Disclosures

Consultant for / research support from:

Bayer
Bracco
General Electric
Medrad
Siemens
Collaborators

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Why Are We Interested in CT Lung Perfusion?

- If large % of lung parenchyma is affected by embolic occlusion, imminent right heart failure warrants a more aggressive regimen such as thrombolysis or embolectomy that carries a small but definite risk.
  
  Pulmonary embolism thrombolysis: broadening the paradigm for its administration. Goldhaber SZ; *Circulation*. 1997

- Quantitative assessment of the affected lung parenchyma may bear more important information for patient management than the direct visualization of emboli alone.

  Association between thrombolytic treatment and the prognosis of hemodynamically stable patients with major pulmonary embolism: results of a multicenter registry. Konstantinides S; *Circulation* 1997
# Techniques for CT Lung Perfusion

<table>
<thead>
<tr>
<th>Static</th>
<th>Dynamic</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Unenhanced CT attenuation analysis</td>
<td>• Electron beam CT</td>
</tr>
<tr>
<td>• Color coded perfusion maps</td>
<td>• Dynamic spiral CT</td>
</tr>
<tr>
<td>• Non-contrast / contrast subtraction CT</td>
<td>• Dynamic volume CT</td>
</tr>
<tr>
<td>• Dual Energy CT</td>
<td></td>
</tr>
</tbody>
</table>
Detection of Lung Perfusion Abnormalities Using Computed Tomography in a Porcine Model of Pulmonary Embolism

EBCT Dynamic Lung Perfusion in Acute PE

Schoepf et al. Radiology 2001
EBCT Dynamic Lung Perfusion in Acute PE

Schoepf et al. Radiology 2001
EBCT Dynamic Lung Perfusion in Acute PE

Schoepf et al. Radiology 2001
Color Coded Perfusion Maps in Acute PE

Herzog, Wildberger, Schoepf et al. Acad Radiol 2003
Broad Detector vs. Dynamic “Shuttle” CT
Pre treatment | Post treatment | Right lung almost restored; large defect remains in left lung

Courtesy: Edwin J.R. van Beek, CRIC, University of Edinburgh, UK
“Shuttle” Mode Dynamic CT Perfusion Imaging
“Shuttle” Mode Dynamic CT Perfusion Imaging
Integrative Cardiopulmonary Imaging: Dual-Energy CT
DECT Imaging in Acute PE
DECT Imaging in Acute PE
DECT Lung Perfusion in Acute PE
DECT Lung Perfusion in Acute PE
DECT Lung Perfusion in Acute PE

Henzler et al. JCCT 2011
Foreign Body Embolization

Henzler, J Cardiovasc Med 2010
DECT Lung Perfusion in Acute PE: Pitfalls
DECT Post-Processing

- 140kV
  - Bone: 450 HU
  - Iodine: 144 HU

- 80kV
  - Bone: 670 HU
  - Iodine: 296 HU

- 140kV
  - Bone: 450 HU
  - Iodine: 144 HU
DECT Lung Perfusion in Acute PE: Pitfalls
## Contrast Media Injection Strategies

<table>
<thead>
<tr>
<th>Group</th>
<th>Iodine concentration (mg/ml)</th>
<th>Total volume</th>
<th>Injection rate (ml/s)</th>
<th>Iodine delivery rate (gI/s)</th>
<th>Injection time (s)</th>
<th>Total iodine load (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>400</td>
<td>80</td>
<td>3</td>
<td>1.2</td>
<td>26.7</td>
<td>32</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>80</td>
<td>4</td>
<td>1.6</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>300</td>
<td>107</td>
<td>5.4</td>
<td>1.6</td>
<td>19.8</td>
<td>32</td>
</tr>
<tr>
<td>D</td>
<td>300</td>
<td>107</td>
<td>4</td>
<td>1.2</td>
<td>26.8</td>
<td>32</td>
</tr>
</tbody>
</table>

*Nance et al. Invest Radiol 2011*
High IDR in combination with highly concentrated CM reduces artifacts for DECT

Nance et al. Invest Radiol 2011
Static or Dynamic? DECT vs. TWIST MRA
Static or Dynamic?

Hansmann J et al. RSNA 2011
DECT Lung Perfusion in Acute PE: Prognosis

Kaplan-Meier analysis

R. Bauer et al., Eur Radiol 2011
### DECT Lung Nodule Characterization

Chae et al. Radiology 2008

<table>
<thead>
<tr>
<th>Analyzed Data</th>
<th>Malignant Nodules (n = 25)</th>
<th>Benign Nodules (n = 20)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT number on iodine-enhanced image (HU)</td>
<td>36.5 ± 16.0</td>
<td>17.3 ± 21.8</td>
<td>.001</td>
</tr>
<tr>
<td>Degree of enhancement (HU)</td>
<td>37.0 ± 14.6</td>
<td>17.0 ± 17.9</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analyzed Data</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT number on iodine-enhanced image</td>
<td>92.0 (52.2, 85.9)</td>
<td>70.0 (47.9, 85.7)</td>
<td>82.2 (56.5, 82.4)</td>
</tr>
<tr>
<td>Degree of enhancement</td>
<td>72.0 (73.9, 98.9)</td>
<td>70.0 (47.9, 85.7)</td>
<td>71.1 (68.4, 90.7)</td>
</tr>
</tbody>
</table>
DECT Lung Cancer Staging
DECT Lung Cancer Characterization
DECT Lung Cancer Imaging: Therapy Response
Summary

Why CT Perfusion in PE?

Feasibility Studies

State of the art

Increase Diagnostic Accuracy

Assessment of RVD

Therapy Monitoring

EBCT

Single Level Dynamic Spiral CT

Perfusion Weighted Color Maps CT

CE Non CE Subtraction CT

Dynamic Volume CT

Dual Energy CT
Summary

- DECT maybe the most practical approach to establish comprehensive imaging
  - Easy to integrate in clinical workflow
  - No additional dose, CM and room time → No additional costs

- Prospective multicenter studies on:
  - Impact on treatment decisions
  - Usefulness for therapy monitoring
  - Patient outcome