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Research Article

The Utility of Video Assisted Thoracoscopic Surgery in Identifying Imaging-Occult Diaphragmatic Injury in Patients Undergoing Surgical Stabilization of Rib Fractures

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Abstract

Objectives: Diaphragmatic injuries are associated with rib fractures and often missed on Computed Tomography (CT) imaging. Surgical Stabilisation Of Rib Fractures (SSRF) provides mortality and morbidity benefit in the right cohort of patients with rib fractures, however, whether to routinely perform thoracoscopy during fixation is unclear. The Aim of this study is to see if the use of routine thoracoscopy will help identify imaging-occult diaphragmatic injury.

Methods: We conducted a retrospective analysis of all patients undergoing SSRF and thoracoscopy at The Royal Melbourne Hospital (Level 1 Trauma Centre) between January 2010 to November 2019. Primary outcome of interest was thoracoscopic detection of diaphragmatic injury where not detected on CT scan.

Results: A total of 190 patients underwent SSRF with thoracoscopy. 188 patients were surgical fixation following acute trauma. Thirteen (6.8%) patients had diaphragmatic injuries that were operatively managed, of whom six (46.2%) had imaging-occult injury.

Conclusion: Imaging-occult diaphragmatic injuries occurred almost as frequently as those detected on CT scans. Thoracoscopy in patients undergoing SSRF can be performed safely and effectively to provide timely treatment to missed traumatic diaphragmatic injuries.

Introduction

Surgical Stabilisation Of Rib Fractures (SSRF) is increasingly performed to stabilise the chest wall, improve pain, and optimise function, and has been proven to provide benefits in mortality and morbidity [1]. However, whether to routinely perform thoracoscopy during SSRF remains unclear. Benefits of video assisted thoracoscopic surgery (VATS) with SSRF include enhanced anatomical definition of rib fractures; evacuation of retained haemothorax; facilitation of precise extra pleural catheter placement, as well as identification and evaluation of the inner chest wall and surrounding anatomy including diaphragmatic injuries. Diaphragmatic injury is an uncommon but important consequence of blunt chest trauma with significant association with mortality and morbidity [2]. It may occur through three distinct mechanisms: direct penetration by rib fractures; central tendon disruption; or disruption of the peripheral muscular attachments of the diaphragm. Rib fractures are known to increase the likelihood of an associated diaphragmatic injury [3] and despite its known association, there is still a high rate of missed diaphragmatic injury on Computed Tomography (CT) imaging [4,5]. This study describes our institution's experience of the use of VATS with SSRF, and the utility of VATS in the diagnosis and management of imaging-occult diaphragmatic injury. We also endeavour to understand the relationship between rib fracture pattern and solid organ injury, namely to the liver and spleen. In all, this study will aim to provide precedence for the utility of routine VATS when performing SSRF.

Methods

A retrospective review was undertaken of all patients undergoing SSRF and VATS at the Royal Melbourne Hospital (RMH), a Level 1 Trauma Center, between 1st January 2010 and 1st November 2019. Surgical stabilisation of rib fractures is routinely performed at our institution and all SSRFs are performed with the assistance of thoracoscopy. The inclusion criteria for this study was all patients who underwent SSRF between 1st January 2010 and 1st November 2019. No patient was excluded. Patient data was collected from the Lung Cancer Informatics Database (LCI) database, which has prospectively collected information on all patients who have undergone SSRF at our institution since 2006. Criteria for SSRF at our institution includes patients with flail chest, multiple rib fractures, severe and chronic pain, failure to extubate and/or chest wall deformity. Recorded data included baseline demographic data, presence of diaphragmatic injury, haemothorax and/or pneumothorax, number of rib fractures, degree of injury, along with modality of fixation and any post-operative complications. The method of diagnosing diaphragm injury was noted, which was identified either preoperatively on CT scans, intraoperatively or post-mortem, as well as the relationship of diaphragmatic injury and rib fracture pattern.

Results

A total of 190 patients underwent SSRF and VATS at our institution between 1st January 2010 and 1st November 2019. Patient demographics and mechanism of injury are outlined in Table 1. The mean age of patients who underwent SSRF with VATS was 53.8 years (SD 15.1 years). 188 cases (99%) of SSRF and VATS occurred acutely following trauma. Of the remaining two cases, one SSRF and VATS was undertaken following removal of a NUSS bar for treatment of pectus excavatum, while the other occurred non-acutely in the context of managing symptomatic rib fracture site non-union. Of the total 188 acute trauma patients, 13 (6.8%) had diaphragmatic injuries that were operatively managed during their SSRF and VATS. Of those 13 patients, seven were diagnosed on pre-operative CT imaging, while six patients had imaging-occult injury, identified only during VATS (Figure 1). Rib fracture pattern in patients with diaphragmatic injury diagnosed by CT and on VATS is compared in Table 2. In the CT diagnosed group, 57.1% (4/7 patients) of patients had right diaphragmatic injuries, compared to 60% (4/6 patients) in the imaging-occult group. In both sides of injuries there were rib fractures that extended the entire thorax. Diaphragmatic hernia was present in only 1/6 (16.7%) patients in the imaging-occult group versus 5/7 (83.3%) in the CT group. It was also identified that all patients who underwent SSRF had a degree of a haemothorax seen on thoracoscopy and was subsequently drained during VATS and ICC was placed under direct visualization (Table 3).

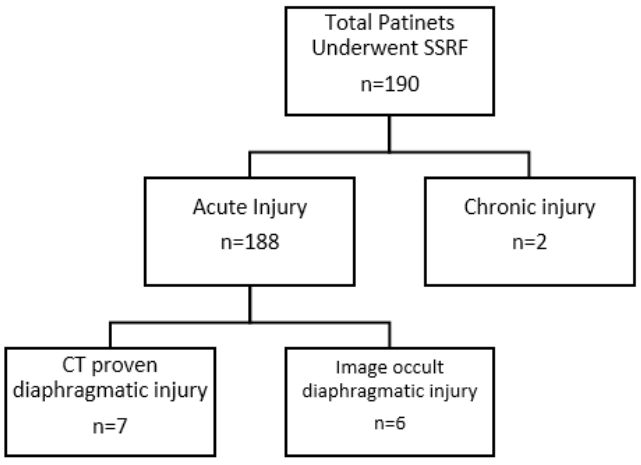

Figure 1: Diagnosis of image occult injury.

	N	Percentage (%)
Age	53.8 +/- 15.1 years	
Male	131	68.9%
Female	59	31.1%

Table 1: Patient demographics.

Mechanism of injury	N	Percentage (%)
MVA	59	31.1%
MBA	41	21.6%
Fall	42	22.1%
Cycle	11	5.8%
Assault	3	1.5%
Crush injury	9	4.7%
Kicked by horse	12	6.3%
Ped vs vehicle	7	3.7%
Other	6	3.2%

Table 2: Mechanism of Injury.

	CT proven diaphragmatic injury		**Image occult diaphragmatic injury**	
The side of diaphragmatic injury	4/7 (57.1%) right sided	3/7 (42.9%) left sided	4/6 (60%) right sided	2/6 (40%) left sided
Diaphragmatic hernia	5/7 (83.3%) patients		1/6 (16.7%) patients	
Solid organ injury (liver or spleen)	6/7 (85.7%) patients		0 patients	
ipsilateral flail segments	3/7 (42.9%)		3/6 (50%)	

Table 3: Difference in CT proven and Image occult diaphragmatic injury.

Post-operative complications occurred in a total of 34 patients (17.9%). Many of these complications were pneumonia occurring at a rate of 10% (19 patients) and haemothorax or bleeding occurring at 6.8% (13 patients). One patient suffered a myocardial infarction, and one patient died as result of un-survivable traumatic brain injuries.

Discussion

This retrospective single arm cohort study analysed 10-years of data of patients that underwent Surgical Stabilisation of Rib Fractures (SSRF) which included Video Assisted Thoracoscopic Surgery (VATS) at our institution. The total number of acute cases that required VATS and SSRF were from a set of 188 patients who were either referred from the RMH trauma service or an isolated trauma transfer from a regional centre. Blunt chest wall trauma and rib fractures in the acute setting have a known correlation with traumatic haemothorax. From the sample pool that was identified it was noted that all patients who underwent SSRF were seen to have a degree of a haemothorax. This was subsequently drained and washed under thoracoscopy and followed by placement of intercostal catheter under

visualization. Pieracci FM, in May 2019, outlined the theoretical benefits of thoracoscopic surgical stabilization of rib fractures including evacuation of retained hemothorax, guided placement of loco-regional anaesthesia and chest tubes, and identification and repair of associated, intra-thoracic injuries which have all been mentioned above [6]. However, stated that "early attempts at thoracoscopic SSRF have been limited by both user inexperience and inadequate instrumentation".

Wu TH et al, highlighted one of the major indications, which is inability to wean off ventilation and or failure to be extubated [7]. Their study emphasised a shortened length of ventilator use reduces the pneumonia rate in patients with severe chest blunt injury when SSRF in conjunction with VATS is undertaken, which in turn leads to decreased hospital stay. Similar results were seen in Lin HL et al, who also emphasized that adding SSRF and VATS in the management of retained hemothorax can contribute to decreased hospital admission [8]. A question that this study raises is: What injury patterns can lead to intrathoracic or diaphragmatic injury that may be missed on CT and thus may benefit from conjunctive thoracoscopy? In our study, no such pattern that is predictive of said injuries was recognised. Previously it was identified in Maduka et al, that that there should be a low threshold for thoracotomy or laparotomy in blunt trauma patients with severe low rib fractures [9]. Similarly, Powell et al. reported greatest diagnostic yield with thoracoscopy was achieved in patients with multiple rib fractures involving the lower chest wall [3]. However, when analyzing the pattern of injury in cases of both image occult and CT identified injuries, it was noted that location of rib fractures varied among the entire thoracic cage and not just including the lower ribs. The data, however, did show that there was no image occult contralateral diaphragmatic injuries and that all missed injuries were seen on the ipsilateral side.

One of the limitations of this study is that our institution consistently utilizes VATS with all SSRF. As such, there is a lack of comparison data on rates of detection of imaging-occult diaphragmatic injury. Although this comparison would be useful in comparing patient morbidity and mortality, it would still not provide any clarification regarding missed injuries as the injury may remain undetected. As a result, the lack of predictive factors of image occult intra thoracic injury or diaphragmatic injury would suggest the need for more frequent use of thoracoscopy. This more frequent use of VATS would reduce the amount of missed and unknown injuries that may contribute to increased morbidity and mortality.

Conclusion

While the overall prevalence of a diaphragmatic injury in patients undergoing SSRF was not high, the risk of missing a potential image occult injury raises the question of whether thoracoscopy should be a routine part of practice when performing SSRF.

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