



Case 49: Penetrating Chest Trauma

- **Chief complaint**
 - 30-year-old male presents with a penetrating chest injury
 - EMS Report (if requested): EMS was called to a construction site for a worker who had fallen 6 feet from a low scaffolding, and landed chest-first onto a slab of concrete studded with steel rebar. His co-workers noticed that one of the rebar had penetrated his chest. They pulled him off the slab, administered first aid with direct pressure to the chest, and called 911. The patient was alert and oriented upon EMS arrival but complaining of severe pain in the chest. The patient denied any allergies, medical problems or use of medications. No other obvious injuries. No loss of consciousness, but has become increasingly confused en route to the ED.
- **Vital signs**
 - **HR: 122 BP: 100/84 RR: 28** Sat: 97% on RA T: 36.8°C Wt: 80 kg
- **Patient appearance**
 - Patient is a young male in moderate distress. A pressure dressing is applied to the left anterior chest and is soaked in blood.
- **Primary survey**
 - Airway: Patient is speaking in short sentences, no stridor, no tracheal deviation
 - Breathing: tachypneic, using accessory muscles in obvious respiratory distress, breath sounds equal bilaterally, clear lungs
 - Circulation: pale clammy skin, cool peripheries, thready distal pulses
 - Disability: PERRL, opens eyes to pain, confused but able to answer questions, moves extremities spontaneously and follows commands (E2, V4, M6 = GCS 12), distal sensation intact
 - Exposure: (remove clothing, log-roll with spinal precautions maintained) 1.3 cm round laceration in the left parasternal region of the anterior chest wall, oozing blood. No other injuries are immediately noted.
- **Instructor Prompt:** The learner may reasonably choose to stop and intervene / resuscitate at any of the above points during the primary assessment before moving on.
 - The learner may consider intubation after “Breathing”, however, this should be avoided as long as possible in the setting of pericardial tamponade or tension pneumothorax.
 - Penetrating chest trauma with abnormal vital signs should prompt the learner to assess for pericardial tamponade or pneumothorax.

- If POCUS is used to assess for pericardial tamponade, [Video 49.4 \(D\)](#) may be shown
 - If additional views are requested, [Figure 49.3](#) may be shown
 - RUQ view: negative
 - LUQ view: negative
 - Pelvis view: negative
 - *Prioritize subxiphoid view: +pericardial effusion with tamponade physiology
 - Lungs: normal lung sliding bilaterally
 - If the learner attempts pericardiocentesis (must describe the procedure) this will momentarily improve vitals, but output will decrease secondary to clots and case should continue with the decompensation pathway that is outlined below.
- **Action**
 - Place patient on the monitor
 - 15 L/min oxygen by nonrebreather (NRB) mask
 - Advanced airway equipment and crash cart to the bedside
 - Two large bore peripheral IV lines (draw rainbow top)
 - Start 1 L IVF bolus (wide open or under pressure), replace with blood once available
 - Transfuse uncrossmatched blood (O+), and call blood bank to request more blood products
 - Order Labs
 - CBC, CMP, PT/INR, PTT, blood type and crossmatch
 - Consider lactate, EtOH level
 - Order stat portable CXR
 - POC glucose (85, if requested)
 - Emergent trauma surgery consult (not immediately available)
- **Instructor Prompt:** discuss positive findings from the primary assessment and initial adjunctive investigations
- **History**
 - Source: EMS
 - HPI: (see EMS report above) Patient is confused and unable to contribute more information.
 - PMHx: none
 - PSHx: none
 - Allergies: none
 - Meds: none
 - Social: consumes alcohol on weekends, non-smoker, denies EtOH
 - FHx: non-contributory
 - Code Status: full code

- **Physical Exam**

- **General:** confused, unwell-appearing, acute distress
- HEENT: normal
- **Neck:** jugular venous distension
- **Chest:** 1.3 cm-wide circular laceration in the left parasternal region at the level of the 5th intercostal space with moderate active bleeding
- **Heart:** Distant heart sounds, tachycardia
- **Lungs:** tachypnea, equal breath sounds bilaterally
- Abdomen: normal
- Rectal: normal
- Pelvic: normal
- **Extremities:** cool, thready radial peripheral pulses, dorsalis pedis pulses are not palpable
- Back: normal
- Neuro: pupils equal and reactive, GCS 12, moves all four extremities spontaneously
- **Skin:** Pale, cool clammy skin
- Lymph: normal

- **Instructor Prompt:** learners should discuss differential diagnosis / diagnostic clues for pericardial tamponade

- **Action**

- Stat portable CXR ([Figure 49.2](#)- no pneumothorax, no hemothorax)
- Consider stat ECG ([Figure 49.1](#)- sinus tachycardia and electrical alternans)
- POCUS e-FAST ([Figure 49.3](#))
 - Subxiphoid 4 chamber view, showing hemopericardium with RV diastolic collapse consistent with tamponade
 - Thoracic views demonstrate normal lung sliding bilaterally, no pneumothorax
 - No intraperitoneal free fluid
- If pericardiocentesis is attempted, ask the learner to describe the procedure; this will initially improve vital signs, but output from the drain will decrease due to clots. The case should continue with the decompensation pathway outlined below, including need for intubation and thoracotomy.
- Order meds
 - IV analgesia (opioids)
 - Tdap IM (tetanus vaccine)
 - IV antibiotic prophylaxis (consider cefazolin IV or broad coverage)

- **Response/Results**

- Reassess vitals:
 - **BP: 90/60 HR: 135 RR: 32 Sat: 90% on non-rebreather mask** (unless already intubated)
 - Eyes do not open, incomprehensible sounds, withdraws from painful stimulus (E1, V2, M4 = GCS 7)

- **Action**

- Advanced airway equipment and crash cart to the bedside (if not already completed)
- Intubate for airway protection
 - Rapid sequence intubation (learner should identify approach, meds and dosages used)
 - Post-intubation care (learner should provide vent settings, post-intubation sedation including pain control, post-intubation OGT, CXR, foley)
- Reassess vitals after intubation:
 - **BP: 90/62 HR: 140 RR: 20 Sat: 100%** on ventilator
- Transfusion of blood products
 - Transfuse uncrossmatched blood (O+), and call blood bank to request more blood product (consider massive transfusion protocol)
- Consult trauma surgery / cardiothoracic surgery (if not already done): express concern for pericardial tamponade and need for emergent pericardial window

- **Response/Results**

- [Case 49 Lab Results](#) (significant for **Hb 10.0**)
- **Pulses are not palpable, no BP**

- **Instructor Prompt:** Discuss indications for ED thoracotomy

- **Action**

- ED thoracotomy should be performed (describe procedure) to identify source of bleeding
 - Thoracotomy reveals large amount of blood and clot in pericardium, and a 1 cm hole in the right ventricle that is actively bleeding
 - Tamponade wound site with finger, Foley catheter or by oversewing
 - As the hemopericardium is released by the intervention, the patient regains spontaneous circulation with **HR 120** and **BP 90/45**
- Discuss case with trauma surgery consultant
- Patient transported emergently to the OR by the surgical team

- **Diagnosis**

- Primary Diagnosis: hemopericardium and pericardial tamponade secondary to penetrating chest trauma

- **Critical actions**

- Resuscitation with blood products
- Recognition of pericardial tamponade clinically, or by performing e-FAST
- Intubation for airway protection
- Perform ED thoracotomy upon cardiac arrest
- Consultation with trauma surgery
- Emergent disposition to the OR

- **Instructor Guide**

- This is a case of pericardial tamponade in a patient presenting with penetrating chest trauma. The patient was hemodynamically unstable on arrival, with tachycardia and hypotension with a narrow pulse pressure. Clues on examination include evidence of chest wall injury, jugular venous distension, and distant heart sounds. Important early actions include ABCDE trauma assessment and resuscitative efforts, early blood products, and rapid POCUS to identify the etiology of hypotension. Pericardiocentesis may be attempted, however it is unable to clear clotted blood and may delay definitive treatment. Intubation will be required for airway protection (low GCS) and progressive respiratory failure. Upon cardiac arrest, emergency department thoracotomy should be performed to identify the source of the blood. Definitive treatment is emergent surgical repair.

- **Case Teaching Points**

- The differential diagnosis for hemodynamic instability in a patient with penetrating chest trauma should include tension pneumothorax, hemothorax, pericardial tamponade, and exsanguinating hemorrhage. A tension pneumothorax should be considered in this patient with chest trauma and signs of obstructive shock, however, normal breath sounds should prompt consideration of pericardial tamponade. The e-FAST exam is an important diagnostic tool in distinguishing pericardial tamponade from tension pneumothorax. Exsanguinating hemorrhage is another complication of penetrating trauma to the chest. If a defect in the pericardium fails to tamponade, hypovolemic shock occurs and presents with flat neck veins or a hemothorax and rapid death. Additionally, the patient had a fall from height in addition to a penetrating chest wound and additional blunt trauma injuries can not be excluded.

- **Pathophysiology of pericardial tamponade**

- As fluid enters the pericardial cavity, intrapericardial pressure rises, and eventually exceeds the normal diastolic pressure of the right heart chambers (lower pressure system relative to the left heart). At this point, the filling of the right ventricle is compromised, and the effusion is defined as pericardial tamponade.
- Back-up of blood from the right heart into the vena cava increases central venous pressure (CVP).
- Rising intrapericardial pressure eventually exceeds LV diastolic pressure, resulting in reduction in the stroke volume and systolic blood pressure, thus reducing the pulse pressure and cardiac output and eventually causing obstructive shock.
- The compensatory mechanisms include a catecholamine surge which increases systemic vascular resistance (SVR) and heart rate to maintain blood pressure.

- **Etiology of pericardial tamponade**

- Non-traumatic pericardial tamponade

- Gradual accumulation of fluid in the pericardial cavity causes stretching of the fibrous parietal pericardium and accommodation of relatively large volumes before a rise in intrapericardial pressure beyond that of the intraventricular pressures (and thus causing tamponade). For this reason, relatively large effusions may be seen in non-traumatic cases of pericardial tamponade.
 - Causes:
 - Metastatic malignancy
 - Acute or chronic Pericarditis
 - Uremia
 - Hemorrhage
 - Systemic lupus erythematosus
 - Traumatic pericardial tamponade
 - Occurs in up to 2% of all penetrating thoracic / upper abdominal trauma. A common source is stab wounds. Impalement causing hemopericardium is rare, although it is reported in the literature. Hemopericardium is less common in blunt chest trauma.
 - Causes of tamponade in the context of penetrating thoracic trauma:
 - Pericardial defect
 - Right ventricular wound
 - Coronary artery injury
- **Clinical presentation of acute traumatic pericardial tamponade**
 - History
 - Penetrating trauma to the chest, usually a stab wound
 - Examination
 - Beck's triad
 - Hypotension
 - Distant / muffled heart sounds
 - Difficult to appreciate in the noisy setting of the ED
 - Distended neck veins
 - May be absent in a trauma patient with co-morbid hypovolemia secondary to hemorrhage
 - Although Beck's triad is a classic presentation for pericardial tamponade, it is rare and present in less than 10% of cases.
 - Narrow pulse pressure
 - Pulsus paradoxus (drop in SBP by 10-15 mmHg during inspiration)
 - Kussmaul's sign (increase in JVP during inspiration)
 - Investigations
 - Echocardiography
 - Effusion: anechoic rim of fluid surrounding the heart
 - Tamponade: collapse of the RV during diastole

- **Chest X-ray in pericardial effusion**

- Pericardial effusions with a volume of less than 200 mL of fluid are typically not visible on plain film CXR, and thus chest radiography has limited diagnostic utility in acute pericardial tamponade.
 - Rapid accumulation of pericardial fluid, such as in a trauma, typically requires only small volumes (60-100 mL) to produce hemodynamic effects on the heart and lead to symptoms.
 - On the other hand, an effusion that has accumulated chronically, such as in malignancy, may gradually stretch the pericardium to become visible on CXR. In these cases, one may observe the “water bottle sign” on CXR, where the expanded cardiac silhouette becomes globular in appearance.

- **Management of pericardial tamponade**

- When possible, intubation should be avoided until tamponade (or tension pneumothorax) is treated.
- Temporizing measures:
 - Resuscitation with IV fluids or blood products
 - Increases the central venous pressure temporarily to maintain diastolic filling and thus preserve the cardiac output
 - Pericardiocentesis
 - Ultrasound-guided subxiphoid approach to aspirate blood or other fluid from the pericardial space and thus reduce intrapericardial pressure
 - Pericardiocentesis is a temporizing maneuver and does not omit the need for emergency surgery, particularly for traumatic mechanisms
 - ED thoracotomy (see below)
- Definitive management:
 - Emergency surgery

- **Indications for ED thoracotomy (EDT)**

- EDT is a temporizing measure, and should only be performed in a facility with surgical capabilities for definitive treatment.
- Indications for EDT for penetrating thoracic trauma:
 - Cardiac arrest at any point in a patient who had vitals at the scene
 - SBP < 50 mmHg after IV fluid resuscitation
 - Severe shock with clinical signs or evidence of tamponade
- EDT for blunt thoracic trauma:
 - Cardiac arrest in the ED
- Goals of ED thoracotomy:
 - Relieve tamponade
 - Identify and repair cardiac injuries or injuries of the great vessels
 - Cross-clamping of the aorta to improve perfusion to heart and brain

- Control serious intrathoracic bleeding
- Perform direct cardiac compressions (more effective than closed-chest CPR)

- **ED Thoracotomy Procedure**

- Consider performing (or having an assistant perform) a right-sided finger or tube thoracostomy, if not already done
- Consider right main-stem intubation
- Prep the skin with betadine or chlorhexidine (may be omitted)
- Perform an incision in the L chest at the level of the inframammary fold (women) or just inferior to nipple (men) using one smooth motion from the right side of the sternum to the posterior axillary line cutting through skin and subcutaneous tissues
- Using scissors, dissect the intercostal muscles and pleura superior to the margin of the rib and avoiding the neurovascular bundle
- Using hands, spread the ribs taking care if the ribs are broken/sharp
- Insert the rib spreader with the handle aimed towards the patient's feet
- Spread the ribs to provide a view of the pericardium
- Using pickups with teeth, grab the pericardium and make a small incision in it caudally and extend w/ scissors superiorly (parallel to phrenic nerve)
- Bluntly dissect with hands anterior to vertebral bodies to expose then clamp the aorta
 - Associated with increased risk of spinal cord ischemia
 - Palpate for NG tube to help identify the esophagus vs aorta prior to cross-clamp
- Options for controlling hemorrhagic cardiac wounds
 - Use 2-0 or 3-0 monofilament or suture (non-absorbable silk can also be used) or surgical staples
 - Place a Foley catheter into the defect, inflate the balloon with saline, clamp the catheter to prevent air embolism, apply gentle traction to stem bleeding, place a purse-string suture, deflate Foley balloon and remove catheter while closing the wound with the purse-string suture
 - Horizontal mattress stitches through Teflon pledgets for linear lacerations
- If right sided injury suspected, perform clamshell (right sided thoracotomy)

- **POCUS Pearls**

- In life threatening penetrating trauma the FAST exam should be focused to evaluate windows that will directly impact management. In this case a rapid evaluation for pneumothorax and pericardial effusion could prompt chest tube placement, expedite operative care, or indicate need for emergent thoracostomy. A complete exam should not be performed at the expense of other potentially lifesaving interventions.
- FAST exam includes a subxiphoid view or parasternal long axis view of the heart; it doesn't matter which view you use, perform the view you are most comfortable with that will reliably get you the best images.
- Acute hemopericardium may appear as an anechoic stripe, but in cases of partially clotted blood you may see an area of mixed echoes within the pericardial sac. Appearance will vary.

- Don't be fooled by the anterior pericardial fat pad, which can appear anechoic or hypoechoic. Generally a pericardial effusion layers posteriorly first. However, in a case such as this one, any 'fluid-like' appearance in the pericardial sac is blood until proven otherwise.
- Hemorrhagic pericardial effusions occur rapidly and therefore can cause tamponade with even a small amount of fluid. In the case of penetrating trauma with potential cardiac injury, any effusion is worrisome, even in a stable patient.

- **Attributions**

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■ Image References

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- CXR from Radiopedia:
<https://radiologypics.com/2013/02/05/portable-chest-radiograph/>
- POCUS images courtesy of: Northwestern Emergency Medicine POCUS Image Bank and Emory Emergency Medicine POCUS Archive

Case 49 Lab Results

Basic Metabolic Panel:

Na	138 mEq/L
K	4.0 mEq/L
Cl	104 mEq/L
CO ₂	24 mEq/L
BUN	15 mg/dL
Cr	0.9 mg/dL
Gluc	86 mg/dL

Liver Function Panel:

AST	32 U/L
ALT	14 U/L
Alk Phos	90 U/L
T bili	1.1 mg/dL
D bili	0.3 mg/dL
Lipase	40 U/L
Albumin	4.0 g/dL

Complete Blood Count:

WBC	8.2 x 10 ³ /uL
Hb	10.1 g/dL
Hct	30.3%
Plt	285 x 10 ³ /uL

Urinalysis:

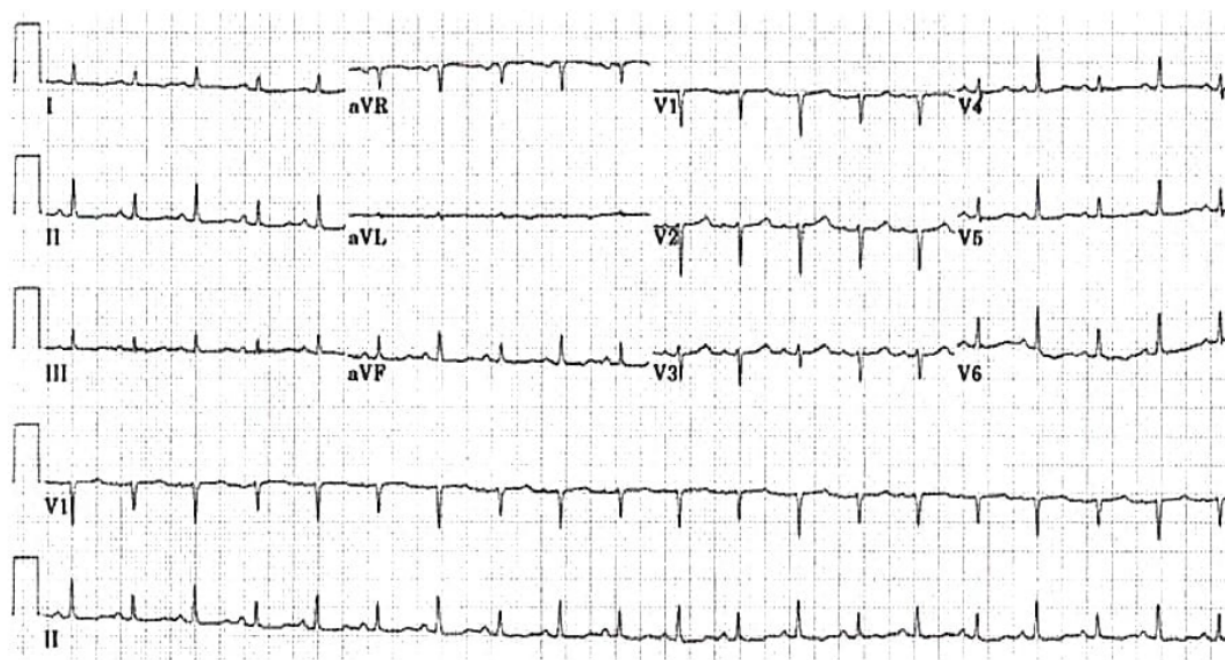
SG	1.018
pH	6.8
Prot	Neg
Gluc	Neg
Ketones	Neg
Bili	Neg
Blood	Neg
LE	Neg
Nitrite	Neg
Color	Yellow

Coagulation Panel:

PT	13.1 sec
INR	1.0
PTT	28 sec

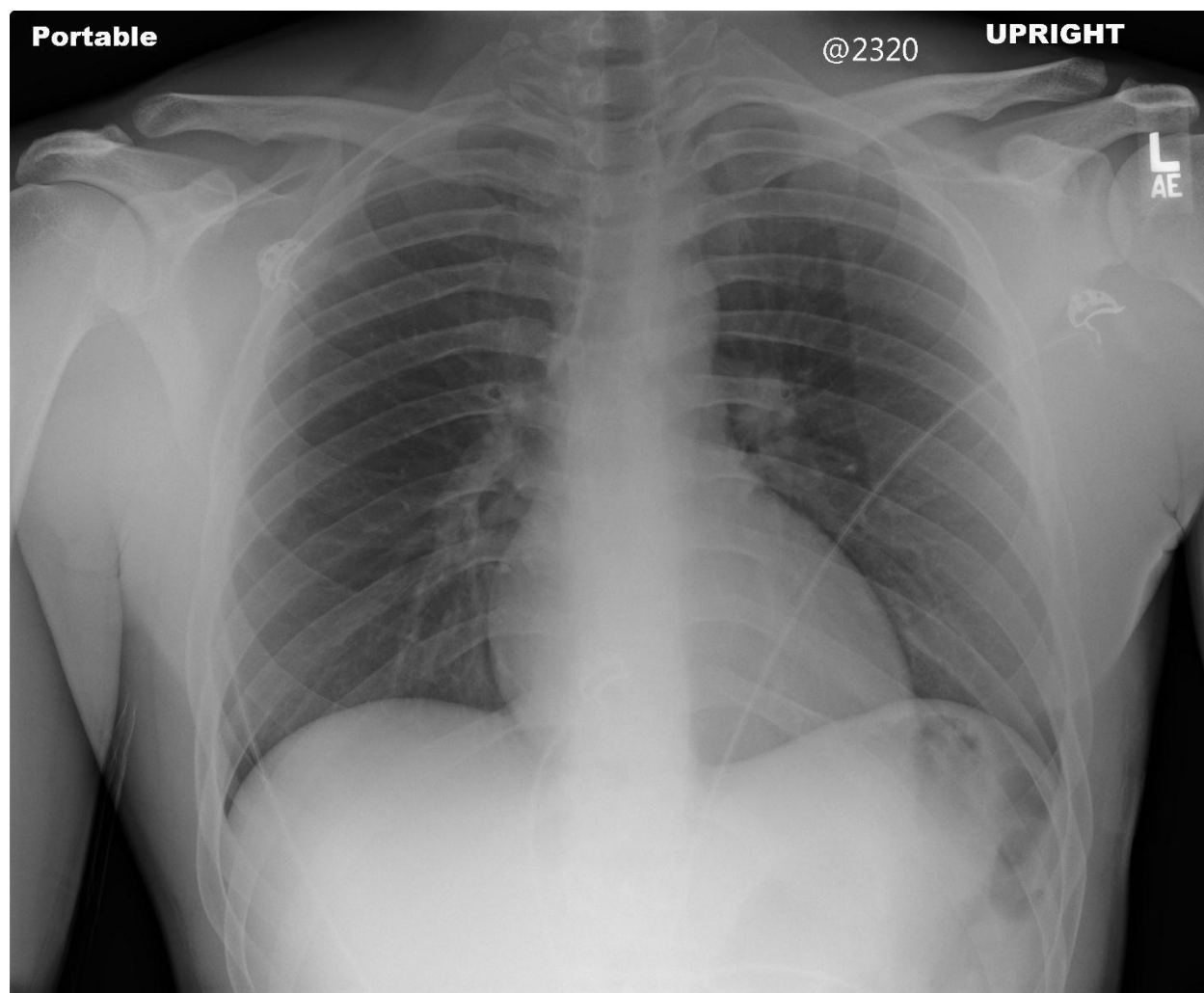
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Figure 49.1- ECG

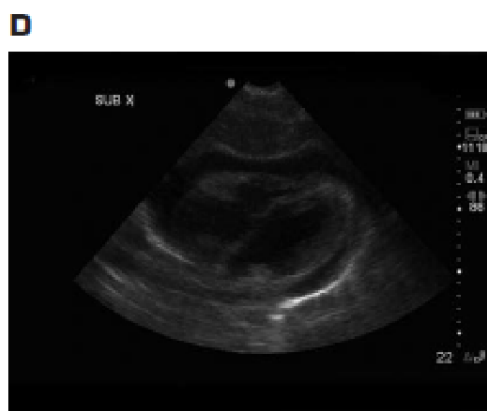


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Figure 49.2- CXR



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Figure 49.3- POCUS e-FAST Exam**A. RUQ****B. LUQ****C. Suprapubic****D. Subxiphoid****E. Right Thoracic****F. Left Thoracic**[Back to case](#) (early)[Back to case](#) (later)

Video 49.4- POCUS e-FAST

- A. [RUQ view](#)
- B. [LUQ view](#)
- C. [Pelvis view](#)
- D. [Subxiphoid view](#)

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