



## Minimally invasive approach in diaphragmatic injuries due to stab wounds: 10 years of experience

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### Abstract

**Objective:** We aimed to evaluate minimally invasive methods in the diagnosis and treatment of stabbing diaphragmatic injuries.

**Methods:** Between January 2013 and January 2023, 66 patients with suspected diaphragmatic injury (DI) due to stab wounds, were diagnosed and treated with video assisted thoracoscopic surgery (VATS). The records of age, gender, concomitant injuries, surgical approach, morbidity and length of hospital stay were reviewed retrospectively.

**Results:** The mean age of the patients was 26.39 years and they were 59 males and 7 females. Of the patients, 42 (63.4%) were on the left side and 24 (36.4%) were on the right side. According to the sites, The wounds were anterior in 32 (48.5%) of the cases and posterior in 34 (51.5%). Concomitant injuries were seen in 47 cases. DI was confirmed in 30 (45.5%) cases. Of these, 18 (60%) were on the left and 12 (40%) were on the right. The surgeries were VATS alone in 36 (54.5%), VATS via stab wounds in 22 (33.3%), and mini-thoracotomies in 8 (12.1%) of the cases, respectively. DI was confirmed in 30 (45.5%) cases. Eighteen (60%) of them were on the left, and 12 (40%) were on the right (p0.05). The mean duration of hospital stay was 4.58 days in anterior injuries and 6.11 days in posterior injuries. No patient died.

**Conclusion:** As a minimally invasive method, VATS is the method of choice for the detection and treatment of DI in thoracoabdominal injuries caused by stabbing.

**Keywords:** minimally invasive approach, stabbing, diaphragma, injuries

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## Kesici delici alet yaralanmasına bağlı diyafragma yaralanmalarında minimal invaziv yaklaşım:10 yıllık deneyim

### Öz

**Amaç:** Kesici delici alet yaralanması(KDAY) nedenli diyafragma yaralanmalarının tanı ve tedavisinde minimal invaziv yöntemleri değerlendirmeyi amaçladık.

**Yöntemler:** Ocak 2013 ile Ocak 2023 arasında KDAY bağlı diyafragma yaralanması (DY) şüphesi olan 66 hastaya video yardımlı torakoskopik cerrahi (VATS) teşhisi kondu ve tedavi edildi. Yaş, cinsiyet, eşlik eden yaralanmalar, cerrahi yaklaşım, morbidite ve hastanede kalış süresi kayıtları retrospektif olarak incelendi.

**Bulgular:** Hastaların yaş ortalaması 26.39 olup 59 erkek, 7 kadındı. Hastaların 42'si (%63,4) sol tarafta, 24'ü (%36,4) sağ tarafta yaralanma mevcuttu. Yerlerine göre yaralanmaların 32 'si (%48,5) anterior, 34 'ü (%51,5) posterior idi. Kırk yedi vakada eşlik eden yaralanmalar görüldü. Cerrahi işlemler sırasıyla olguların 36'sına (%54,5) tek başına VATS, 22'sine (%33,3) ek cerrahi insizyon uygulamadan mevcut olan KDAY yerinden VATS, 8'ine (%12,1) mini torakotomi uygulandı. DY, 30 (%45.5) vakada doğrulandı. Bunların 18'i (%60) solda, 12'si (%40) sağdaydı (p0.05). Ortalama hastanede kalış süresi anterior yaralanmalarda 4,58 gün, posterior yaralanmalarda 6,11 gün olarak değerlendirildi. Hiçbir hastamız hayatını kaybetmedi.

**Sonuç:** Minimal invaziv bir yöntem olan VATS, KDAY ile oluşan torakoabdominal yaralanmalarda DY'nin saptanması ve tedavisi için tercih edilen yöntemdir.

**Anahtar kelimeler:** Minimal İnvaziv yaklaşım, Bıçaklanma, Diyafragma yaralanması.

### INTRODUCTION

The diaphragm, the most important muscle of the respiratory system, also separates the abdominal and thoracic cavities. Intact diaphragmatic tissue creates variable pressure, leading to the maintenance of lung functions and the creation of intra-abdominal pressure<sup>1</sup>. Traumatic diaphragmatic injury (DI) is rare and can cause high mortality and morbidity if not diagnosed and treated. It can occur as a result of both blunt and penetrating trauma to the thorax and abdomen. Its incidence is between<sup>15%</sup><sup>2-4</sup>. Diaphragmatic integrity is impaired in nearly 20% of penetrating injuries to the thorax and abdomen<sup>5</sup>. Among penetrating injuries, sharp puncture and stab wounds are the least responsible for the etiology of DI.

Physical examinations are unreliable for detecting thoracoabdominal DI. Commonly used for chest radiography, computed tomography of the thorax (CT) may be overlooked in small-sized injuries when there is no diaphragmatic hernia. Although the specificity of CT is high, operative diagnostic

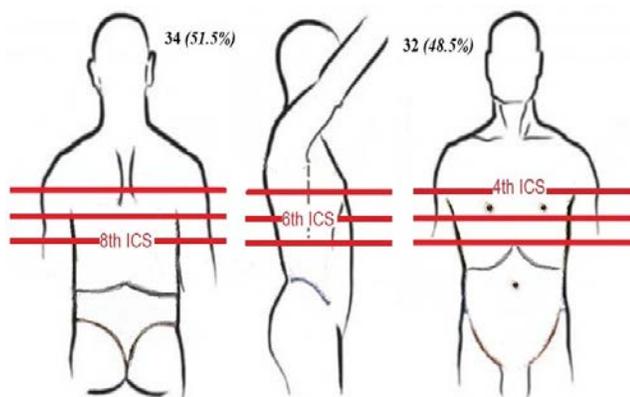
methods can be used for definitive diagnosis in such cases<sup>1,2,6</sup>. The aim of this study is to determine the diaphragmatic injury in patients with stabbing close to the thoracoabdominal region, to evaluate the effectiveness of minimally invasive methods, and to review the treatment methods.

### METHODS

The records of 66 patients who underwent VATS for suspected DI between January 2013 and January 2023 and who were exposed to penetrating stabbing were reviewed retrospectively. Injuries close to the thoracoabdominal region were evaluated. Their demographic characteristics, gender, localization of the injury, diagnostic tools, surgeries, morbidity, causes of mortality, and length of hospital stay (LOS) were examined. Also, concomitant injuries such as hemo/pneumothorax, lung laceration, lung contusion, and related infections were reviewed. Those who had abdominal and thoracic penetration treated with

laparotomy/thoracotomy were not included in the study.

All injuries limited to the thoracoabdominal region were divided into 2 regions: the anterior injury area (mid-axillary line and parasternal area), and the posterior injury region (middle axillary line to para-vertebral area) (Figure 1). DI was described in the thoracoabdominal area of inframammary and upper abdominal injuries. Firstly, direct radiographs were taken for diagnosis then a CT scan was taken to evaluate the abdomen and thorax. Tube thoracostomy (TT) was used in the patients with hemo/pneumothorax. VATS was planned for cases where there was doubt in the evaluation of DI after the relevant clinical opinions were obtained. When DI is detected, VATS alone, VATS via stabbing entry site, and mini-thoracotomy were surgical interventions according to the patient's condition.



**Figure 1:** Analysis of injuries by region

### Statistical Analysis

The IBM SPSS 21.0 for Windows statistical package program was used in the statistical evaluation of the research data. Measured variables were presented as mean  $\pm$  standard deviation (SD), and categorical variables were presented as numbers and percentages (%). A Pearson Chi-square ( $\chi^2$ ) was used for the triple comparison of qualitative variables, and Fisher's Exact Chi-square ( $\chi^2$ ) analysis and

Yates Chi-square ( $\chi^2$ ) were used for pairwise comparisons. In addition, the Mann Whitney U test was used in the comparison of two groups that were not normally distributed. The hypotheses were two-sided, and a statistically significant result was accepted if  $p \leq 0.05$ .

### RESULTS

In the study period, 7 (11%) patients were female and 59 (89%) were male. Their mean age was 26.39 (16-55) years. Chest X-rays and thorax tomography were taken in all cases. Forty two (63.4%) of the patients were exposed to stabbing on the left side and 24 (36.4%) on the right side. According to the injury sites, the anterior injury was 32 (48.5%) and posterior injury was 34 (51.5%) (Figure 1). VATS was performed to detect DI if the abdomen was not compromised after the evaluation. All of the injuries were thoracic and TT was applied. The number of patients with additional pathology such as hemothorax, pneumothorax, and lung contusion was found in 47 (71.2%) cases (Table 1). This was 25 (53.2%) in the posterior injuries and 22 (48.8%) in the anterior injuries. Pericardial injury in one case (1.5%), liver laceration in one case (1.5%), omental injury in 1 (1.5%) case injury, lung injury in 9 (13.7%) cases, pneumo/hemopneumothorax in 35 (74%) cases were seen, respectively.

**Table 1:** Concomitant pathologies due to injuries

	Anterior injuries		Posterior injuries	
	right	left	right	left
Lung injuries	1	2	1	5
Hemo/Pneumothorax	5	12	9	9
Liver injuries	1	0	0	0
Omentum injuries	0	1	0	0
Pericard injuries	0	0	0	1

The surgical treatment of the cases were started with VATS and a camera port was introduced from the TT incision. Stabbing access sites were used as the second utility incision in cases where the incision site of VATS was not sufficient. In this way, when the exposure was not suitable, mini-thoracotomy was performed

in cases of additional pathology. The number of surgical interventions performed with VATS alone was 36 (54.5%), the number of surgical interventions with VATS via stabbing site was 22 (33.3%), and the number of interventions with mini-thoracotomy was 8 (12.1%).

DI was confirmed in 30 (45.5%) cases. Eighteen (60%) of them were on the left, and 12 (40%) were on the right. Statistically, the left-sided DI was significant ( $p \leq 0.05$ ). The abdominal organs

such as the omentum and intestinal loops herniated into the thorax with the effect of intra-abdominal pressure in 8 (27%) of these injuries. Eighteen (60%) patients with DI were identified anteriorly and 12 (40%) patients posteriorly. These were 11 (61.1%) cases anteriorly and 7 (38.9%) cases posteriorly on the left side and 7 (53.3) cases anteriorly and 5 (41.7%) cases posteriorly on the right side, respectively (Table 2).

**Table II:** Clinical and demographic characteristics of injury sites.

	Anterior injuries		Posterior injuries		Diaphragmatic repair	p
	number	%	number	%		
Gender, female/male	6/26	9/39.4	1/33	1.5/50.0	3/27	$p > 0.05$
Side, left/right	20/12	30.3/18.1	22/12	33.3/18.1		$p > 0.05$
DI, left/right	11/7	16.6/10.6	7/5	10.6/7.5	18/12	$p \leq 0.05$
Concomitant Pathology	22	69	25	74		$p \leq 0.05$
VATS alone	20	30.3	16	24.2	18	$p > 0.05$
VATS+stab site	12	18.1	10	15.1	6	$p > 0.05$
Mini-thoracotomy	0	0	8	12.1	6	$p \leq 0.05$
Age, years	26±14.24		22.75±6.71			$p > 0.05$
LOS, days	4.58±0.66		6.11±2.74			$p > 0.05$

DI larger than 2 cm was detected in 11 (37%) of the cases and the muscle layer was completely opened. In this type of injury, the abdomen can be clearly distinguished from the thorax. Partial DI was a rupture smaller than 2 cm at least, and it was in the form of incisions that were not prolapsed in the continuation of the incision. In all cases of DI, 1-0 silk sutures were stitched.

As surgical treatments, VATS alone was used in 20 (56.6%) cases, and VATS via the stabbing entry site was performed in 12 (54.5%) cases of DI anteriorly. In the posterior DI, VATS alone in 16 (44.4%) cases, the VATS through the stabbing access site in 10 (45.5%) cases, and the mini-thoracotomy approach in 8 (12.5%) were used ( $p \leq 0.05$ ). In this series of DI due to stabbing, the treatment of choice was VATS in 6 cases, VATS via stabbing site in 18 cases and mini thoracotomy in 6 cases, respectively.

The mean hospital stay (LOS) was calculated as 5.22 days. This was 4.58 (ranging 4-6) days in the anterior DI and 6.11 (ranging 3-14) days in the posterior DI. According to surgical treatments, LOS was found as 4.56 days for VATS alone, 5.09 days for VATS via stabbing site, and 8.63 days for mini-thoracotomy. Complications were wound infections and atelectasis in 13 cases and no patient died in this series.

### DISCUSSION

The possibility of DI should be considered in penetrating thoracoabdominal injuries<sup>2,6,7</sup>. The location, size, full-thickness, or partiality of the injury in DI may cause a variable clinical picture between 1 and 4 years. To maintain lung function, the diaphragm muscle may enlarge with variable pressure in small, full-thickness, and partial DI over time, leading to

complications such as strangulation and herniation in the following years. It results in diaphragmatic hernia at a rate of 30%, especially after left-sided thoracoabdominal injuries<sup>1,4,6-10</sup>. Traumatic diaphragmatic ruptures do not have specific symptoms and signs. Diaphragmatic rupture due to trauma can be overlooked at a rate of 7-66% even if the diagnosis is suspected because of the nonspecificity of almost half of the radiological examinations in the preoperative period and the symptoms related to other organ injuries<sup>5,9</sup>. Different diagnostic methods have been constantly sought so that DI cannot be overlooked. With traditional diagnostic methods, it can be diagnosed in cases with chronic herniation, but it may not be possible to diagnose with chest X-ray and CT unless the abdominal organs prolapse upwards in the acute phase<sup>11</sup>. However, in acute injuries, radiological images must be supported by intraoperative images. In a study, CT images and operative methods were compared, and it was concluded that operative methods are more definitive diagnostic<sup>10</sup>. Thoracoscopy has been recommended as an intraoperative method for the detection and repair of DI, especially in lower-level thoracic and upper-abdominal injuries<sup>2,12-14</sup>. For years, general surgeons have preferred laparoscopy in cases where diagnostic methods have been inadequate in upper abdominal PSW injuries. Thoracic surgeons, successfully meet this need with VATS, especially in lower penetrating thoracic injuries<sup>12-14</sup>. VATS was used as a diagnosis and treatment method in hemodynamically stable patients with suspected DI in our clinic. In our clinic, 30 of 66 patients were diagnosed with VATS.

An intact diaphragm is essential for proper breathing. Even a small tear in this muscle, which tends to be so strong and constantly contracted, can become gigantic over time. Whether this tear is partial or total, it makes no

difference in causing serious complications. In such cases, the size of the injury does not matter, it should be repaired immediately<sup>1,7,8</sup>. In our study, 11 large and 19 partial DI were primarily diagnosed with VATS. When they were diagnosed, they were repaired with VATS, or mini-thoracotomy.

The most important condition in the choice of VATS or laparotomy in the diagnosis of DI is the accompanying abdominal organ injury<sup>14</sup>. There are studies that support the use of VATS over the laparoscopic method, notably in posterior and lateral DI. VATS should be preferred in posterior penetrating region injuries and also if there is hemopneumothorax<sup>5</sup>. The VATS approach is very successful, especially in injuries smaller than 3 cm<sup>5</sup>. In our study, patients with no suspected intra-abdominal injury and stable hemodynamics, but suspected DI were treated with VATS. In cases where VATS was not sufficient, the entry site of PSW was slightly enlarged, and the existing TF could be more easily intervened upon. In cases where the injury was large, mini-thoracotomy was continued.

In DI, thoracotomy is easily performed when VATS is not sufficient. In a study, they performed 66% of their cases with thoracotomy and 15% with VATS<sup>6</sup>. In a study with the largest series performed with VATS, it was applied to 35% of the cases, and open surgery was recommended only for anterior and large diaphragmatic injuries<sup>14</sup>. In a similar study, surgery was performed with VATS in 8% of cases. In this application, they performed VATS on a total of 21 cases, 11 of which were on the right and 10 on the left<sup>13</sup>. In our study, DI was detected on the left side in 18 of the cases and on the right side in 12 cases. More DI was found in anterior region injuries. In anterior region injuries, VATS was sufficient in DI, while mini-thoracotomy was used more frequently in PI.

The things that cause morbidity and mortality in

DI are the accompanying pathologies that may develop in this injury. An in-depth knowledge and documentation of all cases is required to ensure correct medico-legal interpretation of events involving cutting or stabbing injuries<sup>15</sup>. The most important of these are intra-abdominal problems. It causes an increase in morbidity in intrathoracic causes. Some of these are lung parenchymal injuries, hemopneumothorax, pneumonia, atelectasis, postoperative bleeding, and infections. These co-morbidities may increase the length of hospital stay and cause morbidity and mortality. Advanced age and comorbid diseases are the most important causes of mortality and morbidity<sup>14</sup>. The longer the morbidity, the longer the hospital stay. LOS was evaluated as 8.75 days in a study and it was found as 5 days in another study<sup>6,16</sup>. In our study, the mean length of hospital stay was 4.58 days for anterior injuries and 6.11 days for posterior injuries. Mortality did not develop in our cases.

### CONCLUSION

As a result the use of VATS for the early diagnosis and treatment of DI in hemodynamically stable patients is the most important minimally invasive method. With VATS, the morbidity and LOS duration of the patients are significantly reduced. Statistically, DI is seen more frequently in the left-sided penetrations. DI occurs more frequently, especially in anterior thoracoabdominal region injuries. The success rate with VATS in anterior region injuries is quite high. In posterior region injuries, when VATS is not sufficient, it may be necessary to switch to mini-thoracotomy. The use or enlargement of the stabbing access site may save the patient from an unnecessary incision. The most important factors affecting the duration of hospital stay are co-morbidities and non-invasive surgical methods.

**Ethics Committee Approval:** Ethics committee approval was obtained for the study titled

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