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Differences in clinical characteristics according to diaphragmatic injury location: A retrospective observational study

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Abstract

***Introduction*: Although traumatic diaphragmatic ruptures are rare, intra-abdominal organ herniation occurs more commonly in the left diaphragm because the right diaphragm is held by the liver and ligaments underneath. Additionally, right diaphragmatic injuries are sometimes delayed or missed because other comorbidities cover them. This study examined a 10-year experience with traumatic diaphragmatic injuries to better understand the clinical characteristics according to diaphragmatic injury location and improve future treatments.**

***Methods*: This retrospective study enrolled 29 patients with traumatic diaphragmatic rupture admitted to the Chungbuk National University Hospital, South Korea, between January 2011 and December 2020. The patients' clinical characteristics and treatment outcomes were analyzed using the chi-square test and independent t-test.**

***Results*: The injury severity score showed that left diaphragmatic ruptures (31.36, standard deviation [SD] 10.89) were higher than right-sided ruptures (29.33, SD 10.21), but the difference was not statistically significant (p=0.61). Abdominal organ herniations were more common on the left side, and there were two cases of hollow viscus injuries as left-side ruptures and eight cases of abdominal solid organ injuries as right-side ruptures, but there was no statistical difference between the two groups. There was no significant difference between the two groups in the state of shock during the emergency room visits, intensive care unit, and ventilator care, and no difference was observed in survival.**

***Conclusion*: Depending on the location of the diaphragmatic rupture, there were differences in the number of abdominal organ herniation and surgical methods, but there was no difference in injury severity or outcome.**

Key words: Abdomen, diaphragm, injury, rupture, trauma.

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Introduction

Traumatic diaphragmatic rupture is rare but can occur in blunt and penetrating injuries to the chest and abdomen. (1,2) The outcome of patients with diaphragmatic rupture varies depending on the location and size of the rupture, and if the diagnosis is delayed or misdiagnosed due to other trauma, serious consequences may occur. (3,4) Furthermore, because other serious injuries often accompany diaphragm rupture, no specific clinical or physical findings suggest diaphragmatic ruptures; this makes the diagnosis of diaphragmatic injury difficult. Subsequently, it is not easy to make a clear diagnosis with chest radiography alone unless the herniated intra-abdominal organ is visible. (5) Although the method of diagnosis has improved with the introduction of computer tomography (CT), there are still limitations in diagnosis with only imaging studies. (6) A diagnosis is often made during laparotomy, (5) but it has been reported that 15% of cases are not diagnosed even after laparotomy. (7) Thus, close observation and strong suspicion by trauma physicians are necessary to diagnose diaphragmatic injuries.

In consideration of the diaphragm injury mechanism, blunt injury is caused by a momentary, life-threatening, high-energy trauma, (2) in which an abdominal organ herniates through the injured diaphragm into the thoracic cavity after increased abdominal pressure from a motorized vehicle accident or fall. (8) It is reported that diaphragmatic injury occurs more frequently when the impact is applied to the patient's side than to the front or rear. (7) Several studies have reported that left diaphragmatic rupture is higher than right, and herniation of the abdominal organ into the thoracic cavity is more common. (1,9,10) The liver and its ligaments underneath the right diaphragm protect it from injury to some extent, resulting in fewer ruptures and hernias. (11) However, rupture of the right diaphragm can result in serious consequences because the lesion can be hidden, or the diagnosis can be delayed due to anatomical reasons.

This study aimed to understand better the clinical characteristics regarding the location of diaphragm injury and share a ten-year experience with traumatic diaphragm ruptures and develop future treatments.

Method

Patients and data collection

This study was conducted on all trauma patients admitted for traumatic diaphragmatic ruptures at the Chungbuk National University Hospital between January 2011 and December 2020. Only patients older than 18 years and those with diaphragmatic ruptures confirmed by surgical findings were included in this study. Of 31 patients, we excluded one pediatric patient and one patient with missing proper operation records; thus, 29 patients were included in this study. After reviewing the electronic medical records (EMR) and imaging studies, the results were collected based on the radiologist's chest radiography and chest and abdominal CT scans. Clinical records, such as patient history, injury severity score (ISS), mechanism of injury, accompanying injuries, location of the rupture, and length of injury, were collected retrospectively from the EMR of Chungbuk National University Hospital. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki, as reflected in the a priori approval by the institution's human research committee.

Definitions

A fall was defined as a fall from a height of ≥2 m from the ground. Intra-abdominal solid organ damage was defined as a grade one or higher abdominal solid organ injury confirmed by imaging or operative surgical findings. Solid organs include the liver, spleen, pancreas, and kidneys. A hollow viscus injury included intestinal perforations or vessel injuries in the stomach, small intestine, large intestine, and attached mesentery in the abdominal cavity. A traumatic shock was defined as a heart rate >120 beats per minute or when the systolic blood pressure was less than 90 mmHg at arrival in the emergency room. (12) To compare short-term clinical outcomes, intrathoracic herniation of abdominal organs, abdominal solid organ injury, abdominal hollow viscus injury, initial traumatic shock state, intensive care unit (ICU) care, and ventilator care were set as the first outcomes. The length of ICU stay, length of ventilator application, length of hospital stay, and survival were determined as secondary outcomes.

Statistics

An independent sample means analysis was performed using continuous variables, such as patient age, body mass index (BMI), and ISS. An independent t-test was performed to compare the means of mechanical ventilation days, ICU stays, and total hospitalization days between the right- and left-sided groups. Categorical data, such as diagnosis method, diagnosis time, surgical approach, and trauma mechanism, were cross-analyzed using the chi-squared test for comparative analysis, according to the injury location. Statistical significance was set at a two-tailed p-value of <0.05. All statistical anal-

yses were performed using IBM SPSS Statistics (version 23.0; IBM Co., Armonk, NY, USA).

Results

A total of 29 patients were included in this study over ten years. As illustrated in **Table 1**, the average age of all patients was 52.28 years (standard deviation [SD] 16.57), and there were more males (18, 62.1%). The average BMI was 22.99 (SD 2.75), and the ISS was 30.31 (SD 10.40), indicating severe injury. At the time of diagnosis, 23 (79.3%) patients were diagnosed at the initial stage, while the other six (20.7%) patients had a delayed diagnosis. An initial thoracotomy was performed in 19 patients for the surgical approach, higher than that in the abdominal approach. There were 15 (51.7%) patients on the right side and 14 (48.3%) on the left side.

A cross-analysis was performed to verify the difference in the ratio of injury sites, depending on the mechanism. As illustrated in **Table 2**, in the pedestrian versus vehicle accidents, six (66.7%) patients were right-sided, and three (33.3%) were left-sided, whereas for driver or passenger motor vehicle accidents, four (40%) patients were right-sided and six (60%) were left-sided. However, the chi-squared test did not show a significant difference.

Table 3 shows a comparative analysis of the clinical characteristics according to the injury location. The average age of the patients was 52.60 (SD 15.78) for right-sided injuries, which was similar to the left-sided injuries (51.93, SD 17.97), and there was no statistically significant difference (p=0.92). The sex ratio was dominant by males in both groups (right 66.7%, left 57.1%) without a statistically significant difference (p=0.59). The average ISS of the patients with right-sided injuries was 29.33 (SD 10.21), which was lower than left injuries (31.36, SD 10.40) but without significant difference (p=0.61). A delayed diagnosis demonstrated a difference in five (33.3%) patients on the right side and one (7.1%) patient on the left side, but the difference was not statistically significant (p=0.08). As for the method of diagnosis, two right-sided injuries were diagnosed through surgery, unlike no patients with left-sided injuries, but there was no significant difference (p=0.16).

The surgical approach was divided depending on the injury location and compared with a cross-analysis; the results are presented in **Table 4**. For right-sided injuries, 13 (86.7%) patients were accessed using thoracotomy, while only four (28.6%) patients were accessed using thoracotomy for left-sided injuries. However, patients with left-sided injuries underwent laparotomy and thoracoabdominal approach more than those with right-sided injuries, showing a statistically significant difference ($\chi 2$=10.521 and p=0.005).

Table 5 illustrates the results of the cross-analysis of clinical outcomes, depending on the location of traumatic diaphragmatic injury. Intrathoracic herniation of abdominal organs was found in 13 (92.9%) patients on the left side, which was more common than the four (26.7%) patients on the right side, and there was a statistically significant difference (p<0.001). As for abdominal solid organ injuries, eight (53.3%) patients were demonstrated on the right side, which was higher than the five (35.7%) patients on the left side (p=0.34). For abdominal hollow viscus injuries, two (14.3%) patients were demonstrated on the left side, unlike on the right side (p=0.13). However, this difference was not statistically significant. The initial traumatic shock was diagnosed in eight (53.3%) patients with right-sided injuries and nine (64.3%) patients with left-sided injuries without a significant difference (p=0.55). A total of 25 patients received ICU care, among which 11 (73.3%) were from the 15 right-sided injury patients. In comparison, all 14 left-sided injury patients went to the ICU with a statistically significant difference (p=0.04). A total of 21 patients received mechanical ventilation, ten (66.7%) had right-sided injuries, and 11 (78.6%) had left-sided injuries.

Table 6 presents a comparative analysis of the secondary outcomes depending on the diaphragmatic injury location. The average ICU stay was 21.36 days (n=11) for the right-sided injury patients and 22.36 days (n=14) for the left-sided injury patients, but there was no significant difference between the two groups (p=0.95). The duration of mechanical ventilation application was 8.70 days (n=15) on the right side, which was less than that on the left side (19.55 days, n=11), but the difference was not statistically significant (p=0.52). The average length of hospital stay was 53.73 days for the right-sided injury patients and 65.57 days for the left-sided injury patients without a significant difference (p=0.50). One (3.4%) patient died during the hospital stay, and there was no statistically significant difference in survival depending on the location (p=0.29).

Discussion

A study conducted in South Korea reported that most diaphragmatic ruptures occured in the posterolateral part of the left diaphragm, which was the weakest part. (12) Several other studies have reported that left-sided injuries are more common. (1,9,10) However, autopsy studies have reported no difference in the frequency of left and right ruptures. (13) A study in 2019 also reported no difference in frequency regarding the location of traumatic dia-

phragm ruptures (14) and explained that this was because the study was conducted with patients whose diaphragmatic injuries were confirmed only by surgery. Similarly, this study also demonstrated no difference in frequency, as it also involved patients with diaphragmatic ruptures confirmed by surgery.

Ten years of experience by the authors demonstrated that most of the injury mechanisms were due to blunt trauma. Penetrating injury due to stab wound was observed in one out of the 29 patients. Similar results have been reported in several previous studies, (15-17) indicating that most of the causes were blunt injuries, such as traffic accidents and falls; however, left diaphragmatic injuries were more frequently observed. (17) This study did not demonstrate a statistical difference in the frequency of left- and right-sided injuries, depending on the mechanism, except for falls, where left-sided injuries were predominant. The high-energy impact from a fall, causing a sudden increase in abdominal pressure, can easily damage the anatomically weak left diaphragm. However, when a pedestrian is hit by a vehicle, the impact can be primarily applied to either side; (7) thus, the injury frequency on either side is likely to be even.

Traumatic diaphragmatic injuries are sometimes difficult to diagnose early because abdominal organ herniation can be covered by accompanying pneumothorax, hemothorax, or pulmonary contusions. (18) Additionally, when the injury size is small, the diagnosis can be delayed because the abdominal organ is not herniated and symptoms are not observed at an early stage, and the liver underneath the right diaphragm can further delay the diagnosis of small injuries. (19) One study reported that diaphragmatic lacerations or ruptures were not evident initially, and the delayed diagnosis was made after the progression of infection or necrosis. (20) In this study, five patients on the right side demonstrated more diagnosis delays than the left side (one patient), and most of the delays were confirmed within four days after admission. However, two of the right-sided injuries were diagnosed on the 24th and 28th day of admission; therefore, diagnoses of right-sided injuries are expected to be more delayed than those of the left side, but no statistically significant difference was found (p=0.08).

Traumatic diaphragmatic injuries can be diagnosed mainly using chest radiography and CT scans, but past studies have reported detection rates of approximately 30-50% detection rates. (2,21,22) In a study conducted in 2018, (12) the sensitivity of chest and epigastric CT scans was reported to be approximately 73.7%, while other studies (7,20) reported that CT scans could confirm diaphragmatic injuries in all patients, demonstrating a diverse diagnosis rate. In this study, 27 of the 29 (93.1%) patients were diagnosed by radiographic examination. This is presumably because of the retrospective review of the results, including patients with an early diagnosis and those with a delayed diagnosis.

Diaphragm injuries caused by blunt trauma are caused by a momentary high-energy shock (2) and are often accompanied by abdominal or thoracic organ injuries. (7,8,16,17) Penetrating injuries may also be accompanied by abdominal or thoracic organ injuries. (5) Operative management is currently the treatment of choice for a traumatic diaphragmatic injury due to various causes. (14) According to a study conducted in 2018, the surgical approaches differ depending on the injured organ and injury location. (23) The abdominal approach is performed more frequently than the thoracic approach to treat acute injuries. However, some surgeons prefer the thoracic approach, even for acute injuries. (20,23) In this study, thoracic access was performed more frequently (17 patients, 58.6%) than abdominal access (nine patients, 31.0%), but abdominal access was performed predominantly for left-sided injuries (p=0.005). This was probably because there was more abdominal organ herniation through the left-sided injuries than on the right side. A previous systematic review reported that the abdominal approach was chosen in 80% of patients because the diagnosis of abdominal organ herniation in left-sided injuries was easier and clearer. (24) However, several studies have reported that the decision of the surgical approach depends on the specialty of the attending physician (general surgery or thoracic surgery) when trauma patients arrive at the hospital rather than the diaphragm injury location. (24,25)

Several previous studies have reported that the clinical symptoms of diaphragmatic injuries are presented based on the trauma severity and degree of accompanying injuries rather than the diaphragm injury. (1,17,23,25) Additionally, variables that predict patient prognosis include age, ISS, and hemodynamic status, (4,26) and the mortality rate has been reported to range from 1-28%. (4,12,27) Thus, we compared and analyzed the patients' age, ISS, hernia and injury status of accompanying organs, and shock, depending on the location of the diaphragmatic injuries. However, no differences were observed in the patient's age, solid organ or hollow viscus injuries, ISS, or initial shock state. As no differences in factors affecting the patients' prognosis were observed, depending on the location of the injury, we could presume that there were no differences in the length of stay in an ICU (whether me-

chanical ventilation was applied), the total length of hospital stays, and mortality rate, and the results demonstrated likewise.

This study has several limitations. First, although the study period was ten years, there were only 29 patients because of the rare nature of the injuries, and it was conducted in a single center. Subsequently, the study lacked sufficient statistical evidence. Second, the radiology readings and medical records for ten years are inevitably less reliable because it was designed retrospectively and referenced past medical records. Additionally, the attending physicians made the patients' treatment decisions; thus, there was inconsistency in the operative methods and decisions for admission into the ICU. Third, as only patients confirmed by surgery were included in the study, it is difficult to generalize the results of our study because there might be undiagnosed patients among the deceased or transferred patients.

Conclusion

Despite some limitations, this study demonstrated that patients with left-sided diaphragmatic injuries had more herniated abdominal organs and different surgical approaches than those with right-sided injuries; however, it showed no difference in outcomes. In the future, these limitations can be overcome by multicenter and larger-scale studies involving patients confirmed by surgery and those with clear findings suggesting diaphragmatic injuries.

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Author contributions

Conceptualization: SHK, YHS.
Data curation: SHK, JYL, JBY, YHS, JSL, JS, SYY, HRK, MSL, JHC.
Formal analysis: JYL, JBY, JSL.
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Conflict of interest

The authors have no conflicts of interest to declare.

Ethical approval

This study was approved by the Institutional Review Board of the Chungbuk National University Hospital (approval number: 2020-01-009).

Table 1. Clinical characteristics of the patients with traumatic diaphragmatic injuries (n=29)

Characteristics	n (%)
Age*	52.28 (16.57)
Sex - Male - Female	 18 (62.1%) 11 (37.9%)
BMI*	22.99 (2.75)
ISS*	30.31 (10.40)
Time of diagnosis - Initial diagnosis - Delayed diagnosis	 23 (79.3%) 6 (20.7%)
Diagnostic tool - Simple X-ray or CT - Operation	 27 (93.1%) 2 (6.9%)
Initial surgical approach - Thoracotomy - Laparotomy	 19 (65.5%) 10 (34.5%)
Diaphragmatic rupture side - Right - Left	 15 (51.7%) 14 (48.3%)

Legend: BMI=body mass index; ISS=injury severity score; CT=computed tomography.
*Data are presented as average (standard deviation).

Table 2. Classification of patients with traumatic diaphragmatic injury by injury mechanism

	Injury location		Total	χ^2	p
	Right	Left			
Injury mechanism*				8.175	0.07
- Pedestrian TA	6 (66.7%)	3 (33.3%)	9 (100%)		
- In-car TA	4 (40.0%)	6 (60.0%)	10 (100%)		
- Other motor vehicles TA	4 (100%)	0 (0.0%)	4 (100%)		
- Fall	1 (20.0%)	4 (80.0%)	5 (100%)		
- Penetrating trauma	0 (0.0%)	1 (100.0%)	1 (100%)		
Total	15 (51.7%)	14 (48.3%)	29 (100%)		

Legend: TA=traffic accident.
*Data are presented as the number of patients (%).

Table 3. Classification of clinical characteristics according to the TDI location

	Right (n=15)	Left (n=14)	Total (n=29)	p
Age*	52.60 (15.78)	51.93 (17.97)	52.28 (16.57)	0.92
Sex - Male - Female	 10 (66.7%) 5 (33.3%)	 8 (57.1%) 6 (42.9%)	 18 (62.1%) 11 (37.9%)	 0.59
BMI*	23.13 (2.65)	22.83 (2.93)	22.99 (2.75)	0.77
ISS*	29.33 (10.21)	31.36 (10.89)	30.31 (10.40)	0.61
Time of diagnosis - Initial diagnosis - Delayed diagnosis	 10 (66.7%) 5 (33.3%)	 13 (92.9%) 1 (7.1%)	 23 (79.3%) 6 (20.7%)	 0.08
Diagnostic tool - Simple X-ray or CT - Operation	 13 (86.7%) 2 (13.3%)	 14 (100%) 0 (0.0%)	 27 (93.1%) 2 (6.9%)	 0.16
Length of the TDI* (cm)	11.57 (4.66)	12.86 (4.26)	12.19 (4.44)	0.44

Legend: TDI=traumatic diaphragmatic injury; BMI=body mass index; ISS=injury severity score; CT=computed tomography.
*Data are presented as average (standard deviation).

Table 4. Comparison of surgical approaches according to TDI location

		Injury location		Total	χ^2	p
		Right	Left			
Surgical approaches*	Thoracotomy	13 (86.7%)	4 (28.6%)	17 (58.6%)	10.521	0.005
	Laparotomy	2 (13.3%)	7 (50.0%)	9 (31.0%)		
	Thoraco-abdominal	0 (0.0%)	3 (21.4%)	3 (10.3%)		
Total		15 (100%)	14 (100%)	29 (100%)		

Legend: TDI=traumatic diaphragmatic injury.
*Data are presented as the number of patients (%).

Table 5. Comparison of initial outcomes according to the injury location

	Injury location		Total (n=29)	p
	Right (n=15)	Left (n=14)		
Hernia of abdominal organs*				<0.001
- Y	4 (26.7%)	13 (92.9%)	17 (58.6%)	
- N	11 (73.3%)	1 (7.1%)	12 (41.4%)	
Abdominal solid organ injury*				0.34
- Y	8 (53.3%)	5 (35.7%)	13 (44.8%)	
- N	7 (46.7%)	9 (64.3%)	16 (55.2%)	
Hollow viscus injury*				0.13
- Y	0 (0.0%)	2 (14.3%)	2 (6.9%)	
- N	15 (100%)	12 (85.7%)	27 (93.1%)	
Traumatic shock state*				0.55
- Y	8 (53.3%)	9 (64.3%)	17 (58.6%)	
- N	7 (46.7%)	5 (35.7%)	12 (41.4%)	
ICU care*				0.04
- Y	11 (73.3%)	14 (100%)	25 (86.2%)	
- N	4 (26.7%)	0 (0.0%)	4 (13.8%)	
Ventilator care*				0.47
- Y	10 (66.7%)	11 (78.6%)	21 (72.4%)	
- N	5 (33.3%)	3 (21.4%)	8 (27.6%)	

Legend: ICU=intensive care unit.
*Data are presented as the number of patients (%).

Table 6. Comparison of secondary outcomes according to the injury location

	Injury location		Total	p
	Right	Left		
Length of the ICU stay* (days)	21.36 (23.41) n=11	22.36 (44.94) n=14	21.92 (36.37) n=25	0.95
Length of the ventilator apply* (days)	8.70 (5.79) n=10	19.55 (51.28) n=11	14.38 (36.89) n=21	0.52
Length of the hospital stay* (days)	53.73 (31.63) n=15	65.57 (60.19) n=14	59.45 (47.10) n=29	0.50
Survival, n (%)				0.29
- Y	15 (100%)	13 (92.9%)	28 (96.6%)	
- N	0 (0.0%)	1 (7.1%)	1 (3.4%)	

Legend: ICU=intensive care unit.
*Data are presented as mean (standard deviation).

References

1. Lundgren J, Mousavie SH, Negahi A, Varga RNG, Akyürek LM, Nakhaei B, et al. Traumatic diaphragmatic ruptures: A 10-year retrospective study. Trauma Emergency Care 2017;2:1-4.
2. Reber PU, Schmied B, Seiler CA, Baer HU, Patel AG, Büchler MW. Missed diaphragmatic injuries and their long-term sequelae. J Trauma 1998;44:183-8.
3. Marzona F, Parri N, Nocerino A, Giacalone M, Valentini E, Masi S, et al. Traumatic diaphragmatic rupture in pediatric age: Review of the literature. Eur J Trauma Emerg Surg 2019;45:49-58.
4. Turhan K, Makay O, Cakan A, Samancilar O, Firat O, Icoz G, et al. Traumatic diaphragmatic rupture: Look to see. Eur J Cardiothorac Surg 2008;33:1082-5.
5. Miller L, Bennett Jr EV, Root HD, Trinkle JK, Grover FL. Management of penetrating and blunt diaphragmatic injury. J Trauma 1984;24: 403-9.
6. Trésallet C, Menegaux F, Izzillo R, Nguyen-Thanh Q, Cardot V, Chigot J-P. Usefulness of CT reconstructed pictures for diaphragmatic rupture after blunt trauma. J Am Coll Surg 2004;198:666-7.
7. Mahmoud AF, Eldin Raeia MM, Abo Elmakarem MA. Rupture diaphragm: Early diagnosis and management. J Egyptian Soc Cardiothorac Surg 2017;25:163-70.
8. Scharff JR, Naunheim KS. Traumatic diaphragmatic injuries. Thorac Surg Clin 2007;17:81-5.
9. Ercan M, Aziret M, Karaman K, Bostancı B, Akoğlu M. Dual mesh repair for a large diaphragmatic hernia defect: An unusual case report. Int J Surg Case Rep 2016;28:266-9.
10. Ties JS, Peschman JR, Moreno A, Mathiason MA, Kallies KJ, Martin RF, et al. Evolution in the management of traumatic diaphragmatic injuries: A multicenter review. J Trauma Acute Care Surg 2014;76:1024-8.
11. Bekassy SM, Dave KS, Wooler GH, Ionescu MI. "Spontaneous" and traumatic rupture of the diaphragm: Long-term results. Ann Surg 1973; 177:320-4.
12. Lim KH, Park J. Blunt traumatic diaphragmatic rupture: Single-center experience with 38 patients. Medicine (Baltimore) 2018;97:e12849.
13. Puffer P, Gaebler M. Traumatic diaphragmatic rupture in a forensic medicine autopsy sample. Beitr Gerichtl Med 1991;49:149-52.
14. Kwon J, Lee JC-J, Moon J. Diagnostic significance of diaphragmatic height index in traumatic diaphragmatic rupture. Ann Surg Treat Res 2019;97:36-40.
15. Shehata SMK, Shabaan BS. Diaphragmatic injuries in children after blunt abdominal trauma. J Pediatr Surg 2006;41:1727-31.
16. Matsevych OY. Blunt diaphragmatic rupture: Four years' experience. Hernia 2008;12:73-8.
17. Lim BL, Teo LT, Chiu MT, Asinas-Tan ML, Seow E. Traumatic diaphragmatic injuries: A retrospective review of a 12-year experience at a tertiary trauma center. Singapore Med J 2017; 58:595-600.
18. Sanli M, Işik AF, Tunçözgür B, Meteroğlu F, Elbeyli L. Diagnosis that should be remembered during evaluation of trauma patients: Diaphragmatic rupture. Ulus Travma Acil Cerrahi Derg 2009;15:71-6.
19. Gu P, Lu Y, Li X, Lin X. Acute and chronic traumatic diaphragmatic hernia: 10 years' experience. PLoS One 2019;14:e0226364.
20. Zhao L, Han Z, Liu H, Zhang Z, Li S. Delayed traumatic diaphragmatic rupture: Diagnosis and surgical treatment. J Thorac Dis 2019;11:2774-7.
21. Larici AR, Gotway MB, Litt HI, Reddy GP, Webb WR, Gotway CA, et al. Helical CT with sagittal and coronal reconstructions: Accuracy for detection of diaphragmatic injury. AJR Am J Roentgenol 2002;179:451-7.
22. Bodanapally UK, Shanmuganathan K, Mirvis SE, Sliker CW, Fleiter TR, Sarada K, et al. MDCT diagnosis of penetrating diaphragm injury. Eur Radiol 2009;19:1875-81.
23. Akar E, Kaya H. Traumatic rupture of the diaphragm: A 22-patient experience. Biomed Res (India) 2017;28:8706-10.
24. Silva GP, Cataneo DC, Cataneo AJM. Thoracotomy compared to laparotomy in the traumatic diaphragmatic hernia. Systematic review and proportional methanalysis. Acta Cir Bras 2018;33:49-66.
25. Gwely NN. Outcome of blunt diaphragmatic rupture. Analysis of 44 cases. Asian Cardiovasc Thorac Ann 2010;18:240-3.
26. Al-Refaie RE, Awad E, Mokbel EM. Blunt traumatic diaphragmatic rupture: A retrospective observational study of 46 patients. Interact Cardiovasc Thorac Surg 2009;9:45-9.
27. Athanassiadi K, Kalavrouziotis G, Athanassiou M, Vernikos P, Skrekas G, Poultsidi A, et al. Blunt diaphragmatic rupture. Eur J Cardiothorac Surg 1999;15:469-74.

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