Presentations and outcomes in patients with traumatic diaphragmatic injury: A 15-year experience

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BACKGROUND: Traumatic diaphragmatic injury (TDI) is usually associated with multiple injuries. We aimed to evaluate the patterns, associated injuries, and predictors of in-hospital mortality of patients with TDI.

METHODS: The trauma registry from a Primary Adult Resource Center for Trauma was queried for patients admitted with a TDI from January 1995 to December 2009. Patient characteristics, mechanism of injury, associated injuries, management, and outcomes were analyzed. We compared morbidity and mortality in left and right diaphragmatic injuries (LDI and RDI, respectively).

RESULTS: Of the 773 patients, 650 were male (84%), with a mean (SD) age of 33 (15). Mechanism of injury was penetrating in 561 (73%) and blunt in 212 (27%) patients. LDI, RDI, and bilateral injuries were 57%, 40%, and 3%, respectively. The majority of cases were managed by exploratory laparotomy and direct suture repair. LDI was associated with higher rates of splenic, gastric, and pancreatic injuries and prolonged hospital stay in comparison with RDI. In comparison with LDI, RDI was associated with higher rates of deaths (26% vs. 17%, $p = 0.003$). Overall, mortality in TDI was 21%. Age (odds ratio [OR], 1.02, $p = 0.008$), Injury Severity Score (ISS) (OR, 1.09, $p = 0.001$), associated cardiac injury (OR, 2.8, $p = 0.005$), left diaphragmatic injury (OR, 0.53, $p = 0.005$), and operative interventions (OR, 0.32, $p = 0.001$) were independent predictors for mortality.

CONCLUSION: This largest single institution study on TDI in the literature confirms that LDI are more commonly diagnosed than RDI. Exploratory laparotomy is the most common procedure performed for these injuries. Young age and operative interventions are associated with favorable outcome, whereas high ISS, RDI, and associated cardiac injury are independent predictors for mortality. (*J Trauma Acute Care Surg*. 2013;74: 1392–1398. Copyright © 2013 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Epidemiological study, level III.

KEY WORDS: Traumatic diaphragmatic injury; associated injuries; mortality; complications.

Traumatic diaphragmatic injuries (TDI) are relatively uncommon and are usually caused by severe blunt or penetrating trauma of the thoracoabdominal region.[1,2] Diaphragmatic ruptures are usually found in combination with other injuries.[1,2] The overall incidence of TDI varies from 0.8% to 8%, and the incidence of blunt and penetrating trauma differs geographically. A recent report of TDI showed penetrating trauma was the leading cause (65%) of TDI and blunt trauma, representing 35% of all diaphragmatic injuries.[3] Lopez et al.[3] also reported that 64.5% of the patients had left-sided injuries (LDIs) and 35.5% had right-sided injuries (RDIs). This predominance of LDI is possibly caused by the protective effect of the liver on the right side of the diaphragm. Delay in diagnosis is associated with higher morbidity and mortality rates (9–35.7%).[3–5]

Low sensitivity and specificity of routine imaging techniques was attributed to the missed or delayed diagnosis and management of TDI.[6] The range of overlooked diaphragmatic injuries varied from 12% to 66% in patients undergoing conventional management.[7] These missed injuries may remain occult for longer duration and present later with severe complications such as strangulation of intra-abdominal organs and diaphragmatic herniation, leading to higher rates of morbidity and mortality.[8] The present study was designed to evaluate the patterns of injury, incidence of associated injuries, predictors of in-hospital mortality, and early management in patients with TDI, reviewed during a period of 15 years from a single center.

PATIENTS AND METHODS

The trauma registry from R Adams Cowley Shock Trauma Center, a Primary Adult Resource Center for Trauma, was queried for patients admitted with TDI from January 1995 to December 2009. Information regarding demographic characteristics, mechanism of injury (MOI), associated injuries, management, and postoperative outcomes were reviewed. TDI characteristics, length of stay, complications and mortality, as well as method and approach of repair were analyzed. The diagnosis of acutely injured diaphragm was based on the clinical, radiological

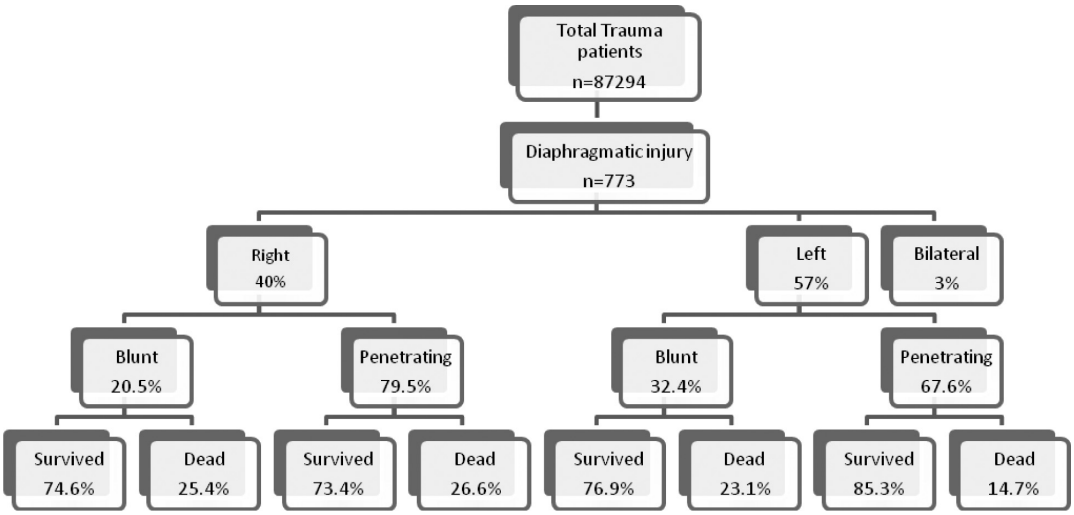

Figure 1. Overview of total trauma patients according to site and MOI.

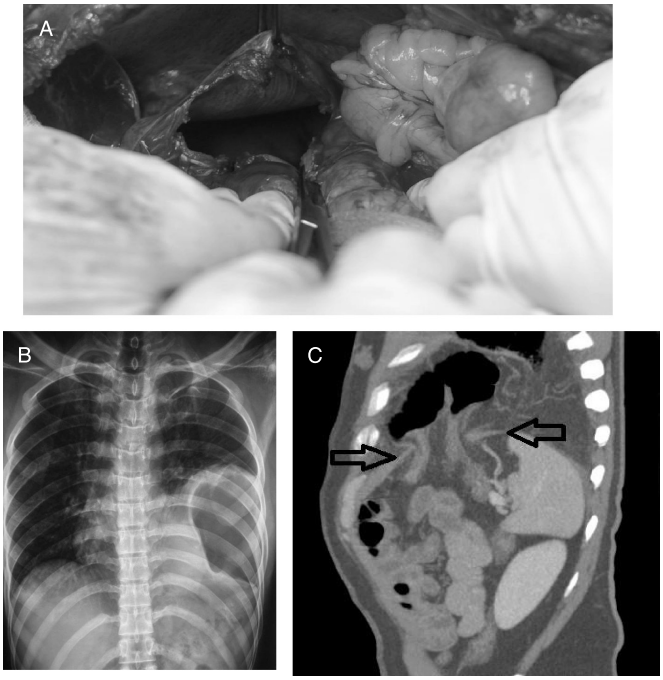

Figure 2. Example of radiological and operative findings in patient with left traumatic diaphragmatic rupture.

(x-ray and computed tomographic [CT] scan of the chest) and operative findings. The data are presented as mean (SD) or total (percentage) as appropriate. Baseline demographic characteristics, presentation, management, and outcomes were also compared between patients having left and right TDIs using the Student's *t* test for continuous variables and Pearson χ^2 test for categorical variables. Furthermore, clinical findings, management, and outcomes were also analyzed according to the site (left vs. right) and mechanism (blunt vs. penetrating) of diaphragmatic injury. Two-tailed *p* value less than or equal to 0.05 was considered statistically significant. The multivariate logistic regression analysis was performed for the predictors of mortality after adjusting the potential covariates that showed significant difference among the univariate analysis. Odds ratio (OR), 95% confidence interval (CI), and corresponding *p* values were analyzed by logistic regression analysis and adjusted accordingly. A subanalysis was performed comparing the demographics and clinical profiles for patients surviving TDI versus those who died. Data were analyzed using the Statistical Package for the Social Sciences version 18 (SPSS Inc., Chicago, IL).

RESULTS

Of the 773 patients with TDI, 650 (84%) were male, and 123 (16%) were female, with age range 20 years to 60 years (mean, 33 years). MOI was penetrating in 561 (73%) and blunt in 212 (27%) patients. Rupture of the diaphragm was left sided in 57%, right sided in 40%, and bilateral in 3% of the patients (Fig. 1 summarizes the study design and outcome). Accompanying injuries in other organs included injury of the lung (77%), liver (52%), spleen (32%), bowel (21%), and stomach (19%) as well as rib fracture (33%). Hemothorax was seen in 54% and pneumothorax in 48%. Two cases sustained traumatic aortic disruption requiring aortic graft. Figure 2 shows an example of the diagnostic tools used in the study (radiological and operative findings of TDI).

The majority of the TDI cases were primarily managed by emergency intervention (77%) including exploratory laparotomy (94%) and thoracotomy (6%). In comparison with patients who underwent emergency intervention, patients without

TABLE 1. Clinical Findings, Management, and Outcomes by Site and Mechanism of Diaphragmatic Injury

	Right-Sided TDI (RDI)*			Left-Sided TDI (LDI)*		
	Blunt	**Penetrating**	***p***	**Blunt**	**Penetrating**	***p***
Age, mean (SD), y	42 (21)	29 (11)	0.001	41 (18)	30 (12)	0.001
Male	70	91	0.001	64	91	0.001
Associated injury						
Lung contusion, %	82.5	77.5	0.38	88	69	0.001
Spleen, %	32	5	0.001	57	41	0.002
Rib fracture, %	54	28	0.001	60	19	0.001
Liver, %	59	80	0.001	34	34	0.97
Bowel, %	21	18	0.69	19	23	0.28
Kidney, %	16	18	0.68	13	19	0.11
Stomach, %	0	9	0.02	5	36	0.001
Cardiac, %	9.5	11	0.75	4.2	9	0.07
Pneumothorax	52	45	0.30	62	43	0.001
Hemothorax, %	52	62	0.19	46	51	0.32
Death, %	25	27	0.84	23	15	0.03
Operative procedure						
Exploratory laparotomy, %	78	92	0.006	97	96	0.78
Thoracotomy, %	22	8	3	4		
Length of hospitalization**	14 (5–21)	6 (1–11)	0.001	12 (5–22)	7 (4–15)	0.001

*3% are bilateral diaphragmatic injury (see text).
**Median (interquartile range).

TABLE 2. Clinical Profiles of Patients Who Survived Diaphragmatic Injury

	Alive (n = 611)	Dead (n = 162)	*p*
Sex			
Male	83.3	87.0	0.26
Diaphragm injury			
Left	59.6	47.8	0.007
Right	36.9	50.3	
Bilateral	3.4	1.9	
Type of injury			
Blunt	26.6	30.4	0.34
Penetrating	73.4	69.6	
Associated injury			
Head	13.1	26.7	0.001
Lung	75	82.6	0.04
Ribs	32.4	36.6	0.30
Spleen	35.3	19.9	0.001
Liver	49.2	62.1	0.003
Bowel	19.9	25.5	0.12
Kidney	17.8	14.9	0.38
Stomach	19.1	16.8	0.49
Cardiac	3.3	21.1	0.001
Pericardium	2.5	13.7	0.001
Pancreas	7.2	8.1	0.70
Pneumothorax	51.6	35.4	0.001
Hemothorax	51.8	60.2	0.05
Operative intervention			
Exploratory laparotomy	77.8	47.2	0.001
Thoracotomy	3.3	9.9	

emergency intervention had higher rate of head injury (25% vs. 13%), cardiac injury (11% vs. 6%), greater mean Injury Severity Score (ISS) (43% vs. 34%), and mortality (38% vs. 15.5%).

The supplemental table (see Table, Supplemental Digital Content 1, http://links.lww.com/TA/A247) shows the MOI, clinical findings, management, and outcomes in RDI versus LDI. LDI was associated with prolonged hospital stay, higher rates of splenic, gastric, and pancreatic injuries compared with RDI. In contrast, RDI had significantly higher rates of liver and cardiac injuries, hemothorax, and mortality (26% vs. 17%, $p = 0.003$). The mean (SD) ISS was comparable among the two groups (29 [16] vs. 28 [15]; $p = 0.33$). Rate of exploratory laparotomy was higher in LDI, whereas thoracotomy was observed more frequently in RDI ($p = 0.001$).

Table 1 demonstrates the clinical findings, management, and outcomes in each side of diaphragm based on the MOI. Among RDI, young age, male sex, liver and gastric injuries, and rate of exploratory laparotomy were more frequently reported in penetrating injuries, whereas blunt injuries were significantly associated with advanced age, splenic injuries, rib fracture, and increased hospital length of stay.

Among LDI, blunt injuries had higher association with advanced age, lung and splenic injuries, rib fracture, pneumothorax, increased hospital length of stay, and mortality.

Mortality

Overall mortality was 21% among TDI patients. In blunt trauma, the mortality was comparable between RDI and LDI (25% vs. 23%, $p = 0.72$); however, in penetrating trauma, the mortality was higher in those with RDI (27% vs. 15%, $p = 0.001$). Table 2 shows clinical profiles of patients who survived diaphragmatic injury versus those who died. Patients who died had higher rate of RDI and associated injuries of the head, lung, liver, and heart. Multivariate logistic regression analysis showed that age (OR, 1.02; 95% CI, 1.01–1.04; $p = 0.008$), mean ISS (OR, 1.09; 95% CI, 1.08–1.12; $p = 0.001$), and associated cardiac injury (OR, 2.83; 95% CI, 1.38–5.82; $p = 0.005$) were independent predictors for mortality, whereas left versus right diaphragmatic injury (OR, 0.53; 95% CI, 0.34–0.83; $p = 0.005$) and operative interventions (OR, 0.32; 95% CI, 0.2–0.53; $p = 0.001$) were independent predictors of survival (Table 3).

DISCUSSION

Diaphragmatic injuries are infrequent and difficult to report owing to a significant number of missed or delayed diagnoses and prehospital deaths.[9] This is a large single-institution report on characteristics, injury profile, management, and outcome of TDI patients, reviewed for a period of 15 years. This study gives us a chance for contemporary analysis of the etiology, MOI, treatment, and outcome in patients with TDI from a primary adult resource center for trauma. The frequency of blunt and penetrating TDI varies depending on the geographic distribution and socioeconomic factors. Table 4 shows a review of literature for injury characteristics and outcome in TDI patients.[3,5,10–26]

In the present study, the majority of our patients with TDI had experienced penetrating trauma (73%) compared with blunt trauma (27%), which is similar to the recent report from Hanna et al.[21] A retrospective review of 15 years data from a Level 1 trauma center also reported penetrating trauma (61%) to be the leading cause of TDI compared with blunt trauma (39%).[19] In contrast, other studies have reported higher incidence of TDI with blunt trauma as compared with penetrating injuries.[12,17,20,25]

These differences in MOI are caused by variation in demography and sociocultural conditions of our study population, which was mainly composed of males of the younger age group. Penetrating injuries in terms of gunshot and stab wounds were the most common cause of TDI in the current report followed by blunt trauma; this was consistent with other previously reported studies.[3,11,19–21] Other studies have

TABLE 3. Multivariate Logistic Regression Analysis for the Predictors of Mortality

Variables	OR	95% CI	*p*
Age	1.02	1.01–1.04	0.008
ISS	1.09	1.08–1.12	0.001
MOI*	1.52	0.87–2.68	0.144
Cardiac injury	2.83	1.38–5.82	0.005
Diaphragm injury**	0.53	0.34–0.83	0.005
Head injury	1.24	0.7–2.19	0.469
Operative interventions†	0.32	0.2–0.53	0.001

*Blunt versus penetrating.
**Left versus right.
†Operated versus none.

TABLE 4. Review of Literature for Injury Characteristics and Outcome in Patients With TDI

References	Duration, y	Age, y	MOI*	Site of Injury**	Mortality, %
Guner et al.[10]	8	46	8 (8/0)	0/8/0	0
Dirican et al.[11]	10	33	48 (15/33)	35/10/3	15
Hwang et al.[12]	8	42	40 (32/8)	36/4/0	17.5
Kuo et al.[13]	9	43	43 (43/0)	24/14/5	9.3
Beigi et al.[14]	4	32	34 (22/12)	22/11/1	14.7
Gwely[15]	10	15–30	44 (44/0)	30/12/0	13.2
Hsee et al.[16]	10	N/A	28 (28/0)	17/10/1	25
Lopez et al.[3]	20	33	124 (44/80)	80/44/0	9
Kishore et al.[17]	5	35	27 (22/5)	23/4/0	11
Al-Refaie et al.[18]	13	36	46 (46/0)	34/12/0	4.3
Tan et al.[5]	7	38	14 (14/0)	9/5/0	35.7
Lewis et al.[19]	13.5	35	254 (99/155)	129/78/9	32
Peer et al.[20]	10	33	29 (24/5)	23/6/0	13.8
Hanna et al.[21]	13	34 (16–79)	105 (39/66)	—	18
Filiz et al.[22]	4	23	13 (6/7)	13/0/0	0
Ozgüç et al., 2007[23]	11	38	51 (26/25)	40/10/1	19.6
Lunca et al.[24]	10	34	61 (15/46)	45/15/1	14.7
Esme et al. [25]	6	35	14 (11/3)	10/4	7
William et al.[26]	22	31	731 (79/652)	(460/263/8)	23
Present series	15	32	773 (212/561)	(441/309/23)	21

*Total number of patients according to MOI (blunt/penetrating).
**Left/right/bilateral.

reported higher incidence of left-sided (60–90%) than right sided TDI (10–36%).[3,11,12,19] Notably, bilateral TDIs are occasionally reported.[14,16]

The present study also showed greater frequency of LDIs after blunt trauma. The frequent blunt LDIs are believed to be caused by less development of the diaphragm at its posterolateral portion, which is the weakest point. A thoracoabdominal pressure gradient develops, resulting in a rupture at the left diaphragm, usually after high-impact blunt trauma such as motor vehicle crash or fall from height.[11] However, the incidence of penetrating trauma is comparable among both sides, which coincides with earlier reports.[19,27,28] The diagnosis of acute TDI remains a challenge because chances of missing small diaphragmatic tears with other associated injuries are high and needs high index of suspicion for diagnosis.[29] In contrast, delayed diagnosis may cause serious complications, leading to increased mortality.[12] The classic clinical signs and symptoms of TDI are not consistently present, and none are specific for diaphragmatic rupture, which can be missed because of more significant associated injuries (90%).[21,22,30] Therefore, a high index of suspicion is required for diagnosis of TDI with related MOI in the trauma setting.

Several investigative modalities are available for the diagnosis of TDI.[31] However, chest x-ray and CT scan are widely used for the routine diagnosis. The diagnosis by initial plain chest x-ray of an acute diaphragmatic tear after trauma has been reported in only 20% to 34% of the cases.[26,30,32,33] The sensitivity of diagnosis may be increased by repeat chest radiographs.

Assessment of diaphragmatic injury by CT examination is more reliable with high sensitivity (33–83%) and specificity (76–100%).[34] Ultrasound examination for trauma patients is useful in detecting large diaphragmatic herniation but insensitive for diagnosing small rupture after penetrating trauma. Current advances in magnetic resonance imaging technique facilitate better visualization of diaphragmatic aberrations, but this technique is not feasible for hemodynamically unstable patients in emergency settings.[35] Minimally invasive techniques found utility in early diagnosis and treatment of TDIs in hemodynamically stable patients.[19,21,36]

The primary attention in the management of the acute phase of TDI should be directed toward the life-threatening injuries. Following stabilization of the patient, a thorough assessment of the patient should be performed, looking for additional injuries.[36] The next question for the surgeon will be which cavity should be entered and whether conventional open approach or minimally invasive approach be used? In most cases, this depends on the patient's hemodynamic stability and the surgeon's preference and skills. In general, there is no superiority of one cavity approach over the other in the management of hemodynamically stable patients, unless the associated injuries mandate a specific approach. Whatever the operative approach for repairing TDI, the main two principles of operative intervention are complete reduction of herniated viscus back to the abdominal cavity and water-tight closure of the diaphragmatic defect. Direct suturing with interrupted or running sutures using nonabsorbable sutures should be adequate. In the present study, the majority of the cases were managed by exploratory laparotomy and direct suture repair. Surgical repair of the diaphragm is important even for small ruptures because spontaneous healing does not occur and eventually may lead to herniation and strangulation.[11] Surgical management can be performed via laparotomy or thoracotomy or through a combination of these procedures.[11] Minimally invasive surgery found utility in the management of TDIs for both diagnosis and therapeutic intervention and as

in open surgery may be applied using thoracoscopic approach or laparoscopic approach.[36]

The overall mortality of TDI patients was 21% in our study, which is similar to the earlier published studies from the United States.[26,37,38] In addition, the mortality rate was significantly higher in our patients who had RDI compared with LDI ($p = 0.003$). In correlation with MOI, the mortality was comparable between RDI and LDI ($p = 0.72$) after blunt injury; however, in penetrating injury, the mortality was almost twofold greater in those with RDI in comparison with LDI ($p = 0.001$).

The present series observed age, high ISS, RDI, associated cardiac injury, and need for exploratory laparotomy to be the independent predictors of mortality by multivariate logistic regression analysis. Earlier studies also projected similar results on mortality with slight variations. Lewis et al.[19] found increased age and high ISS as the factors associated with the risk of mortality among patients with TDI. Hanna et al.[21] also reported ISS and head injury to be the independent predictors of mortality. Other studies have reported high ISS, hemorrhagic shock at admission, and hemodynamic status were the determinants of outcome.[11,37] In a large retrospective review of TDI patients, ISS, blood transfusion, blunt trauma, and pancreatic injury were the major predictors of mortality.[26]

Limitation of the Study

The retrospective nature of the study is one limitation. Details of delayed intervention and follow-up are not elaborated, and the exact reasons for immediate nonoperative intervention are lacking. Moreover, data for spine, pelvic, or limb injuries are not available. Lastly, the modalities of diagnosis do not show what percentage of injuries were apparent at admission chest x-ray, CT scan, and intraoperatively.

CONCLUSION

This largest single-institution study in the literature confirms that LDI are more commonly diagnosed than RDI. Exploratory laparotomy is the most common procedure performed for the management of these injuries. Young age and operative interventions are associated with favorable outcome, whereas high ISS, RDI, and associated cardiac injury are independent predictors for mortality. The present series projected a latest insight of the patterns of injury mechanism, associated injuries, and predictors of mortality, which might be helpful for patient outcome and better understanding of traumatic diaphragmatic injury.

AUTHORSHIP

A.M.Z. was involved in the study design, data collection, and writing of the article. A.E.-M. was involved in the data analysis and interpretation, drafting, and article review. H.A.-T. was involved in the data analysis and interpretation, drafting and article review. T.M.S. was involved in the study design, data interpretation, and review article. W.C.C. was involved in the study design, data interpretation, and article review. All authors read and approved the article.

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DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

1. Kole KL. Traumatic diaphragmatic injuries. *Trauma Q*. 2002;15:109–120.
2. Arsensio JA, Demetriades D, Rodriguez A. Injury to the diaphragm. In: Mattox KL, Feliciano DV, Moore EE, eds. *Trauma*. 4th ed. New York, NY: McGraw-Hill; 2000:603–632.
3. Lopez PP, Arango J, Gallup TM, et al. Diaphragmatic injuries: what has changed over a 20-year period? *Am Surg*. 2010;76:512–516.
4. Chughtai T, Ali S, Sharkey P, et al. Update on managing diaphragmatic rupture in blunt trauma: a review of 208 consecutive cases. *Can J Surg*. 2009;52:177–181.
5. Tan KK, Yan ZY, Vijayan A, Chiu MT. Management of diaphragmatic rupture from blunt trauma. *Singapore Med J*. 2009;50:1150–1153.
6. Mintz Y, Easter DW, Izhar U, et al. Minimally invasive procedures for diagnosis of traumatic right diaphragmatic tears: a method for correct diagnosis in selected patients. *Am Surg*. 2007;73:388–392.
7. Guth AA, Pachter HL, Kim U. Pitfalls in the diagnosis of blunt diaphragmatic injury. *Am J Surg*. 1995;170:5–9.
8. Degiannis E, Levy RD, Sofianos C, et al. Diaphragmatic herniation after penetrating trauma. *Br J Surg*. 1996;83:88–91.
9. Al-Mashat F, Sibiany A, Kensarah A, Eibany K. Delayed presentation of traumatic diaphragmatic rupture. *Indian J Chest Dis Allied Sci*. 2002; 44:121–124.
10. Guner A, Ozkan OF, Bekar Y, et al. Management of delayed presentation of a right-side traumatic diaphragmatic rupture. *World J Surg*. 2012;36: 260–265.
11. Dirican A, Yilmaz M, Unal B, et al. Acute traumatic diaphragmatic ruptures: a retrospective study of 48 cases. *Surg Today*. 2011;41:1352–1356.
12. Hwang SW, Kim HY, Byun JH. Management of patients with traumatic rupture of the diaphragm. *Korean J Thorac Cardiovasc Surg*. 2011; 44:348–354..
13. Kuo IM, Liao CH, Hsin MC, et al. Blunt diaphragmatic rupture—a rare but challenging entity in thoracoabdominal trauma. *Am J Emerg Med*. 2012;30:919–924.
14. Beigi AA, Masoudpour H, Sehhat S, Khademi EF. Prognostic factors and outcome of traumatic diaphragmatic rupture. *Ulus Travma Acil Cerrahi Derg*. 2010;16:215–219.
15. Gwely NN. Outcome of blunt diaphragmatic rupture. Analysis of 44 cases. *Asian Cardiovasc Thorac Ann*. 2010;18:240–243.
16. Hsee L, Wigg L, Civil I. Diagnosis of blunt traumatic ruptured diaphragm: is it still a difficult problem? *ANZ J Surg*. 2010;80:166–168.
17. Kishore GS, Gupta V, Doley RP, et al. Traumatic diaphragmatic hernia: tertiary centre experience. *Hernia*. 2010;14:159–164.
18. Al-Refaie RE, Awad E, Mokbel EM. Blunt traumatic diaphragmatic rupture: a retrospective observational study of 46 patients. *Interact Cardiovasc Thorac Surg*. 2009;9:45–49.
19. Lewis JD, Starnes SL, Pandalai PK, et al. Traumatic diaphragmatic injury: experience from a level I trauma center. *Surgery*. 2009;146:578–583; discussion 583–584.
20. Peer SM, Devaraddeppa PM, Buggi S. Traumatic diaphragmatic hernia—our experience. *Int J Surg*. 2009;7:547–549.
21. Hanna WC, Ferri LE, Fata P, et al. The current status of traumatic diaphragmatic injury: lessons learned from 105 patients over 13 years. *Ann Thorac Surg*. 2008;85:1044–1048.
22. Filiza AI, Kurta Y, Sucullua I, et al. Traumatic diaphragmatic rupture: an experience of 13 cases. *East J Med*. 2008;13:25–29.
23. Ozgüç H, Akköse S, Sen G, et al. Factors affecting mortality and morbidity after traumatic diaphragmatic injury. *Surg Today*. 2007;37:1042–1046.
24. Lunca S, Romedea NS, Moroşanu C. Traumatic rupture of the diaphragm: diagnostic considerations, prognostic factors, outcomes. *Rev Med Chir Soc Med Nat Iasi*. 2007;111:416–422.

25. Esme H, Solak O, Sahin DA, Sezer M. Blunt and penetrating traumatic ruptures of the diaphragm. *Thorac Cardiovasc Surg*. 2006;54:324–327.
26. Williams M, Carlin AM, Tyburski JG, et al. Predictors of mortality in patients with traumatic diaphragmatic rupture and associated thoracic and/or abdominal injuries. *Am Surg*. 2004;70:157–162.
27. Rosati C. Acute traumatic injury of the diaphragm. *Chest Surg Clin North Am*. 1998;8:371–379.
28. Boulanger BR, Milzman DP, Rosati C, et al. A comparison of right and left blunt traumatic diaphragmatic rupture. *J Trauma*. 1993;35:255–260.
29. Khan MA, Verma GR. Traumatic diaphragmatic hernia presenting as a tension fecopneumothorax. *Hernia*. 2011;15:97–99.
30. Shanmuganathan K, Killeen K, Mirvis SE. CT diagnosis of diaphragmatic injuries. *Emerg Radiol*. 2001;8:6–14.
31. Eren S, Kantarci M, Okur A. Imaging of diaphragmatic rupture after trauma. *Clin Radiol*. 2006;61:467–477.
32. Thillois JM, Tremblay B, Cerceau E, et al. Traumatic rupture of the right diaphragm. *Hernia*. 1998;2:119–121.
33. Nursal TZ, Ugurlu M, Kologlu M, Hamaloglu E. Traumatic diaphragmatic hernias: a report of 26 cases. *Hernia*. 2001;5:25–29.
34. Killeen KL, Mirvis SE, Shanmuganathan K. Helical CT of diaphragmatic rupture caused by blunt trauma. *AJR Am J Roentgenol*. 1999;173:1611–1616.
35. Iochum S, Ludig T, Walter F, et al. Imaging of diaphragmatic injury: a diagnostic challenge? *Radiographics*. 2002;22:103–118.
36. Morgan BS, Watcyn-Jones T, Garner JP. Traumatic diaphragmatic injury. *J R Army Med Corps*. 2010;156:139–144.
37. Mihos P, Potaris K, Gakidis J, et al. Traumatic rupture of the diaphragm: experience with 65 patients. *Injury*. 2003;34:169–172.
38. Scharff JR, Naunheim KS. Traumatic diaphragmatic injuries. *Thorac Surg Clin*. 2007;17:81–85.