

The experience of a single center using laparoscopic surgery for traumatic diaphragmatic injuries

Uğur Topal, Muhammet Akyüz, Mustafa Gök, Abdullah Bahadır Öz,
Türkmen Bahadır Arıkan, Merve Hamurcu, Erdoğan Mütevellî Sözüer

Department of General Surgery, Erciyes University Faculty of Medicine, Kayseri, Turkey

ABSTRACT

Introduction: Diaphragmatic injuries are rare and occur in about 3% of all abdominal injuries. While 5% are caused by motor vehicle accidents, 10%–15% are caused by penetrating trauma. Diaphragmatic injury develops in 0.8%–7% of blunt trauma cases and 10%–15% of penetrating trauma cases. The aim of this study was to present a report of patients from a single center who underwent laparoscopic repair with the diagnosis of traumatic diaphragmatic injury during a 2-year period.

Materials and Methods: Patients who underwent laparoscopic surgery at the study center due to traumatic diaphragmatic injury between May 2017 and November 2018 were included in the study. The demographic characteristics of the patients, cause of injury, additional injured organs, anatomical localization of the injury, surgical procedure, quantity of intraoperative hemorrhage, rate of conversion to open surgery, duration of hospitalization, morbidity and mortality rates, and 30-day readmission rate were retrospectively reviewed using hospital files and electronic records.

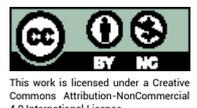
Results: Of the patients enrolled in the study, 3 were female and 1 was male. The mean age was 47.25 years (range: 36–66 years). The injury etiology was penetrating injury for 3 patients and in-vehicle traffic accident for 1 patient. Two patients had a hemopneumothorax, which was treated with a chest tube. One patient displayed hematoma in the liver and spleen. The injury to the left diaphragm was 1–4 cm in diameter in all of the study patients. A primary repair was performed in all cases. The mean quantity of intra-abdominal bleeding was 212 mL (range: 100–300 mL) and the mean postoperative hospital stay was 7.5 days (range: 5–13 days). A postoperative intra-abdominal abscess developed in 1 patient. There was no instance of mortality and no patient was re-admitted in the 30-day period after discharge.

Conclusion: It has been reported in the literature that laparoscopic approaches can be used safely in selected cases of abdominal injury, and can potentially have the benefits of laparoscopy. The results of this study also suggest that laparoscopy can be used safely in cases of traumatic diaphragmatic injury in the appropriate patients.

Keywords: Diaphragm injury; laparoscopy; trauma.



Received: 20.06.2019 Accepted: 30.09.2019
Correspondence: Uğur Topal, M.D., Department of General Surgery,
Erciyes University Faculty of Medicine, Kayseri, Turkey
e-mail: sutopal2005@hotmail.com



This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Introduction

Diaphragmatic rupture was first described by Sennertius in 1541, and the first successful diaphragm repair was performed by Walker in 1889.^[1] The first laparoscopic approach for traumatic diaphragmatic injuries (TDI) was performed by Adamthwaite in 1984.^[2] Penetrating injuries, such as penetrating and sharp tool injuries, gunshot wounds and rib fractures, can cause diaphragmatic rupture. The incidence of diaphragmatic injury caused by penetrating trauma ranges from 0.8% to 15%.^[3] Recent advances in minimally invasive techniques have included laparoscopy in the management of trauma patients. In order to decrease the rate of non-therapeutic laparotomy in patients with penetrating thoracoabdominal trauma, laparoscopy for hemodynamically stable patients has been proposed as an alternative diagnostic, and potentially therapeutic, method.^[4,5]

In this study, we aimed to present the patients who underwent laparoscopic treatment in our center, with the diagnosis of traumatic diaphragmatic injury, in the last 2 years

Materials and Methods

After the study protocol was approved by local Ethics Committee, patients who underwent laparoscopic surgery due to traumatic diaphragmatic injury in Erciyes University Faculty of Medicine General Surgery Clinic between May 2017 and November 2018 were included.

Our selection criteria for laparoscopy in trauma patients were left side thoracoabdominal injuries, hemodynamic stability, Lack of intra-abdominal or pulmonary injury and neurological injury requiring surgical intervention in radiological examinations or clinical examination. Patients under 18 years of age and patients whose records were not accessible were excluded from the study.

A common database was created by examining patient files and hospital information system records. Patient data were retrospectively evaluated using this database. The demographic characteristics of the patients, the cause of injury, additional injured organs, anatomical localization of the injury, diameter of the defect, surgical procedure, amount of intraoperative hemorrhage, rate of converting to open surgery, duration of hospitalization, morbidity and mortality rates, and 30-day readmission rates were examined.

In the statistical analysis of data, IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA) was

used. Categorical measurements were summarized as numbers and percentages, and continuous measurements as mean and standard deviations (median and minimum-maximum where necessary).

Operation Technique

Under general anesthesia, the patient was placed in the reverse Trendelenburg position with 30 degrees. After CO₂ insufflation using a Veress needle (LapraSurge®, France), a 10 mm trocar (Versaport®, Covidien Health Care, USA) was placed above the umbilicus. The entire abdominal cavity was explored with a 30-degree laparoscope. Two 5-mm trocars were placed on the right and left midclavicular lines under direct visual observation. Diaphragmatic defects were closed with Ethibond Excel® (Ethicon, New Jersey) No:0 polyester sutures in all patients. A 10 mm hemovac drain was applied to every patient at the end of the operation.

Results

4 patients were included in our study. 3 were female (75%) and 1 was male (25%). The mean age was 47.25 (36–66). The injury etiology was penetrating injury for 3 patients and in-vehicle traffic accident for 1 patient. One patient had an additional organ injury of hematoma in the liver and spleen. The anatomical localization of the injury was the left diaphragm in all patients. The mean size of the diaphragm injury was 2.37±1.25 (1–4) cm. Primary repair was performed in all patients with No:0 polyester sutures. Calculated intraabdominal bleeding was 212±85 ml (100–300 ml). Surgery was not converted to open surgery in any patients. The mean postoperative hospital stay was 5±3.8 days.^[5–13] An intraabdominal abscess developed in one patient postoperatively. No patients developed postoperative mortality. No patient was re-admitted without being planned, in the 30-day period after discharge. Shown in Table 1.

Discussion

Today, the increase in traffic accidents and increasing violence cause an increase in the incidence of traumatic diaphragmatic injury. In addition, the diagnosis of traumatic diaphragmatic injury can be made at an early stage thanks to the developments in imaging methods.

When clinical suspicion for diaphragmatic injury cannot be confirmed by radiographic assessment or other diagnostic methods, the laparoscopic evaluation of the

Table 1. Demographic and clinical characteristics

Parameter	n (%)
Sex	
Male	3 (75)
Female	1 (25)
Age, mean±SD (min-max)	47.25±12.9 (36–66)
Etiology	
Penetrating sharp object injury	3 (75)
In-vehicle traffic accident	1 (25)
Additional organ injury	
Hematoma in the liver and spleen	1 (25)
Anatomical localization	
Left diaphragm	4 (100)
Defect diameter (cm), mean±SD (min-max)	2.37±1.25 (1–4)
Surgical procedure	
Primary repair	4 (100)
Intraabdominal bleeding (ml), mean±SD (min-max)	212±85 (100–300)
Conversion to open surgery	0 (0)
Postoperative hospitalisation duration (day), mean±SD (min-max)	7.5±3.8 (5–13)
Postoperative complication	
Intraabdominal abscess	1 (25)
Postoperative mortality	0 (0)
30-day unplanned readmission to the hospital	0 (0)

SD: Standard deviation; Min: Minimum; Max: Maximum.

diaphragm may rule out a hidden damage.^[4] One of the biggest advantages of laparoscopy in trauma cases is the decrease in the rate of negative or non-therapeutic laparotomies; this reduces hospitalization, laparotomy-related morbidity and overall costs and improves outcomes. Recent studies of diagnostic laparoscopy-related complications against negative laparotomy have shown that complication rates (3% versus 22%) and hospitalization time (1.4 days versus 5.1 days) were reduced.^[6]

The sensitivity of laparoscopy to the diaphragmatic injuries after penetrating trauma is 100%, specificity is 87.5% and negative predictive value is 96.8%.^[7] Direct laparoscopic imaging of the diaphragm has been shown to be the best diagnostic method to identify diaphragmatic tears.^[8] There is a high risk of diaphragmatic injury after penetrating trauma to the left thoracoabdominal region

and may not present a clinical symptom for a long term when diaphragm injuries are overlooked.^[9] Madden et al.^[10] reported a mortality rate of 36% in patients presenting with delayed diaphragmatic injury deaths occurred due to strangulation of the stomach or colon herniated from the diaphragmatic defect and perforation to the pleural space.

The Eastern Association for Trauma (EAST) suggested that a diagnostic laparoscopy should be considered strongly in patients with penetrating trauma to the left thoracoabdominal region without any other indication for laparotomy.^[11]

In their series Matthews et al.^[4] found the diaphragmatic defect diameter in the laparoscopic diaphragmatic injuries as 4.6 cm, the average operation time as 134.7 minutes, the mean estimated blood loss as 108.5 ml, and the postoperative length of stay was 4.4 days (range, 1–12 days). No intraoperative complications occurred in any of the patients and the most common postoperative complication was associated with the pulmonary system.

Mjoli et al.^[12] found in their series of laparoscopic traumatic diaphragmatic injuries, that the number of male patients was 10 times higher than the female patients, and the mean age was 26.3±7.8. Postoperative hospitalization time was 3.6±4.7 days. In many studies in the literature, shorter hospital stay has been reported in the laparoscopic approach than in the open approach.^[13,14] In our series, male patients were significantly higher, in accordance with the literature. Our mean age was 47.25±12.9 and mean hospitalization time was 7.5±3.8 days. The mean duration of hospitalization was higher than in the literature, and this was due to the prolonged hospitalization of the patient who developed postoperative intraabdominal abscess.

When patients with multiple traumas were evaluated, the incidence of diaphragmatic injury was 3% (0.8%–5.2%).^[14] 75% of the diaphragmatic ruptures are due to blunt traumas and 25% are due to penetrating traumas.^[15] Because the left medial posterolateral tendomuscular area of the diaphragm is the weakest region of the diaphragm in embryological development, rupture is more common on the left side. Left-sided diaphragmatic ruptures are more complicated. These complications occur due to herniation of the abdominal organs.^[15–17] Traumatic diaphragm injuries are seen 10 times more commonly in the left diaphragm than right diaphragm.^[18] In our study, all diaphragmatic injuries were observed in the left diaphragm. Of the di-

Table 2. Recommended repair of traumatic diaphragmatic injury according to grade of injury

Grade of injury	Description	Recommended repair
Grade I	Contusion or hematoma without perforation	No surgical intervention
Grade II	Laceration <2 cm	2–0 or 1–0 absorbable suture
Grade III	Laceration 2 to 9 cm	First layer: 1–0 absorbable suture; interrupted, along irregular borders Second layer: 1–0 absorbable running
Grade IV	Laceration 10 to 25 cm	2–0 non-absorbable suture or 1–0 monofilament/braided suture; interrupted in two layers, with the use of fascia lata or an allogenic material
Grade V	Laceration >25 cm	Use of PTFE mesh or advancement flap

From Lucas CE, Ledgerwood AM: Diaphragmatic Injury. Current Therapy of Trauma and Surgical Critical Care. 2nd Edition, 2016.

aphragmatic injuries in our series, 75% were due to penetrating trauma and 25% due to blunt trauma. Hemopneumothorax is frequently accompanied by diaphragmatic injuries. Hemopneumothorax was detected in 2 patients and both patients were followed with tube thoracostomy.

In the literature, diaphragmatic injuries due to penetrating trauma to the thoracoabdominal area are generally less than 2 cm and have been found to be linear lacerations.^[12] In our study, the mean defect diameter was 2.37 cm. The patient with a defect diameter of 4 cm had a diaphragmatic injury due to blunt trauma following a car accident.

Repair of any diaphragm damage depends on the severity of injury and the amount of tissue loss involved. Generally, large defects are repaired with Polytetrafluoroethylene (PTFE) patches and primary repair is applied in patients with a small defect diameter. Non-absorbable 2–0 or 1–0 monofilament or braided suture is recommended in primary repair.^[11] The recommended repair of traumatic diaphragmatic injury according to the degree of injury is shown in Table 2.^[19] In our series, we performed primary repair because the patients were injured in Grade II–III, we did not use a patch in any patient.

Diaphragmatic injuries in trauma patients often accompany other intraabdominal pathologies, limiting laparoscopy. Accompanying organ injuries have been reported in the literature to be 27%.^[11] Many authors attributed conversion to laparotomy with accompanying organ injury, and found an average of 55%.^[20–22]

In our series, 1 patient had accompanying hematoma in the liver and spleen, and none of our patients required

conversion to open surgery. We believe the reason for this is our conservatism in our choice of patients. During the patient selection, most patients with significant visceral injuries were detected and the laparoscopic approach was not preferred. Most common postoperative complications of laparoscopic diaphragmatic injury repair were reported as being associated with the pulmonary system.^[4,12] None of our patients had postoperative pulmonary complications. One patient had postoperative intrabdominal abscess, this patient had accompanying liver and spleen injury. The patient's abscess was drained by percutaneous intervention and no reoperation was required.

In the literature, the mortality rate for blunt diaphragmatic injuries is reported as 18% and the mortality rate for penetrating diaphragmatic injuries is reported as 8.8% ($p < 0.001$).^[23] Associated organ injuries and severity of trauma are important factors in mortality. Mortality and morbidity are primarily caused by a delay in diagnosis. Overlooked or delayed diagnosis are more common in cases with penetrating trauma etiology.^[6] In our study, none of the patients developed postoperative mortality.

However, it has been reported in the literature that laparoscopic approaches can be used safely in the appropriate patients and they can potentially have the benefits of laparoscopy. Open surgical procedures are associated with increased postoperative pain, prolonged hospital stay, and the development of long-term complications such as incisional hernia. In contrast, laparoscopy is associated with less postoperative pain, faster recovery, and reduced wound complications.^[6]

Diagnostic laparoscopy should be performed to rule out diaphragmatic injury in left thoracoabdominal injuries.

Since laparoscopy provides the possibility of simultaneous repair in patients with injuries, late complications related to injury can be prevented.

Presented at 14. ELCD Congress and "MMESA Spring Meeting", 2019, Bafla K:K:T:C.

Disclosures

Ethics Committee Approval: The study was approved by the Local Ethics Committee.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

References

- Arrendrup CH, Arrendrup D. Traumatic diaphragmatic hernia. In: Nyhus L, Condon ER, editors. *Hernia*, 3th ed. Philadelphia, PA: Lippincott; 1989:708–16.
- Adamthwaite DN. Traumatic diaphragmatic hernia: a new indication for laparoscopy. *Br J Surg* 1984;71:315. [CrossRef]
- Neal M. Abdominal trauma. In: Peitzman AB, Schwab CW, Yealy DM, Rhodes M, Fabian TC, editors. *The Trauma Manual: Trauma and Acute Care Surgery*. 4th ed. LWW; 2013. p. 365–7.
- Matthews BD, Bui H, Harold KL, Kercher KW, Adrales G, Park A, et al. Laparoscopic repair of traumatic diaphragmatic injuries. *Surg Endosc* 2003;17:254–8. [CrossRef]
- Cocco AM, Bhagvan S, Bouffler C, Hsu J. Diagnostic laparoscopy in penetrating abdominal trauma. *ANZ J Surg* 2019;89:353–6. [CrossRef]
- El-Bendary YB, Al-Adawi J, Al-Qadhi H. The use of laparoscopy in the management of trauma patients: Brief review. *Sultan Qaboos Univ Med J* 2016;16:e9–e14. [CrossRef]
- Friese RS, Coln CE, Gentilello LM. Laparoscopy is sufficient to exclude occult diaphragm injury after penetrating abdominal trauma. *J Trauma* 2005;58:789–92. [CrossRef]
- Powell BS, Magnotti LJ, Schroepel TJ, Finnell CW, Savage SA, Fischer PE, et al. Diagnostic laparoscopy for the evaluation of occult diaphragmatic injury following penetrating thoracoabdominal trauma. *Injury* 2008;39:530–4. [CrossRef]
- Baldassarre E, Valenti G, Gambino M, Arturi A, Torino G, Porta IP, et al. The role of laparoscopy in the diagnosis and the treatment of missed diaphragmatic hernia after penetrating trauma. *J Laparoendosc Adv Surg Tech A* 2007;17:302–6.
- Madden MR, Paull DE, Finkelstein JL, Goodwin CW, Marzulli V, Yurt RW, et al. Occult diaphragmatic injury from stab wounds to the lower chest and abdomen. *J Trauma* 1989;29:292–8.
- Tserng TL, Gatmaitan MB. Laparoscopic approach to the management of penetrating traumatic diaphragmatic injury. *Trauma Case Rep* 2017;10:4–11. [CrossRef]
- Mjoli M, Oosthuizen G, Clarke D, Madiba T. Madiba Laparoscopy in the diagnosis and repair of diaphragmatic injuries in left-sided penetrating thoracoabdominal trauma: laparoscopy in trauma. *Surg Endosc* 2015;29:747–52. [CrossRef]
- Cooper C, Brewer J. Laparoscopic repair of acute penetrating diaphragm injury. *Am Surg* 2012;78:E490–2.
- Yahya A, Shuweiref H, Thoboot A, Ekheil M, Ali AA. Laparoscopic repair of penetrating injury of the diaphragm: an experience from a district hospital. *Libyan J Med* 2008;3:138–9.
- Carter BN, Giuseffi J, Felson B. Traumatic diaphragmatic hernia. *Am J Roentgenol Radium Ther* 1951;65:56–72.
- Ocak T, Kuşaslan R, Baştürk M, Yiğitbaş H, Hanım Oral N. Simple Blunt Trauma and Diaphragmatic Rupture Showing Delayed Clinical Signs. *Journal of Emergency Medicine Case Reports* 2012;3:9–11. [CrossRef]
- Sattler S, Canty TG Jr, Mulligan MS, Wood DE, Scully JM, Vallieres E, et al. Chronic traumatic and congenital diaphragmatic hernias: presentation and surgical management. *Can Respir J* 2002;9:135–9. [CrossRef]
- Boulanger BR, Milzman DP, Rosati C, Rodriguez A. A comparison of right and left blunt traumatic diaphragmatic rupture. *J Trauma* 1993;35:255–60. [CrossRef]
- Lucas CE, Ledgerwood AM. Diaphragmatic injury. In: Asensio JA, Trunkey DD, editors. *Current Therapy of Trauma and Surgical Critical Care*. 2nd ed. Philadelphia, PA: Elsevier; 2016, p. 307–16.
- Hanna WC, Ferri LE. Acute traumatic diaphragmatic injury. *Thorac Surg Clin* 2009;19:485–9. [CrossRef]
- 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. [CrossRef]
- Hanna WC, Ferri LE, Fata P, Razeq T, Mulder DS. The current status of traumatic diaphragmatic injury: lessons learned from 105 patients over 13 years. *Ann Thorac Surg* 2008;85:1044–8. [CrossRef]
- Fair KA, Gordon NT, Barbosa RR, Rowell SE, Watters JM, Schreiber MA. Traumatic diaphragmatic injury in the American College of Surgeons National Trauma Data Bank: a new examination of a rare diagnosis. *Am J Surg* 2015;209:864–8; discussion 868–9. [CrossRef]