Quantitative computed tomography of normal lung development in newborn and infants

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Conflict of Interest

• Nothing to disclose
Background

- Lung maturation starts in-utero and continues after birth (first two years of life)
- Chest CT is routinely used for evaluation of acquired and congenital lung abnormalities
- Quantitative CT (qCT) offers additional quantitative information
  - Cystic Fibrosis
  - Asthma
  - Bronchiolitis Obliterans
Background

- Chronic Lung Disease of prematurity shows high heterogeneity on quantitative CT
- Small sample in patients between 0 – 2 years
- No equations for attenuation according to age
- Lack of information per lobe
To characterize lung development in children younger than 2 years of age using quantitative CT of the chest.
## Materials and Methods: Patient population

- Retrospective study
- IRB-approved

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age 0 – 2 years</td>
<td>1. History of lung disease</td>
</tr>
<tr>
<td>2. Available non-contrast chest CT</td>
<td>2. History of thoracic radiation therapy</td>
</tr>
<tr>
<td>128-slice CT scanner</td>
<td>3. Acute respiratory symptoms</td>
</tr>
<tr>
<td>3. No abnormal findings in the lung</td>
<td></td>
</tr>
</tbody>
</table>

Materials and Methods: Image Segmentation

- 3D Slicer version 4.8.1
- A medical doctor and a pediatric radiologist with more than 20 years of experience
- Semi-automated threshold segmentation of the lung
- The major fissures and minor fissure were identified
Materials and Methods: Image analysis

- Parameters of quantitative CT analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Lung Density</td>
<td>Hounsfield Units</td>
</tr>
<tr>
<td>Lung Volume (L)</td>
<td>Liter</td>
</tr>
<tr>
<td>Lung Mass (g)</td>
<td>Function of volume and attenuation</td>
</tr>
</tbody>
</table>
## Results: Demographic information

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Demographic</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 48 children</td>
<td>• 15.1 ± 7.6 months</td>
</tr>
<tr>
<td>• 26 Boys and 18 girls</td>
<td>• BSA = 0.4 ± 0.1 m²</td>
</tr>
</tbody>
</table>
All patients had a diagnosis of cancer or a mass but none of them had positive findings on the chest CT.
### Results: Quantitative information

#### Per patient (both lungs)

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Lung Density (HU)</td>
<td>-571.7 ± 41.8</td>
<td>-571.7 ± 41.8</td>
</tr>
<tr>
<td>Lung Mass (g)</td>
<td>142.2 ± 43.1</td>
<td></td>
</tr>
<tr>
<td>Lung Volume (L)</td>
<td>0.32 ± 0.11</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>RUP</th>
<th>RML</th>
<th>RLL</th>
<th>LUL</th>
<th>LLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Lung Density (HU)</td>
<td>-592.0 ± 46.2</td>
<td>-636.0 ± 42.1</td>
<td>-540.5 ± 53.4</td>
<td>-583.9 ± 45.4</td>
<td>-514.6 ± 54.4</td>
</tr>
<tr>
<td>Lung Mass (g)</td>
<td>21.1 ± 6.59</td>
<td>19.2 ± 6.2</td>
<td>37.0 ± 12.5</td>
<td>32.2 ± 10.2</td>
<td>32.6 ± 14.0</td>
</tr>
<tr>
<td>Lung Volume (L)</td>
<td>0.05 ± 0.01</td>
<td>0.05 ± 0.01</td>
<td>0.08 ± 0.03</td>
<td>0.07 ± 0.02</td>
<td>0.06 ± 0.03</td>
</tr>
</tbody>
</table>
Results: Quantitative information

Mean Lung Attenuation = \(-1.94\) (months) + 5.42

$r = -0.35, p = 0.01$
Results: Quantitative information

Lung Volume (L) = 0.01 (months) + 0.15
Lung Volume (mL) = 10.8 (months) + 1.59

$r = 0.75$, $R^2 = 0.57$, $p < 0.001$
Results: Quantitative information

\[ r = 0.78, \quad R^2 = 0.62, \quad p < 0.001 \]

\[ \text{Lung Mass} = 4.43 \text{ (months)} + 75.16 \]
Discussion

• Lung density decreases linearly after birth
  • Alveolarization
  • Gravitational dependence of lung attenuation
  • Low degree of inspiration in young children

• Lung volume increase linearly with age after birth
  • Highly dependent on age, sex, race, and height
  • Functional Residual Capacity

• Lung Mass showed the strongest correlation
  • Utility in diffuse lung disease
Normal lung parenchyma attenuation declines linearly with age. Lung volume and mass increases during the first two years of life.
Thank you

Questions?

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