

TRAUMATIC INJURY OF THE DIAPHRAGM



"Study of Palm Trees", lithographic print, Edward Lear, (1818-1888).

Amid the barren deserts of Arabia a few cultivated spots rise like islands out of the sandy ocean. Even the name of Tadmor, or Palmyra, by its signification in the Syriac as well as in the Latin language, denoted the multitude of palm-trees which afforded shade and verdure to that temperate region. The air was pure, and the soil, watered by some invaluable springs, was capable of producing fruits as well as corn....

...The eye of Justinian investigated every spot, and his cruel precautions might attract the war into some lonely vale, whose peaceful natives, connected by trade and marriage, were ignorant of national discord and the quarrels of princes. Westward of the Euphrates a sandy desert extends above six hundred miles to the Red Sea, Nature had interposed a vacant solitude between the ambition of two rival empires; the Arabians, till Mahomet arose, were formidable only as robbers; and in the proud security of peace the fortifications of Syria were neglected on the most vulnerable side....

The loss of two hundred thousand soldiers, who had fallen by the sword, was of less fatal importance than the decay of Arts, agriculture, and population in this long and destructive war; and although a victorious army had been formed under the standard of Heraclius, the unnatural effort appears to have exhausted rather than exercised their strength. While the emperor triumphed at Constantinople or Jerusalem, an obscure town on the confines of Syria was pillaged by the Saracens, and they cut in pieces some troops who advanced to its relief; an ordinary and trifling occurrence, had it not been the prelude of a mighty revolution. These robbers were the apostles of Mohammed; their fanatic valour had emerged from the desert; and the last eight years of his reign Heraclius lost to the Arabs the same provinces which he had rescued from the Persians.

*Edward Gibbon, The History of the Decline and Fall of the Roman Empire,
volume 4, 1784.*

In 633 A.D the old Emperor Heraclius, could feel well pleased with himself. After many years locked in a desperate struggle with the Persian Empire, that had seen a kaleidoscopic shifting of fortunes first to one side then to the other and back again, final victory had come at last. Heraclius, now once again, held supreme suzerainty over the lands of the Mediterranean east, Syria and Judea. His quest to restore the integrity of a failing empire had been bloody and hard fought - the Persian invaders had finally been driven back from the Byzantine provinces to within the old pre-war borders. Now it would be time to sit back, relax and savor the sweet fruits of his immense labors....but the war had completely exhausted both empires. Out of Arabia, a place previously of utter insignificance, burst a new threat that would, in the blink of an eye, take away all the Byzantine provinces that had been won back from the Persians. But the Byzantines had things relatively easy - the Persian Empire would be completely annihilated.

The lesson from the history of the Byzantine-Persian wars of the early Seventh Century is that trouble can lurk in the most unexpected of places. From the most unnoticed of these may suddenly emerge great calamity. We must remain ever vigilant to the possibility of diaphragmatic injury in our trauma patients - from a forgotten oasis of seemingly trivial disturbance may later emerge calamity of catastrophic dimensions!

TRAUMATIC INJURY OF THE DIAPHRAGM

Introduction

Diaphragmatic trauma is relatively uncommon, but many be due to:

- Penetrating injury
- Blunt injury resulting in rupture.

Injury to the diaphragm is not usually seen in isolation and is usually associated with other injuries.

It can be a difficult diagnosis to make and lesser injuries are often diagnosed unexpectedly on laparotomy or thoracotomy.

Diaphragmatic injury should be actively excluded in cases of *penetrating* lower thoracic or upper abdominal injuries.

Larger injuries are life threatening, but lesser injuries may be missed without short-term consequences, however these may develop serious complications in the longer term.

Pathology

Penetrating injury

Penetrating injury to the diaphragm is secondary to lower thoracic or upper abdominal wounds.

Penetrating injury to the diaphragm is associated with concomitant injury to the thorax or abdomen.

Perforations are typically **small** and often take a **prolonged period**, even years, before a diaphragmatic hernia occurs.

Blunt injury

Diaphragmatic injuries due to blunt trauma are associated with:

- Lateral torso or thoracoabdominal crush injuries
- Lateral rib fractures
- Pelvic fractures

Blunt injury to the diaphragm tends to **produce large radial tears (most commonly 5-10 cm in length at the left postero-lateral position)** that may lead to **rapid herniation** of abdominal contents into the thoracic cavity.

Traumatic diaphragmatic rupture is more commonly diagnosed on the left side, possibly due to the right side being somewhat more protected by the liver. This may however not reflect the true incidence of relative ruptures between left and right, because left sided ruptures are more easily diagnosed by the appearance of bowel, stomach or nasogastric tube lying within the left hemithorax.

Large ruptures that result in abdominal content herniation into the thoracic cavity may be complicated by:

- Impairment of venous return to the heart
- Impairment of effective pulmonary ventilation.
- Bowel strangulation with eventual perforation and septicaemia

Clinical features

Indicators of possible diaphragmatic injury:

1. Mechanism of injury:

Diaphragmatic injuries should be suspected in particular with:

- High velocity injuries to the lateral chest/ abdomen
- Crush injuries to the lateral chest/ abdomen
- Penetrating injuries to the lower thoracic cage/ upper abdomen.

2. Specific associated injuries include:

Injuries that have an association with blunt diaphragmatic rupture include:

- Lower lateral rib fractures.
- Splenic injuries
- Liver injuries
- Fractures of the pelvis
- Traumatic aortic injury.
- Pelvic fractures

Signs and symptoms:

Smaller injuries will often not be apparent clinically or masked by more significant associated injuries.

Many cases of diaphragmatic injury will present late, even years later in some cases of smaller penetrating injuries. There is gradual herniation of bowel into the thoracic cavity.

Larger injuries may have clinical signs and symptoms, from the outset, which may include:

1. Circulatory shock
2. Respiratory distress
3. Dull percussion note and reduced breaths sounds, if there is gross herniation of abdominal contents into the thoracic cavity, or gross elevation of the hemi-diaphragm
4. On auscultation bowel sounds may be heard within the thoracic cavity

Right diaphragmatic injuries are uncommonly diagnosed on initial presentation, as the liver prevents herniation of abdominal contents into the right hemi-thorax. The only clue to a right sided injury may be an elevated right hemi-diaphragm.

Investigation

Blood tests:

These cannot confirm a diaphragmatic injury but will often need to be done in the general setting of a multi-trauma. The following therefore will need to be considered:

1. FBE
2. U&Es/ glucose
3. Lipase
4. Group or cross-match blood as clinically indicated

CXR:

In larger left sided injuries:

- There may be marked elevation of the hemi-diaphragm.
- Bowel may be seen lying in the left hemi-thorax

- Placement of a radio-opaque nasogastric tube, (providing there is no contra-indication to this, such as a base of skull fracture) will assist in the CXR diagnosis of a left hemi-diaphragmatic rupture. The nasogastric tube will be seen to lie within the left hemi-thorax.

In smaller injuries, plain CXR findings can be far more subtle and may include:

- Blurring or indistinctness of the hemidiaphragm
- Small hemothorax
- An abnormal gas shadow that obscures the hemidiaphragm

In a small percentage of cases the plain CXR may appear entirely normal. In up to 15 % of cases, no intrathoracic pathology is seen on CXR.³

Common plain radiological **misdiagnoses** (i.e misinterpretation) of a ruptured diaphragm include:

- Simple elevated hemi-diaphragm (ie elevated but not ruptured).
- Acute gastric dilation
- Loculated pneumothorax, (see Appendix 1 below)
- Subpulmonary hematoma.

Gastrogaffin Contrast Study

Gastrogaffin contrast studies may diagnose a diaphragmatic rupture by demonstrating bowel loops within the thoracic cavity.

This study will not be necessary if a nasogastric tube has already demonstrated the lesion.

CT Scan:

CT scan will reveal larger defects, but may still miss smaller ones.

Diagnosis will largely depend on the finding of herniation of abdominal contents, rather than direct visualization of the diaphragmatic injury itself.

If herniation of abdominal contents has not occurred, then diagnosis with CT will be far more problematic.

MRI:

Diagnostic yield may be better than CT, however this is not usually a viable modality in acute trauma patients.

Invasive exploration:

Diaphragmatic injury should be actively excluded in cases of penetrating lower thoracic or upper abdominal penetrating injuries.

Smaller occult diaphragmatic lacerations may be diagnosed by:

1. Minimally invasive endoscopic procedures:
 - Laparoscopy
 - Thoracoscopy
2. Thoracotomy
3. Laparoscopy

Management

1. Initial attention to any immediate ABC issues
 - Ensure adequate oxygenation and ventilation.

In severe cases intubation and mechanical ventilation may be necessary.
 - Fluid resuscitation, as required.
2. Stabilize and treat any associated life threatening injuries:
 - Note that great care must be taken when placing chest tubes, when there is also a suspicion of a diaphragmatic injury. Chest tubes may inadvertently perforate abdominal contents that have become displaced into the thoracic cavity.
3. Analgesia:
 - Give IV opioid analgesia, as clinically indicated.
4. Nasogastric tube:
 - A nasogastric tube is useful (when this is able to be placed and if not contra-indicated), as this will help in diagnosis if the tube appears in the chest on CXR.
 - Aspiration of gastric contents will also help to decompress any abdominal herniation.

5. Surgery:

- **Definitive treatment is surgical repair.**
- Surgical repair is necessary, even for small tears, because the defect does not heal spontaneously.

The parieto-peritoneal pressure gradient favors *eventual* enlargement of the defect and herniation of abdominal contents.

Appendix 1



Initial CXR, erroneously interpreted as a large loculated pneumothorax



CXR of above patient after nasogastric tube insertion, showing evidence of left diaphragmatic rupture with gastric herniation.²

References

1. ATLS Manual 10th ed, 2017.
2. From: Brian K.P. Goh, et al. Delayed presentation of a patient with a ruptured diaphragm complicated by gastric incarceration and perforation after apparently minor blunt trauma. *Can J Emerg Med* 2004; 6(4):277-80
3. Fitzgerald M, Gocentas. R. Stevens J. Chest Trauma in Textbook of Adult Emergency Medicine, Cameron et al 4th ed 2015.

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