“Lung Lacerations: Rapid Interpretation Using Mechanism of Injury”

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Purpose and Content

- Review types of lung lacerations based on mechanisms of injury
- Understand the various mechanisms of injury and pathophysiology
- Highlight the CT characteristics and critical imaging findings using with various clinical cases
General

- Thoracic injury accounts for 25% of the 100-140,000 trauma deaths in the US annually
  - Blunt (~70%) vs Penetrating chest Injury
    - Penetrating requires thoracotomy more often (20-40%)

- Lung injury occurred in 11% of 8780 blunt trauma cases at study from Emory from 2001-2006
  - Pulmonary contusion is the most common lung injury (~75% of cases)

- Emergent Imaging
  - Trauma Chest X-ray (single supine view)
  - Chest CT Non-contrast or Contrast-enhanced
    - Chest CT is more accurate and changes management in 20% of cases
Lung Lacerations

• Laceration represents a traumatic tear of the alveolar and interstitial lung parenchyma that is pulled apart by normal thoracic elastic recoil in the form of a cavity

• Laceration cavities acutely occur in foci of pulmonary contusion, which represents an area of alveolar hemorrhage due to rupture/shear

• Traumatic lung lacerations are uncommon, but clinically significant
  • > 50% of patients with laceration or contusion have concomitant major organ injury (Head 50%, Extremity 45%, Abdomen 30%, Pelvis 15%, Spine 10%)
  • Patients younger than 40 years with pliable chest are most susceptible
  • Most common causes: Blunt rapid high-energy trauma or Penetrating Injury

• Chest CT is the most accurate diagnostic test
  • Contusional hemorrhage obscures 50% of lacerations on chest X-ray
  • Secondary traumatic findings are better evaluated
Mechanisms of Lung Injury

**Blunt**

Rapid high speed chest wall compression and decompression combined with laryngeal closure increasing intrathoracic pressure causes the alveoli and interstitium to shear forming a laceration (speed of compression is independent of degree of deformation, thus visceral injury can occur without rib fracture).

- Motor Vehicle Collision (Common)
- Fall, assault injuries, Crush injuries
- Sports Injury (Rare)

**Penetrating**

Object directly punctures the lung and tears through alveoli and interstitium forming a laceration that is often associated with rib fractures and a pneumothorax given violation of the pleura.

- Ballistic (Gunshot)
- Non-ballistic (Stabbing and Rib fracture, Puncture)
CT Findings

Primary Lung Findings
- Thin-walled parenchymal cavities
  - Unilocular or Multilocular
- Single or Multiple
- Content
  - Air (Pneumatocele)
  - Blood (Hematocele or Pulmonary hematoma)
  - Both (Hematopneumatocele)
- Perilesional Contusion
  - Patchy or diffuse ground glass or confluent consolidation and occasionally surrounding interstitial thickening

Associated Findings
- Pneumothorax
- +/- Hemorrhage
- Rib Fracture
- Subcutaneous Emphysema

Wagner classification 1983
4 types of characteristic lung laceration appearances on Chest CT based on mechanism of injury
<table>
<thead>
<tr>
<th>Type</th>
<th>Mechanism</th>
<th>Imaging</th>
<th>CT findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Rapid blunt force compression and decompression causing alveolar rupture</td>
<td>Thin-walled cavity containing lucent air or air-fluid level from hemorrhage (Laceration cavity) with surrounding contusion</td>
<td>Paravertebral laceration cavity with surrounding contusion</td>
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<tr>
<td>Type 2</td>
<td>Rapid blunt force to the more pliable lower chest causing alveolar shearing</td>
<td></td>
<td>Perivertebral laceration cavity with surrounding contusion</td>
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<td>Type 3</td>
<td>Penetrating rib injury through pleura into the lung causing tear</td>
<td></td>
<td>Peripheral laceration cavity with surrounding contusion and possible pneumothorax</td>
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<tr>
<td>Type 4</td>
<td>Blunt force displacing the chest wall at a fixed pleuropulmonary adhesion</td>
<td></td>
<td>Laceration cavity along focus of thickened pleura with surrounding contusion and possible rib fracture, subcutaneous emphysema and loculated hemopneumothorax</td>
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CT Appearances of Lung Lacerations Types

Type 1 - compression rupture lung laceration (deep lung)

Type 2 – shear injury (paraspinal lung air-fluid filled cavity)

Type 3 – rib penetration

Type 4 – adhesion tear (rare, diagnosed on surgery/autopsy)

Type 1 compressive lung injuries are the most common, but generally resolve with conservative management.

Type 3 lacerations are less common, but are associated with increased mortality due to infection and recurrent pneumothoraces from bronchopleural fistulas. These patients require surgical intervention, which is often decided based on imaging findings.
Evolution of Lacerations on CT

1. Traumatic injury with laceration cavity surrounded by contusion
2. Perilesional contusion resorbs in 2-5 days
3. Laceration cavity persists and may progressively fill with blood
4. Regresses over 3-5 weeks
5. Rarely a post-traumatic pseudocyst can persist
Case #1

18 y/o F in a motor pedestrian collision at 35 MPH.
Case #1: Type 1 & 2 Lacerations

**Case Description:** Axial, Coronal and Sagittal 2 mm Chest CT images in lung and bone window show a right 3.5 x 1.4 x 6.0 cm thin-walled cavity containing a dependent hyperdense air-fluid level with surrounding ground glass opacities in the superior segment of the right lower lobe consistent with a Hematopneumatocele and contusion from a **Type 1 laceration** (rapid blunt compression). Multiple smaller pneumatoceles are seen with contusion inferiorly in the paravertebral region indicating additional **Type 2 lacerations**. Also seen are a right hemopneumothorax, right rib fractures and subcutaneous emphysema.
Case #2: Type 1, 2 & 3 Laceration

81 y/o M struck by a truck at 50 mph while walking.

Case Description: Axial and Sagittal 2 mm Chest CT images in lung and bone window show a right penetrating posterior rib fractures with a 3.2 x 4.3 cm large hematocele in the right lower lobe and additional smaller peripheral and paravertebral pneumatoceles along with surrounding consolidation. This is consistent with contusion with Type 1, 2 and 3 lacerations (rapid blunt compression, paraspinal shearing and penetrating rib fracture). Also seen are right middle and lower lobe collapse, right hemothorax with active hemorrhage from the right lower lobe pulmonary artery, multiple right rib fractures and subcutaneous emphysema.
Case #3:

32 y/o M status post gunshot wound.
Case #3: Type 3 Laceration

**Case Description:** Axial and Sagittal 2 mm Chest CT images in lung window show left lung thick-walled laceration track from the left upper lobe, left fissure and superior and posterior segment of the left lower lobe with surrounding ground glass opacities and containing an air-fluid level consistent with a hematopneumatocele and contusion from a Type 3 laceration (penetrating injury). Also seen is a small left pleural effusion. No pneumothorax.
Case #4

52 y/o M with blunt crush injury while being compressed between a truck and a pole.
Crush Injury Related Contusion And Laceration Of Lung, Rib And Sternal Fracture

52 years old male CT images reveal partially collapsed left lung demonstrates airspace opacities and air filled cavities in the lingula due to contusion and pulmonary laceration with possible peripheral bronchopleural fistula.

Multiple medially displaced left-sided rib fractures with associated moderate left hemopneumothorax. Nondisplaced lower sternal body fracture. Mildly displaced comminuted left inferior scapular fracture.

CXR: small left apical pneumothorax (upper arrow), left apical chest tube, left subcutaneous emphysema (lower arrow) and left mid zone opacity due to contusion.

- **Pleural Effusion in Trauma**: Lateral/Decubitus CXR better than supine
- Massive effusion: >1500ml, CT: characterize type and amount assess pleural clot, active extravasation from arterial bleeder
- Treatment: chest tube thoracotomy
Case Description: Axial and Sagittal 2 mm Chest CT images in lung and bone window show a thin-walled Hematopneumatocele in the lingula with contusion from laceration. Multiple smaller adjacent pneumatoceles are seen with contusion along with areas of possible lateral pleural thickening. No paravertebral cavities are present making this a Type 1, 3 and possibly 4 laceration (rapid blunt compression at site of possible pleuropulmonary adhesion and penetrating rib injury). Also seen are a small left hemopneumothorax, left rib fractures and subcutaneous emphysema.
Case #5

26 y/o status post left sided chest stab wound 9 days prior.
Case #5: Type 3 Lung Laceration

Case Description: Axial, Coronal and Sagittal 2 mm Chest CT images in lung windows showing a left lower lobe thin-walled Hematopneumatocele from laceration with small residual surrounding contusion. No paravertebral cavities or pleural thickening are present making this a Type 3 laceration (penetrating injury).
Case #6
Type 3 Lung Laceration from Penetrating Gun Shot

CT images showing right lung laceration and contusion (arrows), small right hemo-pneumothorax, pneumomediastinum, left lower lobe posterior atelectasis, pneumoperitoneum, right chest tube penetrated the right lower lobe.
Case #6
Type 3 Lung Laceration from Penetrating Gun Shot

35 years old Male with GSW to right midclavicular line at 2nd intercostal space. Portable radiograph shows contusion related consolidation in right upper lobe (yellow arrow) and subcutaneous emphysema. Bullet fragment over the right upper chest wall and right apical chest tube.

Chest tube on right drained 500 cc frank blood into pleura vac. No abdominal injury on exploratory laparotomy.

Mechanism of Gunshot Bullet Injury

- Initial ballistic pressure/shock wave
- Pressure gradients related temporary cavity along the trajectory
- Direct tissue laceration and contusion causing permanent cavity

CT images showing right lung laceration and contusion (arrows), small right hemothorax, pneumomediastinum.
31-year-old man status post gun shot wound to right hemithorax. Initial CXR demonstrates large right-sided hemopneumothorax, pneumomediastinum (Continuous diaphragm sign, arrow), pneumopericardium, and pulmonary laceration in right mid-lung.

Radiographics features of pneumothorax
- Visualization of the thin visceral pleura of the lung with surrounding lucency devoid of lung markings
- Deep costophrenic sulcus sign-air
- Visualization of the anterior costophrenic sulcus, Upper quadrant lucency
- Double diaphragm sign-air outlines the dome and anteroinferior insertion of the Diaphragm
- Sharp cardiac silhouette

Coronal MPR CT images following chest tube placement on the same day shows reduction in the pneumothorax, a bronchopleural fistula (arrow), and mediastinal air. Persistent air leak required surgical treatment of the broncho-pulmonary fistula in superior segment RLL.

Causes of Persistent pneumothorax
- malpositioned or kinked chest tube
- airway leak from a direct airway injury or fistula
CXR: Bilateral large-bore chest tubes with tip of right chest tube abutting mediastinum and small hemopneumothoraces bilaterally. Extensive subcutaneous emphysema, left clavicle fracture

Traumatic aortic injury at the levels of the aortic isthmus and a T5 chance fracture. Extensive bilateral rib fractures concerning for flail chest. Bilateral large-bore chest tubes with tip of right chest tube in anterior mediastinum and small residual hemopneumothoraces bilaterally. Extensive subcutaneous emphysema.

Right middle and upper lobe contusion and right middle lobe laceration. Nondisplaced manubrial fracture, inferior left glenoid fracture and left clavicular fracture

56yo F s/p MVC. driver, unknown restraints with 2 ft intrusion into driver's door
Management

- Pulmonary laceration rarely requires emergent resection of lung
  - Most resolve in 3-5 weeks spontaneously

- Associated findings are often treated emergently
  - Chest tube thoracostomy if pneumothorax or large hemopneumothorax
    - Massive hemothorax is >1500 ml
    - Tension Pneumothorax with mediastinal shift
    - Pericardiocentesis for hemopericardium

- 3% require Emergency Thoracotomy (ET)
  - Lung resection or Vessel repair
# Emergent Thoracotomy for Lung Injury: Timing and Indications

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<th>Immediate</th>
<th>Immediate indications:</th>
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<td>Indicated for penetrating injury from a stab wound with maintained pulse, but refractory hemorrhage or persistent air leak with chest tube</td>
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<th>Urgent (1-4 hours)</th>
<th>Urgent indications:</th>
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<tr>
<td></td>
<td>Indicated for persistent cardiac tamponade, high hemorrhagic chest tube output, persistent air leak or air embolism</td>
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<th>Delayed (&gt;24 hours)</th>
<th>Delayed indications:</th>
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<tr>
<td></td>
<td>Indicated for retained hemothorax, post-traumatic empyema, persistent air leak or tracheal/bronchial stenosis from tracheobronchial injuries</td>
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Summary

- Lung Laceration are traumatic tear of the alveolar and interstitial lung parenchyma that is pulled apart to form pneumatocele, hematocele or hematopneumatocele related cavity.
- Types 1-4 lung lacerations based on mechanism of injury and Chest CT findings
- Type 1 compressive lung injuries are the most common, but generally resolve with conservative management.
- Penetrating Type 3 lacerations are less common, but are associated with increased mortality due to infection and recurrent pneumothoraces from bronchopleural fistulas.
References


Thank you!

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