Outline

- Pathophysiology
- Etiology
- Signs & Symptoms
- Lab Data
- Respiratory care Intervention
Costosternal Syndrome

- Sternum (Breastbone)
- Cartilage
- Broken Rib
- Costochondral Separation
Chest Wall Pain

- Chest Wall Pain:
  - costochondritis or
  - costosternal syndrome or
  - costosternal chondrodynia

- Chest wall pain present along with swelling is known as Tietze syndrome.

- Cartilage connecting rib to sternum becomes inflamed, resulting in sharp pain at costosternal joint.

- Pain of costochondritis may imitate MI or other heart problems.

- Most chest wall pain does not demonstrate cause
  - Treatment concentrates on relieving pain
  - Disease generally resolves on its own
Causes of Chest Wall Pain:

- **Injury:** Direct blow to chest
- **Physical Strain:** Strenuous exercise and heavy lifting
- **Arthritis:** Rheumatoid arthritis, ankylosing spondylitis, and osteoarthritis
- **Joint Infection:** Bacteria, fungi, or viruses infecting joints of the ribs
- **Tumors:** Cancer may spread to joint from any other part of body like the thyroid, lung, and breast
- **Infection:** Costosternal joint infection often causes pain in chest wall
Costosternal Syndrome
Signs & Symptoms of Chest Wall Pain

- Pain and tenderness along breastbone
- Chest wall pain affecting more than one rib
- Pain worsens upon taking deep breaths or coughing
- Difficulty breathing
Diagnosis of Chest Wall Pain

- May mimic heart attack, other heart or GI problems
- Thorough subjective and physical examination required
- Tenderness or swelling in breastbone areas may be seen during physical examination
- Diagnostic tests to rule out other conditions may include:
  - Chest radiograph
  - Electrocardiogram
Medications for Chest Wall Pain

- **Nonsteroidal Anti-Inflammatory Drugs (NSAIDs):** naproxen and ibuprofen may be prescribed
- **Narcotics:** codeine-containing codeine include oxycodone and hydrocodone
  - Opioid analgesics
- **Antidepressants:** tricyclic antidepressants like amitriptyline
- **Anti-Seizure Drugs:** gabapentin
Pectus Excavatum
Pectus Excavatum

- Musculoskeletal disorder
- Sunken or funnel chest
- Congenital chest wall deformity
- Several ribs and sternum grow abnormally
- Produce concave, or caved-in, appearance in anterior chest wall
Pectus Excavatum
Concave anterior chest wall
• lower third of sternum usually
Pectus Excavatum: Pathophysiology

- Abnormal bone and cartilage growth in anterior chest wall (overgrowth)
- Ribs 4 & 5 on each side of sternum usually
- Defect widely varies from mild to very severe
- Some patients present with significant asymmetry between right and left sides
- Mechanism of abnormal bone and cartilage overgrowth not known
Pectus Excavatum: Epidemiology

- Most common congenital chest wall abnormality (90%); pectus carinatum (5-7%)
- 1 in 300 to 400 births (male-to-female ratio 3:1)
- Noticed at birth
- >90% of cases diagnosed within 1st year of life
- No known genetic defect
- Familial occurrence is 35%
- Most prevalent among Caucasians
Pectus Excavatum: Signs & Symptoms

- Worsening chest appearance and onset of symptoms reported during rapid bone growth in early teenage years (puberty); > 10 years
- Many patients not seen by pediatric surgeon until patient and family notice such changes
- Chest appearance often disturbing to young teenagers
- Problems with self-esteem and body image perception frequently reported
- Psychological disturbances not unusual in older patients
Many patients are asymptomatic functionally.

Lung compression and cardiac displacement may cause cardiopulmonary impairment.

Cardiac function is usually normal.

Mitral valve prolapse reported in 20%-60%.

Echocardiography often shows atrial compression and cardiac displacement.
Pectus Excavatum: Signs & Symptoms

- Abnormal exercise tolerance frequently reported
- SOB during exertion results from reduced pulmonary reserve
- Frequently associated with scoliosis
- Restrictive PFT pattern in severe cases
- Lung sounds clear, but may be diminished at bases because of decreased lung volumes
In severe cases (sternum almost contacting spinal column), breastbone may compress lungs and heart:

- Decreased exercise tolerance
- Rapid heartbeat or heart palpitations
- Recurrent respiratory infections
- Wheezing or coughing
- Chest pain
- Heart murmur
- Fatigue
Pectus Carinatum
Pectus Carinatum Pathophysiology

- Musculoskeletal disorder
- Anterior chest wall protrusion abnormality
- Classified as either
  - Chondrogladiolar (sternum & costal cartilages)
  - Chondromanubrial (manubrium & costal cartilages)
    - (Cardiac and hemodynamic changes more commonly observed in patients with chondromanubrial prominence)

depending on the site of greatest prominence
Chondromanubrial
Chondrogladiolar
Pectus Carinatum

Signs & Symptoms

- Called “pigeon breast”
- Dyspnea, usually on exertion
- Decreased endurance
- Some patients develop rigidity of chest wall
  - AP diameter almost fixed in full inspiration
  - Vital capacity reduced
  - Decreased lung compliance
  - Progressive emphysema
  - Increased frequency of respiratory tract infections
  - Alveolar hypoventilation
    - Hypoxemia & polycythemia
    - Hypercapnia
  - Cor pulmonale

Dyspnea, usually on exertion

Decreased endurance

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Pectus Carinatum
Signs & Symptoms

- Tenderness and intermittent pain near overgrown cartilage
- Many patients have no physical complaints
  - Poor body image
  - Low self-esteem
  - Decreased mental quality of life
Pectus Carinatum

Etiology

- Cause has not been established
- Tends to run in families, suggesting genetic link
- Increased incidence of positive family history
- Suggested abnormality in connective tissue development
- Associated with overgrowth of rib cage during development of chest wall
- 25% of patients have positive family history of some chest wall deformity
Pectus Carinatum Epidemiology

- Less prevalent than pectus excavatum
- More frequent among Caucasians than Blacks and Asians
- Males 4 times more afflicted than females
- Although present from birth
  - often identified in mid-childhood (11-15 years)
  - deformity often worsens during adolescence
Pectus Carinatum Diagnosis

- Thorough physical exam
- Detailed family history
- Chest radiography determines severity of abnormality
- Computed tomography (CT) or magnetic resonance imaging (MRI) to define chest's anatomy
- Echocardiogram and electrocardiogram to test heart function
- Pulmonary function tests to detect breathing problems
Pectus Carinatum Management

- Surgical repair rarely performed only for cosmetic reasons
- Braces helpful in 65% to 75% of cases
  - External pressure bracing technique corrects deformity by slowly reconfiguring chest wall
  - Customized brace has compression plates positioned front and back of chest adjusted to apply different pressures
  - Brace worn about 16 hours a day for up to two years
    - Good results achieved when teenage patients consistently wear braces for allotted times each day
- Morbidity in later years includes cardiac and hemodynamic changes
Pectus Carinatum Management

- Surgical correction involves chest incision and removal of abnormal cartilage next to sternum
- Ribs are re-formed using small, stainless steel wires
- Procedure requires 4- to 5-day hospital stay following surgery
  - Pain medication for several weeks to manage discomfort
  - Moderate-to-severe cases can be treated effectively by bracing or surgery
Kyphoscoliosis
Kyphoscoliosis Pathophysiology

- Musculoskeletal disorder
- Lateral and posterior curvature of thoracic spine
- Characterized by abnormal curvature of vertebral column in two planes
  - Coronal (frontal plane)
  - Sagittal
- Combination of kyphosis and scoliosis
- Can cause pulmonary hypertension
Coronal: divides body into front (ventral) & back (dorsal).

Sagittal: divides body into right & left sides (closest to midline is medial; furthest away is lateral).

Transverse: divides body into top & bottom (superior & inferior).
Kyphoscoliosis Pathophysiology

- Chest wall compresses lungs
- Restricts thoracic and alveolar expansion
  - Alveolar hypoventilation
  - Atelectasis
- Impaired cough and secretion retention
  - More atelectasis
- Mediastinal shift in same direction as lateral spine curvature
- Increased anatomical dead space ventilation
Kyphoscoliosis Etiology

- Idiopathic in origin
- Affects 1% to 2% of US population
  - 1 to 2 people per 10,000
- Appears mostly in children during growth spurts
- May also be congenital
- Risk factors
  - Trauma to spinal column
  - Legs of different length
Kyphoscoliosis
Laboratory Data

- **Vital signs:**
  - Tachypnea
  - Tachycardia
  - Hypertension

- **Pulmonary function testing (mod to severe):**
  - Restrictive abnormality

- **Arterial blood gases:**
  - Mild to moderate: acute respiratory alkalosis with mild to moderate hypoxemia
  - Severe: compensated respiratory acidosis with moderate to severe hypoxemia
Kyphoscoliosis Laboratory Data

- Chest physical exam:
  - Often visibly apparent
  - Short in stature
  - Breath sounds vary regionally

- Cor pulmonale:
  - Chronic hypoxemia (V/Q mismatch)
  - Polycythemia

- Radiographic findings:
  - Important for diagnosis and pre-surgical review
  - Mediastinal shift
  - MRI useful for pre-surgical evaluation
Kyphoscoliosis
Laboratory Data

- Medications:
  - NSAIDS
  - Possibly muscle relaxants
Kyphoscoliosis Respiratory Management

- Oxygen therapy protocol
- Bronchial hygiene therapy protocol
  - Often have permanent tracheostomy
    - Decreases anatomical dead space volume
    - Increases alveolar volume
- Aerosol/humidity therapy protocol
- Mechanical ventilation protocol
Pneumothorax
Definition:

- Collection of air in the pleural space (cavity) or within the pleura
Pneumothorax

- Types of pneumothoraces
  - Open pneumothorax
    - Trauma
  - Closed pneumothorax
    - Emphysema: rupture of pleural blebs
  - Spontaneous pneumothorax
    - Often among tall, thin young men
  - Tension pneumothorax
    - Air enters pleural space, but cannot leave (trauma)
    - Ingress of air; no egress of air
  - Iatrogenic
    - Caused by a medical procedure, e.g., CVP line insertion, thoracentesis
  - Catamenial
    - Young women during menstruation usually on right side
Pneumothorax

- Signs & symptoms*
  - Respiratory distress
  - Pleuritic chest pain
  - SOB
  - Tachypnea
  - Tachycardia
  - Asymmetrical chest wall movement
    - Ipsilateral side: movement diminished
  - Auscultation
    - Ipsilateral side: distant or absent
  - Percussion
    - Ipsilateral side: hyperresonance
  - Cyanosis

*The presence of mediastinal shift depends on the volume of air collecting in pleural cavity.
Pneumothorax

- **Radiography**
  - **Supine:**
    - Deep sulcus sign
      - Air collects anteriorly and basally within the non-dependent portions of the pleural space
      - Costophrenic angle on ipsilateral side deepens when air collects laterally
    - Depression of ipsilateral hemidiaphragm
    - Compression atelectasis of normal (contralateral) lung
  - **Upright:**
    - Air collects apically
Pneumothorax distribution
Supine

Visceral pleura

Parietal pleura

Pneumothorax: air in pleural space

lung
Deep Sulcus Sign:
deep costophrenic angle

Supine chest radiograph

Deep Sulcus Sign

Left pneumothorax
Pneumothorax

Closed pneumothorax

Open pneumothorax

Tension pneumothorax

Air in pleural space

Air in pleural space

Air in pleural space accumulating

The pleural cavity pressure is < the atmospheric pressure

The pleural cavity pressure is = the atmospheric pressure

The pleural cavity pressure is > the atmospheric pressure
Pneumothorax

The difference between a closed and open pneumothorax depends on the type of trauma that caused either an open wound or a closed wound.

Pressure in pleural cavity less than atmospheric pressure.

Pressure in pleural cavity equal to atmospheric pressure.
Open Pneumothorax

Signs & Symptoms
- Gurgling sound during respiration
- Bubbling wound
- Dyspnea
- Tachypnea
- Diminished breath sound
THORAX - Air in the pleural cavity, resulting in lung collapse...

- Dyspnea
- Anxiety
- Tachycardia
- Pleural Pain
- Asymmetrical Chest Wall Expansion
- \( \downarrow \) Breath Sounds

* Causes *
- Ruptured BLEB (COPD)
- Thoracentesis
- Trauma
- Secondary Infection

* Diagnosed By: *
- Chest X-Ray
- ABG’s

* Treatment: *
- Chest Tube
- Oxygen
**Needle Decompression**

- Oxygen therapy
- 14 to 16 gauge needle
- 2nd intercostal space along mid-clavicular line
- Needle advance until air aspirated into syringe
- Needle is withdrawn; cannula is left open to air
- Immediate rush of air from chest indicates tension pneumothorax
- Thoracostomy tube then inserted
Needle Decompression

- Immediate placement of a 14-g catheter into the second intercostal space at the midclavicular line should yield a rush of air and decompression of the pneumothorax.
- All patients require subsequent chest tube placement.
- Immediate Needle decompression
  - Enter chest
    - 2nd or 3rd intercostal space
    - Mid-clavicular line
    - Leave plastic sheath on needle
    - Several needles may need to be placed
    - Should hear a rush of air through needle
      - Usually very obvious
    - This is initially diagnostic AND therapeutic
    - Patient MUST have definitive chest tube place after this
      - Regardless of air rush or not

http://www.fprmed.com/Pages/Trauma/Tension_Pneumothorax.html
**Treatment**

- **Oxygen therapy**
- **Thoracostomy tube**
  - 2nd intercostal space along mid-clavicular line
    - Air only; no fluid
  - 4th, 5th, or 6th intercostal space along anterior axillary line
    - When fluid present
Atelectasis (lung collapse)

- Plugged bronchioles → collapse of alveoli
- **Pneumothorax** - air in pleural cavity
  - From either wound in parietal or rupture of visceral pleura
  - Treated by removing air with chest tubes; pleurae heal → lung reinflates
Thoracostomy Tube Insertion

- https://www.youtube.com/watch?v=qR3VcueqBgc
- https://www.youtube.com/watch?v=4bDV67V7ujU
• Insertion point is 2nd intercostal space in mid-clavicular line.

• 2nd intercostal space is found by locating end of 2nd rib medially where it attaches at manubriosternal angle.

• The rib space below the 2nd rib is the 2nd intercostal space.
Tension Pneumothorax

- **Signs & symptoms**
  - Respiratory distress
  - Tracheal deviation
  - Distended neck veins
  - Hypotension
  - Compensatory tachypnea & tachycardia
  - Decreased cardiac output

Medical Emergency!!!! Must be treated immediately.
Tension Pneumothorax

- Radiography
  - Mediastinal shift to contralateral side
    - Tracheal deviation
  - Deep sulcus sign
  - Pleural line outlining collapsed lung
Deep Sulcus Sign caused by air collecting basally in the lateral region with patient in supine position.
In a tension pneumothorax, air from a ruptured lung enters the pleural cavity without a means of escape. As air pressure builds up, the affected lung is compressed and all of the mediastinal tissues are displaced to the opposite side of the chest.
Air enters pleural cavity through lung wound or ruptured bleb (or occasionally via penetrating chest wound) with valvelike opening. Ipsilateral lung collapses and mediastinum shifts to opposite side, compressing contralateral lung and impairing its ventilating capacity.

Intrapleural pressure rises, closing valvelike opening, thus preventing escape of pleural air. Pressure is thus progressively increased with each breath. Mediastinal and tracheal shifts are augmented, diaphragm is depressed, and venous return is impaired by increased pressure and vena caval distortion.
Pneumothorax

- Radiologic Findings:
  - Contralateral mediastinal shift
  - Depression of ipsilateral hemidiaphragm
  - Compressive atelectasis of adjacent normal lung

- presence of significant increased intrathoracic pressure

- Role of imaging in patients with pneumothorax:
  1. Confirm the clinical diagnosis
  2. Assess extent of pneumothorax
  3. Detect signs of tension
  4. Follow-up examination to monitor resolution of pneumothorax after drainage

*Fig. 3b* Bilateral tension pneumothorax due to barotrauma from positive pressure ventilation. Note the flattening of the diaphragm. The presence of bilateral abnormality results in no mediastinal shift. Note the collapsed lungs (arrows) and bilateral hyperlucency.
Tension Pneumothorax, cont'd

- Bulging muscle in supraclavicular area
- Wound sites
- Pleural space filled with air
- Collapsed lung
- Bulging intercostal muscles
- Compressed venae cavae
- Compressed aorta
- Compressed heart
- Compressed lung
- Diaphragm
**Intrapulmonary pressure.** Pressure inside lung decreases as lung volume increases during inspiration; pressure increases during expiration.

**Intrapleural pressure.** Pleural cavity pressure becomes more negative as chest wall expands during inspiration. Returns to initial value as chest wall recoils.

**Volume of breath.** During each breath, the pressure gradients move 0.5 liter of air into and out of the lungs.
Flail Chest
**Flail Chest**

- **Definition:**
  - Segment of the thoracic cage separated from the bony thorax
  - 2 or more adjacent ribs broken in 2 or more places
Paradoxical breathing: “free-floating” segment of ribs
Flail Chest Pathophysiology

- Flail segment of chest wall unable to contribute to lung expansion
- Large flail segments involve a greater proportion of chest wall:
  - May extend bilaterally or
  - Involve sternum
- Disruption of normal pulmonary mechanics may require mechanical ventilation
Flail Chest Signs & Symptoms

- **Paradoxical breathing**
  - Flail segment moves in opposite direction from rest of thorax
- **Labored breathing**
- **Tachypnea**
- **Decreased SpO\textsubscript{2}; patient possibly cyanotic**
- **Chest wall pain**
Flail Chest Management

- Management of injury directed toward:
  - Protecting underlying lung
  - Oxygenation: 100% non-rebreather mask
  - Ventilation: bag-valve-mask
  - Bronchopulmonary hygiene

- Strategy aimed at preventing development of pneumonia (most common complication of chest wall injury)

- Young patients easily manage 1 or 2 rib fractures with analgesia

- Same injury in an elderly patient problematic:
  - Frequently leads to pneumonia
  - Respiratory failure if not appropriately managed

- Analgesia is mainstay of therapy for rib fractures

- ECG monitoring for possible heart damage (cardiac contusions)
Endotracheal intubation and mechanical ventilation rarely indicated for chest wall injury alone

Hypoxemia frequently caused by contusions

Positive pressure ventilation may be required for severe chest wall instability resulting in inadequate spontaneous ventilation

Mechanical ventilation usually necessary only until pulmonary contusion resolves

Prophylactic chest tubes for some patients with rib fractures while receiving mechanical ventilation
Normal Thoracic Cage

- Manubrium of sternum
- Body of sternum
- Suprasternal notch
- Sternal angle
- 2nd rib
- 2nd rib interspace
- 2nd costal cartilage
- Cardiac notch of left lung
- Costochondral junctions
- Xyphoid process
- Costal angle
Pulmonary Contusion
Injury to lung parenchyma:
  > edema
  > blood collecting in alveolar spaces
  > loss of normal lung structure & function

Blunt lung injury develops over the course of 24 hours causing:
  > poor gas exchange
  > increased pulmonary vascular resistance
  > decreased lung compliance
  > inflammatory reaction to blood components in lung

50% to 60% of patients with significant pulmonary contusions develop acute respiratory distress syndrome (ARDS)
Pulmonary capillaries and alveoli separated because of blood leaked from contusion.
Pulmonary contusion beneath flail segment
Complications:

- Atelectasis
- Respiratory failure
- ARDS
- Pneumonia

Mortality ranges from 10% to 25%, and 40% to 60% of patients will require mechanical ventilation.
Pulmonary Contusion
Signs & Symptoms

- Rarely diagnosed during physical examination
- Mechanism of injury may suggest blunt chest trauma with obvious signs of:
  - Chest wall trauma
  - Bruising
  - Rib fractures
  - Flail chest
- Suggestive of an underlying pulmonary contusion
- Crackles may be heard, but rarely heard in ER and are non-specific
- Sometimes hypoxemia; definitely with ARDS
Pulmonary Contusion
Signs & Symptoms

- Significant forms diagnosed via chest radiography
- Radiograph often under-estimates contusion size
- Tends to lag behind clinical picture
- Full extent of injury not apparent on chest radiography until 24 to 48 hours following injury
Computed tomography (CT) sensitive for identification
May allow differentiation from areas of atelectasis or aspiration
Allows for 3-dimensional assessment and calculation of the size of contusions
Most contusions visible only on CT scan are not clinically relevant:
› Not large enough to impair gas exchange
› Do not worsen outcome
Pulmonary Contusion Management

- Oxygen therapy via nonrebreather mask
- Usually no other therapy: vigilance
- Large contusions may affect gas exchange causing hypoxemia
- Physiological impact of contusions tends to develop over 24-48 hours
  - Close monitoring is required
  - Supplemental oxygen continued
Many patients will have significant chest wall injury:
  › Pain affecting ventilation
  › Pain affecting secretion clearance

Analgesia for pain

Endotracheal intubation and mechanical ventilation may be necessary
  › Mechanical ventilatory support discontinued with resolution of contusion
Pulmonary Contusion Management

- Goal for fluid management is euvolemia because:
  - Fluid excess: pulmonary edema
  - Hypoperfusion - consequences more severe & long-lasting:
    • inflammatory activation
    • acute lung injury
    • ARDS
    • multiple organ failure
Pulmonary Contusion Management

- Pulmonary contusions usually resolve in 3 to 5 days
- Main complications of pulmonary contusion are:
  - ARDS
  - Pneumonia
- Approximately, 50% of patients with pulmonary contusions develop ARDS
- Pneumonia also common complication:
  - Blood in alveolar spaces provides culture medium for bacteria
Pulmonary Contusion

- Patient suffers from bleeding within the lung tissue
- Bleeding occurs in and around the alveoli and into the interstitial space between the alveoli and capillaries
- Leads to severe hypoxia and can lead to death
- Often seen with flail segment injury
- Other signs/symptoms include shortness of breath, cyanosis, and sign of blunt trauma to the chest
- Oxygenate by NRB at 15 lpm or PPV with supplemental oxygen
Cardiac Contusion

- Occurs when heart is violently compressed between the sternum and spinal column
- Actual bruise may occur to the heart wall
- Heart wall may be ruptured
- Electrical conduction system of the heart may be disturbed
- Right ventricle is the most likely injured
- Signs/Symptoms: Chest pain/discomfort, evidence of blunt trauma, tachycardia, irregular pulse
- Transport promptly