Blunt Thoracic Trauma:

Rib fractures, flail chest, and pulmonary contusion

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Outline

- Introduction
- Mechanisms of injury
- Rib fractures
- Flail chest
- Pulmonary contusion
- Conclusion

Introduction

About Blunt Thoracic Trauma…

- Causes a variety of injuries
  - Simple abrasions and contusions
  - Life-threatening insults to thoracic viscera
- Associated with high morbidity
- 20% of all trauma deaths involve chest injury
  - Second only to head and spinal cord injuries

Picture courtesy of ctsnet.org

About Blunt Thoracic Trauma…

- Most thoracic injuries don't require major intervention
  - Tube thoracostomy
  - Mechanical ventilation
  - Analgesia for pain control
  - Supportive care

Picture courtesy of
http://www.itim.nsw.gov.au/images/chest_tube.jpg

About Blunt Thoracic Trauma…

- Elderly and pts with diminished pulmonary reserve
  - Most vulnerable for respiratory deterioration
  - Higher mortality
  - Require critical care observation

Mechanisms of injury

Motor vehicle crashes are the overwhelming etiology

- 44% of 98,000 unintentional injuries in the US in 2001 were caused by MVCs
- Disabling injuries from MVCs occur every 14 seconds
- Estimated 7% risk of serious thoracic injury with any MVC
- In US, ~1,500 pts present with a life-threatening thoracic injury each day from MVCs alone.

Less Common Causes of Injury

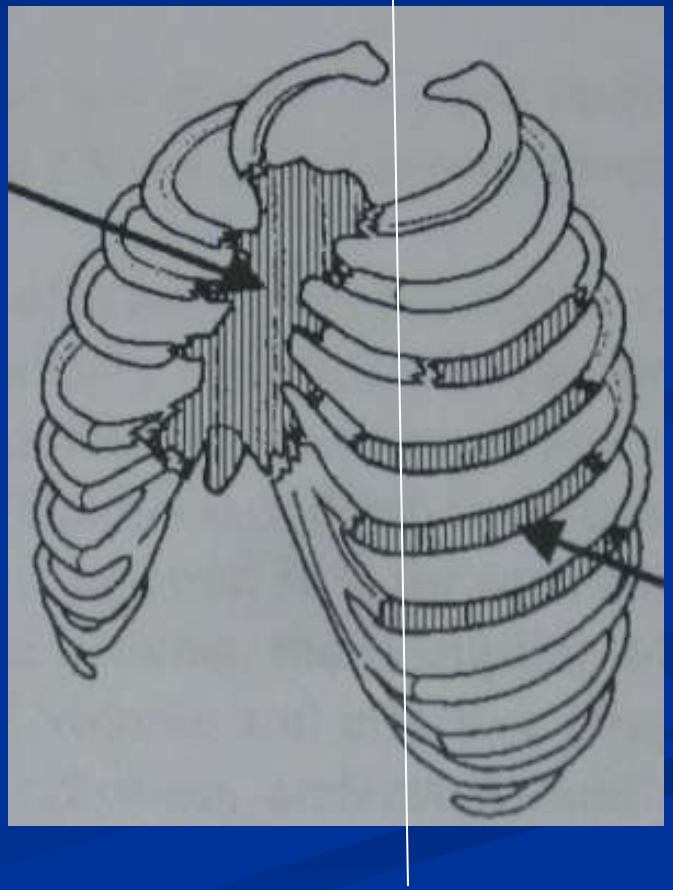
- Falls from height
- Occupational or recreational-related crush injuries
- Assaults

Three types of blunt force leading to thoracic injury

- Compression
- Shearing
- Blast

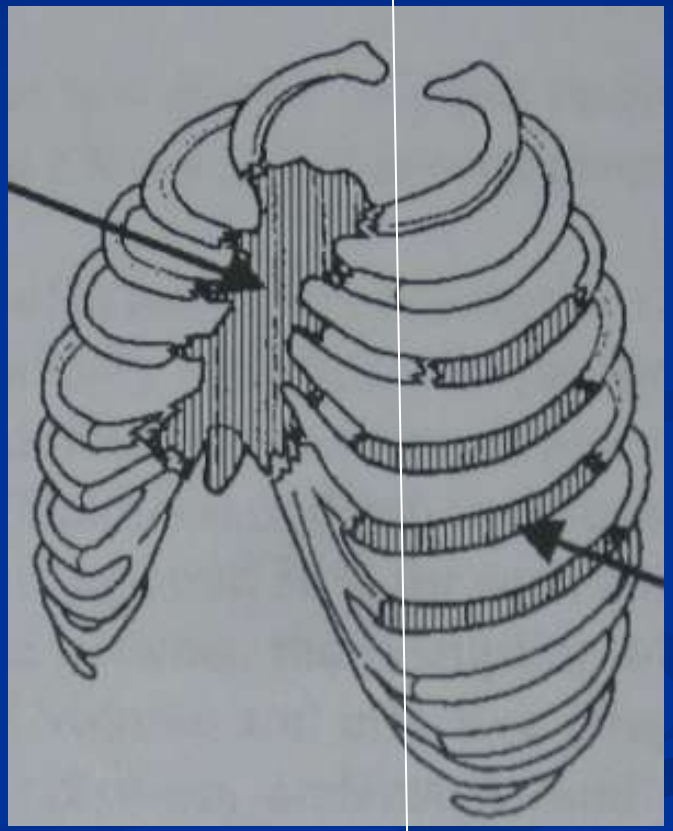
Compression

- Rib fxs occur when applied force to chest exceeds strength of thoracic cage
  - Area of rib weakness is at 60° rotation from the sternum
  - Ribs subjected to lateral or AP compression will fracture at 60° and posteriorly



Compression

- AP compression can create costochondral disruption → sternal flail



Shearing

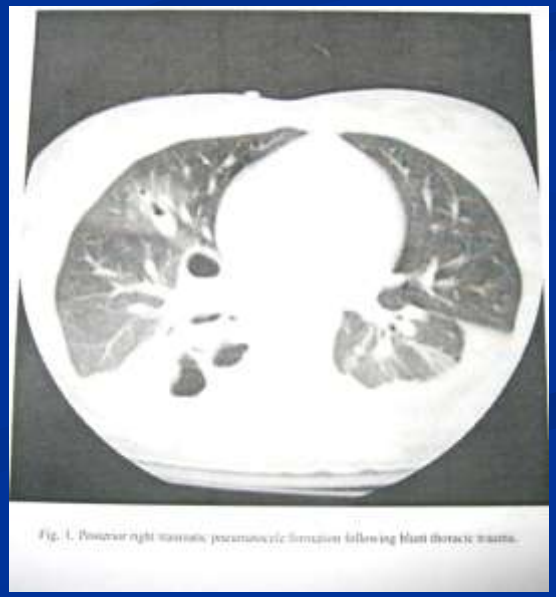
- Due to rapid acceleration and deceleration
- Causes soft tissue and vascular injury
- Soft tissue and vascular organ movement is restricted to anatomic and developmental attachments
- If tensile strength of attached tissue is exceeded, tearing or rupture will occur.

Shearing

- EX: Aortic transection
  - Aorta is tethered by ligamentum arteriosum and the vertebrae below
  - Junction of the more mobile arch and the stationary descending aorta is most common site for disruption.

Shearing

- Lung:
  - Laceration
  - Hematoma
  - Contusion
  - Pneumatocele



Blast injury

- Deadly
  - Due to pressure wave of the blast
  - Victim can be launched considerable distances
  - Surrounding debris become missiles

Blast injury

- Explosions in closed space are more severe
  - Pressure waves are reflected back to the patient, intensifying injury from original blast.
- Typical pulmonary injury: contusion with edema and alveolar hemorrhage.

Rib fractures

Rib fractures

- Difficult to determine prevalence among seriously injured patients
- AP CXR is not very sensitive for detection
- National trauma registries track top THREE diagnoses per pt
  - Rib fxs may not be included for multiply-injured pts.

Rib fractures

- Marker for serious intrathoracic and abdominal injury
- Source of significant pain
- Predictor of pulmonary deterioration, especially in elderly

Rib fractures

- 84-94% of pts with rib fxs have significant associated injuries
  - Pneumothorax
  - Hemothorax
  - Pulmonary contusion
  - Liver laceration or contusion
    - 8th rib or below → 19-56% probability of injury
  - Splenic laceration or contusion
    - 8th rib or below → 22-28% probability of injury

Rib fractures

- Diagnosis
  - CXR
  - Movement toward CT imaging in many centers to evaluate for associated injuries
  - 65% of pts that sustained significant blunt chest trauma who have admission chest CT have other injuries missed by CXR

Rib fractures

- Omnious in CHILDREN
  - Children's bones lack calcification
  - Rib cages are more compliant than that of adults
  - Fxs in children indicate HIGHER absorption of energy than in adults

Rib fractures

- Omnious in CHILDREN
  - Though absence of rib fxs makes significant intrathoracic injuries less likely, this is not zero.
  - 2% of 986 pediatric pts had significant injury following blunt chest trauma, without evidence of rib fractures.
  - 38% of children with pulmonary contusion injury DO NOT have evidence of rib fxs

Rib fractures

- Ominous in ELDERLY
  - Rib fractrures from minimal trauma (ex. ground level falls) make up 12% of all skeletal fractures in elderly
- Osteoporosis, loss of muscle mass, and comorbidities
  - Decrease force required to cause rib fxs
  - Decrease physiologic reserve available to tolerate injury

Rib fractures

- Ominous in ELDERLY
  - Pts with rib fxs older than 65 have TWICE the mortality and thoracic morbidity of pts ≤ 64.
  - Risk of pneumonia increases by 27%
  - Mortality increases by 19% for each addt'l rib fx.

Pain management

Type	Oral or IV NSAIDS or narcotics	Intercostal nerve blocks	Thoracic epidurals
Pros	Can discharge with oral medications	Effective	Controls pain without sedation. *(Found to be indep predictor of decreased mortality and incidence of pulm complications.)*
Cons	Not immediately effective in acute phase of injury. Narcotics cause respiratory depression.	Require reinjection	Requires thoracic spine clearance, and holding of anticoagulation

Flail Chest

Flail chest

- Rare; prevalence among pts with blunt chest wall injury is ~5-13%
- Most serious of the blunt chest wall injuries
- Paradoxical motion of flail segment in spontaneously breathing patient

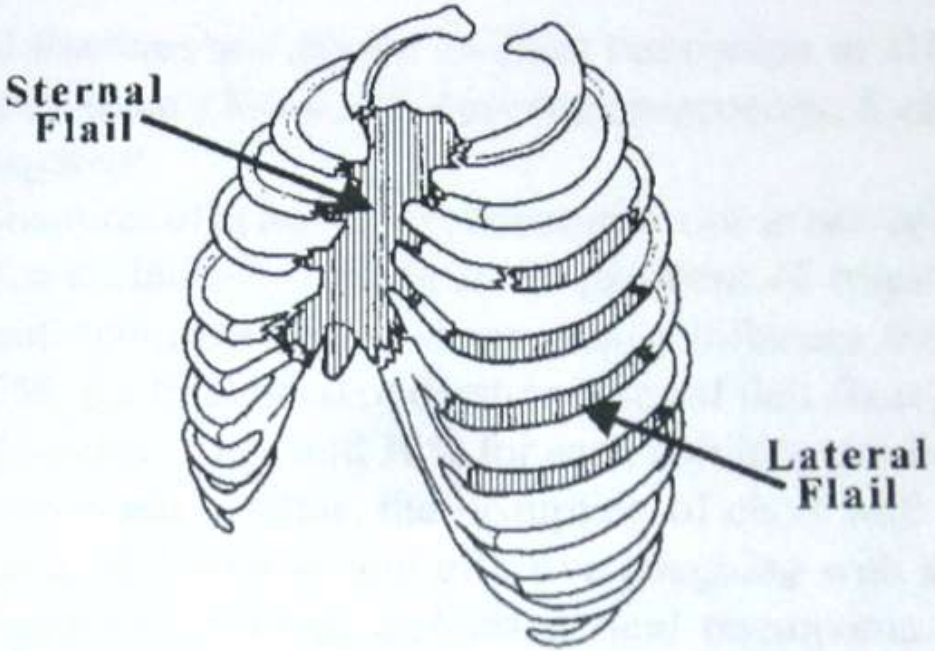


Fig. 2. Two types of flail chest: sternal and lateral. (*From* Mayberry JC, Trunkey DD. The fractured rib in chest wall trauma. Chest Surg Clin N Am 1997;7:239–61; with permission.)

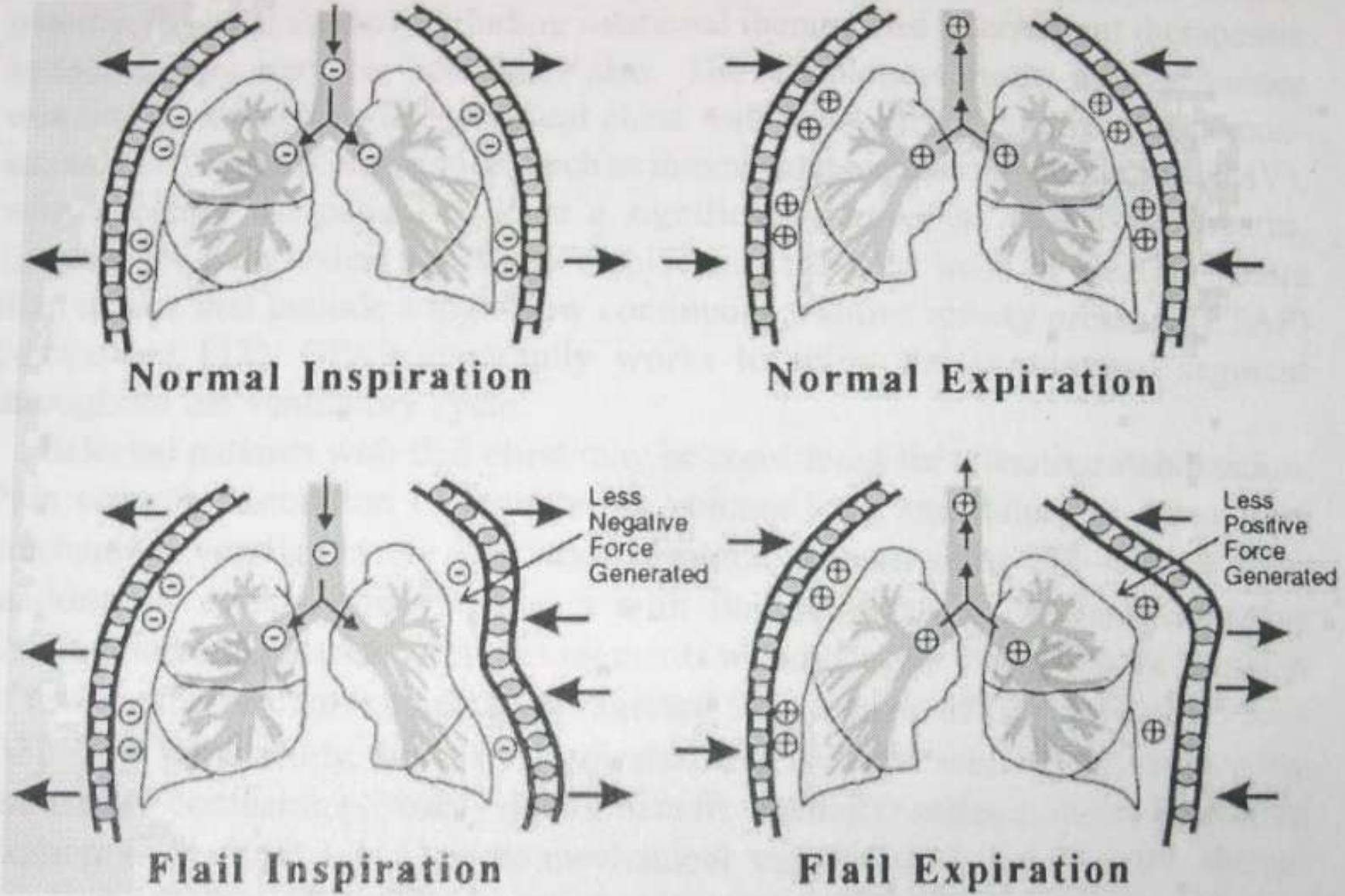


Fig. 3. Flail chest physiology. (*From* Mayberry JC, Trunkey DD. The fractured rib in chest wall trauma. Chest Surg Clin N Am 1997;7:239–61; with permission.)

Flail Chest

- On inspiration, flail segment is pulled in by negative intrathoracic pressure.
- On exhalation, positive pressure forces segment to protrude outward.

Diagnosis

- Muscular splinting of chest may mask the paradoxical motion until flail becomes apparent upon development of fatigue.

- In mechanically vented pts, high degree of suspicion, a good physical examination looking for crepitance and fractures, and review of imaging are key to diagnosis.

Flail chest

- Clinically significant impairment of respiratory function occurs with fractures of at least FOUR consecutive ribs.

- Pt's comorbidities and age influence the clinical effect.

Flail chest

- With age >55, likelihood of death increases:
  - 132% for every 10-year increase in age
  - 30% for each unit increase in ISS.

- In non-intubated patients, there is a dramatic decrease in tidal volume and effective coughing
  - → sputum retention, atelectasis, and pneumonia

Flail chest

- Pulmonary contusion also contributes to development of bronchial obstruction and intrapulmonary shunting.

Treatment

- Low threshold for intubation
  - Especially in patients with medical comorbidities and the elderly
- Early intubation in pts age ≥ 30 w/moderate-to-severe had 6% mortality
  - If intubation was withheld for 24 hrs until they developed evidence of hypoxia or hypercapnia → mortality > 50%

Treatment

- 68% of pts with flail chest and resp failure are extubated by the third post-injury day
- Yet, with more severe resp failure, patients will require prolonged vent support and possibly tracheostomy.

Treatment

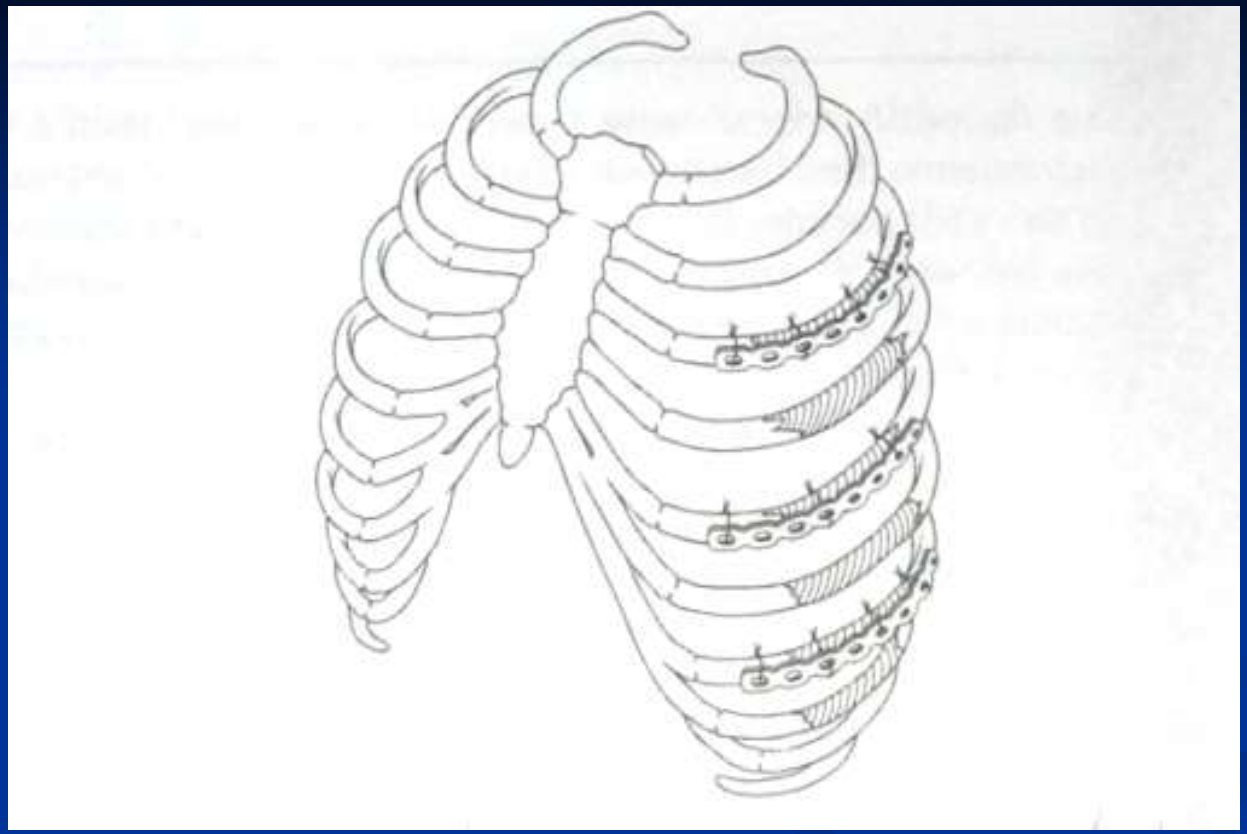
- Pulmonary toilet:
  - Assess efficacy by incentive spirometer or Acapella device
  - Assess effectiveness of cough
  - Chest physiotherapy
  - Therapeutic bronchoscopy

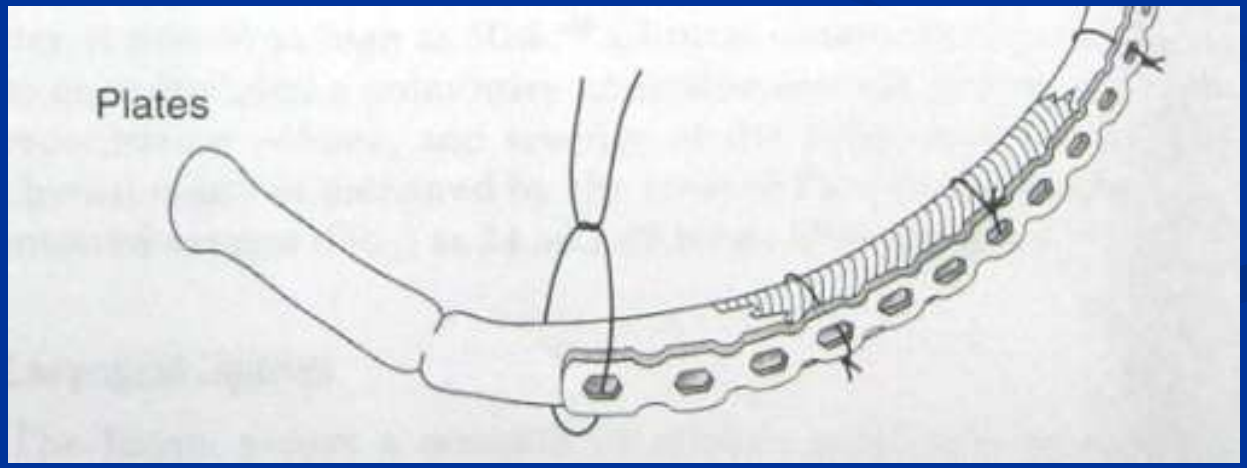
Treatment

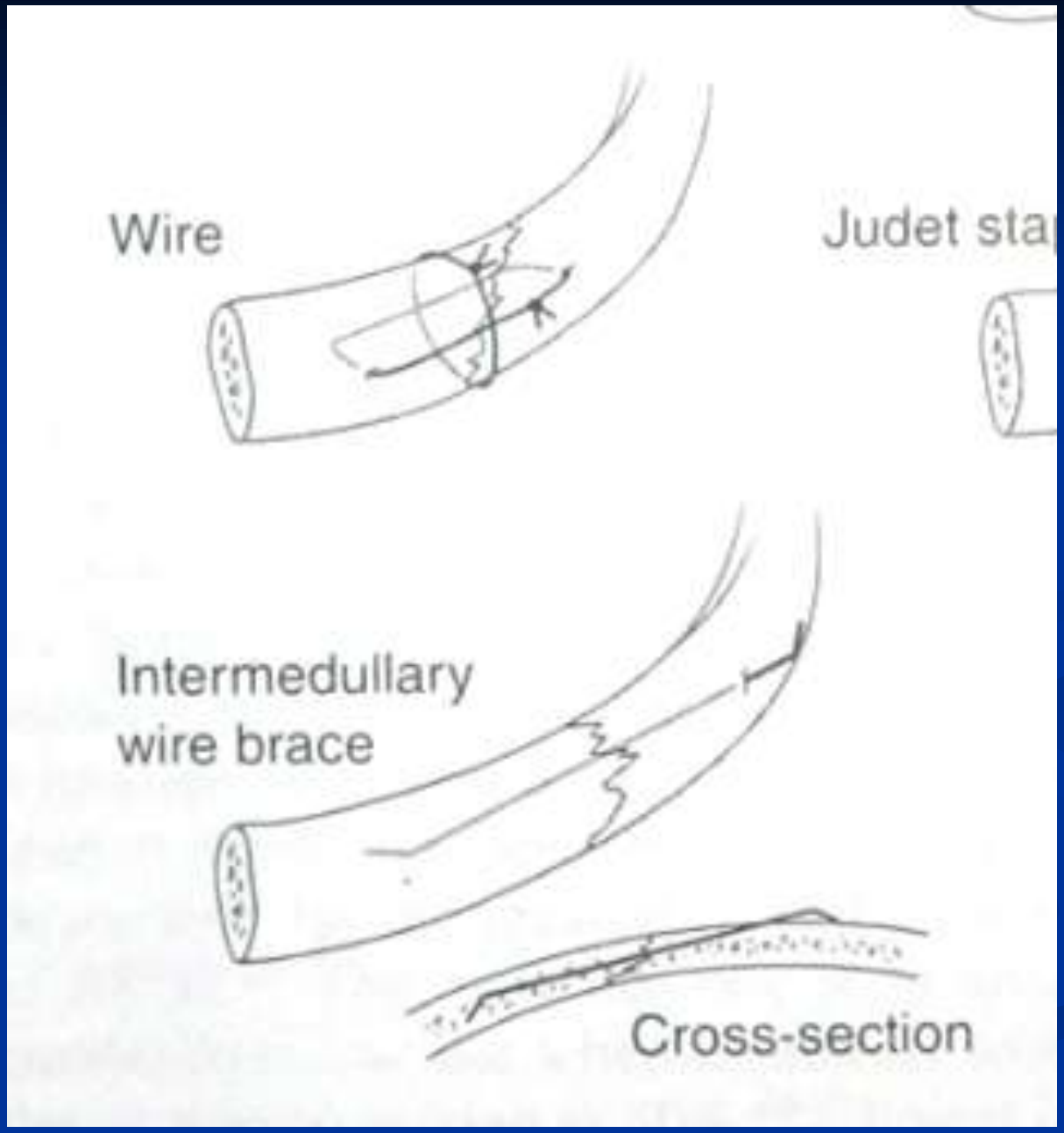
- Vent modes
  - Modes with unassisted breaths (i.e IMV) increase paradoxical chest wall movement → work of breathing
  - Supported breaths and CPAP are preferred

Treatment

- Criteria for operative stabilization
  - Pain control
  - Restoration of hemithorax volume loss
  - Failure to wean from mechanical ventilation




Plates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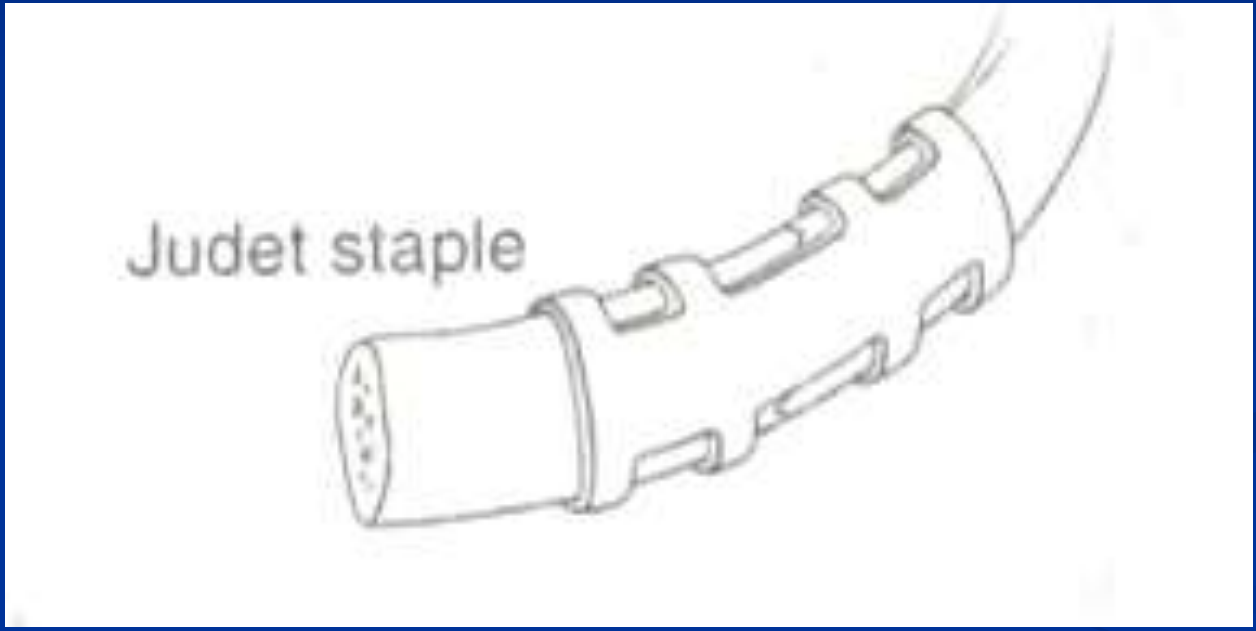
Intermedullary
wire brace
Cross-section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Treatment Considerations

- Intercostal nerve entrapment
- Weak, osteoporotic ribs
- Tension on fixation (as ribs not only move up and down, but in and out)

Treatment

- Nonrandomized study of pts with flail chest who were and were not treated with operative stabilization:
  - # of days (mean) on ventilator
    - 26.7 for non-operative group
    - 6.5 for operative group
  - Shorter ICU stay, lower pneumonia rate, and lower mortality

Voggenreiter G *et al. J Am Coll Surg.*1998;187:130-48.

Treatment

- Kirchner wires and vent vs. vent alone
  - # days on vent (K-wire): 1.3 days
  - # days on vent (vent alone): 15 days
  - Shorter ICU stay, lower pneumonia rate, and lower mortality in K-wire group

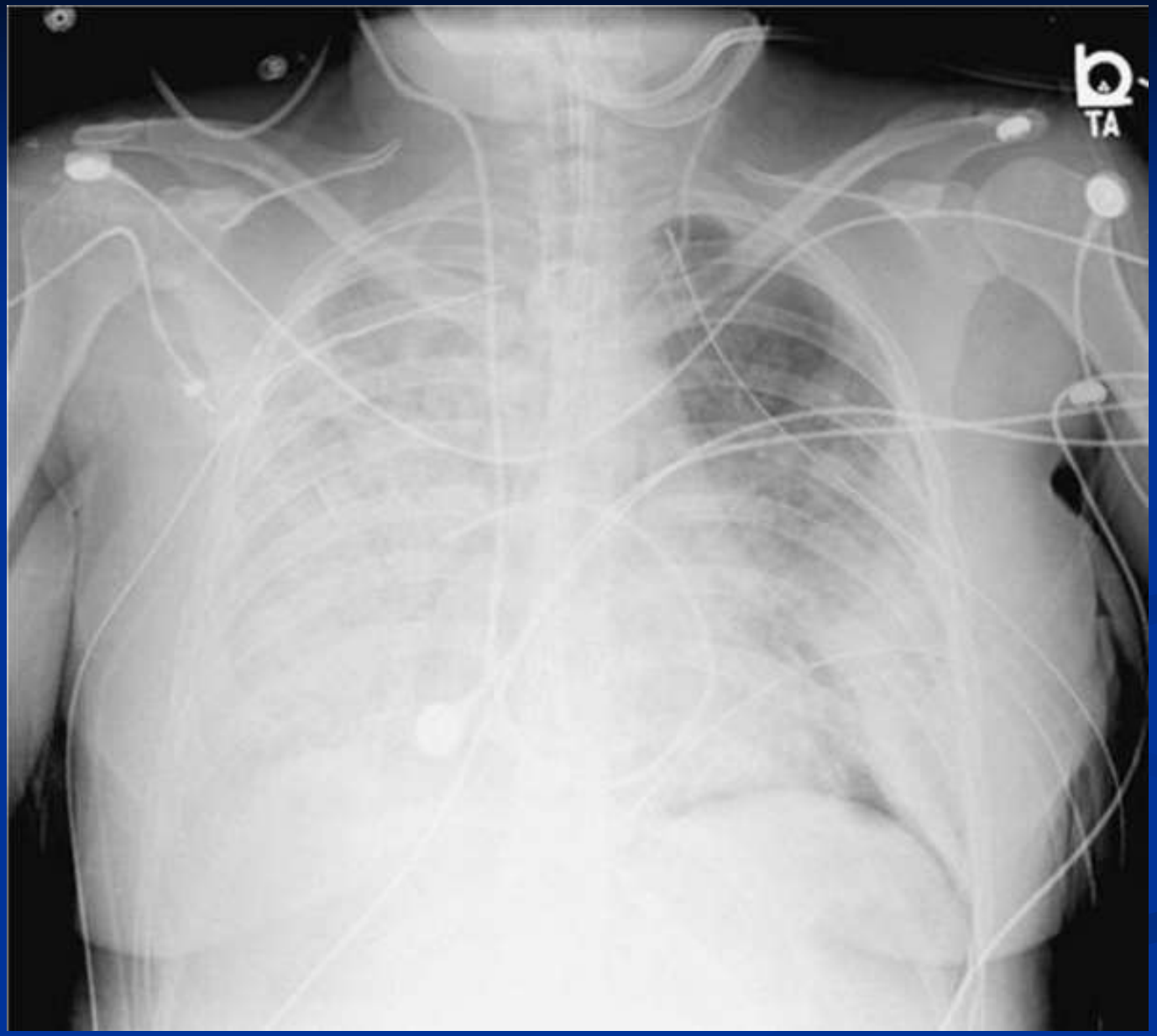
Ahmed Z *et al. J Thor Cardiovasc Surg.* 1995;110:1676-80.

Pulmonary contusion

Pulmonary contusion

- Should be anticipated in pts who sustain significant high-energy blunt chest impact

- **Mechanism** of inciting event and physical findings of **fractures** or **flail segment** increase probability of having pulmonary contusion.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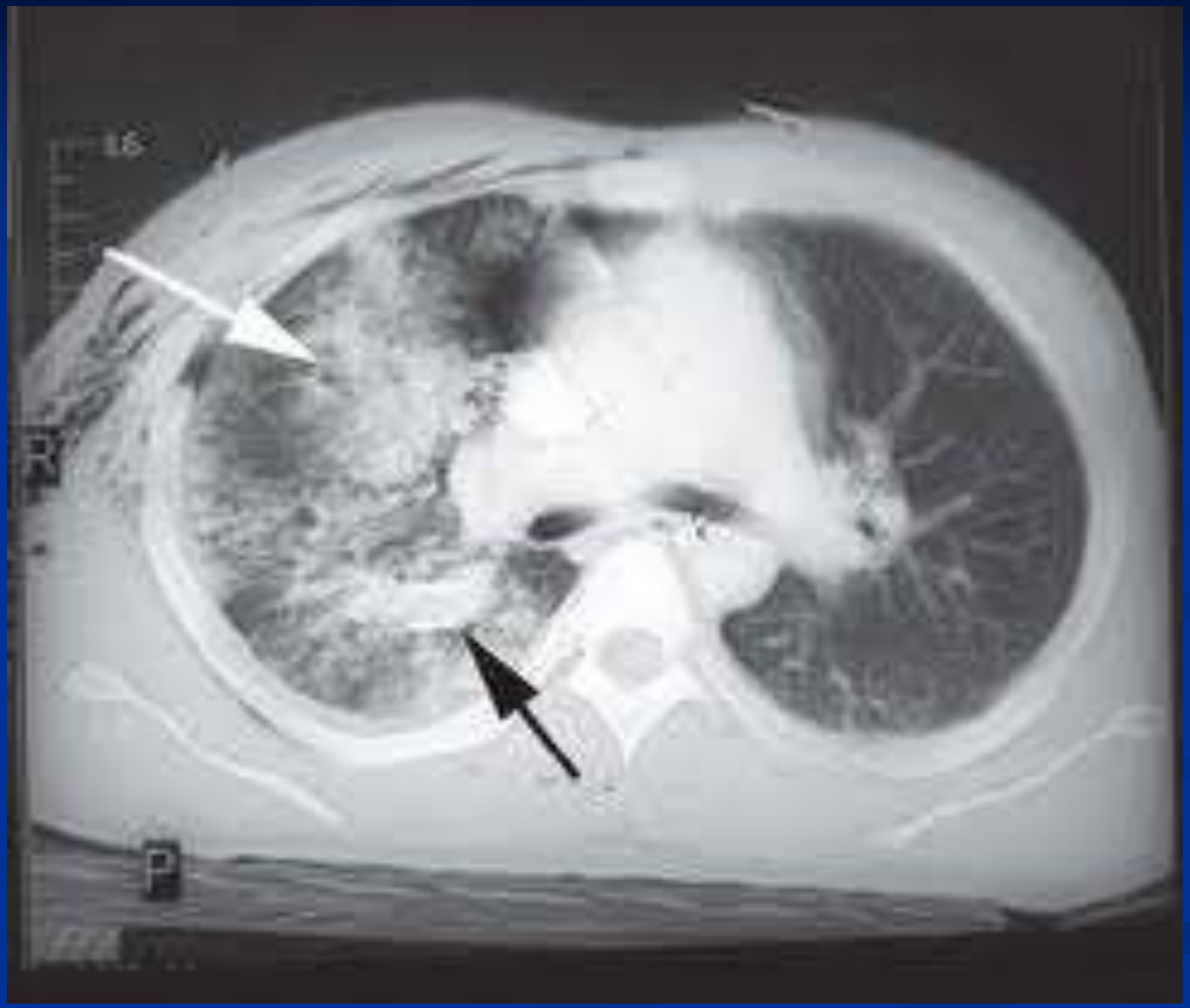
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Diagnosis

- Focal or diffuse opacification on chest x-ray
- Opacification is irregular, does not conform to segments or lobes within lung (unlike aspiration pneumonitis)
- Not always immediately apparent radiographically.
- 1/3rd of pts don't have any evidence on initial CXR

Diagnosis

- Mean time for CXR opacification is 6 hours
- May take up to 48 hours for pulmonary contusion to become evident on CXR
- CT chest is more sensitive for diagnosis, but no changes in management or outcome are associated with their use in pulmonary contusion alone

Treatment

- Pts with pulm contusion > 28% of total volume required intubation.
  - No patients with < 18% contusion required intubation.
- Supportive therapy
  - supplemental oxygen for hypoxia
  - pulmonary toilet: coughing, deep breathing and suctioning

Treatment

- Address associated injuries (i.e. thoracostomy tubes for hemopneumothorax)

- Prophylactic intubation without signs of impending respiratory failure is not indicated.

Fluid management

- Traditional thinking suggests that overzealous use of crystalloids causes exacerbation of hypoxia
  - Not substantiated by data
- Standard resuscitation for euvolemia ideal especially in setting of other traumatic injuries

Treatment

- Steroids show no benefit and may impair bacterial clearance

- Empiric use of antibiotics is not warranted
  - May foster development of resistant organisms
  - Should be reserved for treatment of specific organisms in setting of superimposed pneumonia

Conclusions

- Most cases of blunt thoracic trauma don't require major intervention
- Rib fractures are omnious in children and the elderly
- Pulmonary toilet and analgesia are the mainstay for treatment

Conclusions

- Operative fixation should be considered for flail chest segments to restore thoracic volume or for patients with persistent respiratory failure.
- Patients with pulmonary contusion need supportive care, with intubation for cases in respiratory failure.
- Prophylactic intubation is not necessary for pulmonary contusion in the absence of respiratory failure.

Conclusions

- Antibiotics and steroids are not necessary and make no difference in the management of pulmonary contusion.

- Fluid management should include adequate resuscitation for the multi-injured trauma patient.

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