Advances in the Understanding of Pulmonary Aspergillosis

CT Imaging in Aspergillus Lung Infections

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A. Early detection
B. Characterisation
C. Monitoring
D. Intervention
Fungal Pneumonia

Febrile day 8  Day 3  Day 3
AML, Fever
AML, Neutropenia, Fever

+3 weeks
Early Detection

Probability

100%
80%
60%

p < 10^{-7}, n_{ges} = 188

HRCT: normal
n=76

HRCT: infiltrate
n=112

time after HRCT until CXR positive [d]

Heussel et al., AJR 1997, JCO 1999
<table>
<thead>
<tr>
<th>Procedure</th>
<th>Radiation Exposure (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature p.a.</td>
<td>~1 mSv</td>
</tr>
<tr>
<td>CXR</td>
<td>0.1–0.2 mSv</td>
</tr>
<tr>
<td>MSCT</td>
<td>2–6 mSv</td>
</tr>
<tr>
<td>Low-dose</td>
<td>0.6–2 mSv</td>
</tr>
<tr>
<td>HRCT</td>
<td>0.5–1 mSv</td>
</tr>
<tr>
<td>PET</td>
<td>4 mSv</td>
</tr>
<tr>
<td>MRI</td>
<td>0 mSv</td>
</tr>
</tbody>
</table>

*Kuiper et al., Eur Radiol 2003*
Dose Reduction

Immuncomp. pat. n=30, infiltrate n=23, 1mm SD
dose simulation => spec_{low-dose} 100%→86%

25 mAs ♂1.2/♀1.5mSv

35 mAs ...

50 mAs ...

70 mAs ♂3.2/♀4.2mSv

Courtesy of Yamamura et al., RöFo 2009
Ground-Glass Opacification

HRCT

MRT

Courtesy of Ley S
A. Early detection
B. Characterisation
C. Monitoring
D. Intervention
EORTC Criteria
Fungal Pneumonia

• Major
  - Dense, well-circumscribed lesions
  - With or without a halo sign
  - Air-crescent sign

• Minor

De Pauw et al., Clin Infect Dis 2008
Halo Sign

1984 described\textsuperscript{1}
1985 discussed in 9 patients\textsuperscript{2}

\textsuperscript{1} Gefter et al. Radiology '84
\textsuperscript{2} Kuhlman et al. Radiology '85
Fungal Pneumonia

Halo sign
Candida sepsis (+ hepatolienal C.)
Fungal Pneumonia

Hepatosplenic candidiasis
Halo
Halo
## Value of Halo Sign

IPA, n=235

<table>
<thead>
<tr>
<th>Frequency</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Macronodules</td>
<td>94%</td>
</tr>
<tr>
<td>Halo</td>
<td>61%</td>
</tr>
<tr>
<td>Consolidation</td>
<td>30%</td>
</tr>
<tr>
<td>Infarct-shaped</td>
<td>27%</td>
</tr>
<tr>
<td>Cavitation</td>
<td>20%</td>
</tr>
<tr>
<td>Air-crescent</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Response**
- 52% vs 29%; *p*<0.001

**3-month survival**
- 71 vs 53%; *p*<0.01

*Greene et al. CID '07*
Value of Halo Sign

IPA, n=235

Pro
• Many patients
• Ante-mortem trial

Contra
• Halo = part of inclusion
• 95% hardcopies
• Thick section CT
• 270° of halo not defined

Greene et al. CID ‘07
Septic Embolism

Infected port
M13

Galaxy-sign=

Sarcoid

Halo?

Halo!

465250
Halo

Adeno-ca.

Meta leio-ca
Fungal Pneumonia

Consolidation
Fungal Pneumonia

Air-crescent sign
Fungal Pneumonia

Air-crescent sign
Fungal Pneumonia

Air-crescent sign

IgG deficiency
Fungal Pneumonia
Moving Fungus Ball

prone

supine

+5 month
Tracheobronchitis

Tracheal wall thickening

Oligemia

+ 2 month
Tracheobronchitis

+ 3 weeks

+ 4 months
Psudomembraneous

Plasmodium falciparum ass.

Eckerle I et al., Malaria Journal 2009
Allergic Bronchopulmonary Aspergillosis (ABPA)
Allergic Bronchopulmonary Aspergillosis (ABPA)
Allergic Bronchopulmonary Aspergillosis (ABPA)
A. Early detection
B. Characterisation
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Fungal Pneumonia

Ill-defined nodules + halo sign
### Fungal Pneumonia

**Day 19 of neutropenia**

<table>
<thead>
<tr>
<th></th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halo</td>
<td>68%</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>Air-crescent</td>
<td>8%</td>
<td>28%</td>
<td>63%</td>
</tr>
<tr>
<td>Consolidation</td>
<td>31%</td>
<td>50%</td>
<td>18%</td>
</tr>
<tr>
<td>Volume</td>
<td>= 1</td>
<td>x 4</td>
<td>x 4</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>39%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Caillot et al., JCO '01*
Radiological Course

- day 2: Normal
- day 7: Ill-defined nodules
- day 13: Hemat. recovery
- day 33: Halo reduction
- day 108: Shrinkage
Radiological Course

Voriconacole….l-AmB….
A. Early detection
B. Characterisation
C. Monitoring
D. Intervention
CT-Guided Biopsy

Thrombocytopenia (44 x 10^{-6})
CT-Guided Biopsy

Thrombocytopenia ($44 \times 10^{-6}$)
CT-Guided Biopsy

Thrombocytopenia (44 x 10^{-6})

16.8.10

Post-intervention
CT-Guided Biopsy

PcR: *Aspergillus flavus*

*Courtesy of D. Buchheidt, Mannheim

*Courtesy of P. Schnabel, Pathology, Heidelberg*
46 hematological patients
BC, Leukemia, TBC 9

n=16
Asper. sp. 8
Mold 2
COP 4
TBC 1

n=17
Asper. sp. 8
Mucor sp. 4
Non-spec. 4
2 later
BC, Leukemia, TBC 9

n=17
Asper. sp. 8
Mucor sp. 4
Non-spec. 4
2 later
BAC 1

Lass-Flörl et al., CID 2007

46 hematological patients
n=17
Asper. sp. 8
Mucor sp. 4
Non-spec. 4
2 later
BAC 1

CT-Guided Biopsy

n=16
Asper. sp. 8
Mucor sp. 5
Rhizomucor sp. 3
Absidia sp. 4
Cunnighamella sp. 1
BC, Leukemia, TBC 9

Lass-Flörl et al., CID 2007
Vessel Arrosion

- Hemoptysis in 10-40% of IPA
- ~1 week after reconstitution
- Acute pulmonary hemorrhage
- Mortality ~10%
- Contrast-enhanced CT
- Bronchial- / pulmonary arteries
- Resection ± embolisation

Bowler et al., Chest 1998
Heussel et al., Eur Radiol 1997
Pagano et al., Br J Haematol 1995
Aspergillus Pneumonia + Vessel Erosion
Aspergillus Pneumonia + Pseudo-Aneurism

Pre- Post-embolisation

Heussel et al., Eur Radiol ’97
www.pneumotox.com
www.radiologyassistant.nl
www.ctisus.com
www.mevis.de/~jend/Lunge/inh.html
www.multislice-ct.com
academic.kellogg.cc.mi.us/herbrandsonc/bio201_McKinley/
www.aspergillus.org.uk

Halo: Greene et al. CID (2007) 44
Fungal Pneumonia: Heussel et al. Radiologe (2000) 40
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