

Clinical Outcomes and Surgical Management of Traumatic Diaphragmatic Injuries: A 10-Year Retrospective Analysis

Travmatik Diyafragma Yaralanmalarının Klinik Sonuçları ve Cerrahi Yönetimi: 10 Yıllık Retrospektif Analiz

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Abstract

Background: Diaphragmatic injuries (DIs) are uncommon but life-threatening consequences of both blunt and penetrating thoracoabdominal trauma that may be difficult to diagnose. This study aimed to evaluate the demographic characteristics, injury mechanisms, surgical approaches, and outcomes of patients who underwent surgical management for DI during the study period.

Materials and Methods: We retrospectively reviewed the medical records of 20 patients treated surgically for traumatic DI between January 2015 and December 2025. Data on age, sex, mechanism and side of injury, associated organ injuries, surgical techniques, and postoperative outcomes were analyzed.

Results: The study group consisted of 17 males (85%) and 3 females (15%), with a mean age of 42.5±19.82 years. The mechanisms of injury was included penetrating trauma in 11 patients, including 10 stab wounds and 1 gunshot wound, and blunt trauma in 9 patients. Right-sided and left-sided injuries were equally distributed with 10 patients in each group. While computed tomography (CT) suggested DI in 60% of cases (n=12), the remaining 7 patients were diagnosed intraoperatively during surgery for associated pathologies. The surgical approaches included video-assisted thoracoscopic surgery (VATS) in 11 patients (55%), thoracotomy in 8 (40%), and laparotomy in 1 (5%). Primary repair was performed in 17 patients and one patient required prosthetic mesh reinforcement. Associated organ injuries were present in 9 patients (45%). The mortality rate was 10% (n=2), primarily due to concomitant injuries and shock.

Conclusions: Diaphragmatic injuries remain a diagnostic challenge due to the lack of specific symptoms and the limited sensitivity of imaging. Clinical suspicion is vital when radiological findings are inconclusive. VATS is a reliable and effective minimally invasive tool for both the diagnosis and treatment of DI. In our limited cohort, both deaths occurred in patients with severe associated injuries and hemodynamic instability.

Keywords: Diaphragmatic injury, Trauma, Video-assisted thoracoscopic surgery, Thoracotomy, Surgical repair

Öz

Amaç: Diyafragma yaralanmaları (DY), hem künt hem de penetran travmalar sonrası gelişebilen, tanısı zor ve hayati tehlike oluşturan yaralanmalardır. Bu çalışmada, kliniğimizde 10 yıllık süreçte diyafragma yaralanması nedeniyle cerrahi tedavi uygulanan hastaların demografik özelliklerini, yaralanma mekanizmalarını, cerrahi yaklaşımları ve sonuçlarını değerlendirmeyi amaçladık.

Materyal ve metod: Ocak 2015 ile Aralık 2025 tarihleri arasında travmatik DY tanısıyla opere edilen 20 hastanın verileri retrospektif olarak incelendi. Hastaların yaş, cinsiyet, yaralanma mekanizması, yaralanma tarafı, ek organ yaralanmaları, cerrahi teknikler ve postoperatif sonuçları analiz edildi.

Bulgular: Hastaların 17'si (%85) erkek, 3'ü (%15) kadın olup; yaş ortalaması 42,5±19,82 idi. Yaralanmaların %50'si kesici delici alet yaralanması, %45'i künt travma ve %5'i ateşli silah yaralanması sonucu gelişmişti. Yaralanmaların taraf dağılımı sağ ve sol hemidiyafragma için eşitti (%50 - %50). Bilgisayarlı tomografi (BT) hastaların %60'ında (n=12) DY tanısı koydururken; 7 hastada DY, ek patolojiler nedeniyle yapılan operasyonlar sırasında saptandı. Cerrahi yaklaşım olarak %55 oranında (n=11) video yardımlı torakoskopik cerrahi (VATS), %40 (n=8) torakotomi ve %5 (n=1) laparotomi uygulandı. Hastaların 17'sine primer sütürasyon yapılırken, bir hastada prostetik mesh kullanıldı. Dokuz hastada (%45) ek organ yaralanması mevcuttu. Ortalama hastanede yatış süresi 14,6 gün olarak saptandı. İki hasta (%10) ek organ yaralanması ve şok tablosu nedeniyle hayatını kaybetti.

Sonuç: Diyafragma yaralanmaları spesifik semptomların yokluğu nedeniyle tanınması zorluklar içermeye devam etmektedir. Radyolojik bulguların yetersiz kaldığı durumlarda klinik şüphe esastır. VATS, hem tanı koymada hem de tedavide güvenilir ve etkin bir minimal invaziv yöntemdir. Her iki ölüm de ciddi eşlik eden yaralanmaları ve hemodinamik instabilitesi olan hastalarda meydana gelmiştir.

Anahtar Kelimeler: Diyafragma yaralanması, Travma, VATS, Torakotomi, Cerrahi onarım

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Introduction

The diaphragm, a dome-shaped musculetendinous structure separating the thoracic and abdominal cavities, plays an essential role in respiration and maintaining intra-abdominal pressure. Diaphragmatic injuries (DIs) are uncommon but potentially life-threatening complications of both blunt and penetrating thoracoabdominal trauma. Their reported incidence ranges from 0.8% to 7% among patients with significant thoracoabdominal injuries, however the true incidence may be underestimated due to diagnostic challenges and frequent concomitant visceral injuries (1,2).

Blunt diaphragmatic injuries usually result from high-energy mechanisms such as motor vehicle collisions or falls from height, which cause a sudden increase in intra-abdominal pressure and subsequent diaphragmatic rupture. These injuries occur more frequently on the left side, possibly because of the protective effect of the liver on the right hemidiaphragm. In contrast, penetrating injuries, typically caused by stab or gunshot wounds, may involve affect either hemidiaphragm depending on the trajectory of the penetrating object (3). Clinical manifestations are often nonspecific, and missed or delayed diagnoses remains a major concern. If left untreated diaphragmatic defects may lead to herniation of abdominal viscera into the thoracic cavity, resulting in respiratory distress or strangulation (4).

Computed tomography (CT) has markedly improved the preoperative diagnosis of diaphragmatic rupture, yet definitive diagnosis frequently relies on intraoperative findings. Surgical repair remains the cornerstone of management, via either thoracotomy, laparotomy, or minimally invasive techniques such as video-assisted thoracoscopic surgery (VATS), depending on the injury mechanism, side of involvement, and associated organ injuries (5). Despite advances in diagnostic modalities and surgical management, DIs continue to be associated with substantial morbidity and mortality, primarily due to concomitant injuries involving vital organs, including the liver, spleen, and lungs (6).

In this retrospective study, we reviewed 20 patients who underwent surgical management for DI between 2015 and 2025. This study aimed to evaluate the demographic characteristics, injury mechanisms, surgical approaches, associated organ injuries, and postoperative outcomes. By presenting our institutional experience, we seek to contribute to the understanding of diagnostic and therapeutic challenges in diaphragmatic trauma and to highlight prognostic factors influencing clinical outcomes.

Materials and Methods

Study Design and Setting

This retrospective study was conducted in our clinic, a tertiary referral center in Türkiye. Medical records of patients who underwent surgical intervention for traumatic DI between January 2015 and December 2025 were reviewed. The target population was restricted to patients treated up to December 2025, and active data extraction from the institutional electronic database was initiated after ethics approval was obtained in January 2026. All included patients were followed through their post-traumatic hospital course until final discharge or death.

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Health Sciences Research Ethics Committee of Sivas Cumhuriyet University (approval no. 226-01/114, date: January 29, 2026). Due to the retrospective nature of the study, the requirement for informed consent was waived by the ethics committee.

Patient Selection

A total of 20 patients with diagnosed or suspected DI were included in the study. Patients were identified through the institutional electronic database using surgical and diagnostic International Classification of Diseases (ICD) codes related to diaphragmatic rupture or laceration. The inclusion criteria were: (1) traumatic etiology (blunt or penetrating), (2) confirmed or highly suspected DI requiring surgical exploration, and (3) availability of complete clinical and follow-up data. Patients with non-traumatic or iatrogenic diaphragmatic defects and those with incomplete records were excluded.

Data Collection

Data were extracted from hospital records, operative notes, and radiological reports. For each patient, we recorded demographic characteristics (age and sex), mechanism of injury (blunt or penetrating trauma), and the side of DI (right or left hemidiaphragm). Associated organ injuries including the liver, spleen, lung, kidney, or bowel were also documented. The surgical approach (thoracotomy, laparotomy, or VATS) and the type of diaphragmatic repair (primary or patch/mesh) were also noted. Perioperative variables collected encompassed the duration of chest tube drainage, length of hospital stay, any postoperative complications, and the patients' outcome at discharge.

Diagnostic Evaluation

The diagnosis of DI was based on radiological evaluation and confirmed intraoperatively. Computed tomography served as the primary diagnostic modality, particularly for hemodynamically stable patients. In instances where the diagnosis remained inconclusive, surgical exploration-via either a thoracic or abdominal approach-was undertaken depending on the mechanism and anatomical location of the injury.

Surgical Technique

The surgical approach was determined by the attending surgeon, guided by the mechanism of injury, the presence of associated injuries, and the patient's hemodynamic stability. For penetrating trauma isolated to the thoracic cavity, either thoracotomy or VATS was the preferred approach. In contrast, laparotomy was performed for blunt trauma or when concomitant intra-abdominal injury was suspected. All diaphragmatic defects were repaired primarily with interrupted non-absorbable sutures; however, reinforcement with a prosthetic mesh was required in one patient.

Statistical Analysis

Data analysis was performed purely descriptively. Continuous variables, including age, duration of tube thoracostomy, and length of hospital stay, were expressed as mean±standard deviation (SD). Categorical variables, such as the mechanism of injury, side of involvement, and surgical approaches, were presented as frequencies and percentages. Statistical analyses were summarized using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 20 patients with confirmed or suspected diaphragmatic injury (DI) who underwent surgical exploration were included in the study. DI was identified by preoperative radiological imaging, clinical suspicion, or intraoperatively during surgery for associated intra-abdominal organ injuries. The cohort comprised 17 men and 3 women, with a mean age of 42.5±19.82 years (range, 17-74 years) (Table 1).

Table 1. Demographic, clinical, and surgical characteristics of the patients		
Variable	Value / distribution	Unit / statistical metric
Age	42.5±19.82 (range: 17 - 74)	Mean± SD (years)
Gender		
Male	17 (85%)	n (%)
Female	3 (15%)	n (%)
Mechanism of injury		
Blunt trauma	9 (45%)	n (%)
Penetrating (stab/knife)	10 (50%)	n (%)
Penetrating (gunshot)	1 (5%)	n (%)
Side of injury		
Right	10 (50%)	n (%)
Left	10 (50%)	n (%)
Duration of tube thoracostomy	6.15±(4.06) (range: 0 - 16)	Mean± SD (days)
Length of hospital stay	14.6±(19.92) (range: 4 - 95)	Mean± SD (days)
Type of surgery		
VATS		n (%)
Thoracotomy		n (%)
Laparotomy		n (%)
SD: Standard deviation, VATS: Video-assisted thoracoscopic surgery		

All 20 patients underwent surgical intervention. The mechanisms of injury were gunshot wound in 1 patient, stab wound in 10 patients, and blunt trauma in 9 patients. Regarding the clinical

presentation pathways, diaphragmatic injury was suspected based on thoracic CT findings in 12 patients. In 7 patients without radiological evidence of DI on CT, surgery was performed

for associated pathologies, and diaphragmatic defects were identified and repaired intraoperatively. In addition, to evaluate the diagnostic accuracy and false-positive rates during trauma triage, 2 patients with high clinical/CT suspicion underwent surgical exploration but were found to have an intact diaphragm; as is standard in trauma cohort auditing, these 2 negative exploration cases were included in the primary therapeutic cohort (n=20).

Primary suture repair of the diaphragm was performed in 17 patients, while prosthetic mesh repair was required in 1 patient. Regarding surgical approach, VATS was performed in 11 patients, thoracotomy in 8 patients, and laparotomy in 1 patient. Eight patients were operated on emergently, while 12 underwent elective surgery.

In cases where preoperative radiological evaluation raised suspicion for DI but failed to establish a definitive diagnosis, VATS was effectively utilized both to exclude a full-thickness injury (Figure 1) and to detect and simultaneously repair occult lacerations (Figures 2a-2b).

Eleven patients had no associated organ injuries, whereas 9 had concomitant injuries (Table 1). These included lung injury in 4 patients, liver injury in 2, splenic injury in 2, and renal injury in 1. Lung injuries were managed with primary repair and splenectomy was performed in 1 patient. The remaining associated injuries were managed conservatively.

Right- and left-sided injuries were equally distributed (n=10 each). Flail chest was observed in 2 patients with blunt thoracic trauma. In these patients, DI was identified during VATS performed for rib stabilization and was repaired primarily during the same session.

The mean duration of tube thoracostomy was 6.15 ± 4.06 days (range, 0-16 days), and the mean length of hospital stay was 14.6 ± 19.92 (range, 4-95 days) (Table 1). Two patients (10%) died during the hospital course, while 18 patients were discharged in good condition.

Table 2. Comparative analysis of surgical techniques

Parameter	VATS	Thoracotomy - Laparotomy
Number of patients, n (%)	11 (55%)	8 (40%) - 1 (5%)
Indication / preference	Isolated thoracic penetrating injuries and clinical diagnostic suspicion	More complex cases or those with a risk of hemodynamic instability
Diagnostic success	Capacity for definitive diagnosis in 40-55% of cases missed by CT	Diagnosis typically established during exploration for associated pathologies
VATS: Video-assisted thoracoscopic surgery, CT: Computed tomography		

Discussion

Diaphragmatic injuries resulting from trauma are relatively rare conditions. They may easily be overlooked if careful clinical assessment and appropriate imaging are not performed (7). There are no specific signs or symptoms associated with DI. Furthermore, radiological findings related to concomitant organ injuries following trauma may obscure the diagnosis, even when it is suspected. In the acute phase, diagnosis can be established when abdominal organs are visualized within the thoracic cavity; however, in the absence of visceral herniation, making the diagnosis becomes considerably more challenging (7,8).

Computed tomography of the thorax has higher sensitivity and specificity compared to plain chest radiography in the diagnosis of DIs following both blunt and penetrating trauma (9). However, CT may fail to detect occult injuries in selected patients, with reported rates of undetected DIs ranging from 18% to 55%

(10,11,12). In our study, CT suggested DI in only 60% of cases (n=12); the remaining 7 patients were diagnosed intraoperatively during surgery for associated pathologies. Furthermore, in 2 patients with clinical suspicion of DI based on CT evaluation, no DI was detected intraoperatively. These findings highlight the limited sensitivity of non-invasive imaging modalities and underscore the critical importance of maintaining a high index of clinical suspicion, particularly in penetrating thoracic trauma where injury is often identified intraoperatively (9).

VATS has emerged as a valuable minimally invasive diagnostic and therapeutic approach in selected hemodynamically stable patients. In our series, VATS was the most common surgical approach (55%, n=11), enabling both definitive diagnosis and simultaneous repair in cases with inconclusive radiological findings. When preoperative evaluation raised suspicion for DI but failed to establish a definitive diagnosis, VATS effectively

served to either rule out a transmural defect (Figure 1) or to detect and repair occult lacerations (Figures 2a-2b). In our study, DIs not identified on preoperative imaging were diagnosed during VATS in 6 patients. The decision to proceed guided by clinical suspicion based on trauma mechanism and injury localization-such as blunt abdominal trauma accompanied by thoracic injury or penetrating wounds near the nipple line, lower scapular border, or lower ribs. These findings align with previous

studies emphasizing the importance of VATS, particularly in penetrating thoracic trauma (11,12). While laparoscopy is also an important diagnostic tool, abdominal insufflation carries a risk of inducing tension pneumothorax; therefore, thoracoscopy may be considered a safer diagnostic approach in these patients (13). Minimally invasive surgical approaches have been shown to provide comparable effectiveness to open surgical techniques (14).

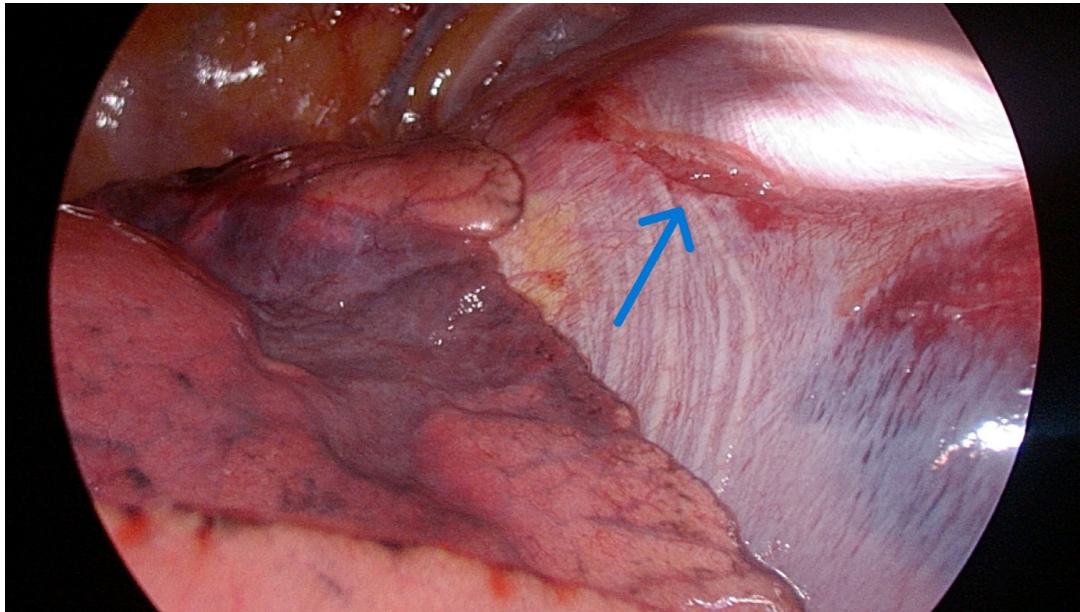


Figure 1. Intraoperative VATS image of a diaphragmatic injury. Although diaphragmatic injury was suspected based on the trauma mechanism and clinical findings, surgical exploration revealed that the structural integrity of the diaphragm remained intact. A partial-thickness (non-transmural) laceration is visible on the diaphragmatic surface (blue arrow); however, no full-thickness defect or associated visceral herniation was identified

VATS: Video-assisted thoracoscopic surgery

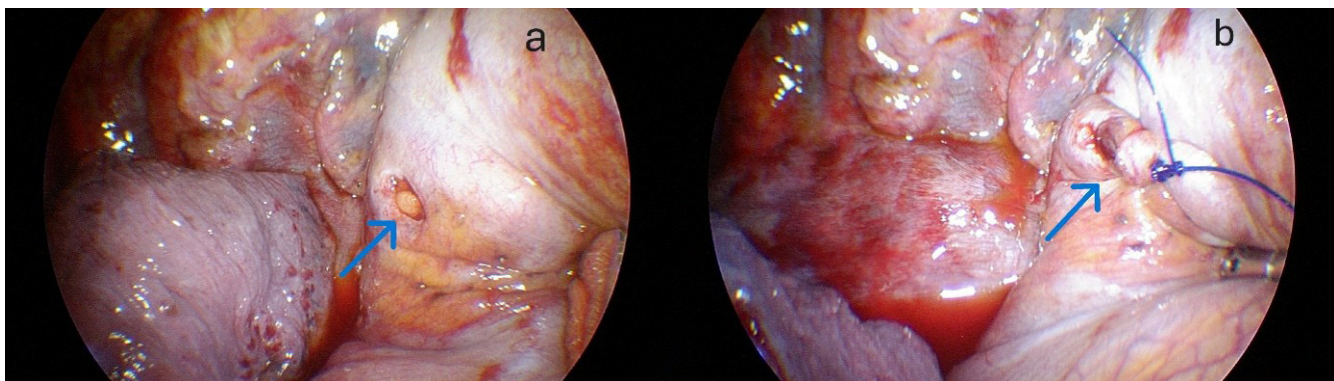


Figure 2. Intraoperative VATS images of a diaphragmatic injury. (A) A full-thickness diaphragmatic laceration identified during exploration in a patient with penetrating trauma (blue arrow). (B) Successful management of the same defect using primary non-absorbable interrupted sutures, restoring the anatomical integrity of the diaphragm (blue arrow)

VATS: Video-assisted thoracoscopic surgery

Primary repair with non-absorbable sutures remains the gold standard for acute diaphragmatic defects and was sufficient in most of our patients (n=17). While primary repair is adequate for small- and medium-sized defects, mesh repair is more appropriate for defects (typically >10 cm); in our series, prosthetic mesh was required in one patient with a large-scale avulsion defect.

The mechanism and laterality of injury in our series provided notable comparisons with the literature. While previous reports have predominantly focused on blunt trauma with left-sided predominance (15), penetrating trauma constituted half of our cases (50%) with an equal distribution of right- and left-sided injuries. This supports the observation that penetrating injuries can occur anywhere along the trajectory of the weapon (16). Although historical reports have focused mainly on blunt trauma, our cohort included a substantial number of penetrating injuries. However, diagnostic challenges were observed regardless of injury mechanism, reinforcing the concept that trauma mechanism alone is insufficient to exclude DI (17).

The reported mortality rate in patients with DI ranges between 1% and 28% (18). In our study, the mortality rate was 10% (n=2), and both deaths occurred in patients with severe associated injuries and hemodynamic instability. This supports the consensus that mortality is more closely related to the severity of associated organ injuries and shock rather than the DI itself (15,16,18). The mean length of hospital stay (14.6 days) in our cohort was relatively longer than some published reports, which may be explained by the higher frequency of associated organ injuries and the heterogeneous nature of our polytrauma patient population.

Study Limitations

Although this study evaluates the challenges in the diagnosis and management of DIs over a 10-year period, it is subject to several limitations. Primarily, the retrospective design and small sample size (n=20) limit the statistical power and restrict generalizability. As a single-center study, the results may be influenced by institutional practices and resource availability. Additionally, the inclusion of both blunt and penetrating trauma mechanisms presents a heterogeneous patient profile. From a diagnostic perspective, the insufficiency of CT in 40% of cases highlights the limitations of radiological imaging and underscores the necessity of high clinical suspicion. Finally, the potential risk of tension pneumothorax associated with laparoscopy is noted as a technical drawback in the selection of surgical approaches, which skewed our preference toward thoracoscopy.

Conclusion

Diaphragmatic injuries remain a diagnostic challenge due to the lack of specific symptoms and the inherent limitations in the sensitivity of radiological imaging. Because these injuries do not heal spontaneously, making a high index of clinical suspicion essential when radiological findings are inconclusive. VATS is a highly valuable, reliable, and effective minimally invasive tool for both the definitive diagnosis and surgical repair of diaphragmatic defects. While primary suture repair is the standard of care for most acute cases, surgical approaches and the need for prosthetic mesh may vary depending on the size of the defect and the surgeon's preference (13). Ultimately, In our limited cohort, mortality was driven by severe associated injuries and hemodynamic instability rather than the diaphragmatic defect itself.

AI Usage Information: During the preparation of this work, the authors used AI tools (ChatGPT and Gemini) improve language and readability. After using this tool, the authors carefully reviewed and edited the content as needed and take full responsibility for the final version of the manuscript.

Ethical Approval: Ethical approval for the study was obtained from the Health Sciences Research Ethics Committee of Sivas Cumhuriyet University (approval no. 226-01/114, date: January 29, 2026).

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Data Collection or Processing: M.Ö., H.D.

Analysis or Interpretation: M.Ö., H.D.

Literature Search: M.Ö., H.D.

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