Performance characteristics of a dual detector small animal SPECT CT camera

Kench P¹, Quinlivan M²,
Gregoire M², Berghofer P²,
Katsifis A² & Meikle S¹

1. Brain & Mind Research Institute 2. Radiopharmaceutical Research Institute. Sydney, Australia
Small animal imaging

- Radiopharmaceutical development
  - Biodistribution
  - Quantification
  - Longitudinal studies on the same animal

- SPECT
  - Detects small quantities of contrast agent
  - Poor spatial resolution compared to CT
Small animal SPECT cameras

• Higher spatial resolution
  – Multiple crystal arrays and PS-PMT
  – Pinhole collimation with small aperture

• Higher sensitivity
  – Multiple detectors
  – Multiple pinholes
X-SPECT (Gamma Medica)

- Multiple Crystal - NaI(Tl)
  - 2 x 2 x 6 mm (x 3136)
- Multiple PS-PMT
  - 25 / detector
- Dual detector
  - FOV 125 mm
- Pinhole
  - 1 mm aperture
- X-ray CT unit
Performance characteristics

- Energy resolution
- Uniformity
- Sensitivity
- SPECT
  - Spatial resolution
  - Contrast resolution
  - Animal imaging
Energy resolution (FWHM)

Energy resolution (FWHM) for crystal 1652:
- 1652 = 10.1%

Energy resolution (FWHM) for crystal D1:
- D1 = 11.7%

Energy resolution (FWHM) for crystal D2:
- D2 = 12.0%
Uniformity

- Detector one (D1)
  - counts max = 15405
  - integral = 6.4 %
  - differential = 5.1 %

- Detector two (D2)
  - counts max = 14316
  - integral = 7.8 %
  - differential = 7.2 %
Sensitivity

• Method
  – Tc-99m, 44 MBq in a 3 ml vial
  – Pinhole collimation with 1 mm aperture
  – Dual detectors at ROR of 20 & 30 mm
  – Measured at 0 and 180 degrees with mean value reported
# Sensitivity

## Results

<table>
<thead>
<tr>
<th>ROR (mm) / MAG</th>
<th>D1 (cps/MBq)</th>
<th>D2 (cps/MBq)</th>
<th>D1 &amp; D2 (cps/MBq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 / x 4.5</td>
<td>62.83</td>
<td>74.56</td>
<td>137.39</td>
</tr>
<tr>
<td>30 / x 3.0</td>
<td>23.81</td>
<td>28.24</td>
<td>52.05</td>
</tr>
</tbody>
</table>
SPECT spatial resolution

- Method
  - line source
    - Tc-99m, 37 MBq, 0.2 mm internal diameter
  - collimation
    - 1 mm pinhole aperture
  - acquisition
    - 360 degrees per detector, 128 Steps at 60 seconds / step
    - ROR = 20, 30 and 40 mm
  - reconstruction and analysis
    - OSEM
    - FWHM reported as the mean of ten x & y measurements
## SPECT spatial resolution (air)

<table>
<thead>
<tr>
<th>ROR (mm) MAG</th>
<th>D1 FWHM (mm)</th>
<th>D2 FWHM (mm)</th>
<th>D1 D2 FWHM (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 x 4.5</td>
<td>1.12</td>
<td>1.03</td>
<td>1.12</td>
</tr>
<tr>
<td>30 x 3.5</td>
<td>1.08</td>
<td>1.05</td>
<td>1.14</td>
</tr>
<tr>
<td>40 x 2.3</td>
<td>1.38</td>
<td>1.55</td>
<td>1.45</td>
</tr>
</tbody>
</table>
SPECT contrast resolution

- Method (cold rod phantom)
  - Plastic tube outer diameter 16 mm
  - Tc-99m, 172MBq, 10 ml water, 4% gelatine
  - Water filled cold rods
    - 2 x 1.3 mm glass capillary
    - 1 x 3 mm plastic tubing
  - Pinhole collimator with 1 mm aperture
  - 360 degrees, 128 steps, 90 sec / step
SPECT contrast resolution

ideal contrast = 0 %

50%  14%
SPECT animal imaging

• Animal Model
  – Cuprizone induced demyelination
  – I-123 CLINDE marker of neurodegeneration

• Acquisition
  – Pinhole 1 mm aperture
  – ROR = 30 mm / x 3 MAG
  – 360 degrees / detector
  – 64 steps at 60 sec / step
Conclusions

• Good performance
  – comparison of commercial versus prototype

• Some challenges remain
  – requires increased sampling
  – normalised of SPECT reconstruction values
  – data misalignment in combined sinograms
    • ROR < 30mm
    • Currently does not effect animal imaging
  – Development multi-pinhole collimation
### SPECT spatial resolution (gelatine)

<table>
<thead>
<tr>
<th>ROR (mm) / MAG.</th>
<th>D1 D2 (mm) FWHM / FWTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 / x 4.5</td>
<td>1.27 / 2.67</td>
</tr>
<tr>
<td>35 / x 2.6</td>
<td>1.30 / 3.03</td>
</tr>
</tbody>
</table>

**Line source dia. = 0.5 mm**  
**Gelatine diameter = 16 mm**