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Original Article

Benefits of routine uniportal thoracoscopy during rib fixation in the diagnosis and repair of diaphragmatic injury

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ABSTRACT

Background: The incidence of missed diagnosis of traumatic diaphragmatic injury (TDI) is about 30%. Lower rib fractures may cause TDI. We aimed to present our clinical results of uniportal video-assisted thoracoscopic surgery (VATS) in terms of detecting and repairing TDI, in patients undergoing rib fixation.

Materials and Methods: In this retrospective study, routine uniportal VATS was performed in patients planned to undergo rib fixation due to flail chest and severely displaced rib fractures between January 2021 and January 2023. The results of 11 patients with TDI were investigated.

Results: All patients were male. Eighty-two percent of the patients had blunt type of injury. Most TDIs were detected during VATS (55%). There were 7 left and 4 right TDIs with diaphragmatic defects varying from 2 to 5 cm in size. Two patients had minor omental herniation. Mean number of fractured ribs was 4. Mean duration of operation was 139 minutes. Mean hospital stay was 7 days. Morbidity developed in 1 patient (9%, wound infection).

Conclusions: Routine VATS in patients undergoing SSRF helps detecting and repair TDIs. Its diagnostic benefit in the diagnosis of acute TDI is greatest in patients with multiple rib fractures involving the lower chest wall, although there are no radiographic evidences of TDI.

Keywords: diaphragm injury, uniportal thoracoscopy, rib fracture, trauma

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Introduction

Traumatic diaphragmatic injuries (TDIs) secondary to blunt or penetrating thoraco-abdominal trauma are difficult to diagnose in the acute trauma setting [1]. Despite advances in radiological imaging, it is known that the incidence of missed or delayed diagnosis of TDI is about 30% [2]. The diagnostic yield of chest radiography and ultrasound in the acute TDI is low [3], and computed tomography has a diagnostic yield of 61-72% [4].

Flail chest and severely displaced rib fractures due to trauma are associated with significant morbidity and mortality, it has been shown that the presence of more than three rib fractures in adults may be a marker for associated solid organ injury [5]. Moreover, lower rib fractures are demonstrated to be related with TDI [1,6]. Delayed massive hemothorax due to TDI secondary to lower rib fractures have been reported [7,8].

The use of exploratory video-assisted thoracoscopic surgery (VATS) for the diagnosis and treatment in traumatic patients with intrathoracic injury has been proposed. VATS is shown to be safe and useful approach in selected patients with thoracic trauma [9-11]. In addition, the benefits of VATS in the diagnosis and treatment of TDI are well-demonstrated [12-15].

In our clinic, we provide surgical stabilization of rib fractures (SSRF) for patients with flail chest injuries or severe multiple rib fractures. We adopted to use routine VATS in the management of these patients, as previously advised [1]. By this way, we had the possibility to detect and treat acute TDIs in patients with traumatic chest wall injury. Here in this report, we aimed to present our experience in this topic.

Materials and Methods

We retrospectively reviewed the patients (n = 980) who presented with chest wall trauma to the emergency department from January 2021 to January 2023. Among them, patients with sternal, clavicular, scapular and thoracic vertebral bony fractures; patients with additional extrathoracic traumas; patients with chest wall injury related soft tissue; patients undergoing emergency surgery due to trauma; and patients with simple rib fractures not necessitating SSRF were excluded. Patients with flail chest and severely displaced rib fractures for whom SSRF were planned, were taken into the consideration. Among them, patient who necessitated conversion to thoracotomy due to relevant indications were also excluded, and 11 patients who underwent SSFR and diaphragmatic repair using VATS included into the study. All patients underwent chest X-ray and computed tomography of the chest at the admittance. Data collected included patient demographics, mechanism of injury, numbers and places of rib fractures, intraoperative findings, length of operation, length of hospital stay, and follow-up results.

VATS was performed using lung isolation with a double lumen endotracheal tube or bronchial blocker placed through a single lumen endotracheal tube. Any previously placed chest tube was removed following the induction of general anesthesia and lung isolation. A 3 cm camera port incision was made anterior to the iliac spine in the 6th or 7th intercostal space, but if the broken ribs were very close to the incision site, a more suitable place was chosen. No CO2 gas insufflation was used. A 10 mm 30-degree thoracoscope was introduced via a 12 mm port into the pleural space. A sucker was inserted through the same port to aspirate ant fluid and/or blood, then the pleural space, lungs, diaphragm and other structures were carefully inspected. The displaced rib fractures were observed and any potential arterial and/or venous bleeding were cauterized or clipped (Figure 1A). Detected lung lacerations were sutured using a running 3-0 polypropylene suture. In TDI was detected, the port incision was extended to 5 cm (Figure 1B). Any herniated abdominal viscera, if present, were reducted to the abdominal cavity and the repair of the diaphragm was performed using interrupted 0-vicryl sutures (Figure 1C). The repair of the diaphragm was done via uniportal approach (Figure 1D). Then using a separate muscle-sparing incision, approximately 4 to 5 cm in size, SSRF was done by placing plates and screws on the external aspect of the ribs in the submuscular space (Figures 2A,B). Following SSRF, the pleural space was investigated using VATS, a 28 Fr chest tube was placed through the camera port, and the incisions were closed appropriately. All patients were extubated at the operating room. All the operations were performed within the first 2 days following the injury.

Postoperatively, all patients received similar analgesic (intravenous patient-controlled analgesia), antibiotic and bronchodilator treatment. The chest tubes were removed when the lungs were totally expanded without air-leak, and the daily drainage was less than 150 mL. Patients were discharged on the day of chest tube removal or the following day, as appropriate. The follow-up scheduled 2 times in a month during 3 months. The study was conducted in accordance with the Declaration of Helsinki and was approved by the local institutional review board (2023/4022). Individual consent for this study was waived from each patient.

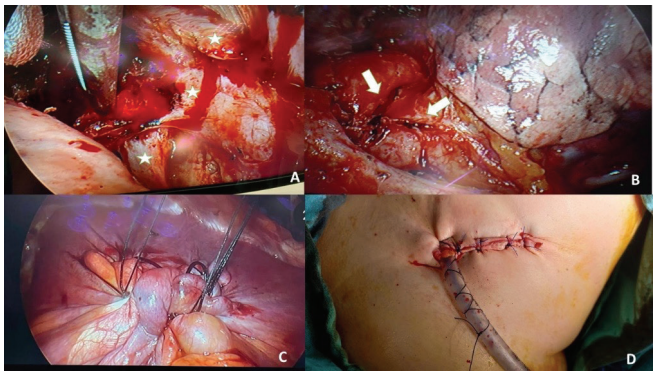

Figure 1. Displaced rib fractures (white stars) and minimal intercostal bleedings **(A)**, injuries in the diaphragm (white arrows) **(B)**, diaphragm after the repair **(C)**, the view of the uniportal VATS approach **(D)**.

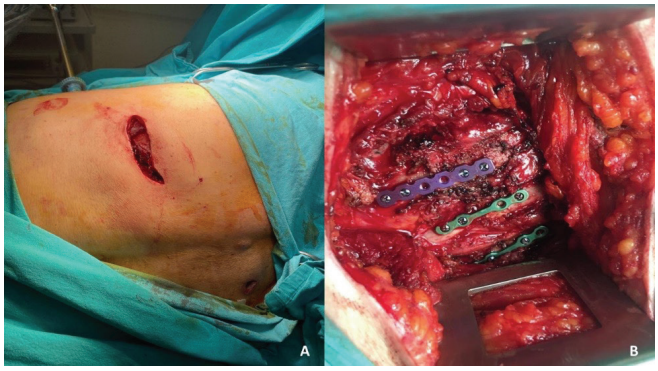

Figure 2. Separate muscle-sparing incision for rib fracture repair **(A)**, the view after the fixation of 3 ribs **(B)**.

Results

The characteristics of the patients, data about the injury, and per- and postoperative outcomes were given in table 1. Blunt type injury predominated (82%). All the broken ribs were lower ribs (7th to 12th ribs), as previously defined [6]. Computed tomography of the chest demonstrated TDI in 5 patients (45%). TDIs were detected peroperatively in the remaining 6 patients (55%). Traumatic pneumothorax and hemothorax were detected in 6 patients (3 for each, 55%). Two patients with penetrating type of injury had both pneumothorax and hemothorax. Each patient underwent tube thoracostomy at the admittance to the emergency department. Pulmonary laceration was seen in 2 patients with penetrating trauma, and sutured. In addition, 5 patients (45%) had pulmonary contusion which resolved with appropriate medication. Diaphragmatic defects varied in size from 2 to 5 cm. Only 2 patients had minor herniation (only part of omentum).

Postoperative periods of the patients were uneventful except for a wound infection in a patient with penetrating trauma which resolved with medical treatment (9%). No mortality occurred during the study. Each patient was followed up 3 months postoperatively. A postoperative computed tomography of the chest was routinely taken at the third month which showed no problem related to rib fractures and TDI, then the follow-up was terminated.

Table 1. Characteristics of the patients, data about the injury, and per- and postoperative outcomes.

Age, years (mean, range)		29 (21-41)
Gender		Male (100%)
Type of injury (%)	Blunt (car accident) Blunt (fall) Penetrating (knife)	6 (55%) 3 (27%) 2 (18%)
Side	Left Right	7 (64%) 4 (36%)
Mean number of rib fractures, (range)		4 (3-5)
Duration of surgery (minutes), mean ± SD		139±12
Chest tube removal (days), mean ± SD		6±1
Postoperative length of stay (days), mean ± SD		7±1

Discussion

Jones et al [16] assessed 36 patients with penetrating thoracic trauma using thoracoscope and presented their results in 1981. Then Graeber and Jones [17] outlined the potential applications of VATS after thoracic injury in 1993. Since then, VATS has been used increasingly in selected patients with thoracic injury. This approach was proved to be useful, especially in the detection of TDI. In a series of 42 patients with both blunt and penetrating thoracic injury, VATS revealed 14 TDIs (33%) [10]. Among 13 patients undergoing VATS due to penetrating thoracic injury, TDI was detected in 5 patients (36%) [11].

We operated 11 patients due to flail chest and severely displaced rib fractures, and by using VATS, we repaired diaphragmatic injuries. In 5 patients (45%) computed tomography had already demonstrated TDI, but VATS helped us to detect TDI in the remaining 6 patients (55%). Our result demonstrates that VATS is a useful approach to detect TDI which is not seen radiologically. Similar results have been given in the literature. In the series of Martinez et al [12] consisting of 40 patients, VATS documented TDI in 67% and a sizable hemothorax in 63% of the patients. In a recent study consisting of 22 patients, the missed TDI rate was 18% although patients were evaluated radiologically using chest X-ray, computed tomography of the chest and abdominal ultrasound [15].

In our series, we noted that patients with multiple rib fractures and TDI were more likely to have ribs in-

volving the lower chest wall. All patients in our study had their lower ribs broken (7th to 12th ribs). Similar results have been reported [1,6]. The mechanism of TDI was penetrating injury from the fractured ribs puncturing and tearing the diaphragm [1]. We agree with this proposed mechanism in the development of TDI for patients with blunt type of trauma however, we had 2 patients with penetrating type of injury in our series. Although each patient had 3 broken ribs, we can't be sure that whether TDI developed from penetrating injury from the fractured ribs or from directly to the knife.

The management of rib fractures has changed in the last two decades. Benefits of surgical stabilization in traumatic flail chest has been proven [18] and the popularity of SSRF in patients with severe chest wall injuries increased [19]. Wemeijer et al [20] favored the use of an inspection through thoracotomy or thoracoscopy during SSRF to diagnose missed intrathoracic injuries. The authors investigated 51 patients with thoracotomy or thoracoscopy while SSRF, and 11 patients was found to have TDI (22%). Of them, 3 patients had radiologically demonstrated TDI but the remaining 8 patients had TDI discovered by inspection during surgery.

Since the beginning of 2021, routine VATS inspection of thoracic cavity during SSRF has been performed in our clinic. The same protocol has been used by Powell et al [1]. In their study, they found and repaired TDI in 15 patients with fractures during SSRF using multiportal VATS approach. Multiportal VATS repair of TDI is a preferred approach [12,13]. Uniportal or single-port VATS approach has been recently reported under CO2 gas insufflation [21,22]. We performed uniportal VATS approach during the repair of TDI in our series. We did not use CO2 insufflation during the surgery, although it is known to make the uniportal approach easier by flattening of the diaphragm [21,23].

In a recent study, Bui et al [24] performed uniportal VATS during SSRF. They divided their patients into two groups: routine VATS and VATS in selected cases. Among 97 patients in total, they detected 31 incidental traumatic findings (32%), especially retained hemothorax (n = 18) and lung laceration (n = 7). They found 2 cases with TDI, both in routine VATS group. Overall, routine VATS detected insignificantly higher number of incidental finding compared to selected VATS group (23 versus 8 findings, $p > 0.05$). Beside they also compared patients undergoing VATS during SSRF and only SSRF, and found out that there were no significant differences between groups in terms of length of hospital and intensive care unit stay, length of operation, ventilator support, and mortality. They concluded that there was no additional risk or increased operative time with performing routine VATS at the time of SSRF.

In conclusion, routine VATS is not associated with increased operative time, length of stay, or mortality in patients undergoing SSRF. It may help detecting incidental traumatic findings. The diagnostic benefit of VATS in the diagnosis of acute TDI is greatest in patients with multiple rib fractures involving the lower chest wall, although there are no radiographic evidences of TDI. But more prospective multi-institutional studies with higher number of patients are needed to determine potential benefits of routine VATS approach in patients undergoing SSRF.

Declaration of conflicting interests

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Ethics approval

The study was approved by the SBÜ Şişli Hamidiye Etfal Research and Training Hospital Clinical Research Ethical Committee (no: 4022, Date: 04/07/2023).

Authors' contribution

OD; conceptualized and designed the study, collected, analyzed and interpreted the patient data, wrote the paper, UT; collected the literature data, revised the final version of the manuscript, and co-wrote the paper. All authors read and approved the final manuscript.

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