

Approach to Diaphragmatic Injuries

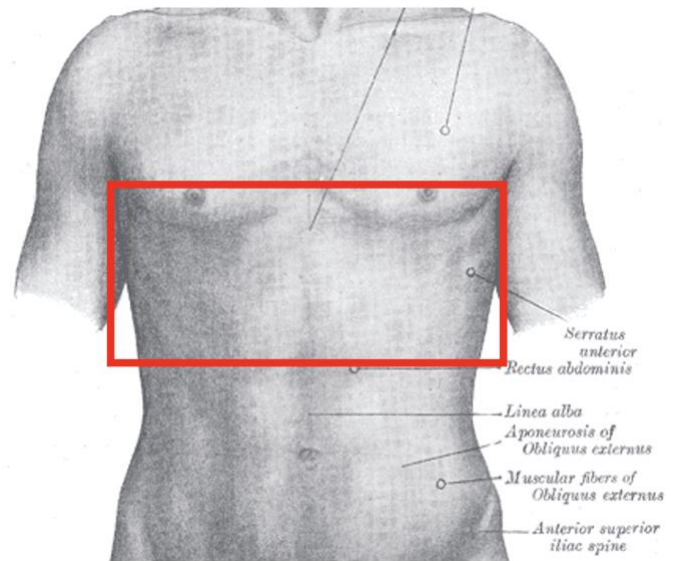
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Background:

Traumatic diaphragmatic injuries can be difficult to diagnose, even with advanced imaging. If a hollow viscus herniates through a defect in the diaphragm, diagnosis can easily be made with a plain chest x-ray. But if the injury consists of only a laceration in the diaphragm, it must be diagnosed by direct visualization. In this chapter we discuss decision making in patients at risk for diaphragmatic injury and surgical planning for patients with acute or chronic presentation of diaphragmatic hernia.

Blunt diaphragmatic injury is caused by a sudden increase in intra-abdominal pressure, which leads to rupture of the diaphragm. This occurs on the left side $\frac{2}{3}$ of the time, where the diaphragm is not “protected” from pressure by the liver. Blunt diaphragmatic injuries are usually large. When bowel is herniated through the defect, the diagnosis can be made by seeing viscera above the left hemidiaphragm on imaging.

Penetrating diaphragmatic injury is caused by a stab or gunshot wound in the “Junctional Region,” anywhere between the nipples and the costal margin anteriorly, or the tips of the scapula and the costal margins posteriorly. Stab or gunshot wounds in this region can also injure the heart, great vessels, esophagus, lungs, or chest wall vessels. The diaphragm defect is smaller than in blunt injury, usually the size of the penetrating object. Because of this fact, herniation of viscera is often not present on presentation, making these injuries difficult to diagnose. Keep in mind that a missile entering the body outside the Junctional Region can still cross the diaphragm if its path is tangential enough.



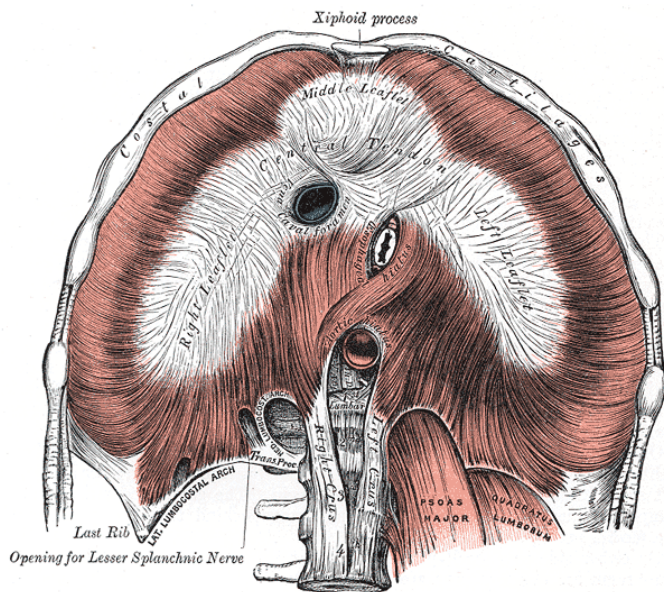
Penetrating injuries inside the “Junctional Region” (Red box) can potentially injure the diaphragm.

Anatomy:

The diaphragm is composed of a central tendinous portion and a lateral muscular portion. Depending on the respiratory cycle, its apex can be located as high as the T4 dermatome, which corresponds with the nipples anteriorly and the tip of the scapulae posteriorly. Innervation is by the right and left phrenic nerves, which begin at the C3, 4, and 5 nerve roots, run anterior to the scalene muscles in the neck and on the lateral surface of the pericardium in the chest, and insert into the central portion of the diaphragm. Anterior and posterior branches of the phrenic nerve then spread through the diaphragm, running parallel to the ribs about 5cm from them. The edge of the diaphragm is innervated by branches of the intercostal nerves.

Approach to Diaphragmatic Injuries

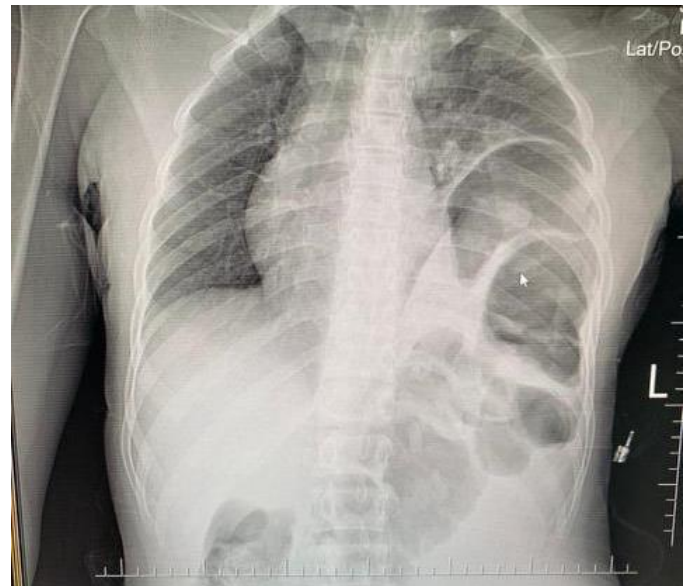
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The diaphragm, seen here from inside the abdominal cavity, consists of a central, tendinous portion and a lateral muscular portion.

Principles:

Diaphragmatic injury occurs in approximately 1% of all blunt abdominal trauma. It should be suspected in any patient presenting acutely after trauma with an indistinct or abnormally shaped diaphragm on chest x-ray. In some cases, the diagnosis will be quite obvious on x-ray, but in others it will be difficult to distinguish from hemothorax and/or pulmonary contusion. A CT scan of the chest and abdomen will almost always make the diagnosis if there is bowel herniated through the defect. If CT is not available to you, you must decide based on the x-ray, as explained further below. If the acute patient has a completely normal diaphragm shadow on x-ray after **blunt** abdominal trauma, diaphragmatic injury is very unlikely. This is definitely not the case in penetrating injury, as explained further below.



This patient presenting acutely after blunt abdominal trauma very clearly has a defect in the left hemidiaphragm with herniated stomach and transverse colon in the chest. No further investigations are needed, they should be taken directly for laparotomy.

Patients presenting more than 6 weeks after blunt abdominal trauma often have intra-thoracic adhesions or compression of the lung that make repair through an abdominal incision impossible. The surgeon must ask thoroughly for a history of trauma, which may have been many years previously. It might be difficult to distinguish between a congenital diaphragmatic hernia. We have even been fooled by a congenital cystic malformation of the lung on one occasion.

Another possible late presentation of diaphragmatic hernia is strangulation and intrathoracic rupture. These patients are often quite sick and sometimes need intervention in both the chest and the abdomen.

In the patient with penetrating trauma, the likelihood of diaphragmatic injury depends on the location of the missile entry. These patients often have an associated injury, such as hemothorax, splenic laceration, or hollow viscus injury. In patients who need laparotomy after penetrating trauma, be sure to examine the diaphragm thoroughly while considering the trajectory of the missile. As always, before surgery you must perform a thorough examination of the completely disrobed patient, no matter how unstable they are. If possible, x-rays with markers at all entry or exit points also help you sort out where to look for damage. Decision

Approach to Diaphragmatic Injuries

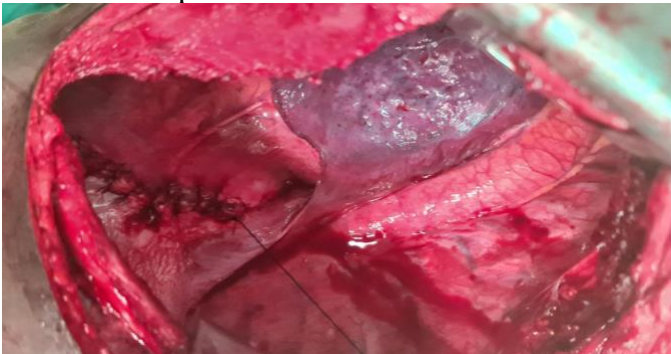
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making in such patients is explained further in [“Approach to Penetrating Abdominal Trauma.”](#)

The difficulty arises when the patient has a stab wound in the lower chest or upper abdomen, but is otherwise able to undergo non-operative management. Even a well performed CT scan with IV contrast is unreliable for detecting a diaphragmatic defect in such cases, as it may be only a few cm long. In such cases we prefer diagnostic laparoscopy. Especially with the patient's upper body tilted upwards, it is possible to examine all of the left and right diaphragm, inspect for other injuries, and even to repair a small laceration.

Decision Making:

In all instances, the diaphragm is repaired using interrupted slowly absorbable or non-absorbable sutures in horizontal mattress configuration. Avoid taking large bites, as these may put tension on the diaphragm or possibly encircle a branch of the phrenic nerve.



Properly placed diaphragm sutures, seen through a left posterolateral thoracotomy. One trick for suturing in a tight space is to not cut the previously placed suture and use it for traction while placing the next one.

Blunt Trauma, Acute Presentation

If the diagnosis is clear, proceed to laparotomy. Make the incision long enough to inspect all of the abdomen, as always in abdominal trauma. Adequate retraction and an incision that goes to one side of the xiphoid are very helpful for operations on the upper abdominal cavity (See [“Midline Abdominal Incision.”](#)) A self-retaining retractor makes this operation much easier, if the defect is large. Irrigate the hemithorax through the diaphragm defect before you close, and leave a small chest tube in the affected hemithorax to evacuate any air and blood.

If the diagnosis is unclear, and you do not have a CT scan, pass a NG tube. If the tip is above the diaphragm, the diagnosis is made. If you are still unclear on what is happening in the chest, place a chest tube, to rule out a hemothorax. If the diaphragm is still not distinct, the most likely diagnosis is acute diaphragmatic hernia and you should operate. Make the incision big enough to inspect all of the intestines. If you can do laparoscopy, and the patient's abdomen is completely nontender, this may save them an unnecessary laparotomy. But if you do not, the morbidity of missing this injury is great enough that you should not hesitate to do a laparotomy if you suspect it.

Blunt Trauma, Late Presentation

There is some controversy as to the best approach here. Many textbooks favor approaching all such diaphragmatic hernias through the chest. This is reasonable if facilities and expertise are available. We offer the following principles:

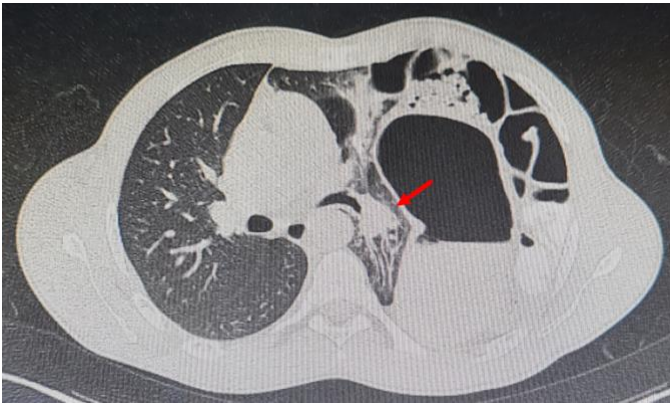
- Most late-presenting hernias, especially those containing bowel that fills the entire hemithorax, should be approached through the chest by a posterolateral thoracotomy (See [“Posterolateral Thoracotomy.”](#)) This allows the surgeon to perform decortication or otherwise free an entrapped lung, if necessary.



X-ray of a delayed presentation of left-sided diaphragmatic rupture with small intestine clearly visible in all of the left chest. This injury is best treated by a thoracic approach. Case courtesy of Dr Lemuel Marquez Narcise, From the case <https://radiopaedia.org/cases/46844?lang=us>

Approach to Diaphragmatic Injuries

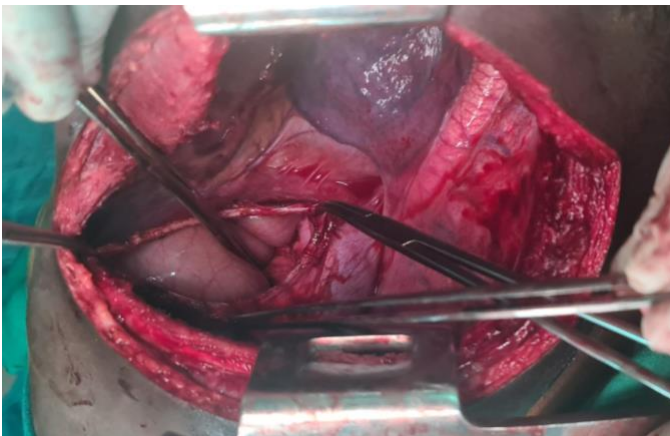
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Stomach and small intestine in the left hemithorax with compression of the lung (Red arrow) in this delayed presentation of traumatic diaphragmatic hernia.



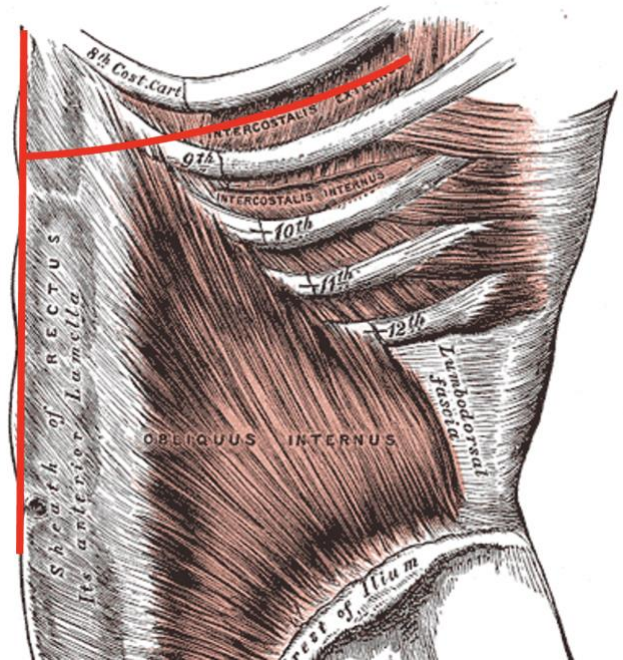
Herniated small and large bowel filling the left chest seen through a posterolateral thoracotomy.



After return of the viscera through the defect, it can easily be closed through the thoracic incision.

- Small hernias containing only part of the stomach or colon can be approached through the abdomen. Most often, even a late-presenting hernia can be completely reduced by this approach.
- If you attempt to reduce a late-presenting hernia through an abdominal approach and

are unable, it is acceptable to convert to a thoracoabdominal incision.



Laparotomy converted to a thoracoabdominal incision after the surgeon is unable to fully reduce the bowel from the chest during abdominal approach for chronic hernia.

- Diaphragmatic hernia with strangulation and intrathoracic perforation of the viscera is a difficult situation. These patients need an intra-abdominal approach for bowel resection and anastomosis or ostomy creation, but they may also need a thoracic approach for adhesions or lung decortication. Place the patient in 30 degrees lateral decubitus and prepare and drape the chest so you can enter it if necessary. After reducing the bowel, irrigate the chest cavity well through the diaphragm laceration and leave a chest tube. If you are unable to reduce the bowel because of adhesions, or if the lung fails to expand, make a thoracoabdominal incision as shown in the figure above.

Penetrating Trauma In The Junctional Region

Patients should be managed according to the principles in “[Approach to Penetrating Abdominal Trauma](#).” Briefly, patients with peritonitis, evisceration, or hemodynamic instability should be operated without delay. Be sure to carefully inspect the diaphragm on both the left and right sides. Those

Approach to Diaphragmatic Injuries

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who do not need urgent surgery may be managed non-operatively by one of the techniques described in the chapter. But there is a potential for missed diaphragm injury if the stab wound is between the costal margin and the nipples anteriorly, or between the costal margin and the tips of the scapulae posteriorly.

In such patients, we favor diagnostic laparoscopy when this is available. You may place the patient in lithotomy position (see “Lithotomy Position”) and stand between the patient’s legs for the best access to the diaphragm area. Perform a thorough inspection of the stomach, small bowel and colon adjacent to the stab wound. If there is any injury to these structures, convert to an open operation unless you are an expert laparoscopist. If there is an injury to the liver or spleen and it is not bleeding, you may safely leave it alone. If it is bleeding, convert to open to deal with it (see the Chapters on Liver and Spleen injury.) If there is a small diaphragmatic defect and no other injury, this is a relatively simple operation so try to advance your laparoscopic skills a bit: place some non-absorbable or slowly absorbable sutures in an interrupted horizontal mattress configuration. Place a small chest tube which you can remove in a day or two.

In the more likely case where you do not have laparoscopy available, you face a difficult situation. A hole in the diaphragm may not have abdominal contents herniated through it at the time, but it almost certainly will if you do not repair it. As always, you must rely on your own clinical reasoning to detect such an injury.

Elements of the history that you should emphasize include pulmonary symptoms, including any dyspnea or cough. The patient’s recollection of the event may provide important clues: how long was the knife? Were they stabbed in an upward or downward motion?

Physical examination on its own is unlikely to detect a diaphragm injury without visceral herniation. However, adjunct investigations can be quite helpful. In a patient with an isolated abdominal stab wound, there should be absolutely no fluid in the chest. If any is seen at chest ultrasound or chest x-ray, diaphragm injury is very likely- a laparotomy and careful inspection of the diaphragm is justified.

As we discuss in the chapter on penetrating abdominal injuries, our goal is to perform laparotomy on patients who need it, and to avoid it on those who do not. In a patient with penetrating trauma who does not otherwise need laparotomy, a clinical scenario which puts them at risk for diaphragm injury is usually enough reason to explore the abdomen.

Avoiding Missed Injuries

Blunt diaphragm injury is one reason why all blunt trauma patients should undergo a chest x-ray. At times it can be difficult to distinguish between hemo-pneumothorax and herniated viscera above the diaphragm. If you see an air collection that is circular or spherical, especially on the left side, consider diaphragm injury. As described above, a nasogastric tube whose tip is above the diaphragm makes the diagnosis (though absence of this sign does not rule it out.)

One final point is worth mentioning: you should get in the habit of exploring the diaphragm very thoroughly in every laparotomy you perform. On the right side, look carefully next to the liver and especially posterolaterally, an area that can be difficult to see. On the left side, make sure you see posteriorly all the way to the retroperitoneum and Gerota’s fascia, the fatty covering of the left kidney. To inspect this area properly, you must have good lighting, good exposure with a strong assistant, and an incision that extends up to one side of the xiphoid. If there are adhesions in this area, you must take them down until you have seen all the diaphragm’s surface.

Conclusion:

Diaphragm injuries are much more easily treated in the acute phase rather than late. Patients whose diaphragm ruptures because of blunt trauma will usually have bowel contents in the chest; this is easily diagnosed by plain chest x-ray. Conversely, patients with penetrating trauma may have injuries to the diaphragm without herniation, though viscera will almost certainly herniate through the defect in the future. The clinician must recognize patients whose injury pattern places them at risk for this complication and take measures to make the



Approach to Diaphragmatic Injuries

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diagnosis. At times, the only way to make the diagnosis will be surgical exploration.

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