The Imaging of Acute Lung Injury

Sujal R Desai

Kings College Hospital, London

Background

Imaging tests vital in the imaging of lung injury

- Increased numbers of patients surviving
- Plain CXR both common and vital; CT and other tests providing a supportive "problem-solving" role
- Further insights from CT...

Aims

- Consider (briefly) the "basic" radiological aspects of imaging critically ill patients
- Review the specifics of imaging in acute lung injury (ALI) & acute respiratory distress syndrome (ARDS)
- Discuss the value of and pathophysiological insights from CT (± other imaging tests) in ALI & ARDS

Chest Radiography on ICU

The Benefits of Digital Radiography

Imaging on the ICU

The Issue of the Routine Chest Radiograph

- A daily routine in many units
- Important for
  - Detection of complications
  - Monitoring progress
  - 15-65% show clinically unsuspected changes / progression

Day 1
Day 5
**Imaging in Lung Injury**

**Some Key Questions**

- What is/are the principal roles of CXR, CT, US in the management of patients with ALI/ARDS?
- Does CT add anything...?
- Is there any prognostic information in imaging tests?

**Imaging in Lung Injury**

**Principal Roles of Radiological Tests**

- Diagnosis
- Monitoring progress / resolution
- Detection of (clinically-unsuspected) complications

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**The Diagnosis of ALI/ARDS**

**ALI & ARDS**

**An Historical Perspective**

12 patients, varied insults
- Shock
- Infection
- Acute Pancreatitis

- Breathlessness
- Refractory hypoxia
- Reduced compliance
- CXR infiltrates


**ALI & ARDS**

**Current Diagnostic (Physiological) Definitions**

<table>
<thead>
<tr>
<th></th>
<th>ALI</th>
<th>ARDS</th>
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</thead>
<tbody>
<tr>
<td>Timing</td>
<td>Acute</td>
<td>Acute</td>
</tr>
<tr>
<td>PaO2 / Fio2</td>
<td>≤ 200</td>
<td>≤ 200</td>
</tr>
<tr>
<td>CXR</td>
<td>Bilat diffuse</td>
<td>Bilat diffuse</td>
</tr>
<tr>
<td>PAWP</td>
<td>≤ 18</td>
<td>≤ 18</td>
</tr>
</tbody>
</table>

*Bernard et al. The American-European consensus conference on ARDS: definitions, mechanisms, relevant outcomes, and clinical trial coordination Am J Respir Crit Care Med 1994;149:818-824*
ALI & ARDS
Pathological-Radiological Findings

**EXUDATIVE**

**PROLIFERATIVE**

**FIBROTIC**

**DIFFUSE ALVEOLAR DAMAGE**

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ALI & ARDS
Aetiology

**PULMONARY**

- Aspiration
  - Infection (bacterial, viral, PCP)
- Near-drowning
- Toxic fume inhalation
- Lung contusion

**EXTRA-PULMONARY**

- Systemic Sepsis
  - (Non-thoracic) trauma
- Hypertransfusion (TRALI)
- Cardiopulmonary bypass (rare)

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ARDS Variable CT Appearances

<table>
<thead>
<tr>
<th>Variable CT Appearances</th>
<th>ARDS</th>
<th>ASL</th>
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<tbody>
<tr>
<td>CT findings</td>
<td>Value</td>
<td>Rate</td>
</tr>
<tr>
<td>Pulmonary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extrapulmonary</td>
<td></td>
<td></td>
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<tr>
<td>Typical</td>
<td></td>
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<tr>
<td>Atypical</td>
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**Note:** Data are median values; data in parentheses are the range. NS indicates no significant difference in the data.

Imaging in ALI/ARDS

Quantification of data on CT images

**KEY PRINCIPLES**

Density

CT Density of lung determined by relative amount of air

Air on CT is black

Decrease in relative amount of air manifests as increasing whiteness

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Hyperinflated (~ > -900 HU)
Normal Aeration (~ -500 to -900 HU)
Poorly aerated (~ -100 to -500 HU)
Non aerated (~ -100 to 100 HU)

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Categorising lung CT patterns

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1 Gattinoni L et al. What has computed tomography taught us about the acute respiratory distress syndrome Am J Respir Crit Care Med 2001;164:1701-1711

Pathophysiological Relationships

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Lung Recruitment

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**Imaging in ALI/ARDS**

*Why the AP Gradient?*


*Why the AP Gradient: A Normal Phenomenon?*

*Imaging in ALI/ARDS*

Cardiac Compression


Cardiac Compression: Effects of Prone Positioning

Albert RK et al. The prone position eliminates compression of the lungs by the heart. Am J Respir Crit Care Med 2000;161:1660-1665

Beneficial Effects of Dependent Atelectasis?


**VENTRAL**

"Unprotected"

**DORSAL**

"Protected"
Imaging in ALI/ARDS

Some Key Questions

• What is/are the principal roles of CXR, CT, US in the management of patients with ALI/ARDS?
• Does CT add anything...
• Is there any prognostic information in imaging tests?

Fibrosis and Prognosis in ARDS

Ichikado K et al. Acute interstitial pneumonia: comparison of high-resolution computed tomography findings between survivors and nonsurvivors. Am J Respir Crit Care Med 2002;165:1551-1556

The Unanswered Questions

• Morphological differences between ALI and ARDS?
• If so, do these predict outcome, duration on ventilator?
• Prediction of likely steroid-responsiveness?

Closing Remarks

• Imaging tests are integral to the management of critically-ill patients
• Plain chest radiography is the "workhorse" investigation; routine probably acceptable for ICU patients...
• CT (+ others) useful supporting role
• CT continues to provide pathophysiological and prognostic insights in lung injury