, and one was in the late group. All patients in the early (acute) group had associated multiorgan injuries [spleen (four), liver (three), aortic intramural hematoma (one), mandibular fractures (one), rib fractures (three), pelvic fracture (three), femur fracture (one), humerus fracture (one), urethral rupture (one), retroperitoneal hematoma (two), small intestine rupture (one), L5 fracture (one)]. Again, a pericardial rupture incidence was 25 % with two patients in the early (acute) group.

The surgical procedures carried out were tube thoracostomy for four cases, thoracotomy + laparotomy for seven cases, thoracotomy for two cases, and laparotomy for one case. Five of the thoracotomies were anterolateral thoracotomy, and the number of posterolateral thoracotomy and lateral thoracotomy was 2 for each. Anterolateral thoracotomy or thoracoabdominal incision was used when immediate access was needed. In eight of the cases, the diaphragm was repaired primarily with a nonabsorbable suture material, and the other two cases were repaired by applying a synthetic patch graft.

The other accompanying injuries in BTDI were rib fractures in nine (90 %); extremity fractures in eight (80 %) [pelvis (four), femurs (two), humerus (one), distal radius (one), ulna (one), and L5 lateral process fractures (one)]; organ injuries such as in the spleen in seven (70 %), liver in four (40 %), pericardium in three (30 %), lung in two (20 %), omentum in two (20 %), stomach in one (10 %), small intestine or bowel in one (10 %), and pancreas in one (10 %); intramural hematoma on the thoracic aorta in two (20 %); urethral rupture in one (10 %); and mandibular fractures in one case (10 %). The herniated organs were the following: the colon and small intestine in nine, omentum in eight, stomach in six, spleen in six, and the tail of the pancreas in one case (Table 1).

Three patients with pericardial ruptures (30 %) were observed. Two of them had cardiac herniation, and the other patient had cardiac herniation with bradyarrhythmia. None was estimated preoperatively, but all were determined during surgery. Surgery was initiated by laparotomy in two cases. When eight BTDI cases seen immediately after trauma were evaluated, the acute pericardial rupture incidence was 37.5 %.

The surgical procedures performed for the other organ injuries were splenectomy in six, hepatorrhaphy in four, pericardiorrhaphy and pericardial window in three, pneumonorrhaphy in two, primary repair for the stomach in one, small intestine resection and mesenteric repair in one, urethral rupture repair in one, primary repair of the pancreas in one, stabilization of mandibular fractures in one, and orthopedic intervention that was performed on the pelvis and extremities in eight cases (Table 2).

The complication rate was 50 %. Pneumonia, atelectasis, and fever in two, lung intraparenchymal hematoma in one, hemopericardium in one, and liver-induced collection in one case were observed as postoperative complications during hospital stay. The average length of hospital stay was 14 days (7–24 days). No complication was seen in the long-term follow-up of the patients after discharge from hospital. The average follow-up duration was 44.8 months (4–120 months).

The mortality rate was 10 % ($n=1$). The patient died due to retroperitoneal hemorrhage. The patient exposed to a blunt trauma due to a traffic accident had left multiple rib fractures, hemothorax, and pelvis fractures. In this case, the first choice should have been left anterolateral thoracotomy. However,

there was grade 4 diaphragmatic injury in the intrathoracic area and bleeding coming from the abdomen. When laparotomy was performed, spleen and small intestine injury with retroperitoneal hematoma was seen. Splenectomy was performed immediately, but the patient died due to retroperitoneal bleeding during the retroperitoneal intervention.

Discussion

The mechanism in BTDI is upper abdominal compression as a result of a sudden increase in intraabdominal pressure, and the diaphragm is torn by this high pressure [8]. In these injuries, due to the embryologic reasons, left-sided hemidiaphragmatic injuries are more common than right-sided hemidiaphragmatic injuries. This is due to the buffering effect of the liver on the right side [9]. In our study, the right diaphragmatic rupture rate was 10 %.

Symptoms vary depending on the type of injury and the accompanying trauma. A traumatic diaphragmatic injury cannot be diagnosed preoperatively in 12–69 % [10]. In our cases, preoperatively, 30 % of them could not be diagnosed radiologically. A traumatic diaphragmatic hernia can show clinical symptoms at different times. After the trauma, symptoms may occur in minutes, hours, days, months, or even years and delayed diagnosis can occur as late as a decade following the trauma [11]. The most common organs herniated from the diaphragmatic defect are the stomach, small intestine, colon, spleen, omentum, and liver [12].

BTDI is often associated with multiple organ injuries. It is reported that in a study performed by National Trauma Database, the associated pathologies in accordance with the observed sequence are liver injury; hemopneumothorax; spleen injury; rib fractures; bowel, limb, and kidney injuries; pelvic injuries; head trauma; and spinal cord and aortic injuries [13]. There was a high incidence of associated injury in our cases. The most common organ injuries were rib fractures (90 %), other bone fractures (80 %), spleen injury (70 %), liver injury (40 %), pericardial injury (30 %), aortic intramural hematoma (20 %), stomach injury (10 %), and intestinal injury (10 %) (Table 1).

Pericardial rupture is rare in BTDI [2, 4, 5]. It was reported that pericardial rupture had only been observed in 17 of 20,000 blunt trauma patients [14]. As a result of the collective literature that is reported by Shah et al. in 1995, it was detected that the left diaphragmatic rupture rate was 68.5 %, right diaphragmatic rupture rate was 24.2 %, and bilateral rupture rate was 1.5 %, while the rate of pericardial rupture was 0.9 % [4]. The heart herniation can occur in pericardial rupture [15, 16]. Pericardial rupture is asymptomatic, unless the heart herniates from the defect or hemorrhage occurs. Cardiac herniation occurs as a result of pericardial rupture and should be repaired surgically as this may cause vascular destruction and sudden

death [17]. In our series, the pericardial rupture rate was 30 %. Two of them were associated with cardiac herniation, and they were detected during surgery (Fig. 2). During exploration of the abdominal cavity and retroperitoneum and during repair of the diaphragm, pericardial rupture was not seen. It was diagnosed during thoracotomy which was performed as complete inspection of the thoracic cavity could not be provided by laparotomy. As we mentioned in our study, it is difficult to diagnose a pericardial rupture associated with BTDI and it is generally diagnosed intraoperatively [17]. Especially in BTDI cases, even though radiographic findings are evaluated as normal, the treating physician must therefore be aware of the intrathoracic organs at each stage of treatment and inspect the thoracic cavity carefully [18].

As the size of diaphragmatic injury gives us an idea about the violence of trauma, CDI is also important for the surgical strategy. Petrone et al. suggested that laparotomy is necessary for central tendon injury and subpericardial area injuries [7]. In our study; there was a case of CDI detected during thoracotomy. In this case, bleeding from the abdomen directed us to laparotomy. However, in a high-grade BTDI case in which the initial surgery is laparotomy if CDI is associated, intrathoracic organs should also be evaluated. Because in our study, as seen in two cases (one with grade 4 BTDI and the other one with CDI) which we began with laparotomy initially, we also performed thoracotomy in order to observe the thorax cavity better and safer repair of the injury. It should not be forgotten that, particularly, pericardial injury can occur silently that is why evaluation of the thoracic cavity is essential in patients with violent trauma and CDI.

In the diagnosis of BTDI, studies such as chest X-ray, abdominal ultrasound, fluoroscopy, CT, magnetic resonance imaging, barium imaging studies of the upper gastrointestinal tract, liver and spleen scintigraphy, peritoneal lavage, thoracoscopy, and laparoscopy should be the diagnostic

Fig. 2 Intraoperative rupture of the diaphragm as concomitant with cardiac herniation

Fig. 3 Grade 5 blunt trauma. The diaphragm is repaired by using a synthetic mesh

methods to be applied if necessary. The most common findings in conventional radiographic studies are the diaphragm contour abnormalities, elevation of the diaphragm, haustra of the intestines and gas shadows seen in the thorax, mediastinal shift, atelectasis, mass image in the lungs, pleural effusion, pneumothorax, and hydropneumothorax [19]. The sensitivity of plain radiographs in the diagnosis of diaphragmatic rupture ranges from 27 to 73 % [5]. In our study, this ratio was 50 %. The loss of continuity of the diaphragm in ultrasonography is useful for diagnosis [19]. CT is a more specific and sensitive method compared to other imaging methods for the determination of intraabdominal and intrathoracic organ injuries. It was reported that the sensitivity and the specificity rates of CT imaging in diaphragmatic injuries range between 14–82 and 87 %, respectively. In the further use of enhanced helical section CT, the sensitivity and specificity of CT in the diagnosis of diaphragmatic rupture were reported as 71 and 100 %, respectively [5, 11]. But the specific findings of CT regarding with the diaphragmatic injury are very low. In our study, the rate of diagnosis by CT was 80 %. Both thoracoscopy and laparoscopy allow the evaluation of all the diaphragmatic surfaces and the detection of additional pathology [20]. In our study, thoracoscopy and laparoscopy were not considered since the cases were unstable and we intervened due to the additional pathologies. Our intraoperative diagnosis rate was 10 % ($n=1$). In this case, there was a mild diaphragmatic elevation radiologically and it was associated with injuries occurring in the subdiaphragmatic space. Ultimately, after laparotomy which was performed for the additional organ damage, diaphragm damage was detected.

The effective treatment of diaphragmatic injury is surgical repair [6]. In emergency cases diagnosed as diaphragmatic rupture, unless there is evidence of significant bleeding, thoracotomy or laparotomy can be applicable. The side which is thought to be organ injury or bleeding is the primary side for surgery. When performing surgery, an additional pathology of the patient and the location and size of the diaphragmatic

injury should be considered [6]. In acute cases, the method of surgery is usually laparotomy [2]. But in 70 % of our cases, thoracotomy + laparotomy was performed. 57.1 % of these was initiated with thoracotomy, and 42.8 % of them thoracotomy was added since thoracotomy provides the best exposure for diaphragmatic repair. Although splenectomy or repair of the spleen can be performed by thoracotomy, thoracotomy is not reliable for inspection of the abdomen. For that reason, laparotomy, thoracotomy, or both can be done [6]. When the right diaphragmatic rupture occurs, if liver injury is absent, thoracotomy should be preferred since it is difficult to see and repair the diaphragm with laparotomy because of the liver. The best approach is thoracotomy for the cases following 1 week after trauma, because rapidly strong adhesions occur between the organs herniated, the thoracic cavity and pericardium. If there are serious injuries in the thorax and hemothorax in the thoracic cavity, thoracotomy is still preferred. In our cases, the reason of preferring thoracotomy was that chest traumas were obvious and tube thoracostomy was performed for 40 % of cases before surgery. Although diaphragm repair can be done successfully with thoracotomy, it is very difficult to return in place the herniated abdominal organs. In such cases, if the injuries on both sides of the diaphragm are suspected, a thoracoabdominal approach should be preferred [21]. Also in a violent BTDI, approaching from both sides of the diaphragm simultaneously is recommended for the safety of the surgical procedure and the patient. It is not recommended to turn the hypovolemic or unstable patients to lateral or semi-lateral position. Supine position should be maintained as much as possible. In our case, the hypovolemic shock rate was 80 %, and we maintained supine position in 62.5 % of them.

After debriding the lacerated edge of the diaphragm, it can be repaired primarily with nonabsorbable suture materials or using a patch, such as a synthetic mesh or an abdominal wall muscle flap if the defect is large. If necessary, sutures are passed around the rib and supported by a Teflon pledget [11]. We used a synthetic mesh in 20 % of the cases (Fig. 3). The abdominal wall muscle flap was not used.

The complication rate is between 30 and 68 % in diaphragmatic injury. Atelectasis, pneumonia, pleural effusion, sepsis, multiple organ failures, and hepatic abscesses may be observed as complications [22]. In our series, the complication rate was 50 % and the most frequent complications were pneumonia and atelectasis.

Mortality is generally due to additional organ injuries during the acute phase. It has been reported that the mortality rate for blunt trauma is 15–40 % [7]. In our study, the mortality rate was 10 %. Mortality was due to retroperitoneal bleeding. Thoracic and abdominal approaches without delay could be lifesaving in such cases. It should not be forgotten that the problems that worsen the case in acute phase such as shock, organ injury, respiratory failure, and coma can cause diagnostic difficulties and delays [23].

There is no correlation between the size of the diaphragm laceration and morbidity or mortality [22]. But the larger size of a laceration in blunt trauma can be an important finding to remember additional organ injuries such as a pericardial rupture.

As a result, in high-intensity blunt trauma, it is necessary to consider the diagnosis of diaphragmatic rupture. If there is CDI in the advanced grades of diaphragmatic injury, multiple organ injury frequency increases, particularly a pericardial rupture. Pericardial rupture rate is higher in patients with advanced grade in cases with BTDI and CDI.

It is important for a surgical strategy not to forget the intrathoracic structure injuries as injury in the pericardium cannot be diagnosed radiologically in perioperative period. Proper diagnosis and early surgical management reduce mortality and morbidity.

Compliance with Ethical Standards

Funding None declared.

Conflict of Interest The authors declare that they have no competing interests.

References

1. Symbas PN, Vlasis SE, Hatcher C (1986) Blunt and penetrating diaphragmatic injuries with or without herniation of organs in to the chest. *Ann Thorac Surg* 42:158–162
2. Şehitoğulları A. ve ark. Diafragmanın Travmatik Yaralanmaları. *Dicle Tıp Dergisi* 2012; 39 (2): 257-61)
3. Mihos P, Potaris K, Gakidis J, Paraskevopoulos J, Varvatsoulis P, Gougoutas B et al (2003) Traumatic rupture of the diaphragm: experience with 65 patients. *Injury* 34:169–172
4. Shah R, Sabanathan S, Mearns AJ, Choudhury AK (1995) Traumatic rupture of diaphragm. *Ann Thorac Surg* 60:1444–1449
5. Limmer KK, Kernstine KH, Granish FW Jr, Weiss LM (2011) Erişkin göğüs cerrahisi. In: Sugarbaker D, Bueno R, Krasna MJ, Mentzer SJ, Zellos L (eds) *Diyaframın malign veya benign hastalıkları*. (Çev. Yüksel M). Nobel Tıp Kitapları, İstanbul, pp 1054–6744
6. Hood RM (1971) Traumatic diaphragmatic hernia. *Ann Thorac Surg* 12:311
7. Petrone P, Leppaniemi A, Inaba K, Soreide K, Asensio JA (2007) Diaphragmatic injuries: challenges in the diagnosis and management. *Trauma* 9:227–236
8. Pomerantz M, Rodgers BM, Sabiston DC (1968) Traumatic diaphragmatic hernia. *Surgery* 64:529
9. Boulanger BR, Milzman DP, Rosati C et al (1993) A comparison of right and left blunt traumatic diaphragmatic rupture. *J Trauma* 35(1):255–260
10. Guth AA, Pachter HL, Kim U (1995) Pitfalls in the diagnoses of blunt diaphragmatic injury. *Am J Surg* 170(3):5–9
11. Bosanquet D, Farboud A, Luckraz H. A review diaphragmatic injury. *Respiratory Medicine CME* 2 (2009)1-6

12. Simpson J, Lobo DN, Shah AB, Rowlands BJ (2000) Traumatic diaphragmatic rupture: associated injuries and outcome. *Ann R Coll Surg* 82(2):97–100
13. National Trauma Data Base® (NTDB). American College of Surgeons, years 2000 to 2004
14. Fulda G, Brathwaite CE, Rodriguez A, Turney SZ, Dunham CM, Cowley RA (1991) Blunt traumatic rupture of the heart and pericardium: a ten-year experience (1979–1989). *J Trauma* 31:167–173
15. Kamiyoshihara M, Nagashima T, Ibe T, Takeyoshi I (2010) Rupture of the diaphragm and pericardium with cardiac herniation after blunt chest trauma. *Gen Thorac Cardiovasc Surg* 58:291–294
16. Witkowski Z, Lasek J, Wujtewicz M, Stasiak M, Marks W, Kawecka A (2005) Pericardiophrenic rupture and cardiac herniation after multiple blunt trauma: diagnostic and therapeutic difficulties. *J Thorac Cardiovasc Surg* 130:1–2
17. Khalpey Z, Rajab TK, Schmitto JD, Camp PC (2011) Traumatic pericardial rupture with skeletonized phrenic nerve. *J Cardiothorac Surg* 6:6
18. Arslan E, Işık AF, Şanlı M, Uluşan A, Elbeyli L (2013) Künt travmanın nadir komplikasyonu; Çocuk olguda diyafram-perikard rüptürü ve kardiyak herniasyon. *Ulusal Travma Acil Derg* 19(4): 363–365
19. Ammann AM, Brewer WH, Maull KI, Walsh JW (1983) Traumatic rupture of the diaphragm: real-time sonographic diagnosis. *AJR Am J Roentgenol* 140:915–916
20. Hasdemir O, Çetinkunar S, Yalçın E, Gazioğlu D, Soylu S (2008) Minör Künt Travmaya Bağlı Diafragma Rüptürü ve Herniasyonu-Olgusu Sunumu. *Ulus Travma Dergisi* 9(1):31–34
21. Asensio JA, Petrone P (2004) Diaphragmatic injury. In: Cameron JL (ed) *Current surgical therapy*, 8th edn. Elsevier Mosby Co, Philadelphia, pp 946–955
22. Beal SL, McKennan M (1988) Blunt diaphragm rupture. *Arch Surg* 123:828
23. Mintz Y, Easter DW, Izhar U, Edden Y, Talamini MA, Rivkind AI (2007) Minimally invasive procedures for diagnosis of traumatic right diaphragmatic tears: a method for correct diagnosis in selected patients. *Am Surg* 73(1):388–392