



# Approach to Traumatic Diaphragm Injuries: Single Center Experience

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**Background:** Traumatic diaphragm injuries are rare. After blunt trauma, injuries occur with a 1–7% rate. This rate increases up to 15% in penetrating injuries. Diagnosis may be difficult and imaging tests may be misleading. The misdiagnosis may lead to herniated abdominal organs towards the intrathoracic cavity, with a mortality rate between 30% and 60%. This study was designed to investigate the data of patients operated for diaphragmatic injury in our clinic.

**Methods:** The files of trauma patients admitted to our hospital between 2014–2019 were reviewed retrospectively. The files of cases with diaphragmatic injury were examined. Patients were evaluated in terms of age, sex, type of injury, localization, additional organ injuries, grade, surgical method, and mortality. Values were statistically analyzed.

**Results:** A total of 20 patients were included in the study. Of the patients, 7 were female and 13 were male. The mean age was 32.7 (17–52) years. Of the cases, 10 were with stab wounds while 4 were in-car traffic accidents and 6 were gunshot wounds. Although all patients had thoracoabdominal injuries, 4 patients had additional pelvic injuries. Of the cases, 14 were accompanied with lung injury while 5 with intestinal, 4 with the spleen, 3 with liver, and 2 with cardiovascular injury. Patients with intestinal resection performed had a longer hospitalization period than others. When the severity of the injury was evaluated, grade 3 injuries were detected most commonly, whereas 3 patients had grade 1, 2, and 4 injuries. Grade 5 injury was detected in 1 patient. Primary repair was performed in 18 patients and mesh repair was performed in 2 patients. In three cases, the repair was performed with a thoracic way. One patient died on the postoperative first day.

**Conclusions:** Diaphragmatic injuries that may be missed during imaging may be damaged with many organs. Diaphragmatic injuries should be kept in mind in the upper abdominal and thoracic injuries.

**Key words:** *diaphragm, injury, primer repair*

## Introduction

Traumatic diaphragm injuries are rare. After blunt trauma, injuries occur with a 1–7% rate. This rate increases up to 15% in penetrating injuries.<sup>1</sup> Diaphragmatic injuries are usually associated with abdominal and thoracic injuries. Diagnosis may be difficult and imaging tests may be misleading.

The sensitivity of conventional imaging techniques varies between 13–63%.<sup>2</sup> Mortality associated with diaphragmatic trauma ranges from 4.3–37.0%.<sup>3</sup> Diagnosis is made during surgery, after the trauma. After an incorrect diagnosis, intraabdominal organs form a hernia in the thorax. The mortality rate due to strangulation can be up to 30–60%.<sup>4</sup>

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We designed this study to investigate the data of patients operated for diaphragmatic injury in our clinic.

## Methods

The files of trauma patients admitted to our hospital during 2014–2019 were reviewed retrospectively and files of patients with diaphragmatic injury were examined. Patients were evaluated in terms of age, sex, type of injury, localization of injury, additional organ injuries, grade, surgical method, and mortality. The research was conducted in accordance with the principles of the World Health Organization Helsinki Declaration “Ethical Principles Regarding Medical Research Containing Human Issues.” Corporate ethics committee approval was obtained for the study. Statistical Package for the Social Sciences (SPSS 21 Inc., Chicago, IL, USA) software was used for bio-statistical analysis. When the data were presented as mean values standard deviation values were given and when presented as median values the minimum (min) and maximum (max) values were given.

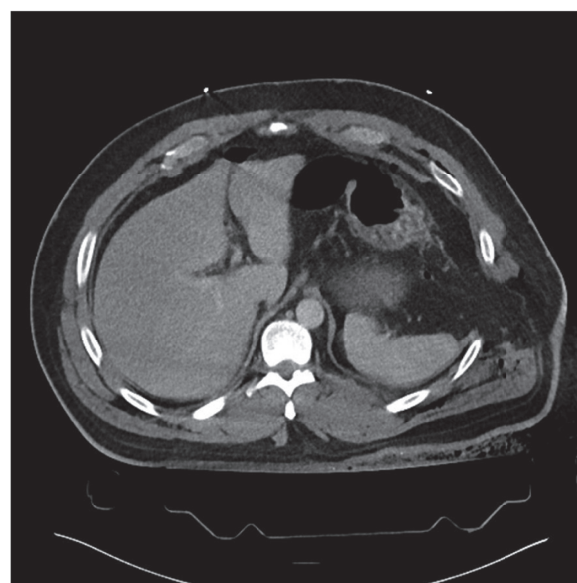
## Results

A total of 20 patients were included in the study, of which 7 were female and 13 male, with a mean age of 32.7 (17–52) years (Table 1). Of these, 10 had stab wounds, 4 had been in in-car traffic accidents, and 6 had gunshot wounds. Although all patients had had thoracoabdominal injuries, four patients had additional pelvic injuries. When the localization of the diaphragmatic injury was examined, the left side was found to be injured in 12 cases, the right side in 6 cases, and the bilateral injury was present in 2 cases. Moreover, of all the cases, 6 had hemodynamic instability (Fig. 1). Two cases underwent emergency surgery without imaging studies. One of these patients had a cardiac injury and died in the early postoperative period.

Of all the cases, 14 were accompanied with lung injury while 5 with intestinal, 4 with the spleen, 3 with liver, and 2 with cardiovascular injury (Table 2). In addition to diaphragmatic injury, 1 patient had both cardiac and superior vena cava injuries. The patient died in the postoperative period. Hemopneumothorax was present in all lung injuries. In 4 cases, lung contusion was observed. The chest tube was inserted in 10 patients. Splenectomy was performed in 2 patients with splenic injury while splenorrhaphy

**Table 1.** Demographic data

Characteristic	Value
Age, years	32.7 (17–52)
Gender	
Female	7
Male	13
Trauma type	
Penetrating stab wounds	10
In-car traffic accident	4
Firearm injury	6
Localization	
Left	12
Right	6
Bilateral	2
Grade	
Grade 1	3
Grade 2	3
Grade 3	10
Grade 4	3
Grade 5	1



**Fig. 1.** Left diaphragm injury due to stab wounds.

was performed in 2 patients. Hepatorrhaphy was performed in all cases of liver injury. Primary suturing was performed on all patients with bowel injuries. There was an anastomotic leakage in the patient with a gunshot injury. In this case, small bowel resection was performed and the ostomy was opened. Eight

**Table 2.** Organ damage associated with diaphragmatic injury

Damaged organ	n
Lungs	
Contusion	4
Hemo/pneumothorax	10
Intestinal injury	5
Spleen	4
Liver	3
Cardiovascular injury	2

patients underwent a blood transfusion. Four patients with hemodynamic instability underwent preoperative transfusion. The average time between the admittance of unstable patients to the emergency department and the start time of the operation was 30 minutes.

When the severity of the injury was evaluated, third-degree injury was the most common (10 patients), and 3 patients had first-degree, second-degree, and fourth-degree injuries, respectively. One patient had fifth-degree damage (Table 3). For all the cases, surgery was started with a midline incision. Primary repair was performed in 18 patients and mesh repair was performed in 2 patients. In 3 cases, the repair was performed by way of the thorax. The thoracoabdominal way was used in two cases. One patient died on the first postoperative day. Of the injuries, 12 were on the left diaphragm, 6 were on the right side, and 2 were bilateral. The average length of hospital stay for the patients was 8 (5–22) days. The length of hospital stay was longer (average: 10 days) in patients who underwent bowel resection.

## Discussion

The mechanism of injury to the diaphragm varies according to the trauma type and it may occur due

**Table 3.** The diaphragm injury scale of American Association for the Surgery of Trauma

Grade	Description of injury
1	Contusion
2	Laceration < 2 cm
3	Laceration 2–10 cm
4	Laceration > 10 cm with tissue loss < 25 cm <sup>2</sup>
5	Laceration with tissue loss > 25 cm <sup>2</sup>

to blunt or penetrating injury. One-third of the cases are caused by blunt trauma and two-thirds are caused by penetrating trauma.<sup>5</sup> Penetrating traumas can occur in the form of stab wounds or firearm injuries. The diaphragm is a musculotendinous structure that separates the abdominal and thoracic cavities. We can compare the diaphragm to a parachute. There is a membrane structure in the middle, while the edges are composed of muscles. The tendinous central part of the diaphragm is called the centrum tendineum. The diaphragm is attached to the xiphoid process and the costa edge in the anterior and 6–12 costae in the posterior. The diaphragm is attached to the lateral, medial, and median arcuate ligament in the posterior. These ligaments are also attached to m. quadratus lumborum, m. psoas major, and the body of the first three lumbar vertebrae (L1–3). Depending on this anatomical structure, diaphragmatic damage may occur because of penetrating injuries between the 6th and 12th costae. As it is an organ that moves with respiration, the possibility of injury may increase. Diaphragmatic injury due to blunt trauma is rare. It usually develops due to motor vehicle accidents. Diaphragmatic rupture may develop due to a sudden intraabdominal pressure increase. Rupture occurs if the pleuroperitoneal pressure gradient exceeds 150–200 cm H<sub>2</sub>O. Damage is seen on the left side of the diaphragm 2–3 times more.<sup>6,7</sup> Most of our cases were injured by penetrating trauma. Most injuries developed in the left diaphragmatic section.

Additional organ injuries occur in 50% of patients with the diaphragmatic injury.<sup>8</sup> Isolated diaphragmatic injury is observed rarely. The isolated diaphragmatic injury was observed in only four cases. In other cases, injuries in the abdominal organs, mainly the lungs, were observed. The splenic injury was also observed among abdominal injuries.

The diaphragmatic injury should be considered an injury to the chest or upper abdominal region. In the presence of wounds caused by penetrating injuries in this region, the diaphragm should be evaluated. Ecchymosis or deformity of the chest wall can be seen in blunt trauma to this region. Depending on the severity of the trauma and coexistent organ damage, the clinical symptoms may be aggravated. After sudden trauma, lung capacity may decrease due to the abdominal organs moving into the thoracic cavity. Thoracoabdominal computed tomography is important in injury tests.<sup>9</sup> The presence of abdominal organs in

the thorax is an important finding in the diagnosis. If the patient has a nasogastric tube, it can be observed in the thorax. In computed tomography, images such as loss of continuity of the diaphragm, thickening of the diaphragm, herniation in the intestinal organs, back displacement in the intestinal organs, sagging in the diaphragm, collar mark, and band mark can be viewed.<sup>10</sup> Thoracoabdominal injuries were present in all our cases. With preoperative imaging tests, four patients had definitive and four patients had suspicious diaphragm injury findings. The diagnosis was made intraoperatively in all remaining patients. According to the literature, imaging studies were insufficient to make a preoperative diagnosis.

It should be kept in mind that any patient with blunt or penetrating injury may have a diaphragmatic injury. The diaphragm should be evaluated in patients with trauma during the operation. Although there is no evidence of damage to the diaphragm in imaging studies, the diaphragmatic injury may have occurred. These patients should be hemodynamically stabilized. Respiratory functions should be closely monitored. Treatment protocols for concomitant organ injuries should be used.<sup>11</sup> If there is no tissue loss in the diaphragm, primary repair should be performed.<sup>12</sup> However, in cases of tissue loss where the primary approach cannot be applied, mesh repair should be performed.<sup>13</sup> The majority of our patients were treated with primary suturing. There was no serious problem during postoperative follow-up. In two cases, mesh repair was performed. One of these patients died on the first postoperative day due to concomitant organ damage. The other patient was discharged without any serious problem in the postoperative period.

## Conclusions

Diaphragmatic injuries may be missed during imaging in cases where multiple organs have been damaged. Diaphragmatic injuries should be kept in mind when evaluating upper abdominal and thoracic injuries.

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