

Traumatic Diaphragmatic Hernia

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Presentation Agenda

1 Index Patient:

- Clinical presentation
- Imaging

2 Introduction to diaphragmatic injuries

- Anatomy
- Classification
- Facts

3 Gallery of diaphragms

- Anatomic variants
- Diaphragmatic injuries on CXR and CT

4 Summary of findings on CXR and CT

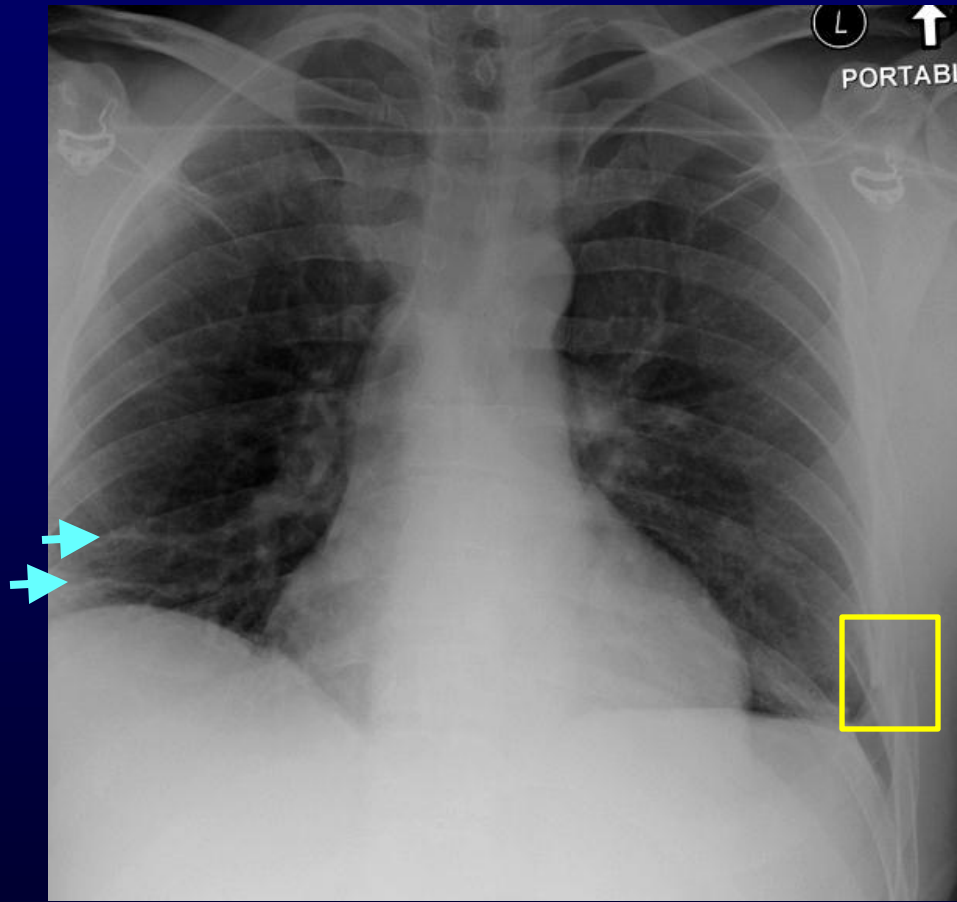


Index Patient: Clinical presentation

- Male presents after fall down 1 flight of stairs
- Pulse ox 92% on arrival
- PMH, PSH, MAH not contributory
- SH: No tobacco, EtOH, drugs

Index Patient: Initial CXR

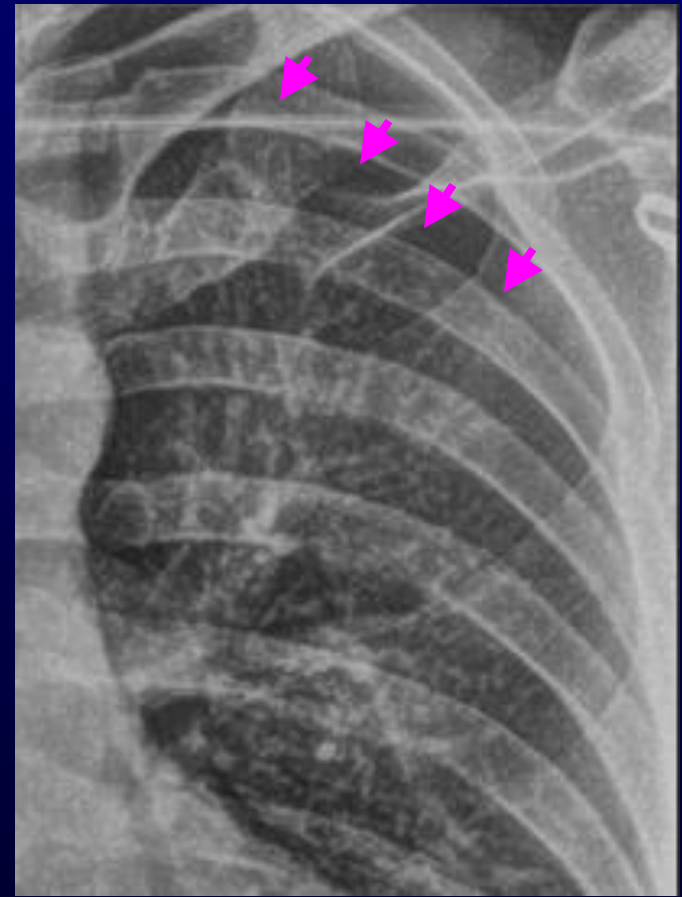
CXR, frontal



BIDMC PACS

- lateral left 6th and 7th rib fx
- linear atelectasis at bases

CXR with edge enhancement



BIDMC PACS

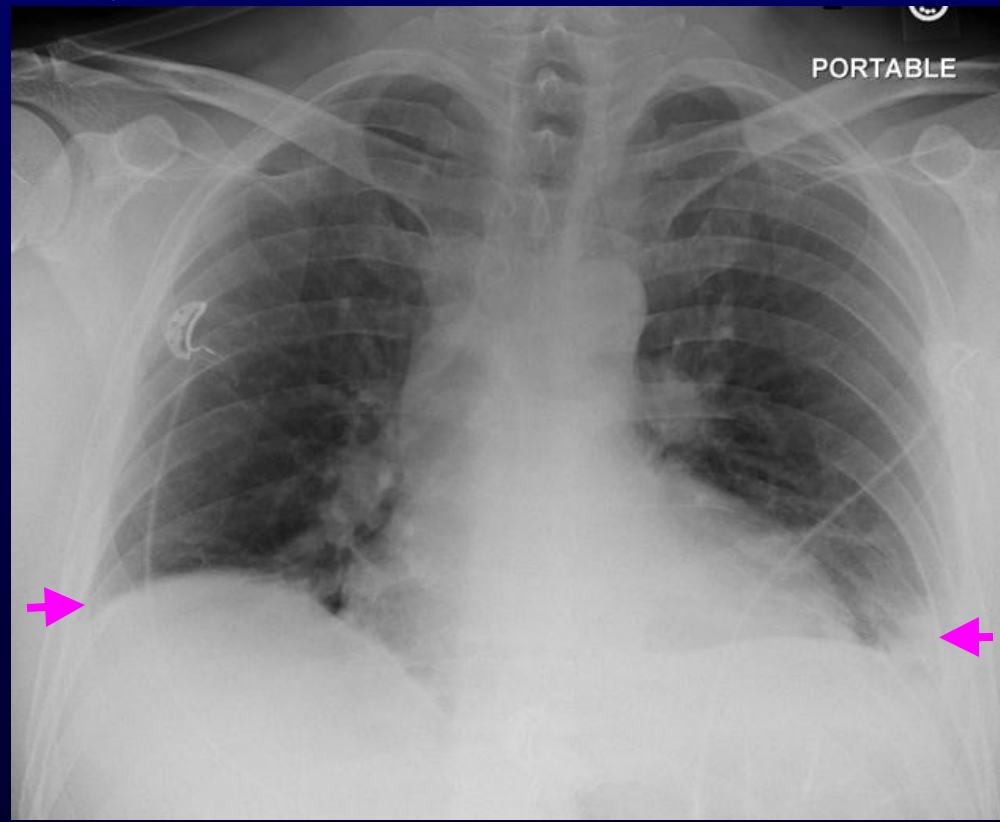
- moderate pneumothorax

Index Patient: Hospital course

- CXR diagnosed multiple rib fractures and a moderate right pneumothorax
- A chest tube was placed and the patient was observed overnight
- Serial CXR documented interval decrease in the pneumothorax and the patient was deemed ready for discharge.

Index Patient: Discharge CXR shows resolved pneumothorax

CXR, frontal



BIDMC PACS

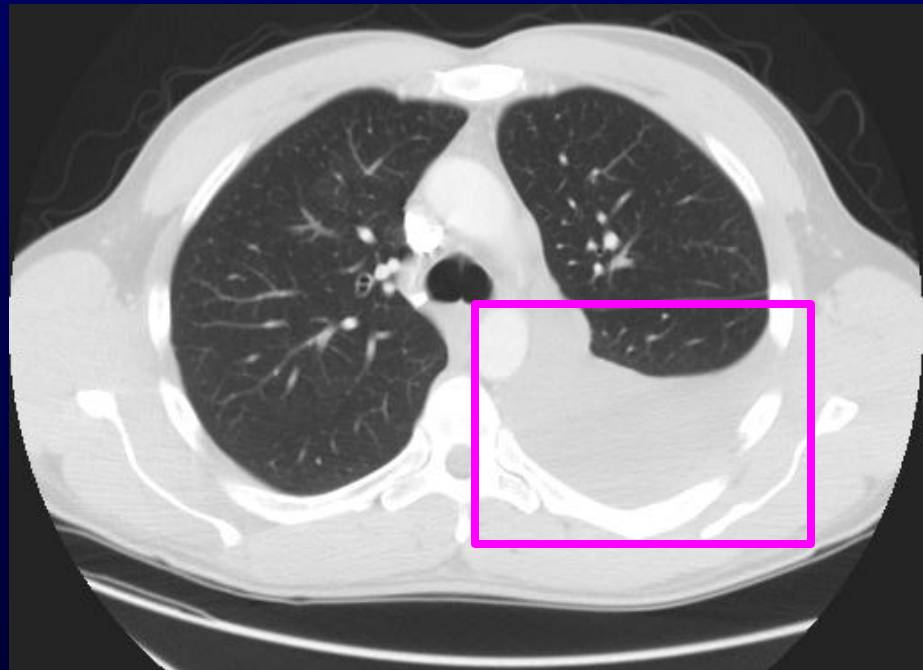
- small infiltrates at bases

Index Patient: Clinical presentation 10 days later

- Persistent pain and shortness of breath since discharge
- Denies abdominal pain or trouble with bowel movements
- Gets CT with contrast to rule out effusion vs hemothorax

Index Patient: CT shows L pleural effusion

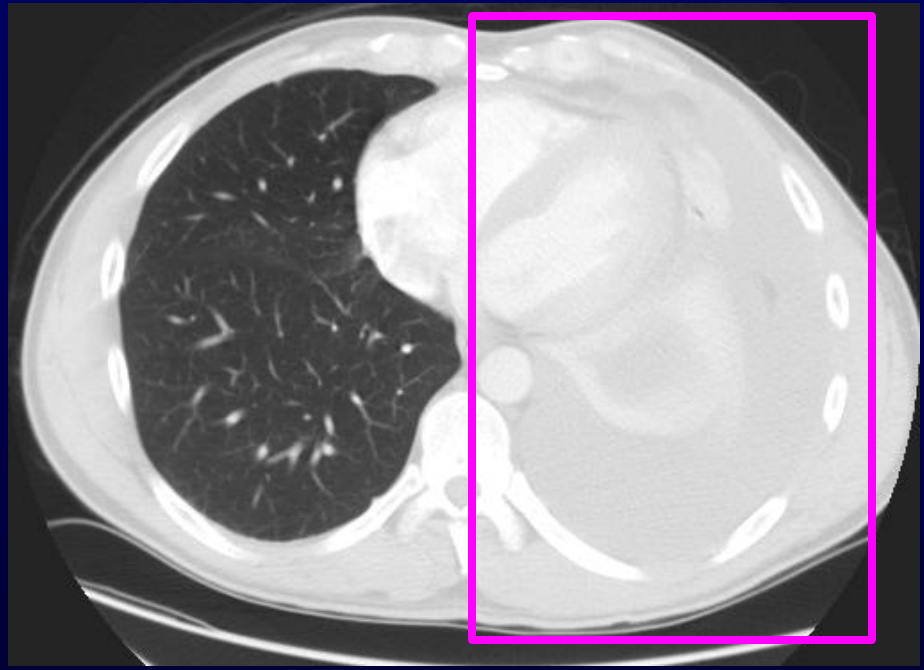
Axial CT slice at the carina



CT with contrast, lung window

BIDMC PACS

Axial CT slice through the heart



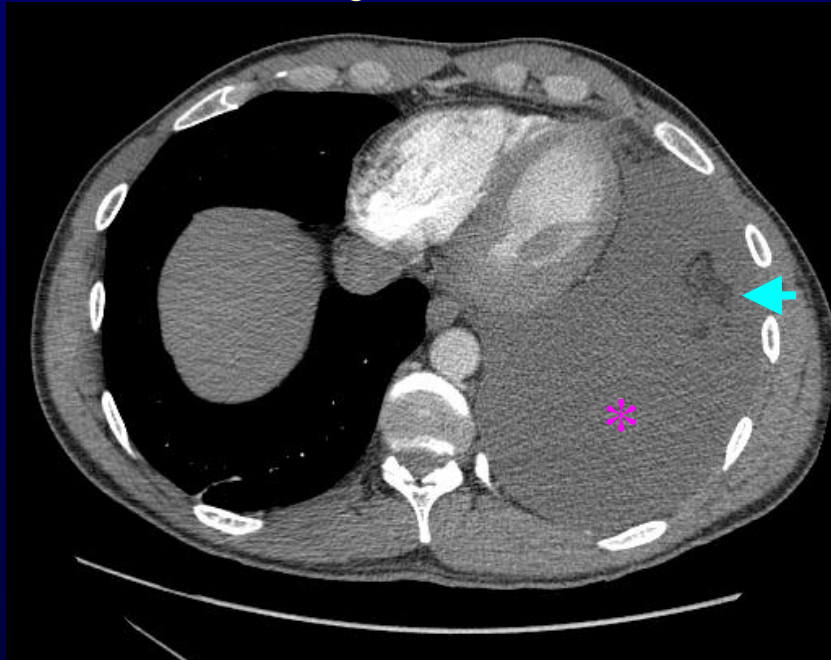
CT with contrast, lung window

BIDMC PACS

- large left pleural effusion

Index Patient: CT shows diaphragmatic hernia

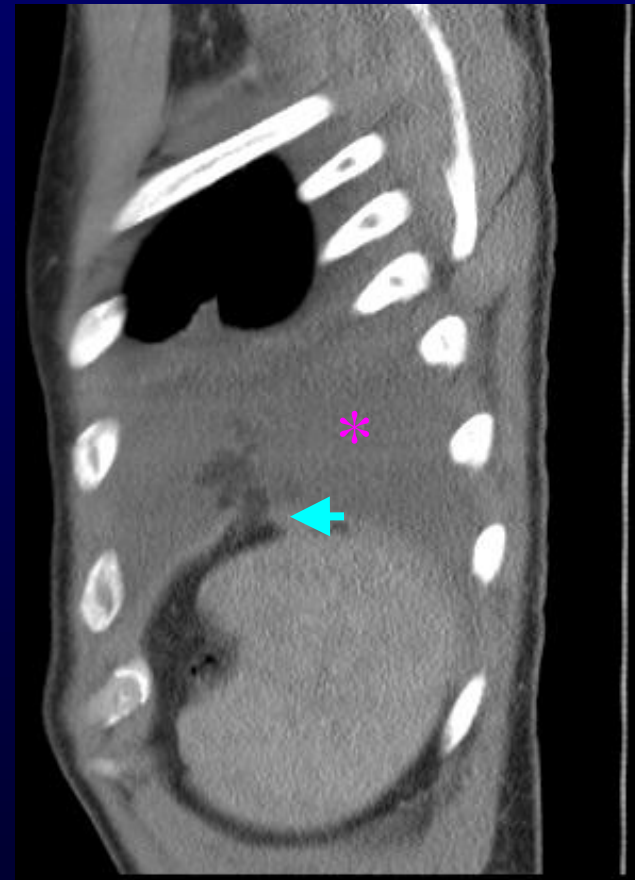
Axial CT slice through the heart



CT with contrast, soft tissue window

BIDMC PACS

Sagittal view



BIDMC PACS

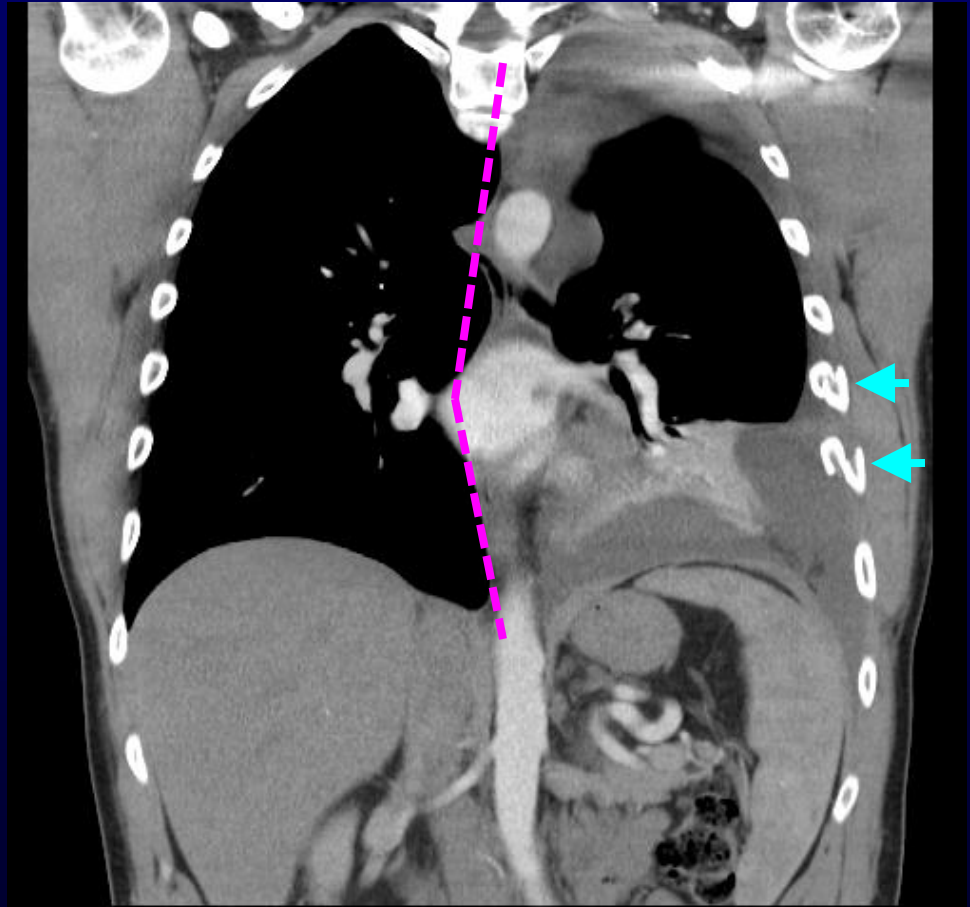
- low attenuation fat herniating through the L hemidiaphragm
- left pleural effusion



Index Patient: CT shows mediastinal shift

- 5-9 rib fractures (only 6-7 shown here)
- Slight mediastinal shift to right due to left pleural effusion
- No bowel in L hemithorax

Coronal view



CT with contrast, soft tissue window

BIDMC PACS

Index Patient: Clinical outcome

- CT showed a small left diaphragmatic hernia. This caused herniation of omental fat and a large pleural effusion, likely responsible for the patient's dyspnea.
- The diaphragmatic tear probably resulted from his fall 10 days ago but was missed on initial presentation.
- The diaphragmatic defect was surgically repaired. Pathology report showed incarcerated omentum.
- Luckily, our patient had no incarcerated bowel in the hernia. This is a major complication of diaphragmatic injuries. It is important to repair diaphragmatic tears before they cause bowel incarceration.

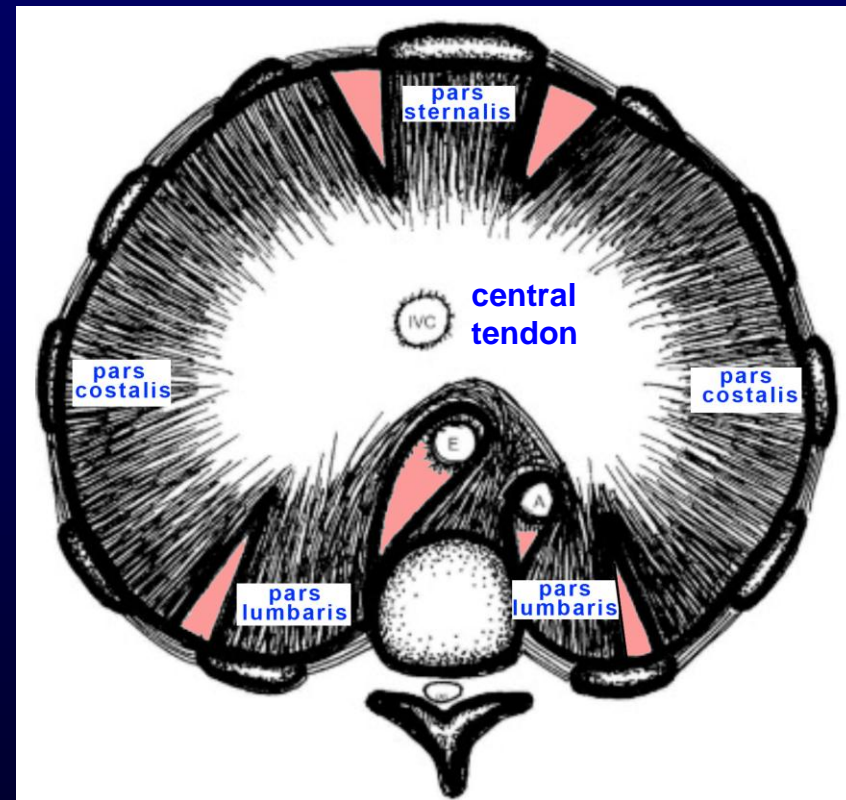
Diaphragmatic injuries are missed in up to 60% of initial presentations!

Let's review the anatomy of the diaphragm in order to understand different diaphragmatic defects.



Diaphragmatic anatomy: Where do injuries occur?

- Divides negative-pressure thoracic from positive-pressure abdomen so there is always a pressure gradient across the diaphragm
- The diaphragm consists of 3 muscle groups and a central tendon
- Gaps between muscle groups are only pleura, peritoneum, and fascia and are weak
- Hernias most often occur in these gaps, in the central tendon, or in the tendon/muscle junction



Adapted from Sandstrom et al. *Curr Prob Diagn Rad* 2011.



Diaphragmatic defects: Classification

Congenital

- Bochdalek – posterior lateral defect (“Boch”dalek = “back”)
- Morgagni – anterior medial defect (“M”orgagni = “M”edial)
- eventration – focal muscular aplasia

Acquired

- Hiatal – commonly associated with GERD
- Traumatic – we will focus on traumatic injuries in the next slide



Traumatic diaphragmatic injury: Facts

- Graded based on injury size and tissue loss BUT grading does not correlate to morbidity or mortality
- Injury occurs via penetration (65%) or blunt force (35%), which causes a sudden increase in intra-abdominal pressure. An increase in pressure gradient across the diaphragm to 150-200 cmH₂O can cause rupture
- Diaphragmatic rupture occurs in 1-6% of major thoracic traumas
- L hemidiaphragm 3x more likely to be injured than right with blunt trauma, likely because the liver protects the right hemidiaphragm
- Only 30-40% of patients get a pre-op diagnosis of diaphragmatic injury



Gallery of diaphragms: How to recognize injury

- Examples of fake-outs
- Examples of diaphragmatic injury on CXR
- Examples of diaphragmatic injury on CT

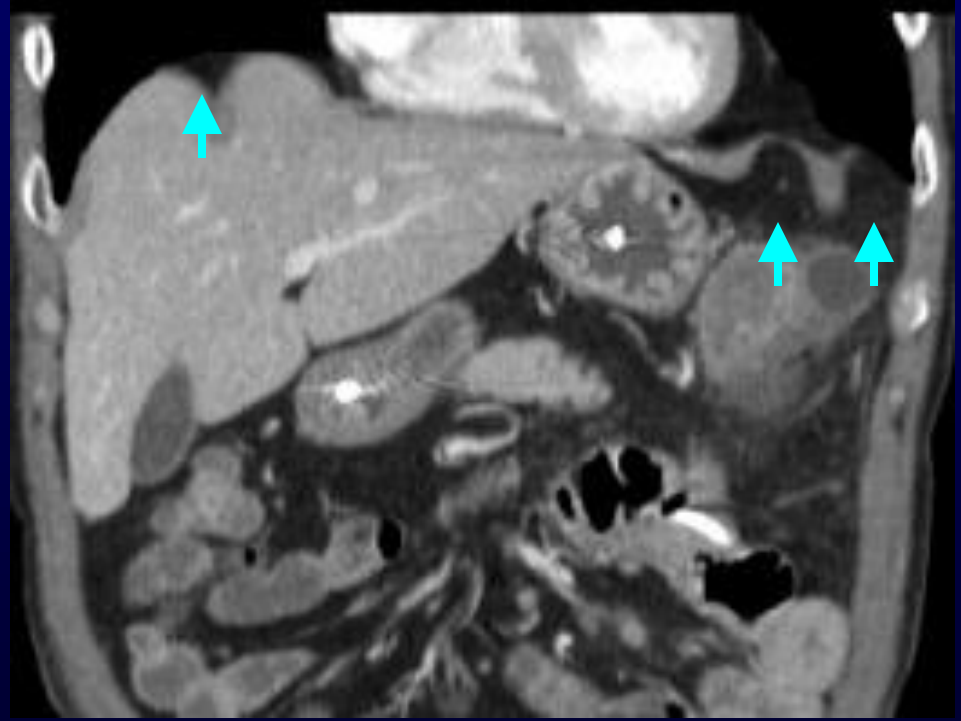
Certain anatomic variants can be mistaken for diaphragmatic injuries on imaging

Let's see some examples in the next two slides...

Companion patient #1: diaphragmatic slip

- Bundles of muscle on inferior surface of diaphragm
- Normal anatomic variant
- Echogenic by ultrasound, can mimic intrahepatic mass

CT abdomen, coronal view

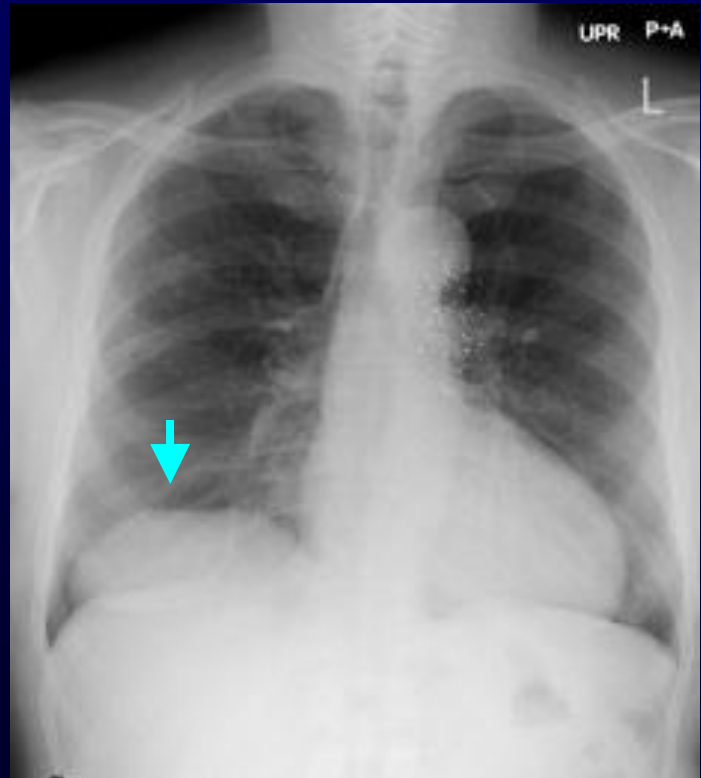


Sandstrom et al. *Curr Prob Diagn Rad* 2011.

Companion patient #2: diaphragmatic eventration

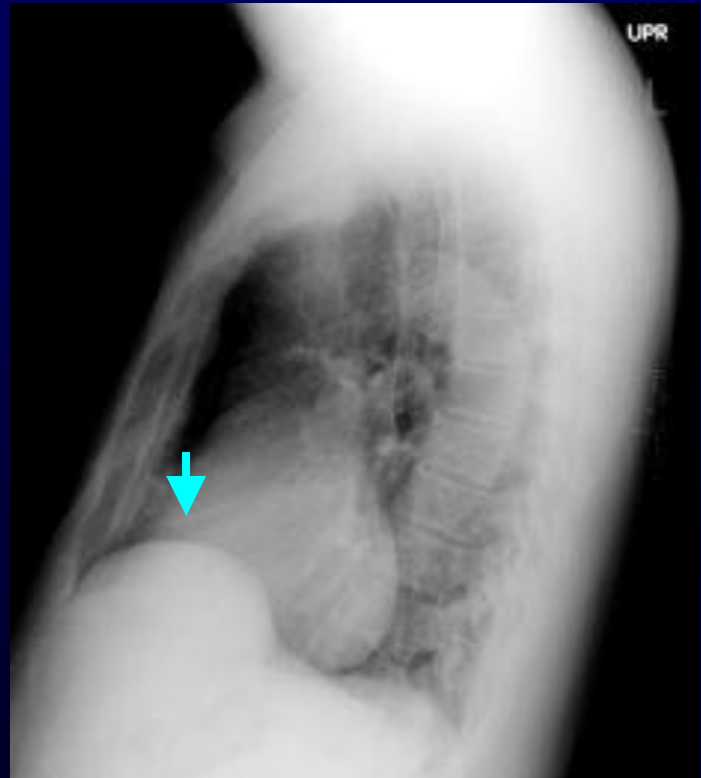
- Focal muscular aplasia causing bulging of diaphragm
- Rarely, may cause dyspnea, failure to thrive, recurrent pneumonia

CXR, frontal



Sandstrom et al. *Curr Prob Diagn Rad* 2011.

CXR, lateral



Sandstrom et al. *Curr Prob Diagn Rad* 2011.

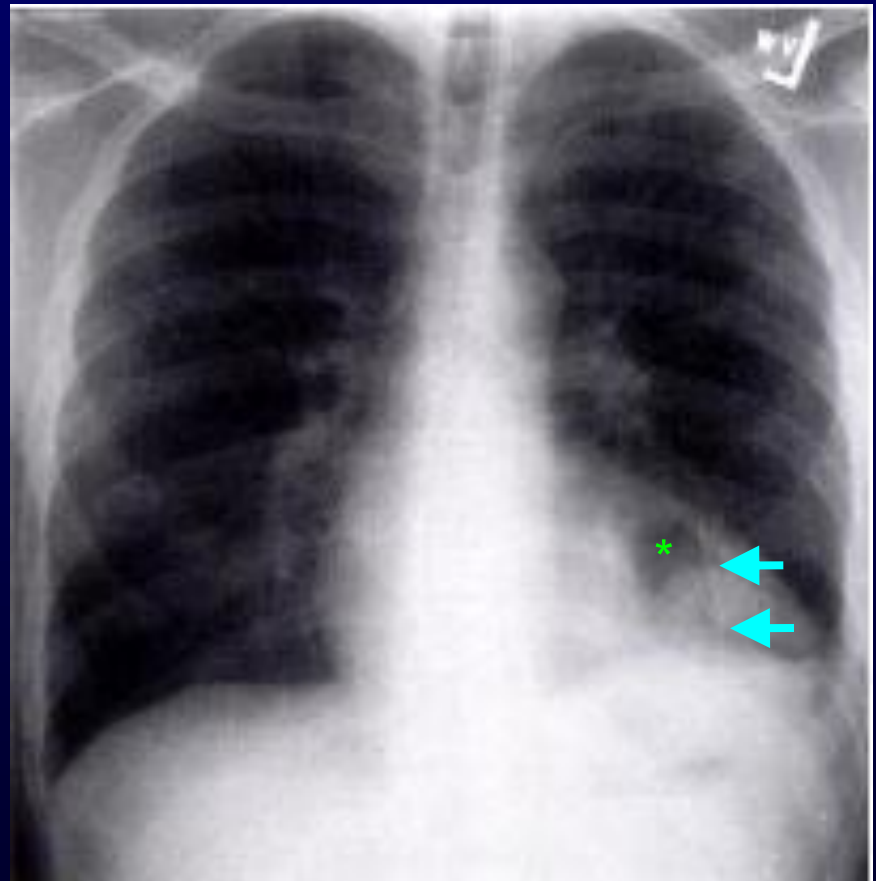


Gallery of diaphragms: How to recognize injury

- ✓ Examples of fake-outs
- Examples of diaphragmatic injury on CXR
- Examples of diaphragmatic injury on CT

Companion patient #3: CXR showing the stomach in the thorax

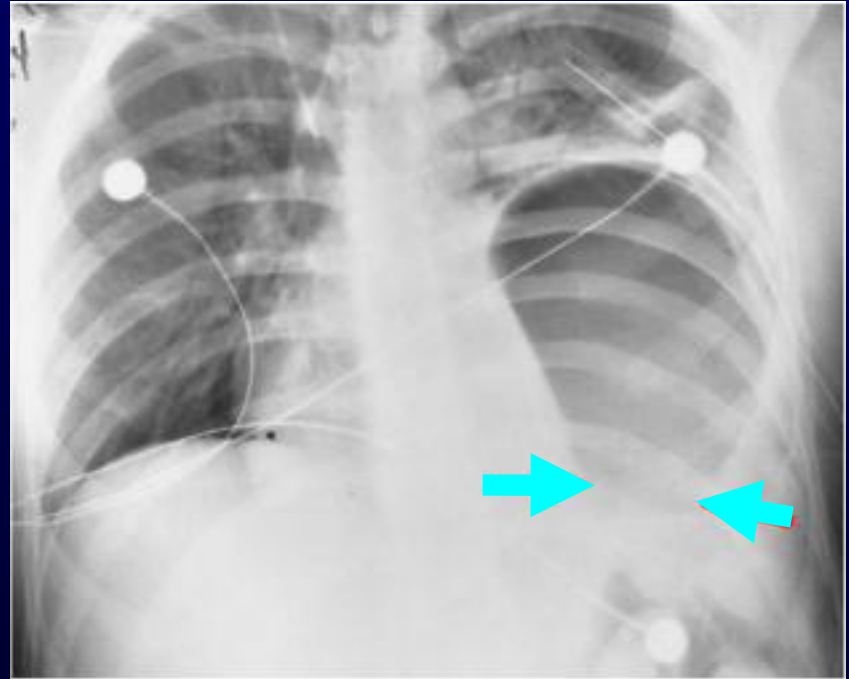
- Abdominal organs in the chest = most obvious sign of diaphragmatic disruption
- Here, the stomach bubble is in the right hemithorax
- A radio-opaque NG tube is seen inside the stomach



Shanmuganathan et al. *J Thor Imag* 2000.

Companion patient #4: CXR showing the collar sign

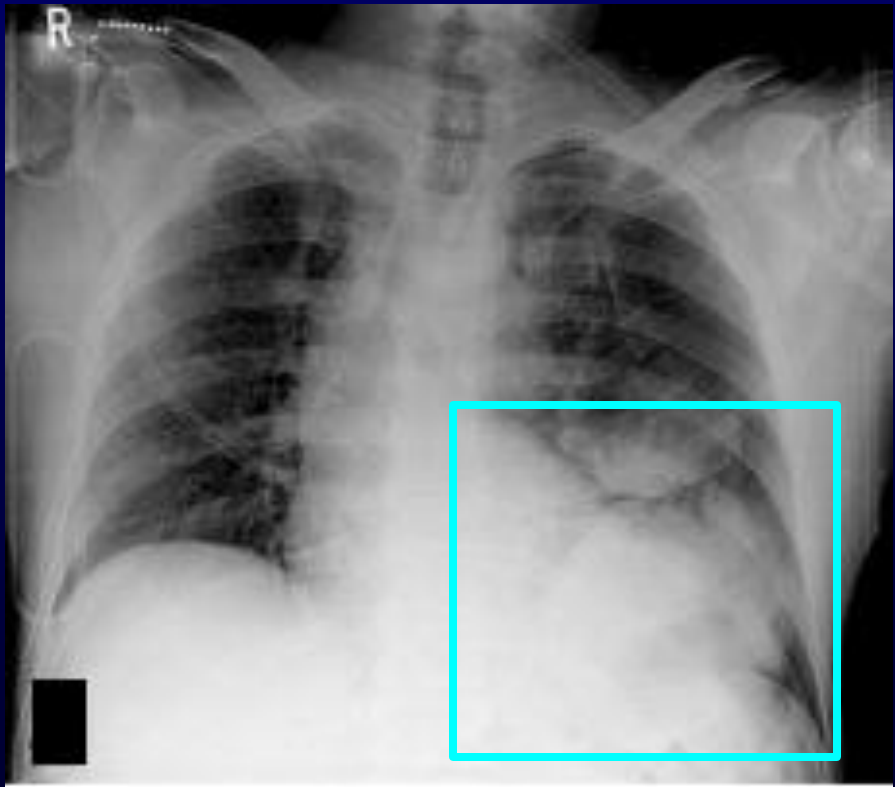
- “Collar sign” = constriction of the organ when it passes through a narrow opening in the diaphragm
- Here, the stomach is constricted at the level of the diaphragm
- Therefore, the stomach is passing **through** the diaphragm, making this finding distinct from diaphragm elevation



Shanmuganathan et al. *J Thor Imag* 2000.

Companion patient #5: CXR showing an indistinct hemidiaphragm

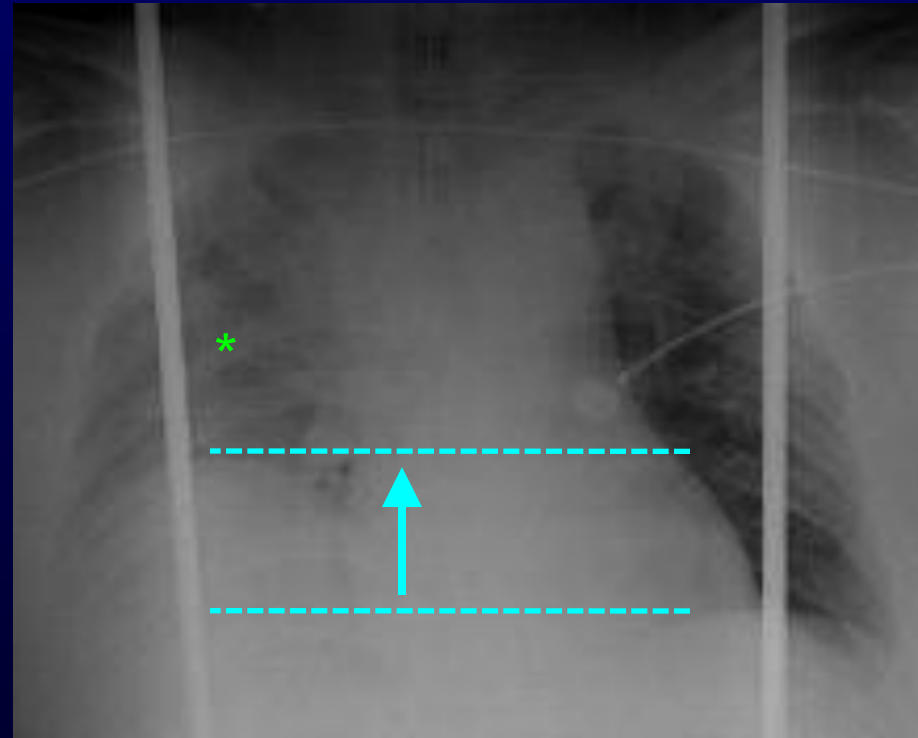
- The left hemidiaphragm is seen laterally but becomes indistinct medially
- This is a very nonspecific sign and can look similar to a pleural effusion or consolidation



Sandstrom et al. *Curr Prob Diagn Rad* 2011.

Companion patient #6: CXR showing elevation of the right hemidiaphragm

- Elevated right hemidiaphragm suggests injury to the muscle and nerves
- Right pleural effusion versus hemothorax
- These are nonspecific signs that may suggest diaphragmatic injury given a history of trauma. However, they may also be caused by infection or malignancy.



Sandstrom et al. *Curr Prob Diagn Rad* 2011.



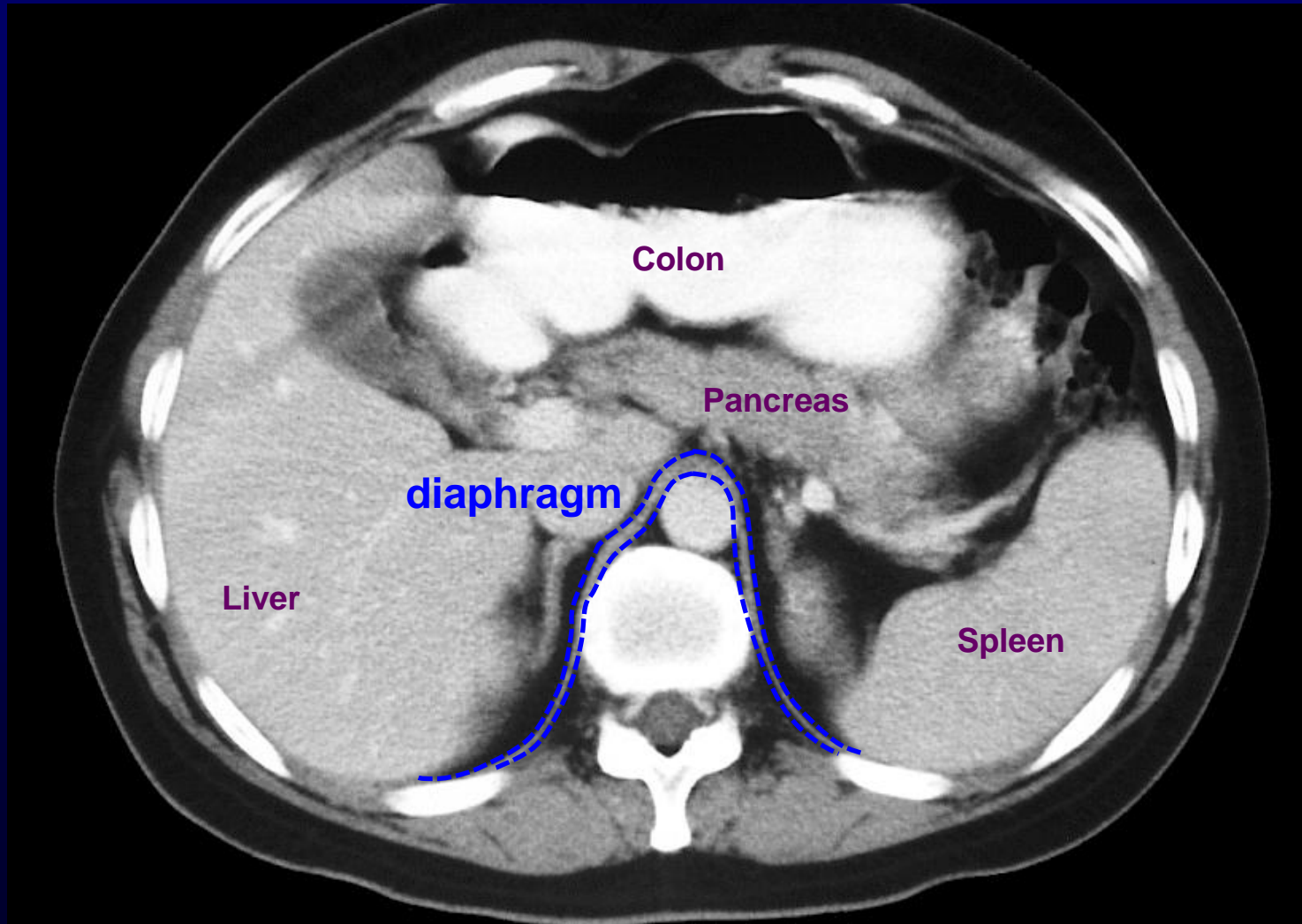
Gallery of diaphragms: How to recognize injury

- ✓ Examples of fake-outs
- ✓ Examples of diaphragmatic injury on CXR
- Examples of diaphragmatic injury on CT

As we have seen, CXR signs of diaphragmatic injury are often nonspecific. The next step in evaluation is CT...



Normal diaphragm on CT, axial view

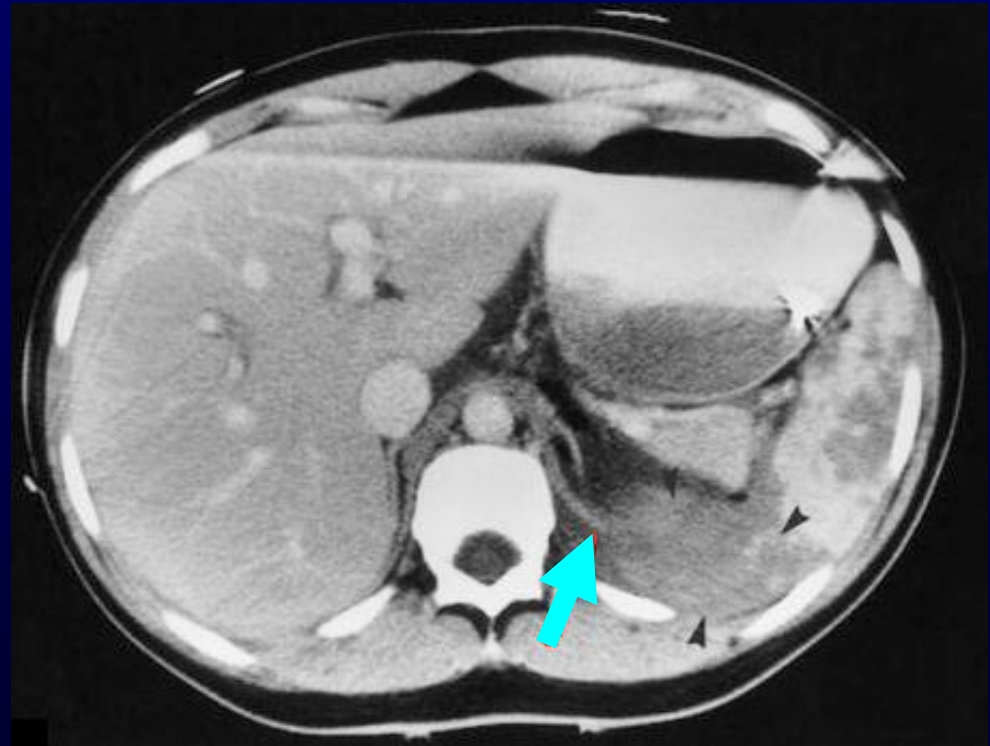




Companion patient #7: CT showing diaphragm discontinuity

- Discontinuity in the left hemidiaphragm with surrounding edema
- Most sensitive sign on CT (~70% sensitivity)

Axial CT slice through top of liver

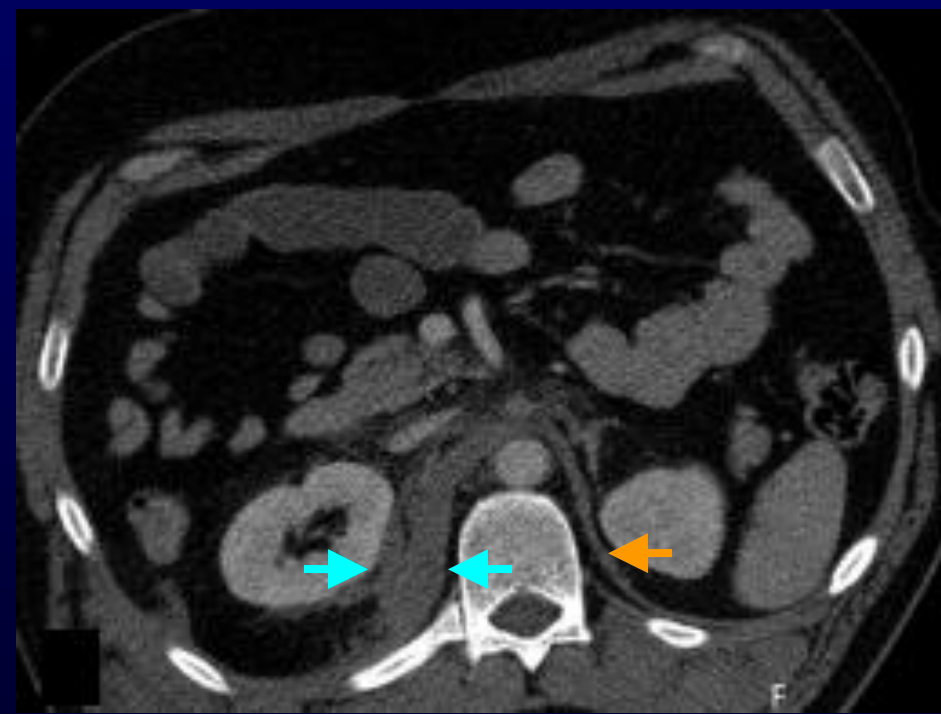


Shanmuganathan et al. *J Thor Imag* 2000.

Companion patient #8: CT showing diaphragm thickening

- Right hemidiaphragm is thickened
- Compare to the normal left hemidiaphragm
- Thickening is caused by muscular contraction, edema, and/or hematoma

CT abdomen, axial slice

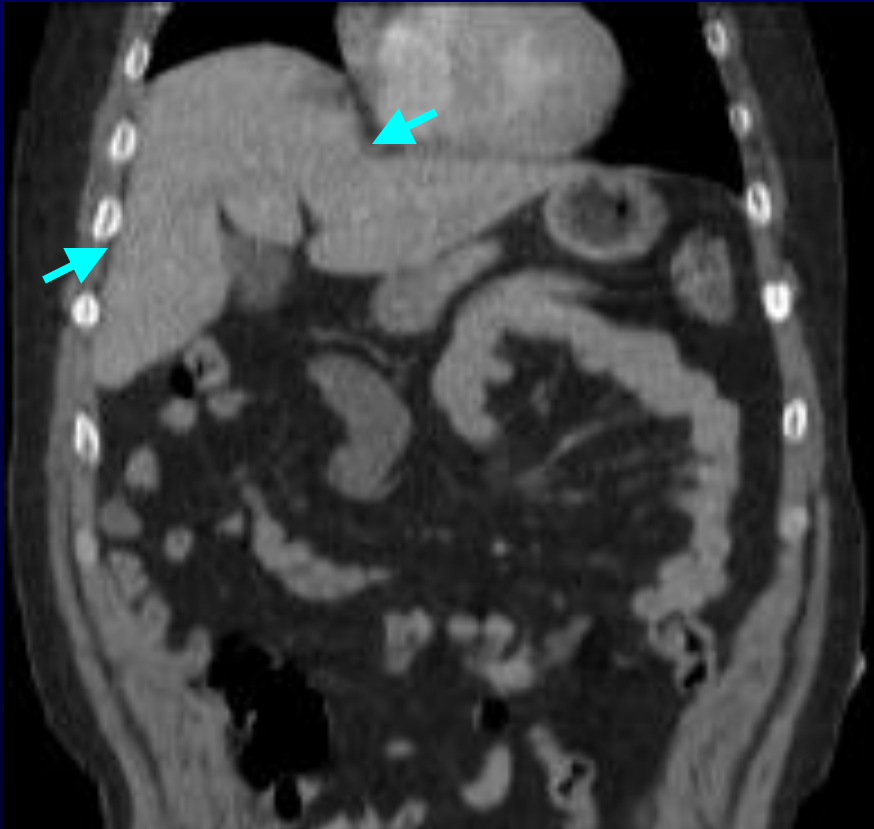


Sandstrom et al. *Curr Prob Diagn Rad* 2011.

Companion patient #9: CT collar sign in the liver

- The herniating liver has a narrow waist where it passes through the smaller diaphragmatic defect
- “Collar sign” is ~30-60% sensitive on CT

CT abdomen, coronal view

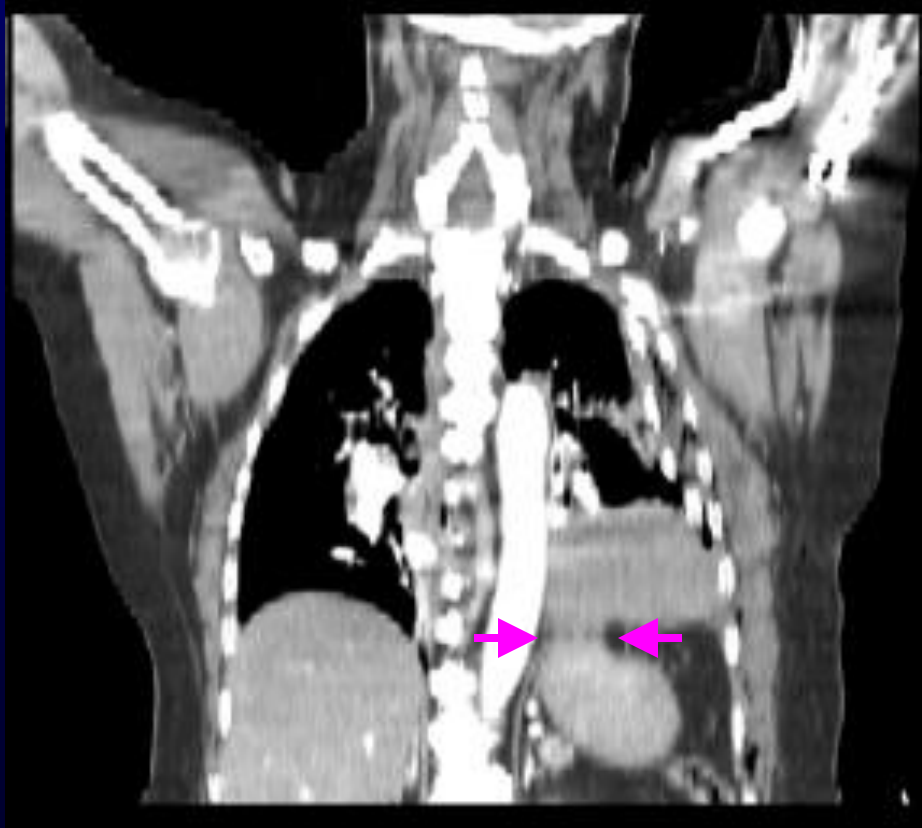


Sandstrom et al. *Curr Prob Diagn Rad* 2011.

Companion patient #10: CT collar sign in the stomach

- The stomach has herniated through a small defect in the right hemidiaphragm
- Refer to companion patient #4 for a similar example of collar sign on CXR

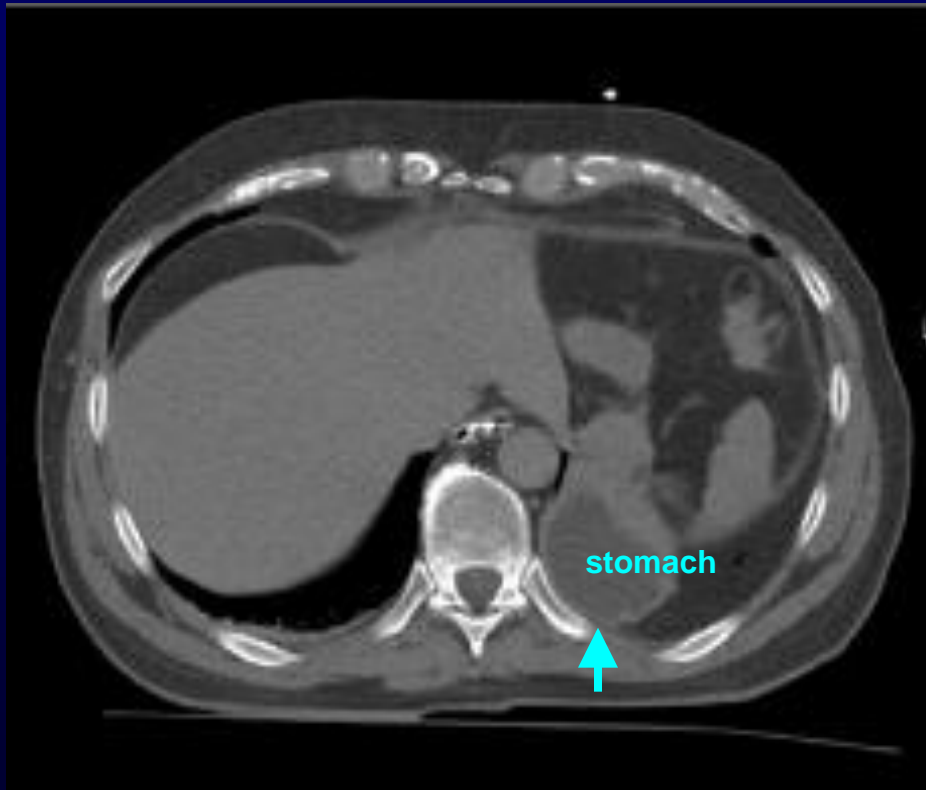
CT chest, coronal view



Companion patient #11: Dependent organ sign on CT

- The stomach directly contacts the posterior rib without intervening lung

- Findings can be more obvious in a different reconstruction



CT with contrast, axial view



CT with contrast, coronal view

The examples we have seen so far show blunt diaphragmatic injuries.

However, 65% of diaphragmatic injuries actually occur from penetrating trauma.

Penetrating trauma usually causes a <2 cm defect, making them especially difficult to visualize. Let us examine an example of penetrating trauma on CXR and CT...

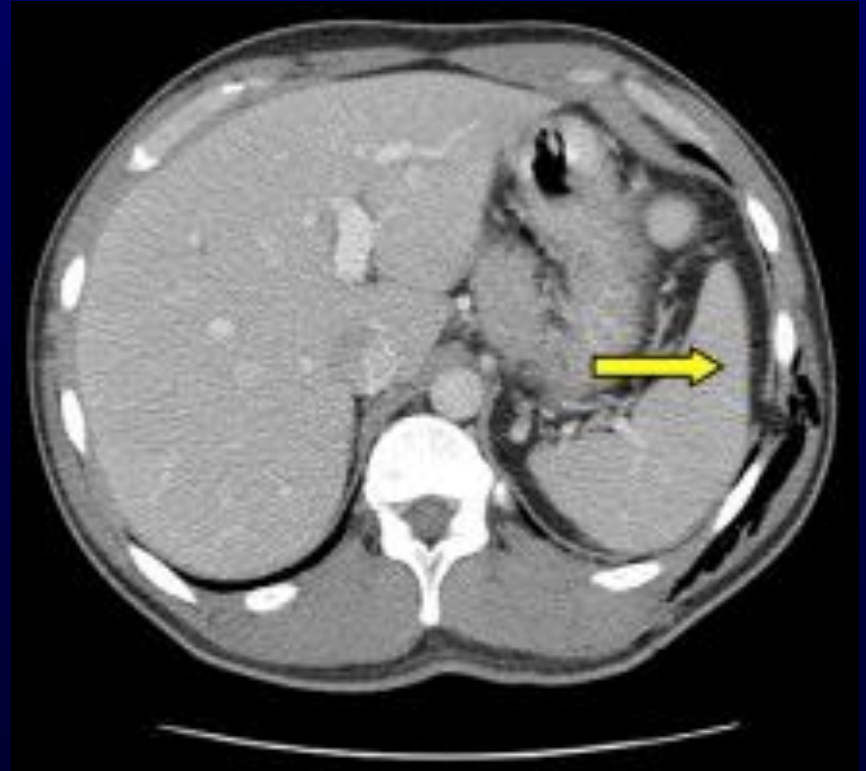
Companion patient #12: Penetrating diaphragmatic trauma

- This patient's CXR is normal



Sandstrom et al. *Curr Prob Diagn Rad* 2011.

- However, his CT shows diaphragmatic discontinuity.



Sandstrom et al. *Curr Prob Diagn Rad* 2011.



Gallery of diaphragms: Summary

- ✓ Examples of fake-outs
 - ✓ Examples of diaphragmatic injury on CXR
 - ✓ Examples of diaphragmatic injury on CT
- We have now seen examples of diaphragmatic injuries from both penetrating and blunt trauma on CXR and CT.



Summary: CXR diagnosis of diaphragmatic injury

- Findings:
 - abdominal organs in chest, “collar sign”
 - elevation of hemidiaphragm
 - indistinct diaphragmatic contour
 - pleural effusion or hemothorax
- These findings have the following ddx:
 - atelectasis, lobar collapse
 - pulmonary contusion
 - loculated pneumothorax
 - pneumonia
 - phrenic nerve palsy
 - eventration
- Any of the above ddx can also coexist with and obscure a real diaphragmatic injury, so CT is often required for further evaluation.

Summary: CT diagnosis of diaphragmatic injury

- Findings:
 - discontinuity of the diaphragm
 - thickening of diaphragm
 - herniation of abdominal contents, “collar sign”
 - abdominal organs contacting posterior ribs, “dependent organ sign”
- Penetrating trauma is especially hard to see; up to 66% missed
- Beware of positive pressure ventilation, which can push herniated organs back down and give a false negative on imaging



Acknowledgements

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Annie Leylek, MD

Attentive audience members!

References

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