

Factors influencing mortality in traumatic ruptures of diaphragm

Travmatik diyafragma rüptürlerinde mortaliteyi etkileyen faktörler

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BACKGROUND

Diaphragmatic injuries are infrequent but severe injuries, associated with high morbidity and mortality.

METHODS

The hospital records of 58 patients with traumatic rupture of diaphragm which was diagnosed during surgery in emergency department during last five years were re-evaluated, in order to identify the factors on mortality.

RESULTS

The mean age of patients was 33 years. The most common cause of diaphragmatic rupture was penetrating injury (52%). The overall mortality rate was 21%. Preoperative diagnoses were accurately made in only twelve (20%) patients and remaining 46 patients were diagnosed during surgery. Rupture was located on the left side in 42 patients. Intrathoracic herniation was seen in eleven cases. Presence of herniation has no effect on mortality ($p=0.155$). All cases with mortal course were blunt trauma and the most common cause of death was haemorrhagic shock. Associated injuries were present in 88% of the patients; 92% of the mortal cases had an associated injury.

CONCLUSION

The diagnosis of diaphragmatic injury is important due to increased morbidity and mortality in traumatic victims. Blunt trauma, increased grade of injury, presence of shock, blood transfusions over three units and splenic injury are factors influencing mortality in traumatic ruptures of diaphragm.

Key Words: Associated injury; diaphragmatic rupture; mortality; revised trauma score; systemic inflammatory response syndrome score.

AMAÇ

Diyafragma rüptürleri sık görülmeyen fakat yüksek morbidite ve mortalite ile seyreden ciddi yaralanmalardır.

GEREÇ VE YÖNTEM

Acil serviste son beş yıl içinde travmatik diyafragma rüptürü saptanan 58 hastanın dosyası mortaliteyi etkileyen faktörleri belirlemek için incelendi.

BULGULAR

Hastaların ortalama yaşı 33, mortalite oranı %21 ve en sık diyafragmatik rüptür nedeni penetran yaralanmalardı (%52). Sadece 12 hasta (%20) ameliyat öncesi dönemde diyafragma rüptürü tanısı alırken kalan 46 hasta ise cerrahi sırasında tanı aldı. Kırk iki hastada sol diyafragma rüptürü saptandı. İntra-toraksik herniasyon 11 hastada saptandı. Herniasyon varlığı mortaliteyi etkilemedi ($p=0,155$). Mortalite ile seyreden tüm hastalarda künt travma vardı ve en yaygın ölüm nedeni hemorajik şok idi. Hastaların %88'inde eşlik eden yaralanmalar vardı ve mortal seyreden hastaların %92'sinde eşlik eden yaralanma mevcut idi.

SONUÇ

Travmalı hastada diyafragma yaralanmasının tanısı yüksek morbidite ve mortalite nedeni ile önemlidir. Travmatik diyafragma rüptürlerinde mortaliteyi etkileyen faktörler; künt travma, yüksek yaralanma şiddeti, şok varlığı, üç üniteden fazla kan transfüzyonu ve dalak yaralanmasıdır.

Anahtar Sözcükler: Diyafragma rüptürü; eşlik eden yaralanma; mortalite; revize edilmiş travma skoru; sistemik enflamatuvar yanıt sendrom skoru.

Diaphragmatic ruptures (DRs) are infrequent but are severe injuries, associated with high morbidity and mortality which occurs in 3-5% of multiple traumas^[1-4] and is a marker for severe trauma.

Surgeons are increasingly facing with DRs because of the increase in high-speed vehicular crashes and the routine use of plain chest roentgenograms in the evaluation of trauma victims, and the advance in trauma care systems.^[5]

Complications such as visceral herniation or strangulation may arise early in the patients clinical course or remote from the traumatic event.^[4] Although diagnostic methods were described for the management of traumatic rupture of the diaphragm^[2,6,7] they showed unsatisfying results.^[2] Correct diagnosis with use of these imaging methods depends largely on the demonstration of herniated abdominal contents rather than the direct demonstration of diaphragmatic tear.

The purpose of the present study was to review the patients operated at surgical emergency department for traumatic rupture of the diaphragm in order to identify the factors influencing the clinical course.

MATERIALS AND METHODS

Ankara Numune Training and Research Hospital is one of the biggest trauma centers of Turkey, and around 2000 trauma cases are admitted each year. The medical records of 58 patients with DRs, which were diagnosed during surgery in Emergency Department at last five years, were retrospectively analyzed. Age, sex, types of injury, the revised trauma score (RTS)^[8,9] and SIRS (systemic inflammatory response syndrome) score,^[10] preoperative findings, associated injuries, the location of injury, the size of the rupture, grade of organ injury,^[11] herniated organs, blood transfusion, duration of hospitalization, and related mortality rates were all recorded and the influence of these factors on mortality was then evaluated.

Statistical analyses

All data were stored using SPSS 10.05 for Windows. Statistical analyses were performed by using independent samples t-test, chi-square test and logistic regression as required. *p* values less than 0.05 were considered as significant.

RESULTS

The age and sex distribution of patients

The mean (range) age of patients was 33 (14-76) years. Male/female (M/F) ratio was 43/15, and 74% of patients were male. The average age and the mechanism of injury were similar in both sex. The overall mortality rate was 21% (12 patients, 7 male). When the mortality rates compared among the sex groups, there was no significant difference between groups (5/15, 33% vs. 7/43, 16%, *p*=0.08) (Table 1).

The mechanism of injury

The most common cause of diaphragmatic rupture was penetrating injury (52%, 30 patients). While 72% of penetrating injuries were from stab wounds, remaining 28% were due to other reasons (gunshot, traffic accident etc.). Blunt injury had a prevalence of 48% (28 patients). Blunt traumas were mostly due to car accident (95%). All cases with mortal course were blunt traumas (*p*<0.001) (Table 1).

Preoperative findings

The revised trauma score and SIRS were calculated for each patient. Average revised trauma score (RTS) was 6.68 (1.96-7.84) in general, it was found to be 5.02 (1.96-6.9) in patients who had mortal course. RTS was 5.75 (1.96-7.84) for the blunt injuries and 7.62 (6.17-7.84) for the penetrating injuries (*p*<0.001).

Average SIRS score was 2.5 (0-4) in general, it was found to be 2.1 in penetrating trauma and 2.9 in blunt trauma and was 3 in patients who had mortal course (*p*=0.099). SIRS score was poorly correlated with blood transfusion and presence of herniation (Spearman's rho=0.395, *p*=0.025, *p*=0.012 respectively).

Only seven (12%) patients had shock status preoperatively and all had mortal course. All patients with shock also had splenic injury (*p*<0.001) (Table 1).

Associated injuries

Associated injuries were present in 51 (88%) patients (33 patients had only intra-abdominal injuries, 3 had rib fractures, 2 had intra-thoracic injury, 11 had both intra-abdominal and intra-thoracic injuries). Most commonly injured abdominal organ was spleen, stomach, liver and colon.

Table 1. The mechanism of injury and related parameters

	Blunt	Penetrating	<i>p</i>
N	28	30	
Male/Female	18/10	25/5	0.087 (ns)
Mortality	12	0	0.001
RTS (*)			0.242 (ns)
<4	10 (100)	6 (0)	
>4	18 (11)	24 (0)	
SIRS (*)			0.154 (ns)
<2	16 (25)	22 (0)	
>2	12 (67)	8 (0)	
Location of rupture (%)			0.214 (ns)
Right	6 (22)	8 (27)	
Left	22 (78)	20 (66)	
Bilateral	0	2 (7)	
Associated intraabdominal organ injuries			0.540 (ns)
Spleen	10	11	
Stomach	1	14	
Liver	5	8	
Colon	2	5	
Gallbladder	1	1	
Over	2	–	
Kidney	1	–	
V. Cava inferior	1	–	
Adrenals	1	–	
Bladder	1	–	
Total (no of cases)	21	23	
Herniated organs			0.005
Stomach	8	1	
Small bowel	5	1	
Spleen	4	1	
Colon	2	–	
Liver	2	–	
Total (no of cases)	10	1	

* Number in brackets represents the percentage of cases with mortality; RTS: The revised trauma score; SIRS: Systemic inflammatory response syndrome; ns: not significant.

Most commonly injured abdominal organ was spleen in blunt injuries, stomach in penetrating injuries. None of the patients had associated head injury.

Preoperative diagnoses

Preoperative diagnoses were accurately made in only twelve (20%) patients based on physical examination, chest film and computed tomography (CT). Remaining 46 (80%) patients were diagnosed during surgery after a positive peritoneal lavage.

Chest film

Preoperative chest film was obtained in 42 of the 58 patients and 15 of those were considered as normal. Chest film could not be taken in remaining 16 patients who had undergone emergent surgery. Diagnostic findings of intrathoracic bowel gas in the chest were present in nine of 42 patients. Non-specific findings, such as elevated hemidiaphragm, hemothorax and pneumothorax were present in 18 patients (Table 2).

Table 2. Pulmonary complications related to trauma according to the chest X-ray (p=0.456)

	Blunt	Penetrating
Atelectasis	0	2
Hemothorax	4	3
Pneumothorax	3	1
Hemopneumothorax	1	4
Flail Chest	1	0
Laceration	1	0
Hemothorax + Flail chest + transection of left pulmonary artery	1	0

p values according to chi-square test.

Chest tubes

Chest tubes were inserted preoperatively in 27 patients. The chest tubes were inserted after the recognition of diaphragmatic injury intraoperatively in the other 29 patients.

Computed tomography (CT)

CT scan was performed in only two patients who had thoracoabdominal trauma during the initial evaluation with the suspicion of DR. Thoracoabdominal CT was diagnostic in these patients as they had left diaphragmatic defects.

Peri-operative findings

In 46 patients (80%), the diagnosis of diaphragmatic hernia could not be established before exploration. Midline incision was the incision of choice in 52 (90%) cases and in remaining six (10%) cases thoracoabdominal incisions were used due to suspected trauma to the heart, great vessels or major bronchi.

The location of rupture

Rupture was located on the left side in 42 (72%), on the right side in 14 (24%) and was bilateral in two (3%) patients. The site of rupture had no influence on outcome and other parameters (Table 1).

Herniated organs

Intrathoracic herniation was seen in eleven (19%) cases. Visceral herniation was significantly higher in patients with blunt injury (10 patients, 91%, p=0.005). The most common herniated organ respectively was stomach, small bowel and spleen. Presence of herniation was found to be strongly correlated with SIRS score, blunt injury and the

Table 3. The grade of diaphragmatic injury (p=0.016)

Grade	Alive	Deceased	Total
I (contusion)	–	–	–
II (laceration <2 cm)	14	–	14
III (laceration 2-10 cm)	20	5	25
IV (laceration >10 cm)	12	5	17
V (laceration + tissue loss >25 cm ²)	–	2	2

p values according to chi-square test.

grade of injury (p=0.012, p=0.005, p=0.001). Presence of herniation has no effect on mortality (p=0.155) (Table 1).

The grade of injury

All ruptures were graded according to previous classification by Asensio et al.^[10] Rupture size was less than 2 cm (grade II) in 14 (24%) patients and was over 2 cm in remaining 34 (59%) patients. It was grade III in 20 (35%) patients. There were strong correlations between grade of injury and type of trauma (p<0.001), RTS (Spearman's rho=-0.379 p=0.039) and herniation (p=0.001). Location of rupture has no affect on grade. There was no correlation between the grade of injury and presence of shock (p=0.061) (Table 3).

Average rupture size was 10.6 (2-30) cm in the penetrating trauma, 3.5 (1-12) cm in the blunt trauma. Average rupture size was 13.1 (3-30) cm in the blunt trauma, 3.1 (1-12) cm in the penetrating trauma and 13 (4-30) cm in patients with mortal course (Table 3).

The diaphragmatic injury was repaired primarily with interrupted non-absorbable sutures in 53 (92%) patients and prosthetic mesh (Prolene Mesh Ethicon Company) in 2 (3%) patients. Ruptures could not be repaired in 3 (5%) patients as they died early on the operating table (Table 3).

Hospital stay

Mean duration of hospital stay for patients with a total cure was 10 (3-30) days, Whereas the duration of hospital stay was 2.7 days in patients with mortal course 9 died peroperatively, one died at postoperative 24th hour, one at 8th postoperative day and other one died at 9th postoperative day. Hospital stay of patients in penetrating trauma was 10.5 (3-30) days and it was 9 (1-15) days in blunt trauma.

Factors influencing mortality

The overall mortality rate was 21% (n=12). All mortalities were seen in patients with blunt trauma and the most common cause of death was hemorrhagic shock (n=7) (Table 4).

Early mortality (<24h) was observed in 17% (n=10). Early mortality resulted from hemorrhagic shock because of severe bleeding from associated injuries. The majority of late deaths (>24 h) were attributed to sepsis, multiple organ failure and ARDS. Average blood transfusion was 2.8 units (1-10) in mortal cases and 0.2 units (0-4) in the remaining patients (p<0.002). Associated organ injuries were present in eleven (92%) mortal cases. The size of rupture was over 5 cm in eight (75%) cases.

The influences of factors on mortality were analysed by using logistic regression and Backward Wald test. Blunt trauma, grade, blood transfusion, presence of splenic injury and presence of shock were all found to be factors influencing mortality. OR (odds ratio) and CI (Confidence interval) evaluation revealed that only grade and presence of splenic injury had strong influence on mortality (OR: 11.9, CI (1.5-92.4); OR: 84.5 CI (5.7-1253.6) respectively.

DISCUSSION

Diaphragmatic hernia after trauma can be divided into three phases: the acute phase; patients in whom diagnosis is correctly established immediately, up to 14 days after injury; the second phase: patients diagnosed in the period after acute injury, but before intestinal obstruction or strangulation and the third phase, patients in whom correct diagnosis is established because of intestinal obstruction or strangulation.^[2,3] In this study we have considered only the first phase.^[12-14]

Diaphragmatic rupture can occur from penetrating or blunt injuries, and rarely occur spontaneously as a result of pregnancy. DR occurs in 10-19% of victims of penetrating trauma to the thorax and abdomen.^[3,15-18] The major causes are gunshot and stab wounds in penetrating trauma. DR occurs in 0.8-7% of major blunt injuries.^[15,19] Car accidents are common causes of blunt injury.^[20] Penetrating injuries are the most common cause of diaphragmatic injuries, with a ratio to blunt injury of 2:1.^[21] In our study, the most common cause of DR was penetrating injuries (52%).

Table 4. Factors influencing mortality

Factor	<i>p</i>
Blunt trauma	0.001
Grade	0.017
Blood transfusion	0.002
Presence of shock	0.001
Presence of splenic injury	0.001

p values according to logistic regression.

The frequency of the two types of injury is a reflection of the geographic and socioeconomic region served by each hospital.^[15,19,20] All reports, including the one presented here, describe that the majority of injuries occurring in men rather than in women.^[6,21]

In our study, the most common trauma in female was blunt trauma (10/15). Hemorrhagic shock and mortality most often occurred in female patients.

The preoperative diagnosis of DR is always difficult in trauma victims.^[15,22,23] Only 20% of the DRs were diagnosed before surgery in the present study which is in correlation with previous reports.^[24] The trauma surgeon must first suspect DR and then progressively build a case to prove or disprove its existence.^[25-27]

Although simple chest X-ray is an helpful investigation,^[28] the films are often technically compromised by the use of portable radiography units, supine projection, and limited patient cooperation. DR was reported to be suspected in only 27% (19.4-50) of cases based on the initial chest film.^[7] In the current study, the initial chest radiogram was diagnostic in only 21% (9/42) of the patients; normal films have been reported in 20-50% of the cases which is in correlation with previous reports.^[23] There is an abnormal pattern of gas seen in a right sided rupture in only the most severe cases, and ruptures on right side are more difficult to diagnose before operation than left-sided ones.^[12] Despite these reports, 8 (19%) out of 42 left sided DR's were accurately diagnosed before operation in our study, which was similar for the right-sided DR's with three out of 14 (21%) were being diagnosed preoperatively. This difference is probably due to the mix pattern of our patient group as most previous reports on this matter include only blunt injuries.

The mechanism of injury for blunt rupture is thought to be a lateral impact distorting and shearing the chest wall or a direct frontal impact causing a sudden increase in intraabdominal pressure. Most ruptures occur in the posterolateral aspect of the hemidiaphragm as this area is structurally weak because of its embryologic origin from the pleuroperitoneal membrane.^[12] Left sided ruptures are more common, possibly due to a buffering effect of the liver on the right hemidiaphragm.^[2,12,17] Injury to the both leaflets of the diaphragm was reported to be relatively uncommon as it was in our study (3%).^[29,30] Present study also confirms the predominance of left sided rupture, as so many other series have noted.^[31] In spite of this, location of rupture had no statistical affect on mortality or other evaluated parameters.

Isolated diaphragmatic injuries are seen infrequently.^[32] Associated injuries were present in 51 patients in the present study, and most frequently were belonging to spleen, stomach, liver, colon and chest wall or lung which is in correlation with previous reports.^[3,15,23,25,28] Thus, the present study like many others, demonstrates the necessity of careful examination of these patients for concomittant organ injuries.^[15,28] Non thoraco-abdominal injuries were absent in all patients.

Visceral herniation to the thorax was seen in 19% of our patients with diaphragmatic rupture. Herniation of the abdominal viscera into the thorax was observed at surgery in 10 of 28 (36%) blunt trauma patients ($p=0.013$), a rate similar to the previous reports of 32-64%.^[12,33] All the blunt traumas with visceral herniation were on the left side and more than ten cm in seven patients (grade IV and V) ($p=0.009$). The most herniated organ was stomach, which was followed by small bowel and spleen respectively in our study which is also mostly in correlation with previous reports.^[28,29,33] On the right side, because of the liver acting as buffer, herniation occurs much less frequently and in general, it occurs more slowly and more gradually.

In our series, the majority of diaphragmatic defects were repaired with a single layer of nonabsorbable sutures. There was no in hospital recurrence and the method of repair was not associated with eventual outcome.

The overall mortality rate was 21% in the present study. This result was in accordance with those

of other series that range from 4.3% in a series of predominantly penetrating injuries to 37% in a series of blunt injuries with most authors reporting 17% to 25% mortality rates.^[3,12,15,24,34]

In the present study, increased mortality rates were noted in patients who arrived emergency departments in shock and in patients with a blunt injury. Increased grade of injury, blood transfusions over 3 units, presence of splenic injury had significant effect on mortality. Pulmonary complications and location of rupture had no statistical effect on mortality and clinical course. Hemorrhagic shock is most often cited as causes of intraoperative or early postoperative deaths; sepsis and multisystem organ failure shown as late causes of death. In order to decrease the early mortality in patients with shock special attention must be given to their care including venous access, blood transfusion, drug therapy etc; starting from transfer via the ambulance to getting into the operating room.

We conclude that the diagnosis of diaphragmatic injury is important in traumatic victims. Preoperative evaluation is usually inadequate and most ruptures were diagnosed during surgery. Therefore, careful visual and manual inspections of entire diaphragm are necessary. Although many factors influence mortality, outcome is almost entirely dependent on associated injuries so that careful attention should be given to their diagnosis and treatment.

REFERENCES

1. Abdel Hadi MS, Al-Mulhim AA, Al-Awad NI, Zakaria HM, Al-Awami MS. Diaphragmatic injury. A clinical review. Saudi Med J 2001;22:890-4.
2. Nau T, Seitz H, Mousavi M, Vecsei V. The diagnostic dilemma of traumatic rupture of the diaphragm. Surg Endosc 2001;15:992-6.
3. Koehler RH, Smith RS. Thoracoscopic repair of missed diaphragmatic injury in penetrating trauma: case report. J Trauma 1994;36:424-7.
4. Huggon AM, Houghton A, Watson DP. Ruptured diaphragm: the latent phase. Br J Clin Pract 1996;50:408-9.
5. Kim HH, Shin YR, Kim KJ, Hwang SS, Ha HK, Byun JY, et al. Blunt traumatic rupture of the diaphragm: sonographic diagnosis. J Ultrasound Med 1997;16:593-8.
6. Mansour KA. Trauma to the diaphragm. Chest Surg Clin N Am 1997;7:373-83.
7. Shapiro MJ, Heiberg E, Durham RM, Luchtefeld W, Mazuski JE. The unreliability of CT scans and initial chest radiographs in evaluating blunt trauma induced

- diaphragmatic rupture. *Clin Radiol* 1996;51:27-30.
8. Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the Trauma Score. *J Trauma* 1989;29:623-9.
 9. Champion HR, Sacco WJ, Carnazzo AJ, Copes W, Fouty WJ. Trauma score. *Crit Care Med* 1981;9:672-6.
 10. American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference: definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. *Crit Care Med* 1992;20:864-74.
 11. Asensio JA, Demetriades D, Rodriguez A. Injury to the diaphragm. In: Mattox KL, Feliciano DV, Moore EE, editors. *Trauma*. 4th ed. New York, USA: McGraw-Hill; 1999. p. 603-32.
 12. Murray JG, Caoili E, Gruden JF, Evans SJ, Halvorsen RA Jr, Mackersie RC. Acute rupture of the diaphragm due to blunt trauma: diagnostic sensitivity and specificity of CT. *AJR Am J Roentgenol* 1996;166:1035-9.
 13. Cruz CJ, Minagi H. Large-bowel obstruction resulting from traumatic diaphragmatic hernia: imaging findings in four cases. *AJR Am J Roentgenol* 1994;162:843-5.
 14. Smithers BM, O'Loughlin B, Strong RW. Diagnosis of ruptured diaphragm following blunt trauma: results from 85 cases. *Aust N Z J Surg* 1991;61:737-41.
 15. Meyers BF, McCabe CJ. Traumatic diaphragmatic hernia. Occult marker of serious injury. *Ann Surg* 1993;218:783-90.
 16. Brandt ML, Luks FI, Spigland NA, DiLorenzo M, Laberge JM, Ouimet A. Diaphragmatic injury in children. *J Trauma* 1992;32:298-301.
 17. Rosati C. Acute traumatic injury of the diaphragm. *Chest Surg Clin N Am* 1998;8:371-9.
 18. Shah R, Sabanathan S, Mearns AJ, Choudhury AK. Traumatic rupture of diaphragm. *Ann Thorac Surg* 1995;60:1444-9.
 19. Beauchamp G, Khalfallah A, Girard R, Dube S, Laurendeau F, Legros G. Blunt diaphragmatic rupture. *Am J Surg* 1984;148:292-5.
 20. Aronoff RJ, Reynolds J, Thal ER. Evaluation of Diaphragmatic injuries. *Am J Surg* 1982;144:571-5.
 21. Kurt N, Oncel M, Kement M, Akyol H, Kargi AB. Prognostic factors effecting mortality in traumatic diaphragm injury. *Ulus Travma Derg* 2002;8:152-5.
 22. Miller L, Bennett EV Jr, Root HD, Trinkle JK, Grover FL. Management of penetrating and blunt diaphragmatic injury. *J Trauma* 1984;24:403-9.
 23. Wiencek RG Jr, Wilson RF, Steiger Z. Acute injuries of the diaphragm. An analysis of 165 cases. *J Thorac Cardiovasc Surg* 1986;92:989-93.
 24. Mihos P, Potaris K, Gakidis J, Paraskevopoulos J, Varvatsoulis P, Gougoutas B, et al. Traumatic rupture of the diaphragm: experience with 65 patients. *Injury* 2003;34:169-72.
 25. Brown GL, Richardson JD. Traumatic diaphragmatic hernia: a continuing challenge. *Ann Thorac Surg* 1985;39:170-3.
 26. Pipkin NL, Hamit HF. Traumatic perforation of the diaphragm. *South Med J* 1988;81:1347-50.
 27. Hacıbrahimoglu G, Solak O, Olcmen A, Bedirhan MA, Solmazer N, Gurses A. Management of traumatic diaphragmatic rupture. *Surg Today* 2004;34:111-4.
 28. Broos PL, Rommens PM, Carlier H, Van Leeuwen JE, Somville FJ, Gruwez JA. Traumatic rupture of the diaphragm. Review of 62 successive cases. *Int Surg* 1989;74:88-92.
 29. Arak T, Solheim K, Pillgram-Larsen J. Diaphragmatic injuries. *Injury* 1997;28:113-7.
 30. Anderson DW. Bilateral diaphragm rupture: a unique presentation. *J Trauma* 2002;52:560-1.
 31. Boulanger BR, Milzman DP, Rosati C, Rodriguez A. A comparison of right and left blunt traumatic diaphragmatic rupture. *J Trauma* 1993;35:255-60.
 32. Shaw JM, Navsaria PH, Nicol AJ. Laparoscopy-assisted repair of diaphragm injuries. *World J Surg* 2003;27:671-4.
 33. Lee WC, Chen RJ, Fang JF, Wang CC, Chen HY, Chen SC, et al. Rupture of the diaphragm after blunt trauma. *Eur J Surg* 1994;160:479-83.
 34. Williams M, Carlin AM, Tyburski JG, Blocksom JM, Harvey EH, Steffes CP, et al. Predictors of mortality in patients with traumatic diaphragmatic rupture and associated thoracic and/or abdominal injuries. *Am Surg* 2004;70:157-63.