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Factors affecting mortality in traumatic diaphragmatic ruptures

Travmatik diyafragma rüptürlerinde mortaliteyi etkileyen faktörler

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Background: This study aims to investigate possible factors affecting mortality in patients with traumatic diaphragmatic ruptures.

Methods: Between May 1997 and May 2009 a total of 30 patients (27 males, 3 females; mean age 42.6 years; range 16 to 88 years) were operated in our clinic with a diagnosis of traumatic diaphragmatic rupture. The patients were evaluated retrospectively in terms of possible factors affecting mortality. Emergency surgery was performed 22 patients within the first seven days. Other two patients were operated in the latent phase and six patients were operated in the obstructive phase.

Results: Thoracotomy was performed in nine patients, laparotomy in nine patients and thoracotomy + laparotomy in 12 patients. Eight patients were diagnosed by explorative laparotomy. The mean duration of hospitalization was 12 days (range, 1-50 days). Morbidity was observed in eight patients (27%), while mortality was seen in seven patients (23%). Five patients had no associated pathology, while various associated pathologies were observed in 25 patients. Additional surgical interventions were required for associated pathologies in 16 of these patients (53%). Older age (p=0.020) and need for longer length of stay in the intensive care unit (p=0.020) were found to be negative prognostic factors affecting mortality.

Conclusion: Associated organ injuries are the main prognostic factors which affect morbidity and mortality. Early weaning from mechanical ventilation, aggressive treatment and close follow-up of patients with elderly and those with organ injuries associated with traumatic diaphragmatic ruptures may reduce morbidity and mortality.

Key words: Diaphragmatic; mortality; rupture; trauma.

Amaç: Bu çalışmada diyafram rüptürü nedeni ile cerrahi uygulanan hastalarda mortaliteyi ekileyen olası faktörler araştırıldı.

Çalışma planı: Mayıs 1997 - Mayıs 2009 tarihleri arasında toplam 30 hasta (27 erkek, 3 kadın; ort. yaş 42.6 yıl; dağılım 16-88 yıl) diyafram rüptürü nedeni ile kliniğimizde ameliyat edildi. Hastalar mortaliteyi etkileyen olası faktörler açısından retrospektif olarak değerlendirildi. Yirmi iki hastaya acil cerrahi girişim ilk yedi günde uygulandı. Diğer altı hasta latent fazda ve iki hasta obstrüktif fazda ameliyat edildi.

Bulgular: Dokuz hastaya torakotomi, dokuz hastaya laparotomi ve 12 hastaya torakotomi ve laparotomi yapıldı. Sekiz hastaya eksploratif laparotomi ile tanı konuldu. Hastanede kalış süresi ortalama 12 gün (1-50 gün) idi. Sekiz hastada morbidite (%27) görülür iken, yedi hastada (%23) mortalite görüldü. Beş hastada eşlik eden yaralanma bulunamaz iken, 25 hastada eşlik eden yaralanmalar vardı. Bu hastaların 16'sında (%53) eşlik eden yaralanmalar için ek cerrahi girişimler gerekti. İleri yaş (p=0.020) ve daha uzun süre yoğun bakım ihtiyacı olması (p=0.020) mortaliteyi negatif yönde etkileyen faktörler olarak bulundu.

Sonuç: Eşlik eden organ yaralanmaları morbidite ve mortaliteyi etkileyen ana prognostik faktördür. İleri yaş ve travmatik diyafram rüptürüne eşlik eden organ yaralanması olan hastaların mekanik ventilatörden erken ayrılması, agresif tedavi ve yakın takibi, morbidite ve mortaliteyi azaltabilir.

Anahtar sözcükler: Diyafram; mortalite; rüptür; travma.

Traumatic diaphragmatic rupture (TDR) usually results from blunt and penetrating traumas in the thoracoabdominal region.[1,2] One form of TDR in which the stomach herniates into the thoracic cavity was first discovered and defined by Sennertus in 1541 during the autopsy of a person who had been stabbed seven months earlier.[2-4] The diagnosis of TDR is often delayed because other clinical conditions such as life-threatening hemorrhagic shock emerge in these cases.[1,2]

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In this study, patients with TDR that required surgical treatment in our clinic were examined with regard to the time and method of diagnosis, type of surgical treatment, causes of death, and factors that influenced these deaths in order to reveal how to decrease the high mortality rate associated with this condition.

PATIENTS AND METHODS

In our study, the medical files of 30 patients (27 males, 3 females; mean age 42.6 years; range 16 to 88 years) who underwent diaphragmatic repair due to TDR between May 1997 and May 2009 were retrospectively examined. The medical history, X-rays, and other laboratory findings of these patients as well as their follow-up schedules and operation records were reviewed. In addition, they were evaluated with regard to their demographics, such as age and sex, complaints, methods of diagnosis, trauma etiologies, associated organ injuries, operative treatment methods, complications, hospitalization periods, and factors that influenced mortality. The length of time to diagnosis was divided into three groups: the acute phase, the latent phase, and the obstructive phase. The Injury Severity Score (ISS), Revised Trauma Score (RTS), and Trauma and Injury Severity Score (TRISS) values were then calculated, and their relationship to mortality was examined.

The results were expressed as mean ± standard deviation (SD), and the Kolmogorov-Smirnov test was used to analyze whether the quantitative data complied with normal distribution. In addition, the Mann-Whitney U test was used to compare the data, and a chi-square test was utilized for intergroup analysis of the qualitative data. Statistical data was analyzed using the Statistica version 7.0 software (StatSoft Inc., Tulsa, OK., USA), and a p value of <0.05 was considered to be statistically significant.

RESULTS

The etiology of the TDR involved blunt traumas in 19 patients (63.4%) and penetrating traumas in the other 11 (36.6%). The symptoms of the acute TDR patients included trauma-related chest pain and dyspnea resulting from compression on the organs that were herniating into the thoracic cavity. Chest pain and dyspnea were also seen in the latent phase, and an inability to defecate was noted in the obstructive period.

Eighteen patients were diagnosed in the preoperative period. Conventional pulmonary X-rays were utilized in six of these patients (Figure 1a) while computed tomography (CT) was used with seven others (Figure 1b, 2a, b). In addition, both X-rays and CT were employed for four patients, and X-rays and passage assessed by barium swallow graph (BSG) was used in one patient (Figure 3). Furthermore, twelve of these 18 patients were perioperatively diagnosed as having TDR during emergency surgical procedures performed because of associated pathologies.

Twenty-two patients were diagnosed within seven days and underwent emergency operations while two were diagnosed in the obstructive phase and had surgery under emergency conditions. Furthermore, five patients were diagnosed in the latent phase and had elective surgery while one underwent emergency surgery.

Surgical exploration was performed via a thoracotomy, laparotomy, or thoracotomy + laparotomy

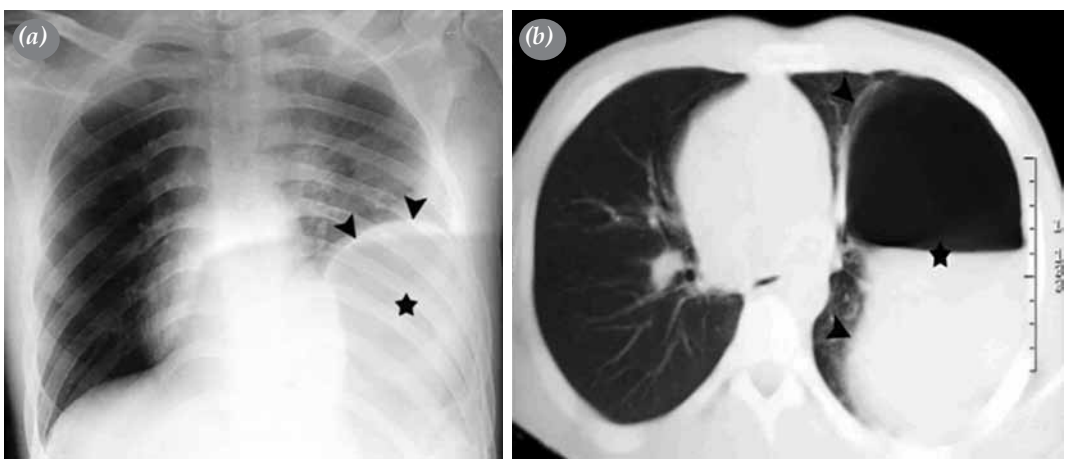

Figure 1. (a) Chest X-ray of a patient with acute diaphragmatic rupture (arrowheads). **(b)** Computed tomographic image of the same patient showing the herniation of the stomach into the thoracic cavity (stars).

depending on the phase of the TDR. The rupture was located on the left side in 23 patients (76.7%) and on the right side in seven (23.3%). Hernia reduction followed by diaphragmatic repair was performed for patients with only a hernia, and diaphragmatic repair alone was performed on patients with only a rupture. This repair was performed with separated nonabsorbable sutures for all of the patients.

Nine patients underwent a thoracotomy, nine more had a laparotomy, and a thoracotomy + a laparotomy was performed on 12 others. The defect in diaphragm ranged in size from 2-25 cm, and a hernia was present in 20 patients (67%) (Figures 2c and d). The herniated organs included the following: the colon in 14 patients (47%), the stomach in 13 (43%), the omentum in 10 (33%), the spleen in eight (27%), the jejunum in three (10%), the liver in three (10%), the ileum in one (3%), the caecum in one (3%), and the gall bladder in one other patient (3%). Additionally, no associated pathology was found in five of the patients. However, various associated pathologies were identified in 25 others, and additional surgical procedures were necessary for 16 (53%) of them (Table 1). Five patients also needed a resection/anostomosis.

The hospitalization period reflected a mean of 12 days (range 1-50). Morbidity was present in eight patients (27%), with the following conditions being observed in one patient each: empyema, acute respiratory distress syndrome (ARDS), anastomosis fistula and wound site infection, renal failure, pulmonary thromboembolism (PTE), catheter infection and multiple organ deficiency syndrome (MODS), rerupture, and disseminated intravascular coagulation (DIC). Mortality occurred in seven patients (23%) including three by sepsis and one each by MODS, ARDS, DIC, and PTE. We believe that the cause of death was late presentation to our clinic along with the complications connected with additional surgical procedures performed for associated coexisting injuries.

In our study, older age (p=0.020) increased the need for intensive care (p=0.020), and the TRISS values (p=0.008) were related to mortality. However, no other significant relationships between the other parameters and death were found (Table 2). The cause of the longer intensive care unit (ICU) stays of the deceased patients were ARDS, MODS, and DIC in one patient each and sepsis in three patients. In addition, one patient died suddenly because of a pulmonary thromboembolism (p=0.020).

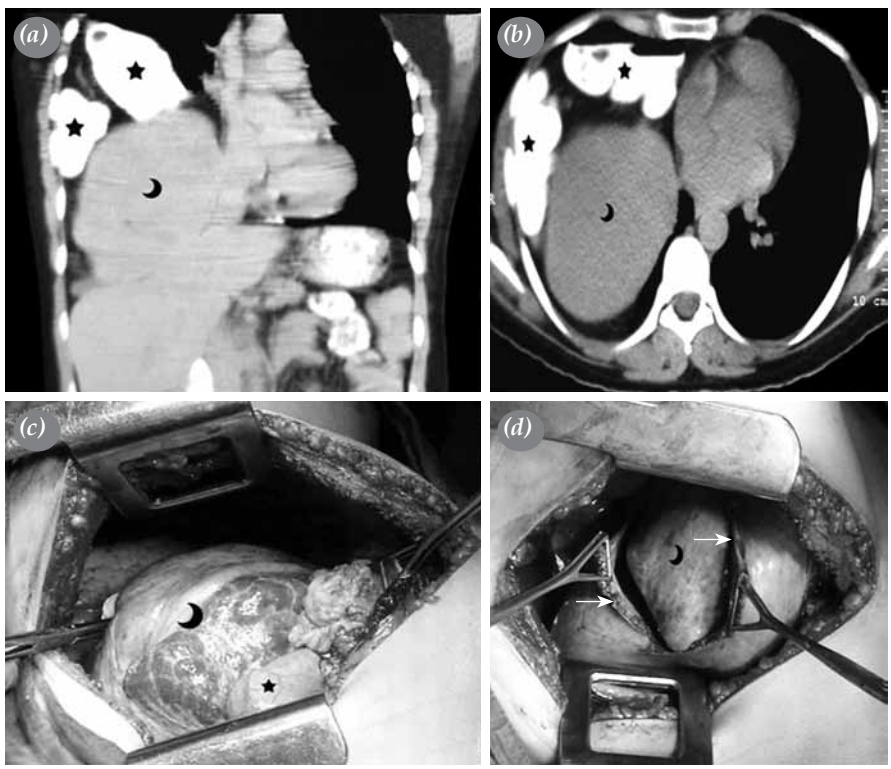

Figure 2. (a, b) Computed tomography images showing the right diaphragmatic rupture in the latent phase along with the liver (crescent), and colon (stars); **(c)** A preoperative view of the same patient showing the liver (crescent) and colon (stars); **(d)** An image showing the liver (crescent) and the leaf of the diaphragm (arrows).

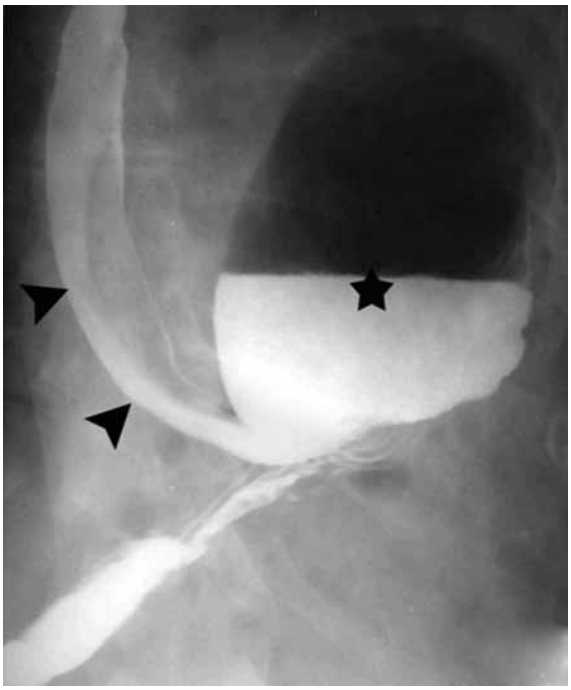

Figure 3. An image showing the stomach (star) and esophagus (arrowheads) of a patient shown by barium-contrasted X-ray.

DISCUSSION

Traumatic diaphragmatic rupture is caused by penetrating or blunt traumas to the thoracoabdominal region,[2,3] and the ratio of penetrating traumas to blunt traumas varies geographically.[2,5] In current published series, it was demonstrated that 35-78% of diaphragmatic ruptures were the result of blunt traumas, whereas penetrating traumas accounted for 22-65% of the cases.[2,4,7] Similar to the literature, 63% of our cases underwent operations due to TDR caused by blunt traumas while 37% had surgery as a result of penetrating traumas. In a study conducted by Düzgün et al.,[6] they determined that blunt trauma is a poor prognostic factor for mortality, and Hanna et al.[7] observed that there was no significant difference between blunt and penetrating traumas with regard to mortality. In our study, we also found no relationship between these types of trauma and the deaths that occurred.

Table 1. Coexisting pathologies that accompanied the traumatic diaphragmatic rupture cases

Type of injury	Number of patients
Spleen laceration	6
Liver laceration	6
Stomach rupture	6
Rib fractures	5
Colonic rupture	4
Hemothorax	3
Extremity fractures	3
Pericardial laceration	2
Scapula fracture	2
Pneumothorax	1
Lung laceration	1
Lung contusion	1
Kidney rupture	1
Sigmoid volvulus	1
Pelvis fracture	1
Nasal fracture	1
Small intestine rupture	1

The acute phase of TDR features patients who were diagnosed during their first hospitalization due to trauma. The latent phase is comprised of TDR cases who were not diagnosed during their first hospitalization but were diagnosed before obstruction and strangulation occurred. Finally, the obstructive phase is made up of late TDR cases who were diagnosed after intestinal obstruction and strangulation occurred.[3] Delayed diagnosis is not rare, with some cases having been identified as much as 40 years later.[2,3] In our study, 22 cases were diagnosed and operated upon in the acute period while the diagnosis for the other eight cases occurred within a period ranging from between one month and 26 years later.

A diagnostic accuracy range for TDR of between 27 and 62% for the left side and 17-33% for the right side has been reported in various published series when conventional pulmonary X-rays were used.[1,2,4,8] In our study, a diagnosis of diaphragmatic rupture was made via this method in just 10 of the patients (33%). In hemodynamically stable subjects who cannot be diagnosed with conventional pulmonary X-rays, CT may be used. Furthermore, CT is also a valuable tool for determining the pathologies associated with this condition. In our study, we determined there was a sensitivity of 71% (50% on the right side, 78% on the left side) and a specificity of 100%.[1,2] It has also reported that BSG can be used for TDR cases in the latent phase.[1,2] In fact, a diagnosis was made via BSG in one of the cases in this study. Coronal and sagittal magnetic resonance imaging (MRI) ensures that the whole diaphragm is optimally imaged and that organs which are herniating into the thoracic cavity can be clearly viewed.[8] However, MRI is not often used since it is more time consuming than other imaging methods. For this reason, we did not use MRI in any of our cases.

Düzgün et al.[6] reported that TDR was diagnosed and treated via surgery aimed at pathologies associated

Table 2. Factors associated with mortality in the traumatic diaphragmatic rupture cases

	Fatalities (n=7)		Survivors (n=23)		
	n	Mean±SD	n	Mean±SD	*p*
Age (years)		59.4±22.6		37.1±17.9	0.020 (<0.05)**
Gender					
Male	7		20		1.000 (NS)*
Female	0		3		
Preoperative diagnosis					
Right	4		14		1.000 (NS)*
Left	3		9		
Hernia					
Right	4		16		0.657 (NS)*
Left	3		7		
Organ injury					
Right	7		18		0.304 (NS)*
Left	0		5		
Side of rupture					
Right hernia	1		6		1.000 (NS)*
Left hernia	6		17		
Phase of traumatic diaphragmatic rupture					
Acute	5		17		0.622 (NS)*
Latent	1		5		
Obstructive	1		1		
Surgical treatment method					
Thoracotomy	1		8		0.490 (NS)*
Laporotomy	2		7		
Thoracotomy + laporotomy	4		8		
Injury severity score					
<16	5		13		0.669 (NS)*
>16	2		10		
Revised trauma score		7.5±0.4		7.7±0.4	0.199 (NS)**
Trauma and injury severity score		8.4±4.2		2.9±2.5	0.008 (<0.05)**
Blood transfusion		2.3±1.3		2.6±1.3	0.576 (NS)**
Size of the rupture		10.7±7.7		10.9±7.3	0.961 (NS)**
Trauma etiology					
Blunt	4		15		1.000 (NS)*
Penetrating	3		8		
Postoperative intensive care		9.9±6.4		2.7±10.4	0.020 (<0.05)**

SD: Standard deviation; NS: Non-significant; * Chi-square test used for analysis; ** Mann-Whitney U test of the method used in the analysis.

with this condition in 80% of cases, whereas the rate was 57% in a study by Hanna et al.[7] and 74% in a study by Mihos et al.[4] In our study, 12 patients were diagnosed in the acute phase while undergoing this type of surgery, and diaphragmatic repairs were performed.

Defects in the diaphragm tend to expand over time due to negative intrathoracic pressure and diaphragmatic motions. Furthermore, the progressive herniation of organs often leads to cardiorespiratory or obstruction-related symptoms.[2] The smaller size of diaphragmatic ruptures along with the lower frequency of herniation, particularly in penetrating traumas, increases the rate of missed diagnosis. Therefore, some authors have recommended a diagnostic thoracoscopy or laparoscopy for penetrating traumas involving regions inferior to the nipple on the anterior side, the subscapular thoracic region on the back side, and the upper abdomen. Freeman et al.[9] performed a thoracoscopy in all cases of penetrating thoracic traumas and found TDR in 35% of them. In a prospective study conducted by Friese et al.,[10] a diagnostic laparoscopy was performed on all 34 asymptomatic cases characterized by hemodynamic stability and penetrating thoracoabdominal traumas, and they reported that a sensitivity of 100%, a specificity

of 87.5%, and a negative predictive value of 96.8% for this procedure. In our study, nine patients were operated on via a thoracotomy, and nine underwent a laparotomy. In addition, a thoracotomy combined with a laparotomy were carried out on 12 others. Most of the patients were diagnosed in the preoperative period using various imaging methods. However, the patients who were not diagnosed with TDR preoperatively underwent surgery characterized by open procedures under emergency conditions due to the emergence of associated pathologies. However, none of our patients underwent a diagnostic thoracoscopy or laparoscopy.

Isolated diaphragmatic rupture is a rare condition, and injuries connected with this occur in 52-100% of the cases.[2,7,8] The rate of organ damage associated with diaphragmatic trauma was reported as 86.9% by Hanna et al.,[7] 95% by Mihos et al.,[4] and 88% by Düzgün et al.[6] In addition, those authors reported that 92% of the patients who died had associated pathologies. In our study, the rate of organ injury associated with TDR was 83%, but this rate was 100% in the seven deceased patients.

In cases of TDR, nonabsorbable suture material is widely utilized for diaphragmatic repair, although the use of absorbable suture material has also been recognized.[1,2,7,11] The diaphragm can be repaired using interrupted sutures, horizontal mattress sutures, or continuous sutures, all of which achieve the same effects. Although the use of grafts is rarely required in cases of acute rupture, it is possible in cases with in the latent phase in which the layers of the diaphragm cannot be approximated.[1,2] The diaphragm was repaired in all of our patients using interrrupted nonabsorbale suture. In one case, the patient was found to have TDR in the latent phase on the second postoperative day. We believe this stemmed from atrophy and paralysis in the diaphragmatic muscles caused by a blunt diaphragmatic trauma suffered one year earlier.

A mortality rate of between 7.4 and 25% has been noted in various series, and the reported causes included irreversible shock and cranial trauma in the intraoperative and early postoperative periods and cardiac failure, ARDS, MODS, and sepsis in the late postoperative period.[1,4-6] In our study, perioperative mortality was not seen, but the postoperative rate was 23%. We believe this lack of early mortality was due to the absence of severe head trauma and hemorrhagic shock. In addition, a pulmonary thromboembolism was observed in one patient in the hospital.

Various trauma scores are used to determine severity. The ISS is obtained by summing the squares of the highest AIS scores in the three body regions with the most serious injuries.[12] The RTS is largely dependent on the Glasgow Coma Scale (GCS), which is influenced by cranial trauma.[13] The TRISS reflects the possibility of survival and is calculated using the ISS, RTS, and age of the subject.[14] In a study conducted by Hanna et al.[7] that focused on which factors increased mortality rates, the authors found that an ISS of >15 and traumatic cranial damage were the culprits. Mihos et al.[4] reported in a series of 65 cases that the presence of hemorrhagic shock alone and an elevated ISS had an additive effect on mortality. Moreover, Düzgün et al.[6] in a series of 58 cases determined that blunt trauma, the size of the rupture, blood transfusions, the presence of splenic damage, and hemorrhagic shock were the cause of increased mortality rates. In our patients, we observed that advanced age, an increased need for intensive care, and elevated TRISS scores influenced the number of deaths. Furthermore, contrary to the findings of Mihos et al.[4] and Hanna et al.,[7] we believe that the ISS was not a negative prognostic factor for survival in our series because normally our cases were exposed to isolated thoracoabdominal traumas. The lack of a relationship between the RTS and mortality can be supported by the absence of cranial trauma in our patients. Furthermore, Çobanoğlu et al.[15] compared a group of patients with penetrating traumas with a group with blunt traumas according to the ISS and found no statistical differences.

The characterization of the TRISS as a prognostic factor for mortality in our study was linked with the age component. In the studies conducted by Mihos et al.[4] and Hanna et al.,[7] age was not a prognostic factor for survival, but it was in our series. This can be explained by the fact that advanced age is a predisposing factor for the increased need for intensive care and that most of our cases who died had secondary complications that developed during the intensive care follow-up.

Düzgün et al.[6] found herniation in 19% of their cases but could not link this to mortality. However, they were able to determine that the number of deaths was influenced by the size of the rupture. In our series, no significant relationships were found between the presence of herniation, rupture size, and mortality.

Complex diaphragmatic injuries pose intraoperative challenges for the surgeon because of the degree and complexity of the associated thoracic and/or abdominal injuries as well as the need to open more than one body cavity. Delayed presentation can make the diagnosis even more difficult for the

clinician since the events of the initial injury are usually not known.[16] When diagnosed, surgery must be performed as soon as possible as any delay might cause the herniation of any abdominal organ. A laparotomy is recommended for patients who were diagnosed early to allow for the exploration of the intraabdominal organs in order to find any associated injuries. In delayed presentations, a thoracotomy may be required since the formation of adhesions with the intrathoracic structures may not allow for the contents to be reduced through a purely abdominal approach.[4,17,18]

With the increasing use of laparoscopies and thoracoscopies, more diaphragmatic injuries are being correctly diagnosed and, in some cases, repaired without the need for a laparotomy. Some groups have advocated a period of clinical observation for those who are clinically stable, followed by a diagnostic laparoscopy for all patients who sustained a left thoracoabdominal penetrating trauma.[19,20] Thoracoscopies have been used to diagnose diaphragmatic injuries for over a decade and remain a very sensitive and useful tool with diagnostic accuracy rates of between 98 and 100%.[21] However, there are disadvantages to this procedure such as the time it takes to place the patient in the thoracotomy position and the subsequent difficulty in repairing the diaphragm.[20]

Conclusion

Most patients with injuries associated with TDR can be diagnosed in the early or late postoperative period. However, a delay in the diagnosis of a small diaphragmatic tear can result in significant morbidity or death from the herniation of the abdominal contents. The definitive factors that influenced the survival rate in our study were advanced age and the corresponding heightened need for postoperative intensive care. Traumatic diaphragmatic rupture should be considered in all patients with trauma, and when it is definitively diagnosed, early surgical intervention is necessary. In cases with no intraabdominal organ injury, diaphragmatic repair via a thoracotomy is an easy and suitable method of treatment, especially for right-sided injuries or when significant herniation has occurred. In some cases with a limited penetrating injury in which an abdominal injury is believed to be unlikely, the repair can be accomplished through a thoracotomy or VATS. The choice of whether to use a thoracoscopy or a laparoscopy remains controversial, and the surgeon most often must rely on his experience to make the correct decision.

Declaration of conflicting interests

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