



Surgery for Diaphragmatic Hernia Repair: A Longitudinal Single-Institutional Experience

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Background: This study analyzed and described the clinical characteristics and surgical outcomes of diaphragmatic hernia (DH) repair according to the operative approach.

Methods: After excluding cases with a combined approach and hiatal hernias, we analyzed 26 patients who underwent DH repair between 1994 and 2018. The baseline and perioperative characteristics of the thoracic approach group and the abdominal approach group were described and analyzed.

Results: Fifteen of the 26 patients were treated through the thoracic approach, including 5 patients who underwent video-assisted thoracic surgery (VATS). Eleven patients underwent the abdominal approach. The thoracic approach was associated with a longer duration of DH than the abdominal approach (2 vs. 0.1 months), herniation of the right-sided abdominal organs, and herniation of the retroperitoneal organs. During the median follow-up of 23 months, there was no recurrence of DH.

Conclusion: The surgical approach should be chosen considering the duration of DH and the location of herniated organs. VATS might be a safe and feasible option for repairing DH.

Keywords: Diaphragm, Hernia, Abdominal organ, Surgery, Video-assisted thoracic surgery

Introduction

A diaphragmatic hernia (DH) is the incursion of abdominal contents into the thoracic cavity through a defect in the diaphragm. Typically, it is caused by 2 major etiologies: congenital or traumatic. Congenital DHs are rare, occurring in 1 of 3,000 live births, and usually present early in life [1]. However, the reported incidence of traumatic DH varies from 20% after blunt trauma to as high as 47% after penetrating thoracoabdominal trauma [2]. Nevertheless, surgical repair is the definitive treatment for DH [3,4].

Surgical treatment involves reducing herniated organs into the abdominal cavity and repairing the diaphragmatic defect. However, debate continues regarding the timing of surgery and the optimal surgical approach [5-7]. Although the abdominal approach has been more common in the management of DH, the thoracic approach has emerged as an acceptable surgical approach [8-10]. The

thoracic approach is usually performed by video-assisted thoracic surgery (VATS), which has the following benefits: easy access to the hernia sac with good visibility, easy lysis of adhesion to the intrathoracic structures, and possible aid of CO₂ insufflation in the reduction of herniated organs to the abdominal cavity [11]. However, there are no established criteria for selecting the operative approach for DH repair. Therefore, we investigated clinicopathologic characteristics to evaluate outcomes according to the surgical management (thoracic versus abdominal approaches) in patients with DH in a single-center retrospective cohort.

Methods

Patients

With the approval of the Institutional Review Board (approval no., 2022-08-103-001), patients with a DH who



underwent surgical repair between 1994 and 2018 (n=59) were selected from the Registry for Thoracic Surgery at Samsung Medical Center, Seoul, Korea. The requirement for informed consent was waived by the Review Board due to the retrospective nature of this study. We excluded patients with hiatal hernia (n=31) and those who underwent a combined thoracic and abdominal approach (n=2). Among the remaining 26 patients, 15 and 11 underwent surgery using the thoracic and abdominal approaches, respectively. The thoracic approach group included patients who underwent thoracotomy or VATS (Fig. 1).

Treatment strategy

The thoracic approach was performed through thoracotomy or VATS. In most thoracotomy cases, posterolateral thoracotomy through the sixth intercostal spaces was performed, although the level of thoracotomy varied from the fourth to eighth intercostal spaces depending on the level of the hernia sac. In VATS cases, 3- or 4-port approaches were performed. The hernia sac was incised on the diaphragm, and then herniated organs were pushed through the diaphragmatic defect into the peritoneal cavity. In cases of strangulation, the hernia sac and incarcerated bowel were resected, and the bowel was anastomosed under thoracotomy. The defect of the diaphragm was closed primarily with 1-0 Prolene or closed using a polytetrafluoroethylene (PTFE) patch or knitted monofilament polypropylene mesh.

The abdominal approach was usually performed through an upper midline laparotomy. The herniated organs were pulled to the peritoneal cavity with adhesiolysis between herniated organs and intrathoracic structures. If there were

suspicions regarding the viability of the herniated bowel, resection and anastomosis were performed. The defect of the diaphragm was closed primarily with an interrupted suture using 1-0 Prolene.

Definitions and statistical analysis

Patients' demographic, clinical, and perioperative data, including symptoms, the duration of DH, the type and site of herniation, hospital stay, and perioperative complications, were collected by reviewing the electronic medical records. DH was considered to be traumatic if the patient had a history of thoracic or thoracoabdominal trauma, iatrogenic if the patient had a history of surgery near the diaphragm, and congenital if the patient had no trauma history and the surgical findings were compatible with Morgagni or Bochdalek hernia, regardless of the timing of the presentation. The duration of DH was defined as the interval between the initial diagnosis of DH and surgery for DH repair.

The primary outcome was defined as the recurrence of DH. The secondary outcomes were in-hospital morbidity, mortality, and length of hospital stay. Continuous variables were compared using the Mann-Whitney test and expressed as the median and interquartile range (Q1–Q3). All analyses were performed using SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA).

Results

Patients' characteristics

The median age of the 26 patients was 55 years (interquartile range [IQR], 36–64 years) and 50% (n=13) were men (Table 1). Left-sided hernias (61.5%) were more frequent than right-sided hernias (38.5%). Most patients were symptomatic: Abdominal pain (34.6%) and respiratory symptoms (30.8%), including dyspnea or cough, were the most common symptoms. Strangulation was observed in 2 cases and required emergency surgery. Iatrogenic (30.8%) and traumatic hernia (26.9%) were the major causes of DH. Congenital DH was observed in 5 cases, of which 3 (11.5%) were Morgagni hernias and 2 (7.7%) were Bochdalek hernias. The omentum was the most frequently herniated organ, followed by the colon.

The clinical characteristics were similar in patients who underwent surgery using the thoracic approach and those in whom the abdominal approach was performed. The thoracic approach was associated with right-sided DH

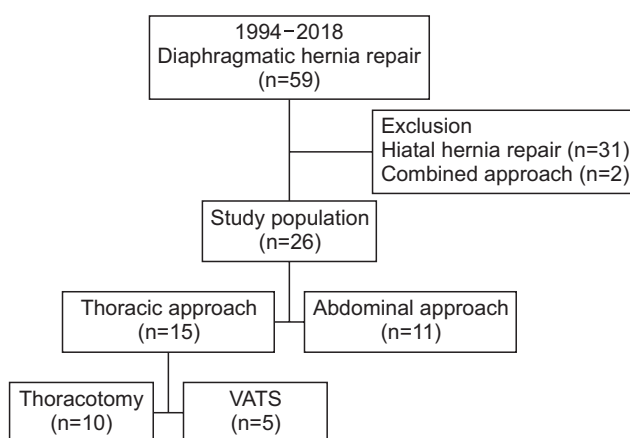


Fig. 1. Flow chart of patient selection and classification. VATS, video-assisted thoracic surgery.

Table 1. Baseline characteristics

Characteristic	Total (n=26)	Transthoracic approach (n=15)	Transabdominal approach (n=11)
Age (yr)	55 (36–64)	53 (35–62)	56 (39–64)
Sex, male	13 (50.0)	8 (53.3)	5 (45.5)
Location			
Right	10 (38.5)	7 (46.7)	3 (27.3)
Left	16 (61.5)	8 (53.3)	8 (72.7)
Duration of DH (mo)	0.8 (0.1–5.0)	2 (0.3–5.5)	0.1 (0–0.7)
Symptom			
Abdominal pain	9 (34.6)	6 (40.0)	3 (27.3)
Respiratory symptoms (dyspnea, cough)	8 (30.8)	4 (26.7)	4 (36.4)
Gastrointestinal symptoms (dysphagia, vomiting, indigestion)	5 (19.2)	2 (13.3)	3 (27.3)
Asymptomatic	5 (19.2)	4 (26.7)	1 (9.1)
Strangulation	2 (7.7)	1 (6.7)	1 (9.1)
Hernia type			
Iatrogenic	8 (30.8)	4 (26.7)	4 (36.4)
Traumatic	7 (26.9)	5 (33.3)	2 (18.2)
Morgagni	3 (11.5)	0 (0.0)	3 (27.3)
Bochdalek	2 (7.7)	1 (6.7)	1 (9.1)
Uncertain	6 (23.1)	5 (33.3)	1 (9.1)
Herniated organs			
Omentum	12 (46.2)	6 (40)	6 (54.5)
Colon	11 (42.3)	5 (33.3)	6 (54.5)
Stomach	4 (15.4)	2 (13.3)	2 (18.2)
Small bowel	5 (19.2)	4 (26.7)	1 (9.1)
Spleen	4 (15.4)	3 (20.0)	1 (9.1)
Liver	3 (11.5)	3 (20.0)	0
Gall bladder	2 (7.7)	2 (13.3)	0
Kidney	1 (3.4)	1 (6.7)	0
Pancreas tail	1 (3.4)	1 (6.7)	0

Values are presented as median (interquartile range) or number (%). DH, diaphragmatic hernia.

(46.7%), abdominal pain (40%), and traumatic etiology (33.3%). In contrast, the abdominal approach was associated with left-sided DH (72.7%), respiratory symptoms (36.4%), and iatrogenic etiology (36.4%). The median duration of DH was 2 months (IQR, 0.3–5.5 months) and 0.1 months (IQR, 0–0.7 months) in the thoracic and abdominal approach groups, retrospectively (Fig. 2). In cases of organ herniation in the right side of the abdomen and the retroperitoneum, a thoracic approach was usually performed (Table 2).

Surgical characteristics

Among 15 patients who underwent the thoracic approach, 10 underwent thoracotomy and 5 underwent VATS (Table 2). There were 2 emergency cases in this group. Hernia sac resection was performed in 2 patients, and bowel resection and anastomosis were performed in 1 case. Knit-

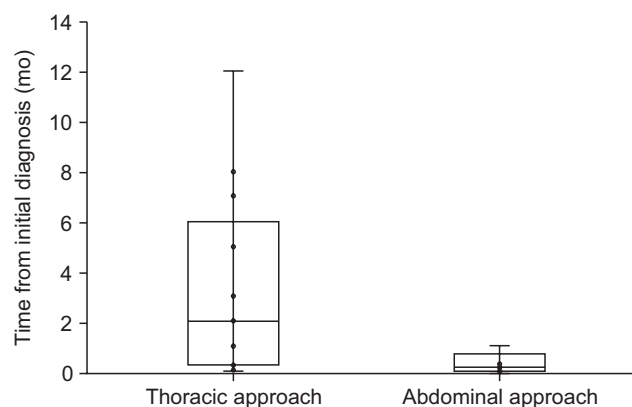


Fig. 2. A box plot of the duration of diaphragmatic hernia in each approach. The median duration in the thoracic approach group was 2 months (interquartile range [IQR], 0.3–5.5 months), and 0.1 months (IQR, 0–0.7 months) for the abdominal approach group. Variables out of the boxes were omitted: 1 patient in the thoracic approach group had a duration of 84 months, and 2 patients in the abdominal approach group had durations of 7 months and 12 months, respectively.

Table 2. Perioperative characteristics

Variable	Total (n=26)	Transthoracic approach (n=15)	Transabdominal approach (n=11)
Emergency operation	5 (19.2)	2 (13.3)	3 (27.3)
Resection of hernia sac	6 (23.1)	2 (13.3)	4 (36.4)
Bowel resection and anastomosis	2 (7.7)	1 (6.7)	1 (9.1)
Type of diaphragm repair			
Primary repair	19 (73.0)	8 (53.3)	11 (100.0)
Proceed mesh or GORE-TEX	7 (26.9)	7 (46.7)	0
Operation time (min)	208 (181–243)	208 (194–243)	185 (139–265)
In-hospital outcomes			
No. of mortality	0	0	0
Median length of stay (day)	9 (7–12)	10 (7–13.5)	9 (7–11)
Complications			
Pneumonia	1 (3.8)	1 (6.7)	0
Pneumothorax	0	0	0
Pleural effusion	0	0	0
Recurrence	0	0	0
Wound dehiscence	1 (3.8)	1 (6.7)	0
Median follow-up duration (mo)	23 (1.5–79.5)	31 (2.25–82)	15 (1–68)

Values are presented as number (%) or median (interquartile range).

ted monofilament polypropylene mesh or PTFE materials were used in 7 patients in the thoracic approach group. The median operation time for the thoracic approach was 208 minutes (IQR, 194–243 minutes).

Among 11 patients who underwent surgery with the abdominal approach, 10 underwent median laparotomy, whereas 1 required conversion to laparotomy from laparoscopic surgery due to small bowel strangulation. There were 3 emergency cases in this group. Hernia sac resection was performed in 4 patients, and bowel resection and anastomosis were performed in 1 case. In contrast to the thoracic approach, no prosthetic materials were used to close the diaphragmatic defect. The operation time was 185 minutes (IQR, 139–265 minutes).

Surgical outcomes

There were no cases of in-hospital mortality (Table 2). Pneumonia (n=1) and wound dehiscence (n=1) occurred in the thoracic approach group. The median length of hospital stay was 10 days (IQR, 7–13.5 days) and 9 days (IQR, 7–11 days) in the thoracic and abdominal approach groups, respectively. During the median follow-up of 23 months (IQR, 1.5–79.5 months), there was no recurrence of DH in either group (Table 2).

Discussion

In this retrospective study, the thoracic approach was associated with a longer duration of DH, herniation of the right-sided abdominal organs, and herniation of the retroperitoneal organs. Iatrogenic and traumatic DH occurred more frequently in patients treated with the thoracic approach than in those who underwent the abdominal approach. There were few morbidities and no recurrence in either surgical approach group.

In this study, there was no recurrence of DH after surgical repair. The recurrence of DH has been reported to be rare after surgery for traumatic DH [12]. This suggests that regardless of the approach selected, surgical repair is associated with low morbidity and mortality and excellent long-term outcomes with a low rate of recurrence. In our experience, adequate tension around the diaphragmatic defect is essential. This may be achieved by primary closure of the diaphragmatic defect or the application of prosthetic material.

The transthoracic approach was more frequently performed in patients with a longer duration of DH. This might be because a long duration of DH is possibly associated with the adhesion of herniated organs to intrathoracic structures. Lysis of adhesions through the diaphragmatic defect via the abdominal approach is challenging and may result in injury of thoracic organs, eventually requiring further procedures. In this clinical scenario, the thoracic

approach offers a high likelihood of the safe removal of the adhesions with good visualization of the diaphragm [4,6,13]. In the present study, the thoracic approach was preferred when patients had a long duration of DH. In the thoracic approach group, the median duration of DH was 2 months, while it was 0.1 months in the abdominal approach group. In our experience, if DH lasts more than 6 months from the inciting events, adhesions between the herniated tissues and intrathoracic structures become too tight for removal through the transabdominal approach. Further analysis is needed to predict the development of tight adhesions that may preclude a transabdominal approach.

The laterality of a hernia was identified as another factor determining the choice of surgical approach in the present study. The thoracic approach was performed in 57.7% of all DH cases in our study. In right-sided DH, the thoracic approach offers better access since access to the herniated organ becomes difficult owing to the liver on the right side in the abdominal approach [6]. In addition, access to posterior diaphragmatic defects is easily achieved through the thoracic approach. In our experience, concomitant bowel injury or strangulation could be repaired through an intrathoracic approach, which suggests that a suspicion of bowel ischemia does not preclude the thoracic approach [14]. Therefore, our findings suggest that in right-sided DH, regardless of the viability of herniated organs, the thoracic approach is the preferred method.

In this study, 33.3% of cases using the thoracic approach were performed by VATS. Since VATS has been widely adopted in the field of thoracic surgery, the repair of DH through VATS has been reported [14-19]. Accordingly, VATS became the preferred approach at our institution in 2017, regardless of the type of hernia. VATS has benefits such as enhanced postoperative recovery with less pain than open thoracotomy [20,21]. In our study, VATS showed comparable surgical outcomes to the open approach with a shorter hospital stay. We also prefer to use CO₂ gas during the repair of DH through VATS. The positive pressure created by CO₂ may provide additional drawing forces down to the abdominal cavity during the reduction of herniated organs. A further large cohort study is needed to confirm the benefits of VATS compared with thoracotomy in DH patients considering the thoracic approach.

Our study has several limitations. First, as an observational study, there was potential residual confounding. Second, the size of the study population was too small to draw statistical significance, and the cohort was heterogeneous, insofar as there were patients with both congenital and traumatic DH together. Third, changes in surgeons' prefer-

ences and technical advances occurred during the study period. Since 2017, VATS has been most frequently used to repair DH, and the last case using the abdominal approach was performed in 2015. These time-dependent differences may have contributed to differences in the results. Finally, our analysis was based on data from a single tertiary cancer center, and the results of our study might not be generalizable to patients in other settings. A multicenter, prospective cohort study is needed to validate our results.

In conclusion, this study showed that the surgical repair of DH due to congenital or acquired lesions could be successfully performed either through the abdominal or thoracic approach. The duration of DH was an important factor affecting the choice of surgical access. The location of the hernia and the presence or absence of concomitant injuries should also be carefully considered. Lastly, our study demonstrated that VATS might be a safe approach for DH repair and could be a feasible option in selected patients.

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Author contributions

Conceptualization: JHC. Data curation: SKL, SO. Formal analysis: SO, JL. Methodology: SO, SKL, JL. Writing—original draft: SO, SKL, JL. Writing—review & editing: all authors. Final approval of the manuscript: all authors.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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