Real-time lung ultrasound for the diagnosis of alveolar consolidation and interstitial syndrome in the emergency department

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Introduction

- Limited as thoracic bones and pulmonary air cause production of artifacts
- Development of modern lung ultrasound procedures is mainly based on discovering of the significance of sonographic artifacts

Technical equipment

- Microconvex 5MHz probe - deep, small
- Curvilinear (abdominal) probe 3–5MHz - wider visualization, deep enough, save time
- Linear probe - higher resolution images of pleural line

Technique

- 1&2: upper anterior and lower anterior
- 3&4: upper lateral and basal latera
- Probe:
  - Longitudinal
  - Oblique

Normal lung

- Focus: depth of the pleural line
- Margins of normal ribs
- 'Bat sign'
- 'Lung sliding'
Normal lung

- M mode
- 'seashore sign'

'A lines' & 'B lines'

- Ultrasound beam is irregularly reflected back to the probe by the microspheric surfaces of the air inside the moving alveoli.

Pulmonary pathologies

- Alveolar consolidations: high liquid content and loss of air
- Pleural-based hypoechoic or anechoic image with pleural line breakdown
- 'Superficial fluid alveologram'
- Limited specificity in distinguishing between pneumonia, lung cancer, atelectasis, pulmonary infarction.

Shape and margins

- Pneumonia: blurred margins and irregular, bizarre shape
- Embolism: sharp margins, wedge or round shaped and pleural based
- Peripheral malignancies: sharp margins, round shaped

Echotexture

- Bronchograms

  - Air or fluid inclusions in the bronchial tree, trapped in the consolidated area
  - Echoic (air) or anechoic (fluid), linear or lentil sized
  - Inspiratory centrifugal movement - nonretractile consolidation (pneumonia)
  - Static - late-stage retractile condition (atelectasis)
**Lung pulse**
- vibration in rhythm with the heartbeat of the consolidated lung
- nonventilated lung
- mainstem intubation or mucous plugging

**B lines**
- area surrounding alveolar consolidation
- increased fluid content of the interstitium
- predicts a neighboring consolidated area

**Diffuse interstitial syndrome**
- abnormal increase of fluids in the interstitium
- Thickening of interlobular septa
- cardiogenic and lesional pulmonary edema, infectious interstitial processes and chronic diffuse parenchymal lung diseases

**Sonographic sign**
- **B line, comet tail, ultrasound lung comet**

**‘lung rockets’ or B+lines**
- Several B lines visible in a single scan
- more scans on each lung defines diffuse alveolar-interstitial syndrome

**Definition of abnormal patterns**
- First step: definition of pathological single scan-
  - microconvex probe ≥ three B lines
  - linear probes > six artifacts per scan
  - abdominal probe ≥ three artifacts with a distance between adjacent lines of not more than 7mm
**Definition of abnormal patterns**

<table>
<thead>
<tr>
<th>Area of thoracic ultrasound</th>
<th>Positive scans</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper anterior right</td>
<td>4</td>
<td>2.8</td>
</tr>
<tr>
<td>Lower anterior right</td>
<td>4</td>
<td>2.8</td>
</tr>
<tr>
<td>Upper lateral right</td>
<td>7</td>
<td>4.9</td>
</tr>
<tr>
<td>Laternalateral right</td>
<td>3</td>
<td>2.1</td>
</tr>
<tr>
<td>Upper anterior left</td>
<td>3</td>
<td>2.1</td>
</tr>
<tr>
<td>Lower anterior left</td>
<td>4</td>
<td>2.8</td>
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<tr>
<td>Upper lateral left</td>
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<td>5.1</td>
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<tr>
<td>Laternalateral left</td>
<td>33</td>
<td>22.8</td>
</tr>
</tbody>
</table>

- Agricola et al: bilateral multiple comet-tail images either disseminated all over the anterolateral lung surface or limited to the lateral lung surface
- at least two scans on each thoracic side, performing four transthoracic scans per side (two anterior and two lateral)

**Diagnostic limit of B+ diffuse pattern**

- low specificity
- cardiogenic and inflammatory pulmonary edema, pulmonary fibrosis, or interstitial pneumonia?

**Evaluating acute dyspnea in the emergency department**

- B+ diffuse pattern v.s. CXR in the alveolar-interstitial syndrome
  - ICU: sensitivity 93.4%, specificity 93.0%, and a feasibility rate of 99%
  - ED: sensitivity 85.7%, specificity 97.7%, feasibility 98.3%
- differentiation between COPD with AE and pulmonary edema with a sensitivity of 100% and specificity of 92%

**Hemodynamic assessment**

- sonographic score is complex to apply
  - retrospective analysis of frozen images
  - not always possible to count B lines
  - ‘shining’ lung
  - sum of positive scans as sonographic scoring

**Conclusion**

- Lung ultrasound: time, cost, and sometimes life saving
- The best way to learn bedside lung application of sonography is to study literature and practice it regularly in the ED.