Patients with lower thoracoabdominal stab wounds may have hidden diaphragmatic injuries that could finally lead to chronic diaphragmatic hernia. In this study, we analyzed 30 patients with penetrating thoracoabdominal injuries that were stable hemodynamically and did not need emergency exploration. They underwent thoracoscopy in order to find a probable diaphragmatic injury from March 2005 to October 2007. The mean age was 26.2 years and the M/F ratio was 5:1. We observed five occult diaphragmatic injuries (16.7%) in thorascopic evaluations. Three cases (9.9%) were repaired through a thorascopic approach while laparatomy was inevitable in two (6.6%) patients. Pulmonary parenchymal lacerations were observed in two patients (6.6%) which were repaired through thoracoscopy and intra-abdominal injury was observed in one patient (3.3%) which was repaired via laparatomy. We performed thoracoabdominal CT-scan 6 months later and chronic diaphragmatic hernias were not reported. Diagnostic accuracy of thoracoscopy was 100%. Owing to the high diagnostic accuracy rate, minimal invasiveness and therapeutic potency of thoracoscopy we recommend it to be performed in all clinically stable patients with penetrating thoracoabdominal penetrating injury especially in the 8th intercostal space.

© 2009 Published by European Association for Cardio-Thoracic Surgery. All rights reserved.

Keywords: Thoracoabdominal stab wound; Diaphragmatic injury; Thoracoscopy

1. Introduction

The risk of diaphragmatic injury in stab wounds in the lower segment of the chest and the upper segment of the abdomen has been an issue of importance for surgeons during the last four decades [1]. These wounds are often associated with laceration of other intra-abdominal organs or traumatic diaphragmatic hernias. Delay in diagnosis may lead to complications, such as herniation of the abdominal organs into the thoracic cavity named as ‘Delayed stab action’ with a 4.4–48.1% mortality rate [2, 3]. Studies have reported a 15–20% rate of occult diaphragmatic injury in patients with lower thoracoabdominal stab wounds [4]. Lower thoracoabdominal stab wounds routinely undergo surgical exploration in some clinical centers [5]. Although diaphragmatic injuries are discovered by this method, a great fraction of these explorations have negative results and in some cases may lead to some complications. Additionally, it is a time and money-consuming method especially for crowded trauma centers; therefore, patients usually undergo conservative treatment [6]. Different modalities are used to exclude occult diaphragmatic injuries, including chest X-ray, contrast studies, peritoneal diagnostic lavage and laparascopy, and they have all demonstrated a very low diagnostic accuracy in multiple studies [7]. Thoracoscopy has recently been introduced as a minimally invasive procedure with high-accuracy in the diagnosis and treatment of diaphragmatic injuries [8, 9]. Thoracoscopy is an accurate method for diagnosis of occult diaphragmatic injuries, but it also plays an important role in treatment by allowing the surgeon to drain the hemothorax or repair lung or diaphragmatic lacerations [9, 10]. The aim of this study is to assess the diagnostic accuracy of thoracoscopy in patients with thoracoabdominal penetrating wounds.

2. Methods and materials

In this prospective trial, we have studied patients with thoracoabdominal stab wounds who were referred to Qaem, Shahid kamyab and Emam reza hospitals in Mashhad from March 2005 to October 2007. The inclusion criteria were:

1. Thoracoabdominal penetrating injury.
2. Stable vital signs and no requirement for surgical exploration for another cause.

Abstract

Patients with a thoracoabdominal stab wound may have hidden diaphragmatic injuries that could finally lead to chronic diaphragmatic hernia. In this study, we analyzed 30 patients with penetrating thoracoabdominal injuries that were stable hemodynamically and did not need emergency exploration. They underwent thoracoscopy in order to find a probable diaphragmatic injury from March 2005 to October 2007. The mean age was 26.2 years and the M/F ratio was 5:1. We observed five occult diaphragmatic injuries (16.7%) in thorascopic evaluations. Three cases (9.9%) were repaired through a thorascopic approach while laparatomy was inevitable in two (6.6%) patients. Pulmonary parenchymal lacerations were observed in two patients (6.6%) which were repaired through thoracoscopy and intra-abdominal injury was observed in one patient (3.3%) which was repaired via laparatomy. We performed thoracoabdominal CT-scan 6 months later and chronic diaphragmatic hernias were not reported. Diagnostic accuracy of thoracoscopy was 100%. Owing to the high diagnostic accuracy rate, minimal invasiveness and therapeutic potency of thoracoscopy we recommend it to be performed in all clinically stable patients with penetrating thoracoabdominal penetrating injury especially in the 8th intercostal space.

© 2009 Published by European Association for Cardio-Thoracic Surgery. All rights reserved.

Keywords: Thoracoabdominal stab wound; Diaphragmatic injury; Thoracoscopy

1. Introduction

The risk of diaphragmatic injury in stab wounds in the lower segment of the chest and the upper segment of the abdomen has been an issue of importance for surgeons during the last four decades [1]. These wounds are often associated with laceration of other intra-abdominal organs or traumatic diaphragmatic hernias. Delay in diagnosis may lead to complications, such as herniation of the abdominal organs into the thoracic cavity named as ‘Delayed stab action’ with a 4.4–48.1% mortality rate [2, 3]. Studies have reported a 15–20% rate of occult diaphragmatic injury in patients with lower thoracoabdominal stab wounds [4]. Lower thoracoabdominal stab wounds routinely undergo surgical exploration in some clinical centers [5]. Although diaphragmatic injuries are discovered by this method, a great fraction of these explorations have negative results and in some cases may lead to some complications. Additionally, it is a time and money-consuming method especially for crowded trauma centers; therefore, patients usually undergo conservative treatment [6]. Different modalities are used to exclude occult diaphragmatic injuries, including chest X-ray, contrast studies, peritoneal diagnostic lavage and laparascopy, and they have all demonstrated a very low diagnostic accuracy in multiple studies [7]. Thoracoscopy has recently been introduced as a minimally invasive procedure with high-accuracy in the diagnosis and treatment of diaphragmatic injuries [8, 9]. Thoracoscopy is an accurate method for diagnosis of occult diaphragmatic injuries, but it also plays an important role in treatment by allowing the surgeon to drain the hemothorax or repair lung or diaphragmatic lacerations [9, 10]. The aim of this study is to assess the diagnostic accuracy of thoracoscopy in patients with thoracoabdominal penetrating wounds.

2. Methods and materials

In this prospective trial, we have studied patients with thoracoabdominal stab wounds who were referred to Qaem, Shahid kamyab and Emam reza hospitals in Mashhad from March 2005 to October 2007. The inclusion criteria were:

1. Thoracoabdominal penetrating injury.
2. Stable vital signs and no requirement for surgical exploration for another cause.

Abstract

Patients with a thoracoabdominal stab wound may have hidden diaphragmatic injuries that could finally lead to chronic diaphragmatic hernia. In this study, we analyzed 30 patients with penetrating thoracoabdominal injuries that were stable hemodynamically and did not need emergency exploration. They underwent thoracoscopy in order to find a probable diaphragmatic injury from March 2005 to October 2007. The mean age was 26.2 years and the M/F ratio was 5:1. We observed five occult diaphragmatic injuries (16.7%) in thorascopic evaluations. Three cases (9.9%) were repaired through a thorascopic approach while laparatomy was inevitable in two (6.6%) patients. Pulmonary parenchymal lacerations were observed in two patients (6.6%) which were repaired through thoracoscopy and intra-abdominal injury was observed in one patient (3.3%) which was repaired via laparatomy. We performed thoracoabdominal CT-scan 6 months later and chronic diaphragmatic hernias were not reported. Diagnostic accuracy of thoracoscopy was 100%. Owing to the high diagnostic accuracy rate, minimal invasiveness and therapeutic potency of thoracoscopy we recommend it to be performed in all clinically stable patients with penetrating thoracoabdominal penetrating injury especially in the 8th intercostal space.

© 2009 Published by European Association for Cardio-Thoracic Surgery. All rights reserved.

Keywords: Thoracoabdominal stab wound; Diaphragmatic injury; Thoracoscopy

1. Introduction

The risk of diaphragmatic injury in stab wounds in the lower segment of the chest and the upper segment of the abdomen has been an issue of importance for surgeons during the last four decades [1]. These wounds are often associated with laceration of other intra-abdominal organs or traumatic diaphragmatic hernias. Delay in diagnosis may lead to complications, such as herniation of the abdominal organs into the thoracic cavity named as ‘Delayed stab action’ with a 4.4–48.1% mortality rate [2, 3]. Studies have reported a 15–20% rate of occult diaphragmatic injury in patients with lower thoracoabdominal stab wounds [4]. Lower thoracoabdominal stab wounds routinely undergo surgical exploration in some clinical centers [5]. Although diaphragmatic injuries are discovered by this method, a great fraction of these explorations have negative results and in some cases may lead to some complications. Additionally, it is a time and money-consuming method especially for crowded trauma centers; therefore, patients usually undergo conservative treatment [6]. Different modalities are used to exclude occult diaphragmatic injuries, including chest X-ray, contrast studies, peritoneal diagnostic lavage and laparascopy, and they have all demonstrated a very low diagnostic accuracy in multiple studies [7]. Thoracoscopy has recently been introduced as a minimally invasive procedure with high-accuracy in the diagnosis and treatment of diaphragmatic injuries [8, 9]. Thoracoscopy is an accurate method for diagnosis of occult diaphragmatic injuries, but it also plays an important role in treatment by allowing the surgeon to drain the hemothorax or repair lung or diaphragmatic lacerations [9, 10]. The aim of this study is to assess the diagnostic accuracy of thoracoscopy in patients with thoracoabdominal penetrating wounds.

2. Methods and materials

In this prospective trial, we have studied patients with thoracoabdominal stab wounds who were referred to Qaem, Shahid kamyab and Emam reza hospitals in Mashhad from March 2005 to October 2007. The inclusion criteria were:

1. Thoracoabdominal penetrating injury.
2. Stable vital signs and no requirement for surgical exploration for another cause.
3. Patient’s attendance for performing diagnostic and therapeutic thoracoscopy.
4. Patient’s attendance in the follow-up sessions.

The exclusion criteria consisted of:
1. Indication for emergency surgical exploration due to other reasons.
2. Patient’s refusal for performing thoracoscopy and post-operation follow-up.
3. Unstable patient who could not tolerate general anesthesia.
4. Gun shot wound.

According to our protocol, only hemodynamically stable patients were included in this trial. In our center, all stable cases with asymptomatic thoracoabdominal penetrating injury are assessed by CXR and those with hemothorax or pneumothorax undergo chest tube insertion and would be followed-up, and those with normal CXR would be discharged after skin repair. But, all the patients who filled the inclusion criteria underwent diagnostic thoracoscopy under general anesthesia.

Occult diaphragmatic injuries are repaired by thoracoscopy in the same session, if possible, except those cases who are suspicious of a coexistent abdominal injury. In these circumstances, laparatomy is performed. In patients where no diaphragmatic injury was observed, all the blood and fluid collections were drained by thoracoscopy and a chest tube was placed and observation continued.

In order to assess the diagnostic accuracy of thoracoscopy, all cases were examined by a chest and upper abdominal CT-scan with oral and intravenous contrast, 6 months later to find any chronic herniation of intra-abdominal organs, which is an indication of an occult diaphragmatic injury, which might be missed during thoracoscopy. The Fisher exact test was used for statistical analysis and comparing patients with or without diaphragmatic injuries.

## Results

Thirty patients were enrolled in this study, 25 (23.3%) males and 5 (16.7%) females with a mean age of 26.2 ± 6.32 years, (ranging between 12 and 51 years). The site of trauma was in the 6th and 7th intercostal spaces in most cases (Table 1).

By comparing distribution of injury site among groups of patients with and without diaphragmatic injury, the difference was significant according to Fisher’s exact test. \( P<0.05 \), so probability of diaphragmatic injury was higher among patients with penetrating injury to the 8th intercostal space.

Penetrating injury was in the right hemithorax in 19 cases (63.3%) and in the left hemithorax in 11 cases (36.7%) and they were mostly in the midclavicular and anterior axillary lines. The chief clinical symptom was chest pain which was observed in 25 cases (83.3%), dyspnea in 5 cases (16.5%) and decreased pulmonary sounds in 5 cases (16.7%). Abnormal chest X-ray was seen in 28 cases (93.4%) and 2 patients (6.6%) had normal chest X-rays. The most common finding in chest X-rays was hemopnemothorax which was detected in 25 patients (83.3%) patients while 3 patients (9.9%) had isolated pneumothorax.

### Table 1

<table>
<thead>
<tr>
<th>Site of trauma</th>
<th>Frequency (%) among all cases</th>
<th>Frequency (%) among diaphragmatic injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th intercostal space</td>
<td>4 (13.3)</td>
<td>–</td>
</tr>
<tr>
<td>6th intercostal space</td>
<td>7 (23.3)</td>
<td>–</td>
</tr>
<tr>
<td>7th intercostal space</td>
<td>14 (46.7)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>8th intercostal space</td>
<td>3 (10.0)</td>
<td>3 (75.0)</td>
</tr>
<tr>
<td>9th intercostal space</td>
<td>2 (6.7)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>10th intercostal space</td>
<td>1 (3.3)</td>
<td>–</td>
</tr>
</tbody>
</table>

In thoroscopic evaluations, occult diaphragmatic injury was observed in 5 cases (16.7%) while in 25 patients (83.3%), diaphragm was intact. The size of diaphragmatic injury was <3 cm in all five cases and thoracoscopic repair of the diaphragmatic injury was done in three cases. In these three patients, exploration of diaphragmatic injury via thoracoscopy showed intact peritoneum, but in the other two cases laparatomy was performed because of the wound depth and high suspicion of intra-abdominal organ injury, so diaphragmatic injury was repaired through the abdomen while exploring other abdominal organs. Considering co-existing injuries, lung injury was observed in two patients who were treated by thoracoscopic method. A co-existing splenic injury was also observed in one patient during laparatomy who underwent splenorrhaphy. Thoracoscopy was performed in other patients according to study planning in order to explore the hemidiaphragm and for better drainage of blood and fluid loculations. Finally, a chest tube was inserted.

No adverse effect was reported either due to thoracoscopy or any other procedure. All patients underwent chest and abdominal CT-scan with oral and intravenous contrast six months after thoracoscopy to assess the possibility of chronic diaphragmatic hernia and all patients had normal follow-up CT-scan. The diagnostic accuracy of thoracoscopy in occult diaphragmatic injury after penetrating wound was 100% in our study.

### 4. Discussion

Penetrating diaphragmatic injuries are usually due to stab wound or gun shot wound in the lower segments of the chest or upper part of the abdomen. Diaphragmatic injuries due to stab wound may not be seen in the acute phase [11]. But, because of the difference in pressure between the abdominal and thoracic cavity, small injuries often become large injuries after a short time. This result in the herniation of abdominal organs and serious complications of such herniation (vascular disorder and gangrene of hollow viscous organs, such as colon and the stomach) is accompanied with a high mortality rate, ranging between 9.4% and 48.1% [3]. In the acute phase, the clinical symptoms are not a definitive indicator of diaphragmatic injury, although positive abdominal signs may be suggestive of probable diaphragmatic injuries. In a study performed by Weineck et al., common clinical signs and symptoms in patients with thoracoabdominal injury were chest and upper abdominal pain, dyspnea, decreased pulmonary sounds and hemoptysis [12]. In our study, pain, dyspnea and decreased pulmonary
sounds were also more common symptoms. In another study conducted by Miller et al., 43% of the patients with penetrating thoracoabdominal injuries had a normal chest X-ray, while 57% had an abnormal CXR. Other findings such as hemotorax and pneumothorax was 96% and herniation of intra-abdominal organs and pneumoperitoneum was 2% [13]. In our study, abnormal chest X-rays were observed in 28 patients (93.4%), but only 2 (6.6%) had a normal chest X-ray. The most common radiographic abnormality was pneumoneumothorax which was detected in 25 patients (83.3%) and an isolated pneumothorax was observed in three cases (4.4%).

There is a variety of opinions towards the diagnostic approach in penetrating thoracoabdominal injuries with the possibility of diaphragmatic laceration. In the study conducted by Miller et al., surgical exploration is vital and inspecting the diaphragm without considering clinical symptom is highly suggested in all cases and co-existent intra-abdominal injury is reported in 13% of patients [13]. Most studies have demonstrated that surgical exploration is unnecessary in every patient with thoracoabdominal stab wounds, but essential in gun shot wounds [14, 15]. Other diagnostic procedures including peritoneal lavage, finger exploration and laparoscopy have been reported with low diagnostic accuracy in similar studies [4].

Several studies have been conducted to assess the diagnostic and therapeutic accuracy of thoracoscopy in hidden diaphragmatic injuries. In a study by Uribe et al., on 28 patients with penetrating thoracoabdominal injuries, thoracoscopy was established as an accurate diagnostic and therapeutic procedure for injury in penetrating thoracoabdominal injuries [15]. In our study, occult diaphragmatic injury was observed in five patients (16.7%).

There is also controversy regarding therapeutic approach after diagnosing diaphragmatic injury by thoracoscopy. In other comprehensive studies performed by Smith et al., thoracoscopy was established as the most assured treatment in repairing diaphragmatic injuries, whereas laparotomy comes into practice in cases suspicious of intra-abdominal organ injury which could not be repaired through thoracoscopy [9].

In our study, the diaphragmatic injuries were repaired with thoracoscopy in three patients, but in the other two cases, laparotomy was performed because of high suspicion of intra-abdominal injury. Two patients had co-existent lung parenchymal injury which was repaired thoracoscopically.

Double contrast CT-scan or MRI are standard diagnostic methods for diagnosing chronic diaphragmatic hernias following hidden penetrating thoracoabdominal injuries and the best timing has been noted as 3–6 months after trauma [8]. In our study, CT-scan with intravenous and oral contrast was performed 6 months after surgery to detect herniation, which probably was not diagnosed by thoracoscopy. Missed diaphragmatic injury was not reported in our series. In our study, diagnostic accuracy of thoracoscopy was 100%.

5. Conclusion

Considering the possibility of occult diaphragmatic injury in penetrating thoracoabdominal injuries can cause serious complications and high mortality due to chronic diaphragmatic hernia, we suggest thoracoscopy as a minimally invasive method with high diagnostic accuracy and therapeutic efficacies in hemodynamically stable patients with penetrating thoracoabdominal injuries especially in the 8th intercostal space.

Acknowledgments

The authors wish to thank the research vice-presidency of Mashhad University of medical sciences who supported this project financially and further and also Dr Esmaeili and Toktam Moghiman for their kind assistance in data analysis and writing of this study.

References


Conference discussion

Dr. A. Tcherweniakov (Sofia, Bulgaria): I would like to ask you about the exclusion criteria for any other method of surgery and if there is any patient, unconscious patient, for example, or a patient who needs laparotomy or laparoscopy. Would you definitely exclude VATS for thoracic trauma? Your conclusion was that VATS is recommended in such cases. This is the reason that I think that you can perform VATS in these types of injuries, even in cases where they need laparotomy or laparoscopy or any other method of surgery.

Dr. Bagheri: In laparotomy or laparoscopy for emergency exploration, the diaphragmatic injury was seen, but it is important that in cases similar to this pictured case, after simple chest tube insertion, normal chest X-ray, and then the patient is discharged
from the hospital, the chance of diaphragmatic herniation in this case is high.

Dr. Tcherveniakov: Do you still support the exclusion criteria for VATS or any other method of surgery?

Dr. Bagheri: For this protocol exclusion criteria, no more VATS for trauma. For this protocol of patient, this exclusion criteria, no more VATS exclusion criteria.

Dr. D. Cohen (Boston, Massachusetts): This is a bit like McCain talking about change. Why did not you use CT-scan in the acute setting to make the diagnosis and then use thoracoscopy to do the repair? Why go to the trouble of taking the patient to the operating room to make the diagnosis and then in some instances not doing anything at all beyond evacuating hematoma, which could easily be evacuated with a chest tube?

Dr. Bagheri: You cannot see a small laceration in a CT-scan.

Dr. Cohen: A fine-cut CT-scan would definitely help in making the diagnosis.

Dr. D. Grunenwald (Paris, France): Is it the same surgeon who is doing the thoracoscopic approach and the repair in the abdominal region?

Dr. Bagheri: Repairing the abdominal region?

Dr. Grunenwald: Is it the same surgeon or a thoracic surgeon associated with an abdominal surgeon? Is it the same surgeon who is doing the thoracoscopic approach?

Dr. Bagheri: Yes. With the Iranian education, you first get the national board of general surgery and then the subspecialty of thoracic surgery.

Dr. Grunenwald: So, it is the general surgeon who is doing the thoracoscopic approach?

Dr. Bagheri: Yes.