A patient with multiple rib fractures: Imaging modalities and clinical significance

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MS III
Core Radiology Clerkship
Agenda

- Presentation of patient
- Basic anatomy of ribs
- Menu of radiological tests
- When to image the ribs and their significance
- Causes of rib fractures and associated complications
Our Patient

- A 34 year old female pedestrian presents to the ED after being hit by moving vehicle on her left side at a speed of 30mph while crossing street, and landed on the hood of car.

- She had no loss of consciousness.

- She was brought to ED by ambulance.

- Patient was hemodynamically stable with good ventilation. Vital signs were within normal limits and she was AOx3.

- Physical exam was normal except for left sided chest wall pain and a left elbow laceration.

- Her lab work was unremarkable.
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Rib Anatomy

- Thorax consists of the 12 ribs, sternum [with manubrium (M), sternum (S), xiphoid (X)] and clavicle (C).
- Scapula is located posteriorly.
- First 7 ribs are connected with the vertebral column, posteriorly, and with the sternum, anteriorly, by means of the costal cartilages. So called, true ribs
- Ribs 8-10 are attached to the cartilage of the rib above.
- The 11th and 12th ribs are free anteriorly.

A Transverse Diagram of the Thorax

Shown at level of 9th rib
- CVJ – costovertebral junction
- VB – vertebral body
- CCJ – costochondral junction
- S – sternum

Anatomic Correlation

Fracture of the first to third ribs
- extremely rare and more commonly associated with either multiple rib fractures or life-threatening injuries. Fractures of the first rib imply a violent force
- These patterns of fractures may signify injury to the adjacent subclavian vein and brachial plexus
- First rib often fractured posteriorly

Fracture of the fourth to tenth ribs
- 4-10 ribs are most often broken.
- Multiple fractures can present as flail chest
- Inward displacement of the fracture fragments at the time of the injury may lacerate the lung parenchyma, heart and vessels and other internal thoracic structures.

Fractures of eleventh to twelfth
- Risk of hemorrhage around and within the visceral organs
- Fractures of the lower ribs are also commonly associated with liver, spleen, kidneys, and diaphragm

Source: Doty CI and Sinert RH. http://emedicine.medscape.com/article/825981-overview
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Menu of Radiological Tests:

- Chest X-ray
- Computed tomography
- Ultrasound
- MRI
- Bone Scan
- Single Photon Emission CT (SPECT)
Menu of radiological tests: Chest X-ray

- Initial study of choice.
- CXR may miss up to 50% of rib fractures, but is still useful.
- Not sensitive for costal cartilage or stress fracture.
- Also, important for diagnosing processes associated with rib fractures such as:
  - pneumothorax
  - hemothorax
  - pulmonary contusion
  - pneumomediastinum
  - pneumoperitoneum
  - aortic injury.

Source: Bhavnagri SJ and Mohammed TLH.
Our patient: AP Chest X-ray showing fractures of the 4th and 5th Ribs.

There is a subtle step-off pattern.

Patient was imaged with trauma board.
Menu of radiological tests: Ultrasound

Advantages
- more sensitive than chest radiograph (78% vs. 12%).
- Detects costal cartilage fractures and costochondral junction fractures better than radiography.
- view of multiple planes and visualize in real time.
- You can scan entire rib at site of maximal tenderness and then adjacent ribs. Once rib fracture diagnosed, one can quickly rule out pneumothorax and hemothorax as well.

Drawbacks
- Not widely used.
- Time consuming and more costly than plain radiograph.
- Skill dependent
- Can't assess first rib under clavicle and upper ribs under scapula.
- Role limited to situations in which the diagnosis of a rib fracture alone is important

Long-axis view of a fractured left third rib of a patient using a 12-MHz linear transducer. The disruption of the hyperechoic cortical alignment is shown by the arrows.

Menu of radiological tests: Computed Tomography

Advantages
- Best modality to visualize ribs
- May help detect fracture lines, fracture fragments, callus formation, pleural hematoma, or pneumothorax.
- Can be used to evaluate costal cartilage injury.
- Specific bone reconstruction algorithms and 3D reconstructions improve detection by CT.

Disadvantage
- Costly, time consuming, not always available, radiation exposure

Source: Bhavnagri SJ and Mohammed TLH.
Menu of radiological tests: RN Bone Scan, SPECT, MRI

Radionuclide Bone scan
- sensitive but not specific
- Technetium (Tc 99m) methylene diphosphonate bone scanning

SPECT
- can help localize abnormal hot spot on bone
- can represent number of conditions beside rib fracture.
- very sensitive for stress fractures.

MRI
- No role yet in rib fracture evaluation

Source: Bhavnagri SJ and Mohammed TLH.
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When to image the ribs and their significance

Recommended clinical management of patients with a history of chest trauma.

Bhavnagri, SJ and Mohammed, TLH. When and how to image a suspected broken rib. Cleveland journal of medicine. (2009) 76(5):309
When to image the ribs and their significance

- In patients with minor blunt trauma, with little suspicion of associated injury or complication, **plain radiography** is likely sufficient.

- **CT** is imaging study of choice in patients with penetrating or major chest or abdominal trauma.

Rib fractures correlate significantly to mortality and morbidity.

- In elderly, multiple rib fractures are associated with increased number of ventilator days, intensive care unit days, and length of stay (Bulger et al)
  - Pneumonia occurred in 31% of elderly vs. 17% of young and mortality was 22% in elderly vs. 10% in young.

- Mortality increased as number of rib fractures increased. (Sharma et al)
  - Patients with 1 or 2 rib fractures had a 3% mortality rate, and patients with 6 or more fractures had a 32% mortality.

- Fractures can cause flail chest (when two or more ribs are fractured in two or more places) and can lead to ventilatory insufficiency due to ineffective respiratory action. (Doty and Sinert)
  - This condition requires aggressive pain control, pulmonary toilet, and mechanical ventilation.
Why confirm a rib fracture?

1. Detect associated injury
   - pneumothorax, hemothorax pulmonary contusion, flail chest, pneumonia, vascular and nerve damage, abdominal organ injury

2. Prevent complications such as atelectasis and acute respiratory failure

3. Document the injury
   - medical-legal issues especially in cases of assault, motor vehicle crash, occupational injury or abuse

4. Find appropriate pain management
   - undiagnosed patients can have long standing refractory pain.
   - NSAIDs are usually given for soft tissue injury but rib fracture may need narcotics or nerve block.

5. Detect pathologic fractures

6. Count how many ribs are broken
Management of rib fractures

- Uncomplicated rib fractures do not require radiographic diagnosis because it has little impact on patient management.

- Treatment is aimed at pain management

- Operative management of rib fractures still topic of debate and not used widely.

- Indications: flail chest, chest wall deformity, pain and disability, non-union
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Causes of rib fractures

Rib fractures most commonly identified injuries of the chest. 10% of all traumatic injuries and 14% of all chest-wall injuries

- **Trauma**- the most common cause of rib fractures, includes penetrating injuries and blunt injury to the chest wall. MVA, assault, sports, cardiopulmonary resuscitation, physical abuse, and rarely, paroxysms of coughing.

- **Cancer**-causes pathologic fractures. Primary tumors or metastases.

- **Stress fractures** - high level athletes whose activity involves repetitive musculoskeletal loading. Activities include rowing, pitching, throwing, basketball, weight-lifting, ballet, golf, gymnastics, and swimming.

- **Metabolic**- hyperparathyroidism, glucocortical steroid administration, Paget’s disease, gout

- **Inflammatory**- ankylosing spondylitis

- **Infection**

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Back to our Patient: 35 year old female is brought to the ED after being hit by motor vehicle.

- A chest x-ray was performed which showed left sided rib fractures (3-6)

- CT scans of the head, c-spine, abdomen showed no traumatic process.

Fracture of the 6th rib on CT axial view
Our patient had a CT which showed multiple rib fractures.
A CT axial image taken superiorly shows a pneumothorax with pulmonary contusion.
CT image of 5th rib fracture on sagittal view

5th rib fracture seen as hyperdense line
CT coronal view of chest showing fractures of rib 3rd and 5th rib.

PACS, BIDMC

3rd and 5th rib fractures. Patient also has fractures of 4th and 6th rib which are not visible on this plane.
Rib fracture with callus formation in 76-year-old man. CT image shows well-defined fracture (arrow) and periosteal callus formation (c).

Case continued…

- Patient was admitted to the medicine floor with chest pulmonary toilet and pain control.

- Days later, she transferred to the intensive care unit with worsening respirations, partly due to pain control for her rib fractures and her worsening contusions. She was intubated electively in the intensive care unit.

- She later developed a pneumonia, which was treated with levofloxacin. She remained on the ventilator for one week and was later extubated and transported to the medicine floor.

- She was discharged in a good condition
Here are two more examples...
Companion patient # 2. CT of a 40 M after 18ft fall with multiple rib fractures on coronal view.

He suffered a hemopneumothorax, grade III splenic laceration and an adrenal hematoma (not visible on image)
Companion patient #3. CT of a 60M post MVC with flail chest (rib fractures 6-12), pulmonary contusion, grade V shattered spleen, and shock bowel.
Take Home Points

- Rib fractures are common pathologies.
- Most are managed conservatively.
- Confirmation is important, however, because rib fractures can have associated complications.
References

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