Ventilatory Imaging

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Pulmonary Imaging

- Anatomic imaging
- Functional imaging
- Molecular imaging
Anatomic Imaging

- Multislice CT
- Micro-computed CT
- MRI
- Reconstruction techniques
- Ultrasound imaging
Carotid stenosis
End expiratory images at 10 cm H$_2$O PEEP within minutes of postural change
Study Protocol

68 Patients enrolled with diagnosis of acute lung injury or ARDS

Recruitment maneuvers

PEEP trial with PEEP at 5 and 15 cm of water (random sequence) and physiological variables

Recruitment maneuver

CT with inspiratory plateau pressure of 45 cm of water

Recruitment maneuvers

CT with PEEP at 5 and 15 cm of water (random sequence)

Quantitative analysis

34 With lower percentage

34 With higher percentage

Distribution of Patients According to the Percentage of Potentially Recruitable Lung
Distribution of Patients According to the Percentage of Potentially Recruitable Lung and CT Images at 5 and 45 cm

Mortality in Relation to the Percentage of Potentially Recruitable Lung

Anatomic Imaging by CT

- CT densities may represent airway/alveolar fluid rather than collapse
- Where is the lung edema distributed?
  - airway/alveoli or interstitium
- Are we over-treating CT densities at the risk of injury to non-dependent lung?
Sonography after Pulmonary Embolism

Respiration 2003;70:87-94
Functional Imaging

- Virtual bronchoscopy
- CT evaluation of ventilation and perfusion
- CT evaluation of lung mechanics
- Positron emission tomography
- Hyperpolarized 3-He MRI
- Electrical impedance tomography
PERFLUROCHEMICALS AS PULMONARY CONTRAST AGENTS

- **Plain film x-ray**
  limited perspective to assess distribution

- **Computerized tomography (CT)**
  3D imaging along X, Y, and Z axes
  qualitative and quantitative analysis

- **High resolution CT**
  thin section 3D imaging along X, Y, and Z axes
  qualitative and quantitative analysis
Partial Liquid Ventilation in Premature Newborns
Carina 3D Image

No PFC

PFC

Acad Radiol 8:583-586, 1997
4th Generation 3D Image

No PFC

PFC

Acad Radiol 8:583-586, 1997
Quantitative Regional Lung Expansion by CT

Proc ATS 2:2005; 517-21
PET Image During Methacholine-induced Bronchoconstriction

Proc ATS 2:2005; 522-27
Functional Imaging

- Electrical impedance tomography
Electrical Impedance Tomography (EIT)

Production of a cross-sectional image of
(changes in)
electrical impedance distribution in order to estimate
(changes in)
air distribution
Electrical Impedance Tomography (EIT)

Resistivity (at 50 KHz) relative to blood:

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Resistivity</th>
</tr>
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<tbody>
<tr>
<td>whole blood</td>
<td>1</td>
</tr>
<tr>
<td>muscle</td>
<td>1.6</td>
</tr>
<tr>
<td>liver</td>
<td>5</td>
</tr>
<tr>
<td>lung, deflated</td>
<td>8</td>
</tr>
<tr>
<td>lung, inflated</td>
<td>16</td>
</tr>
<tr>
<td>bone</td>
<td>50</td>
</tr>
</tbody>
</table>
Electrical Impedance Tomography

Cross-sectional image of electrical impedance change

Current injection
Voltage measurement

reconstruction
special communication

Monitoring changes in lung air and liquid volumes with electrical impedance tomography

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J Appl Physiol 83 (5), 1997
Fig. 4. Lung volume calculated by EIT ($\hat{x}$) as a function of syringe volume. Values are means ± SD; $n = 9$ animals. FRC, functional residual capacity.
Regional pressure volume curves by electrical impedance tomography in a model of acute lung injury

Peter W. A. Kunst, MD; Stephan H. Bohm, MD Gilberto Vazquez de Anda, MD; Marcelo B.P. Amato, MD; Burkhard Lachmann, MD, PhD; Piet E. Postmus, MD, PhD; Peter M. J. M. de Vries, MD, PhD

Crit Care Med 2000; 28:178-183
Critical Care Med 2000, 28:178-183
Estimation of regional lung volume changes by electrical impedance tomography during a pressure-volume maneuver
Regional pressure-volume curve

Ventral

Ventral

Dorsal

* lower corner point
O maximal slope
* linear upper edge
Regional lung volume during high-frequency oscillatory ventilation by electrical impedance tomography*

Huibert R. van Genderingen, PhD; Adrianus J. van Vught, MD, PhD; Jos R. C. Jansen, PhD

Crit Care Med 2004; 32:787–794
Relationship between impedance change and mean airway pressure during HFOV

Crit Care Med 2004; 32:787–794
IMPEDANCE CHANGES

UPPER LUNG

TOTAL LUNG

LOWER LUNG

M. Amato (personal communication)
IMPEDANCE CHANGES

Time (min)

M.Amato (personal communication)
3 m/o, Bronchiolitis
Servo 300, PC/PS PIP 27, PS 10, PEEP 5

Vt 35 cc
Vt 25 cc
Regional ventilation in dependent areas
Regional ventilation in nondependent areas
Patient on Sensormedics – disconnection -suctioning
Ideal Clinical Monitor

- Describes regional changes in anatomy/physiology
- Non-invasive
- Portability to the bedside
- Short processing time
- Dynamic data updating
Molecular Imaging

- Micro-PET and micro-SPECT
- Bioluminescence imaging
- Inflammation imaging
- Molecular imaging of pulmonary gene expression using PET
“Americans will always do the right thing once they have tried everything else....”

Winston Churchill