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Background: Epidemiology of Traumatic Diaphragmatic Rupture

- Trauma is the 4th most common cause of death in the USA and the leading cause of fatalities in those younger than 45 years-old.

- Traumatic diaphragmatic rupture (TDR) injuries occur in 0.8 to 8% of patients who sustain blunt (MVC and fall from height) and penetrating trauma.

- Mortality from TDR is 14-50%. This increases to 77% when associated with shock and head injury.

Sangster G, Ventura V, Carbo A, et. al
Background:
Complications and common associations of TDR

- Diagnosis of TDR missed in up to 48% of blunt trauma patients on routine chest films and 30% of body CT scans. Failure to identify the abnormality may cause acute or delayed severe complications
  - Cardiovascular-respiratory insufficiency
  - Bowel strangulation and ischemia
- Left hemidiaphragm injured 4 times more commonly than the right. Bilateral cases are rare (5-8%)
- Most commonly herniated organs: stomach > small and large bowel > spleen > liver
- Associated intra-abdominal injuries common (75% of TDR patients have associated intra-abdominal injury)

Eren S, Kantarci M, Okur A.
Background:
Clinical symptoms as poor indicators of detecting TDR

- Most commonly experienced clinical symptoms of TDR include dyspnea, chest pain, abdominal pain, vomiting
- The clinical diagnosis of TDR is difficult and missed in up to 65% of patients
- Therefore, imaging is essential
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Menu of Tests: Plain Chest Film

- Plain film chest radiography 1st test of choice to evaluate suspected TDR

- Sensitivity of the chest plain film for the detection of the DR range from 27 to 60% for left-sided hernias and 17 to 33% for the right

- The most specific radiographic findings of DR include intrathoracic herniation of hollow viscera (small bowel, stomach, or colon) and identification of the nasogastric tube above the level of the left hemidiaphragm

Gelman R, Mirvis SE, Gens D.
Differential diagnosis for NG tube tip overlying the chest on plain film:

1) Tip is still inside the stomach – diaphragmatic rupture

2) Tip is outside of the GI tract – in a bronchus or the pleural space

3) Tube is outside the patient
Menu of Tests:
Plain Chest Film, Limitations

- Failure to diagnose TDR on plain films range from 12 to 66%

- Concurrent pulmonary abnormalities such as pleural effusion, pulmonary contusion and atelectasis can mimic or mask TDR on plain chest films

- A herniation at the costo-phrenic angle may be misdiagnosed as a pleural effusion or hemothorax on the initial chest radiograph, and a thoracic drainage tube could accidentally be placed into the herniated organs

Shapiro MJ, Heidberg E, Durham RM, et. al.
Menu of Tests: CT

- Multidetector CT (MDCT) has TDR detection rates of 73–92% = Gold standard for diagnosis

- Because TDR is rarely isolated, CT is advantageous in the evaluation of other associated injuries

Nchimi A, Szapiro D, Ghaye B, et. al.
Menu of Tests: CT Findings for TDR

- **Diaphragm discontinuity and “Dangling diaphragm sign”**
  73% sensitivity, 90% specificity

- **Intrathoracic herniation of abdominal contents**
  55% sensitivity, 100% specificity

- **“Collar sign:” Constriction of the herniated abdominal viscera**
  67% sensitivity, 100% specificity

- **“Dependent viscera sign: ” Visualization of the herniated viscera against the posterior chest wall**
  100% sensitivity, 90% specificity

Axial contrast CT through the abdomen. Arrowhead shows construction of the stomach as it passes through the diaphragmatic defect, this is the "Collar sign." The relatively newly discovered "dangling diaphragm sign" is seen with the arrow, representing the torn free edge of the left hemidiaphragm.
Axial contrast CT through the thorax, showing the “**Dependent viscera sign.**” The stomach is lying adjacent to the posterior ribs instead of within the expected confines of the dome of the diaphragm.
Menu of Tests:
Lesser Used Studies to evaluate TDR

- A barium study can be performed as a complement to diagnosis if the patient can tolerate the study. If intestinal passage is normal, barium filling intestinal loops are detected within the thorax.

- MRI also used, but not a practical imaging technique in acute emergency setting for multi-trauma patients, as it is a slower modality than CT.

- Surgical laparotomy may detect any unseen, subtle tears in the diaphragm. Preferred over thoracotomy.

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Our Patient J.C: History of Present Illness

- 23 M helmeted, riding a scooter at 15 mph struck by a motor vehicle and thrown from scooter 10 feet
- No LOC, with GCS of 14 at scene
- Negative FAST ultrasound
Our Patient J.C:
Plain Chest Film

AP Supine Portable Chest Film

PACS, BIDMC
Patient J.C: Plain Chest Film Findings

- AP chest supine plain film
- Lungs are clear with no pneumothorax
- The right hemidiaphragm appears intact
- Partial herniation of the stomach into the chest
- Detailed evaluation limited by underlying trauma board

AP Supine Portable Chest Film
Our Patient J.C:
CT Scout Image
Our Patient J.C:
CT Axial Image

CT C+ Axial Image through the thorax

PACS, BIDMC
Our Patient J.C: CT Axial Image Findings

- Confirmation of herniation of stomach partially into the thorax
- No comment made about potential liver elevation from axial images
Our Patient J.C:
CT Sagittal Image

Sagittal C+ CT image through level of the stomach and left hemidiaphragm
Our Patient J.C: CT Sagittal Image Findings

- **Discontinuity** of left hemidiaphragm with **herniation of stomach** into left chest
Normal Patient vs. Our Patient J.C:
CT Sagittal Images

NORMAL

OUR PATIENT J.C.

Sagittal C+ CT images through level of the liver
Normal patient on the left, Our Patient J.C on the right

PACS, BIDMC
Normal Patient vs. Our Patient J.C:
CT Sagittal Image Findings

- Elevation of the dome of the liver into the chest in patient JC, compared to normal smooth confines of upper dome of liver in normal patient on the left.

- Confirmation of right hemidiaphragm tear with herniation of dome of liver not made on imaging, but later by the surgeon during emergency laparotomy.
Our Patient J.C: Post diaphragmatic repair CXR and CT

Upright plain film of the chest

Sagittal C+ CT Image through the liver
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- **Companion Patient A.B.**
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Companion Patient A.B.

- 22 M unrestrained rear seat passenger in high speed MVC, with GCS of 5 at scene

- “Rhonchi” appreciated in left lung on auscultation
Companion Patient A.B: Plain Chest Film

AP Supine Portable Chest Film
Companion Patient A.B:
Plain Chest Film Findings

- AP chest supine plain film
- Complete opacification of the left chest. **Multiple rib fractures** including 2\(^{nd}\), 3\(^{rd}\), 4\(^{th}\) left ribs
- The **mediastinum is shifted to the right**
- Impression: "Given the trauma history this could well represent pulmonary contusion or hemorrhage"
Companion Patient A.B:
CT Scout Image

- Left diaphragm rupture with herniation of the spleen, stomach, small bowel and a portion of the large bowel into the left thorax.
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The diaphragm is created by the fusion of four discrete structures at the 7th week of development:

- **Septum transversum**
- **Pleuroperitoneal membrane**
- **Lateral body wall mesoderm**
- **Dorsal mesentery**

“Several Parts Make the Diaphragm”

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Diaphragmatic Trauma “Fake-out” 1: Congenital Hernias

- **Bochdalek** (90%) – Back of diaphragm, left (5:1)
  - Posterolateral and result from failed fusion of pleuroperitoneal folds at the eighth week of gestation

- **Morgagni** – Middle of diaphragm
  - Foramen of Morgagni hernias are located posterior to the xiphoid process and are caused by failed migration of the cervical somites
Diaphragmatic Trauma “Fake-out” 1: Congenital Hernias on CXR

- In newborns, if massive defect, apparent on plain film; morbidity related to degree of pulmonary hypoplasia

- Differentiate from TDR by absence of trauma

Images courtesy of Dr. Julia Rissmiller, BIDMC
Diaphragmatic “Fake-out” 2: Diaphragmatic Eventration

- Congenital absence of functional diaphragmatic musculature with incomplete muscularization of the diaphragm and a thin membranous sheet replacing a portion of the diaphragmatic muscle.

- Frequently involves the anteromedial portion of the right hemidiaphragm.

- Diaphragm retains its continuity and attachments to the costal margin.

- Weakened hemidiaphragm is displaced into the thorax, which can compromise breathing.

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Conclusions

- TDR is an uncommon injury (0.8 – 8% of traumas), but with a high mortality (14 - 50%)

- TDR is difficult to diagnose clinically, and frequently missed on supine plain films

- CT is the gold standard noninvasive diagnostic modality and allows visualization of other associated intra-abdominal injuries

- Beware TDR “fake-outs” in the absence of trauma: congenital hernias and diaphragmatic eventration

- Always wear a seatbelt
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References


