Pleural Diseases
Pleural Effusion & Pneumothorax

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Disclosure

- None
Objectives

• Anatomy of pleura
• Mechanism of pleural fluid turnover
• Etiology and pathogenesis of pleural effusion
• Clinical manifestations
• Radiographic examination
• Approach to the patient with pleural effusion
• Management of the patient with pleural effusion
• Etiologies of pneumothorax
• Management of pneumothorax
Anatomy and Physiology of Pleural Space

- Pleural cavity is created between the 4th and 7th week of embryologic development

- Five microscopic layers:
  - Single layer of mesothelial cell layer facing the pleural space
  - Thin layer of connective tissue
  - A superficial elastic layer
  - Irregular connective tissue layer containing adipose tissue, vessels, nerves and lymphatics
  - Deep fibroelastic layer (in parietal pleural called endothoracic fascia)

Anatomy and Physiology of Pleural Space

• Proteins and cells are removed mainly from the preformed stomata and the lymphatic lacuna present in the lower mediastinum, portions of the diaphragm

• Parietal pleura senses pain
Reflexion Lines and Recesses of the Pleura

Fig. 2. Lateral view of the right hilum showing the anatomy of the right inferior pulmonary ligament (triangular ligament).

Fig. 1. Lateral view of the left hilum showing the anatomy of the left inferior pulmonary ligament (triangular ligament).

Anatomy and Physiology of Pleural Space

Parietal pleura:
- Costal
- Mediastinal
- Diaphragmatic
- Cupola
Anatomy and Physiology of Pleural Space

Fig. 1. – Schema of the morphofunctional design of pleural space; s.c.: systemic capillary; p.c.: pulmonary capillary.
Anatomy and Physiology of Pleural Space

- Normal rate of production about 0.01 mL/kg/h
- Secreted from systemic pleural vessels (systemic capillaries)
- Reabsorbed via stomata on the parietal and diaphragmatic pleura, and drain into lymphatics
- Absorb fluid at a rate of approximately 0.28 mL/kg/h

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Fluid accumulation:
Substantially increased pleural fluid production (28-fold)
Reduce the ability of the lymphatics to clear the fluid
Both increase production and decrease lymphatic clearance.

Anatomy and Physiology of Pleural Space

Nerve Supply
- Intercostal nerves: Parietal pleura
  (somatic, sympathetic, parasympathetic)
- Visceral pleura receptors (VPRs) in animals
  mediate sensory transduction of painful stimuli

Lymphatics
- Rich network runs through BM of visceral pleura (lower lobes)
- Drains to intralobular and hilar LNs,
- Direct drainage to mediastinal LN results in N2 Dz w/o N1 Dz in some patients with lung cancer especially in upper lobes
- Visceral pleura minor role in clearance of pleural fluid
- Lymphatics have endoluminal valves

Anatomy and Physiology of Pleural Space
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Richard W Light
Anatomy and Physiology of Pleural Space

Light (1980):
Water-filled U-shaped manometer connected to an Abram needle.
- determining the clinical utility of pleural manometry
- evaluate the safety of large volume thoracentesis

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Pleural fluid was removed until:
- Ppl fell to < −20 cm H2O
- no more fluid could be obtained
- patients developed symptoms

Initial Ppl varied widely (−21 cm H2O to 18 cmH2O)
Initial Ppl < −5 cm H2O: MPE or trapped lung
Anatomy and Physiology of Pleural Space

• Pleural elastance (Eps), change in pressure in the pleural space divided by the volume of fluid removed in liters

• Malignancy, trapped lung: Eps > 25 cm H2O/L

• None of the patients with an Eps > 19 cm H2O (after draining 500 mL of fluid) had successful pleurodesis compared with 98% of those with an Eps < 19 cm H2O

• Manometry is predictive in identifying patients appropriate for pleurodesis

• Ppl correlates with the development of chest discomfort during thoracentesis
Etiology of Pleural Effusion
Etiology of Pleural Effusion

• Approximately 1.5 million people develop a pleural effusion in the US each year.

• CHF is by far the leading cause of transudate pleural effusions.
## Etiology of Pleural Effusion

<table>
<thead>
<tr>
<th>Condition</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHF</td>
<td>500,000</td>
</tr>
<tr>
<td>Parapneumonic effusion</td>
<td>300,000</td>
</tr>
<tr>
<td>Malignant pleural effusion</td>
<td>200,000</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>60,000</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>50,000</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>40,000</td>
</tr>
<tr>
<td>Other cancer</td>
<td>60,000</td>
</tr>
<tr>
<td>Pulmonary embolization</td>
<td>150,000</td>
</tr>
<tr>
<td>Viral disease</td>
<td>100,000</td>
</tr>
<tr>
<td>Cirrhosis with ascites</td>
<td>50,000</td>
</tr>
<tr>
<td>Post-CABG surgery</td>
<td>50,000</td>
</tr>
<tr>
<td>Gastrointestinal disease</td>
<td>25,000</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>2500</td>
</tr>
</tbody>
</table>

*Estimated annual incidence of various causes of pleural effusions in the United States*
Box 1
Differential diagnoses of pleural effusion

1. Transudative pleural effusions
   a. Congestive heart failure (CHF)
   b. Cirrhosis
   c. Nephrotic syndrome
   d. Superior vena caval obstruction
   e. Fontan procedure
   f. Urinorthorax
   g. Peritoneal dialysis
   h. Glomerulonephritis
   i. Myxedema
   j. Cerebrospinal fluid leak to pleura
   k. Hypoalbuminemia

2. Exudative pleural effusions
   a. Neoplastic diseases
      i. Metastatic disease
      ii. Mesothelioma
      iii. Body cavity lymphoma
      iv. Parapneumonic effusion
   b. Infectious diseases
      i. Bacterial infections
      ii. Tuberculosis
      iii. Fungal infections
      iv. Parasitic infections
      v. Viral infections
   c. Pulmonary embolization
   d. Gastrointestinal disease
      i. Pancreatic disease
      ii. Subphrenic abscess
      iii. Intrahepatic abscess
      iv. Intraspinal abscess
      v. Esophageal perforation
      vi. Postabdominal surgery
      vii. Diaphragmatic hernia
      viii. Endoscopic variceal sclerosis
      ix. Postliver transplant
   e. Heart diseases
      i. Postcoronary artery bypass graft (post-CABG) surgery
      ii. Postcardiac injury (Dressler) syndrome

   iii. Pericardial disease
   iv. Pulmonary vein stenosis postcatheter ablation of atrial fibrillation
   f. Obstetric and gynecologic disease
      i. Ovarian hyperstimulation syndrome
      ii. Fetal pleural effusion
      iii. Postpartum pleural effusion
      iv. Meigs syndrome
      v. Endometriosis
   g. Collagen vascular diseases
      i. Rheumatoid pleuritis
      ii. Systemic lupus erythematosus
      iii. Drug-induced lupus
      iv. Immunoblastic lymphadenopathy
      v. Sjögren syndrome
      vi. Familial Mediterranean fever
      vii. Churg-Strauss syndrome
      viii. Wegener granulomatosis
   h. Drug-induced pleural disease
      i. Nitrofurantoin
      ii. Dantrolene
      iii. Methysergide
      iv. Ergot drugs
      v. Amiodarone
      vi. Interleukin 2
      vii. Procarbazine
      viii. Methotrexate
      ix. Clozapine

i. Miscellaneous diseases and conditions
   i. Asbestos exposure
   ii. Postlung transplant
   iii. Postbone marrow transplant
   iv. Yellow nail syndrome
   v. Sarcomiosis
   vi. Uremia
   vii. Trapped lung
   viii. Therapeutic radiation exposure
   ix. Drowning
   x. Amyloidosis
   xi. Milk of calcium pleural effusion
   xii. Electrical burns
   xiii. Extramedullary hematopoiesis
   xiv. Rupture of mediastinal cyst
   xvi. Whipple disease
   xvii. iatrogenic pleural effusions
   j. Hemothorax
   k. Chylothorax
   l. Pseudochylothorax
Clinical Manifestations
Clinical Manifestations

• Dyspnea
• Cough
• Chest pain
• Other symptom may suggest the underlying disease process:
  - increasing LE edema, orthopnea, PND $\rightarrow$ CHF
  - night sweats, fever, weight loss $\rightarrow$ TB
  - hemoptysis $\rightarrow$ malignancy
  - purulent sputum production, pleuritic CP $\rightarrow$ PNA
Physical Examination

- Closely correlated to the volume of effusion
- Decreased or absent tactile fremitus
- Dullness to percussion
- Diminished breath sounds
Pleural Effusion imaging

- Subpulmonic
- Free-flowing
- Loculated
- Fissural (pseudotumor)
Pleural Effusion imaging

- A minimal amount of fluid (approximately 175 mL) is required to produce detectable blunting costophrenic angle.

- As much as 500 mL of pleural fluid can be present without apparent changes on the frontal view.
The difference in an effusion on an upright film and on a supine film with the typical veil type density layering on the supine film and the upright film showing findings more suspicious for an elevated hemidiaphragm due to subpulmonic collection of fluid.
Large pleural effusion collecting laterally along the right lateral chest wall with extension into the minor fissure.
Films shows a pleural pseudo tumor due to loculated fluid tracking in the major fissure on the PA and lateral.
Films shows a pleural pseudo tumor due to loculated fluid tracking in the major fissure on the PA and lateral.
Approach to the patient with pleural effusion
Figure 1: Diagnostic algorithm for the investigation of a unilateral pleural effusion
Approach to the patient with pleural effusion

Thoracentesis
Approach to the patient with pleural effusion

Pleural Effusions: The Diagnostic Separation of Transudates and Exudates

RICHARD W. LIGHT, M.D.; M. ISABELLE MACGREGOR, M.D.; PETER C. LUCHSINGER, M.D., F.A.C.P.; and WILMOT C. BALL JR., M.D.

[+] Article, Author, and Disclosure Information

See Correction:
Correction: Oncotic Pressure and Transudates


Requests for reprints should be addressed to Wilmot C. Ball, Jr., M.D., The Johns Hopkins Hospital, 601 N. Broadway, Baltimore, Md. 21205.
Approach to the patient with pleural effusion

Light’s criteria (one or more of the following three)
Ratio of pleural-fluid protein level to serum protein level > 0.5
Ratio of pleural-fluid LDH level to serum LDH level > 0.6
Pleural-fluid LDH level > two thirds the upper limit of normal for serum LDH level

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See Correction:
Correction: Oncotic Pressure and Transudates


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### Table 2. Tests Indicated, According to the Appearance of the Pleural Fluid.

<table>
<thead>
<tr>
<th>Appearance of Fluid</th>
<th>Test Indicated</th>
<th>Interpretation of Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloody</td>
<td>Hematocrit</td>
<td>&lt;1% → nonsignificant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-20% → cancer, pulmonary embolus, or trauma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( \geq 50% ) of peripheral hematocrit → hemothorax</td>
</tr>
<tr>
<td>Cloudy or turbid†</td>
<td>Centrifugation</td>
<td>Turbid supernatant → high lipid levels</td>
</tr>
<tr>
<td>Turbid supernatant</td>
<td>Triglyceride level</td>
<td>&gt;110 mg/dL → chylothorax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;50 mg/dL, but ≤110 mg/dL → obtain lipoprotein analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Presence of chylomicrons → chylothorax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;50 mg/dL and cholesterol &gt;250 mg/dL → pseudochylothorax</td>
</tr>
<tr>
<td>Putrid odor</td>
<td>Stain and culture</td>
<td>Putrid odor → possible anaerobic infection</td>
</tr>
</tbody>
</table>

### Table 3. Sensitivity of Tests to Distinguish Exudative from Transudative Effusions.*

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity for Exudate</th>
<th>Specificity for Exudate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light’s criteria (one or more of the following three)</td>
<td>98</td>
<td>83</td>
</tr>
<tr>
<td>Ratio of pleural-fluid protein level to serum protein level &gt;0.5</td>
<td>86</td>
<td>84</td>
</tr>
<tr>
<td>Ratio of pleural-fluid LDH level to serum LDH level &gt;0.6</td>
<td>90</td>
<td>82</td>
</tr>
<tr>
<td>Pleural-fluid LDH level &gt; two thirds the upper limit of normal for serum LDH level</td>
<td>82</td>
<td>89</td>
</tr>
<tr>
<td>Pleural-fluid cholesterol level &gt;60 mg/dL (1.55 mmol/liter)</td>
<td>54</td>
<td>92</td>
</tr>
<tr>
<td>Pleural-fluid cholesterol level &gt;43 mg/dL (1.10 mmol/liter)</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>Ratio of pleural-fluid cholesterol level to serum cholesterol level &gt;0.3</td>
<td>89</td>
<td>81</td>
</tr>
<tr>
<td>Serum albumin level – pleural-fluid albumin level ≤1.2 g/dl</td>
<td>87</td>
<td>92</td>
</tr>
</tbody>
</table>
Pleural Fluid Analysis

• The primary problem with the Light criteria is that they identify 15% to 20% of transudative effusions as exudative effusions.
Pleural Fluid Analysis

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• Difference between the serum protein and PF protein
  - Transudative > 3.1 gm/dL

Pleural Fluid Analysis

• The primary problem with the Light criteria is that they identify 15% to 20% of transudative effusions as exudative effusions.

• Difference between the serum protein and PF protein
  - Transudative > 3.1 gm/dL

• CHF: Elevated NT-proBNP (> 1500 pg/mL) in PF and serum


Pleural Fluid Analysis

- Appearance of the pleural fluid (cloudy, milky, bloody)
- Protein and LDH levels in serum and pleural fluid
- Cell count and differential
- Glucose
- pH
- Cytology
- Smears and cultures for bacteria, mycobacteria, and fungi
- Adenosine deaminase (ADA) >40 U/L; (tuberculous pleuritis)
- NT-proBNP
Pleural Fluid Analysis

Cell count

• Nucleated cell count
  - most transudates: < 1000/mm³
  - most exudates: > 1000/mm³

• Small lymphocytes: pleural tuberculosis, malignancy, post-CABG

• Eosinophilic pleural effusions: >10% eosinophils
  - idiopathic
  - malignancy
  - hemothorax, pneumothorax
Pleural Fluid Analysis

Glucose <60 mg/dL
1. Complicated parapneumonic effusion,
2. MPE
3. TB
4. RA pleural effusion
5. Hemothorax
6. Paragonimiasis
7. Churg-Strauss syndrome
8. occasionally lupus pleuritis

Pleural fluid pH
- Empyema (pH <7.20 indicates the need for drainage of the fluid)
- RA
- Pancreatitis
Pleural Fluid Analysis

Cytology

- Diagnostic about 65% - 70% (mostly adenocarcinoma)
- Mesothelioma (10%), SCC (20%)
- Lymphoma (25% - 50%), sarcoma (25%)
- Low yield after second thoracentesis
Cancer Ratio (Plus)

Cancer Ratio
- predictive of malignant effusion
- serum LDH / pleural ADA ratio
Sen 0.95 (95% CI 0.87-0.98)
Spec 0.85 (95% CI 0.68-0.94)

Cancer Ratio Plus
- Cancer Ratio / pleural fluid lymphocyte count
Sen 0.63 (95% CI 0.51-0.73)
Spec 0.94 (95% CI 0.78-0.98)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (N = 118)</th>
<th>Malignant pleural effusion (N = 84)</th>
<th>Tubercular pleural effusion (N = 34)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>65 (19–87)</td>
<td>69 (35–87)</td>
<td>56 (19–87)</td>
<td>0.23</td>
</tr>
<tr>
<td>Pleural ADA (U/L)</td>
<td>10.6 (5–54)</td>
<td>9 (5–42)</td>
<td>42 (5–54)</td>
<td>0.001</td>
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<tr>
<td>Serum LDH (IU/L)</td>
<td>512 (322–2992)</td>
<td>525 (322–2992)</td>
<td>494 (336–947)</td>
<td>0.08</td>
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<td>Pleural fluid lymphocyte count (%)</td>
<td>0.7 (0.1–1.0)</td>
<td>0.61 (0.10–1.0)</td>
<td>0.86 (0.60–1.0)</td>
<td>0.007</td>
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<tr>
<td>Cancer ratio</td>
<td>51.5 (7–173)</td>
<td>74 (15–173)</td>
<td>13 (7–67)</td>
<td>0.008</td>
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<tr>
<td>Serum LDH/pleural fluid lymphocyte count</td>
<td>765.5 (336–7771)</td>
<td>1015 (498–7771)</td>
<td>593 (336–1230)</td>
<td>0.006</td>
</tr>
<tr>
<td>Cancer ratio/pleural fluid lymphocyte count</td>
<td>87.2 (7.5–1295.2)</td>
<td>127 (29–1295)</td>
<td>16 (8–67)</td>
<td>0.002</td>
</tr>
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Data presented in median (range).
### Table 1: General characteristics and univariate analysis.

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</tr>
</tbody>
</table>

### Table 2: Logistic regression analysis for prediction of malignancy.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Odds</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleural ADA</td>
<td>−0.6011</td>
<td>0.54 (0.27–1.08)</td>
<td>0.0861</td>
</tr>
<tr>
<td>Serum LDH</td>
<td>0.0484</td>
<td>1.04 (0.99–1.11)</td>
<td>0.1015</td>
</tr>
<tr>
<td>Pleural fluid lymphocyte count</td>
<td>−10.224</td>
<td>0</td>
<td>0.1211</td>
</tr>
<tr>
<td>Cancer ratio</td>
<td>1.5744</td>
<td>0.20 (0.05–0.78)</td>
<td>0.0209</td>
</tr>
<tr>
<td>Serum LDH/pleural fluid lymphocyte count</td>
<td>0.0413</td>
<td>0.95 (0.92–0.99)</td>
<td>0.0474</td>
</tr>
<tr>
<td>Cancer ratio/pleural fluid lymphocyte count</td>
<td>1.6536</td>
<td>5.22 (3.15–20.14)</td>
<td>0.0163</td>
</tr>
</tbody>
</table>

### Table 3: Cut-off for cancer ratio (serum LDH : pleural ADA ratio).

<table>
<thead>
<tr>
<th>Cut-off level</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>PPV (95% CI)</th>
<th>NPV (95% CI)</th>
<th>PLR (95% CI)</th>
<th>NLR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10</td>
<td>0.97 (0.90–0.99)</td>
<td>0.26 (0.13–0.44)</td>
<td>0.76 (0.67–0.84)</td>
<td>0.81 (0.47–0.96)</td>
<td>3.2 (2.2–4.6)</td>
<td>0.22 (0.06–0.80)</td>
</tr>
<tr>
<td>&gt;20</td>
<td>0.95 (0.87–0.98)</td>
<td>0.85 (0.68–0.94)</td>
<td>0.94 (0.86–0.97)</td>
<td>0.87 (0.70–0.96)</td>
<td>16 (6.8–37.5)</td>
<td>0.13 (0.05–0.34)</td>
</tr>
<tr>
<td>&gt;30</td>
<td>0.89 (0.80–0.94)</td>
<td>0.94 (0.78–0.98)</td>
<td>0.97 (0.90–0.99)</td>
<td>0.78 (0.61–0.88)</td>
<td>37.5 (9.5–147.3)</td>
<td>0.28 (0.15–0.50)</td>
</tr>
<tr>
<td>&gt;40</td>
<td>0.76 (0.65–0.84)</td>
<td>0.94 (0.78–0.98)</td>
<td>0.96 (0.88–0.99)</td>
<td>0.61 (0.47–0.74)</td>
<td>32 (8.1–125.3)</td>
<td>0.62 (0.43–0.90)</td>
</tr>
<tr>
<td>&gt;50</td>
<td>0.66 (0.55–0.76)</td>
<td>0.94 (0.78–0.98)</td>
<td>0.96 (0.87–0.99)</td>
<td>0.53 (0.40–0.66)</td>
<td>28 (7.1–109.3)</td>
<td>0.87 (0.64–1.18)</td>
</tr>
<tr>
<td>&gt;60</td>
<td>0.57 (0.45–0.67)</td>
<td>0.97 (0.82–0.99)</td>
<td>0.97 (0.87–0.99)</td>
<td>0.47 (0.35–0.60)</td>
<td>48 (6.8–334.1)</td>
<td>1.09 (0.84–1.41)</td>
</tr>
</tbody>
</table>
### Table 4: Cut-off for cancer ratio plus (cancer ratio: pleural fluid lymphocyte count).

<table>
<thead>
<tr>
<th>Cut-off level</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>PPV (95% CI)</th>
<th>NPV (95% CI)</th>
<th>PLR (95% CI)</th>
<th>NLR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;20</td>
<td>1.0 (0.94–1.0)</td>
<td>64.7 (0.46–0.79)</td>
<td>0.87 (0.78–0.93)</td>
<td>1.0 (0.81–1.0)</td>
<td>7.0 (4.1–11.9)</td>
<td>0</td>
</tr>
<tr>
<td>&gt;30</td>
<td>97.6 (0.90–0.99)</td>
<td>94.1 (0.78–0.98)</td>
<td>0.97 (0.90–0.99)</td>
<td>0.94 (0.78–0.98)</td>
<td>41 (10.4–161.3)</td>
<td>0.06 (0.01–0.2)</td>
</tr>
<tr>
<td>&gt;40</td>
<td>92.8 (0.84–0.97)</td>
<td>94.1 (0.78–0.98)</td>
<td>0.97 (0.90–0.99)</td>
<td>0.84 (0.68–0.93)</td>
<td>39 (9.9–153.3)</td>
<td>0.18 (0.08–0.39)</td>
</tr>
<tr>
<td>&gt;50</td>
<td>89.2 (0.80–0.94)</td>
<td>94.1 (0.78–0.98)</td>
<td>0.97 (0.90–0.99)</td>
<td>0.78 (0.61–0.88)</td>
<td>37.5 (9.5–147.3)</td>
<td>0.28 (0.15–0.50)</td>
</tr>
<tr>
<td>&gt;60</td>
<td>82.1 (0.71–0.89)</td>
<td>97.0 (0.82–0.99)</td>
<td>0.98 (0.91–0.99)</td>
<td>0.68 (0.53–0.80)</td>
<td>69 (9.8–483)</td>
<td>0.45 (0.29–0.70)</td>
</tr>
</tbody>
</table>

![Cancer ratio ROC curve](image1)

(a) Cancer ratio

True positive rate (sensitivity)
False positive rate (1 – specificity)
AUC = 0.81

![Cancer ratio plus ROC curve](image2)

(b) Cancer ratio plus

True positive rate (sensitivity)
False positive rate (1 – specificity)
AUC = 0.863

![Serum LDH: pleural lymphocyte ratio ROC curve](image3)

(c) Serum LDH: pleural lymphocyte ratio

True positive rate (sensitivity)
False positive rate (1 – specificity)
AUC = 0.68

Diagnostic Utility of Pleural Fluid Cell Block versus Pleural biopsy
Table 2. Diagnostic yield of flex-rigid pleuroscopy according to histology (N = 35)

<table>
<thead>
<tr>
<th>Final diagnosis</th>
<th>N</th>
<th>Cell block</th>
<th>Pleural biopsy</th>
<th>P value$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung ADC</td>
<td>24</td>
<td>20/24 (83.3%)</td>
<td>24/24 (100%)</td>
<td>0.125</td>
</tr>
<tr>
<td>Lung adeno-small combined</td>
<td>1</td>
<td>1/1 (100%)</td>
<td>1/1 (100%)</td>
<td>1.000</td>
</tr>
<tr>
<td>MPM</td>
<td>7</td>
<td>2/7 (28.6%)</td>
<td>5/7 (71.4%)</td>
<td>0.250</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>3</td>
<td>2/3 (66.7%)</td>
<td>3/3 (100%)</td>
<td>1.000</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>25/35 (71.4%)</td>
<td>33/35 (94.2%)</td>
<td>0.008</td>
</tr>
</tbody>
</table>

ADC, adenocarcinoma; MPM, malignant pleural mesothelioma

$^a$P values were calculated using McNemar $\chi^2$ statistic.
Thoracentesis

- Does it improve the symptoms?
- Does lung re-expand completely after fluid removal?
- Does fluid re-accumulate rapidly?
Thoracentesis

- Does it improve the symptoms?
- Does fluid re-accumulate rapidly?
- Does lung re-expand completely after fluid removal?

- Failure of complete lung expansion
  - main stem bronchial occlusion by tumor
  - trapped lung due to extensive pleural infiltration
    - initial Ppl $<10$ cm H$_2$O at thoracentesis
Non-Expandable Lung: Definitions

• Lung entrapment:
The underlying disease causes the effusion and the lung may not expand due to:
  
  – visceral encasement
  – endobronchial obstruction

• Trapped lung:
  prior pleural inflammation \(\rightarrow\) visceral pleural scarring or thickening with reductions in Ppl \(\rightarrow\) chronic pleural effusion

Three distinct Eps curves:

1) removal of a large amount of fluid with minimal change in pressure (normal Eps, hepatic hydrothorax or CHF)

2) Relatively normal initial curve followed by a sharp drop in pressure (lung entrapment)

3) Negative initial pressure with a rapid drop in pressure (trapped lung)
Courtesy of Dr. C. Lamb
Abnormal Pleura
Re-expansion Pulmonary Edema
Re-expansion Pulmonary Edema

- 185 Patients tapped > 1L
  - 1 (0.54%) patient with clinical RPE
  - 4 (2.2%) patients with only radiographic RPE

Re-expansion Pulmonary Edema

- Clinical (and radiographic) RPE is rare

- No relationship in the development of RPE to the volume of pleural fluid removed, opening or closing Ppl, Eps, or symptoms during the thoracentesis

- Large volume thoracentesis can be done as long as patients do not develop:
  - Ppl < -20 cmH20
  - chest discomfort

Management

• Depends on etiology
  - Observation
  - Repeat thoracentesis
  - Chest drain
  - Indwelling pleural catheter
  - Pleurodesis (talc slurry vs talc poudrage)
  - Thoracoscopy
Pneumothorax
Pneumothorax

- Air within the pleural cavity (between visceral and parietal pleura)

- The air enters via a defect in the visceral pleura (e.g. ruptured bulla) or the parietal pleura (e.g. puncture following rib fracture)
Types of Pneumothorax

• Simple
  - Mediastinum remains central
  - Clinical condition stable
  - Can wait for CXR to confirm diagnosis

• Tension
  - Progressive build up of air in the pleural space, causing a shift of the heart and mediastinal structures away from side of PTX
  - Clinical condition unstable
  - Do not wait for CXR to confirm diagnosis
**Box 1 Typical clinical situations where tension pneumothorax arises**

1. Ventilated patients on ICU.
2. Trauma patients.
3. Resuscitation patients (CPR).
4. Lung disease, especially acute presentations of asthma and chronic obstructive pulmonary disease.
5. Blocked, clamped or displaced chest drains.
6. Patients receiving non-invasive ventilation (NIV).
7. Miscellaneous group, for example patients undergoing hyperbaric oxygen treatment.
Pathology of Pneumothorax

Closed

Open

Tension
Causes of Pneumothorax

- Spontaneous
  - Rupture of an apical bleb

- Traumatic
  - Blunt trauma with rib fractures
  - Penetrating chest trauma
  - Iatrogenic (positive pressure ventilation)
  - Interventional (Bx, thoracentesis, line placement)

- Pre-existing lung abnormality
  - Pulmonary fibrosis
  - Asthma
  - Vasculitis
Primary Spontaneous Pneumothorax

• Young healthy individual w/o underlying lung disease
  • Due to rupture of apical sub-pleural bleb

• Predisposing factors
  - Smoking
  - Tall, thin male

• Recurrence
  - 50% on the same side
  - 10% on the contralateral side
Secondary Spontaneous Pneumothorax

- Due to underlying lung disease
  - Cavitary lesion
  - Cystic lung disease (LAM)
  - Emphysematous bullae
  - Pneumatocele (thin-walled, air-filled cysts that develop within the lung parenchyma)

- Recurrence more common in secondary spontaneous PTX
Clinical Manifestations

• Dyspnea
• Chest pressure/discomfort
• Cough
Imaging features of pneumothorax

- White line of visceral pleura parallel to chest wall
- No lung markings lateral to the line
- There may be associated rib fractures
- Do not confuse the line with skin fold or with scapula
- More sensitive test if in doubt is a CXR taken in expiration
Imaging features of pneumothorax

- Pneumothorax
  - Erect
    - Small pneumothorax
      - Apical lucency
      - Visceral pleural line
    - Large pneumothorax
      - Apical lucency (>2cm in width)
      - Visceral pleural line
    - Tension pneumothorax
      - Lung collapse
      - Mediastinal shift
      - Low flat diaphragm
  - Supine
    - Deep Costophrenic sulcus
    - Lucent Cardiophrenic sulcus
    - Sharp Mediastinal contour
    - Double diaphragm
Complications of Pneumothorax

- Recurrence of spontaneous PTX
- Tension PTX
- Hydro-pneumothorax
- Encysted pneumothorax
- Lung entrapment or Trapped lung
- Bronchopulmonary fistula
- Pneumomediastinum
Management of Pneumothorax
Management of Pneumothorax
Figure 1  Depth of pneumothorax.

a = apex to cupola distance - American Guidelines
b = interpleural distance at level of the hilum - British Guidelines
BTS Pleural Disease Guideline 2010

MANAGEMENT OF SPONTANEOUS PNEUMOTHORAX

Spontaneous Pneumothorax
If Bilateral/Haemodynamically unstable proceed to chest drain

Primary Pneumothorax

- Size > 2cm and/or breathless
  - NO
  - Size > 2cm and/or breathless
    - YES
      - Aspirate
        - 16–18G cannula
        - Aspirate <2.5l
        - Success
          - < 2cm and breathing improved
          - YES
            - Consider discharge review in OPD in 2–4 weeks
          - NO
          - NO
            - Aspirate
              - 16–18G cannula
              - Aspirate <2.5l
              - Success
                - Size now < 1cm
                - YES
                  - Chest drain
                    - Size 8–14Fr
                    - Admit
                  - NO
                  - NO
                - NO
            - NO
            - NO
              - Aspirate
                - 16–18G cannula
                - Aspirate <2.5l
                - Success
                  - Size now < 1cm
                  - YES
                    - Admit
                    - Size 1–2 cm
                    - NO
                      - Aspirate
                        - 16–18G cannula
                        - Aspirate <2.5l
                        - NO
      - NO
  - NO

Secondary Pneumothorax

- > 2 cm or breathless
  - YES
    - Measure the interpleural distance at the level of the hilum
  - NO

Figure 1: Management of spontaneous pneumothorax

* In some patients with a large pneumothorax but minimal symptoms conservative management may be appropriate

Admit
High flow oxygen (unless suspected oxygen sensitive)
Observe for 24 hours
Thank you