Patient Dosimetry Audit for Establishing Local Diagnostic Reference Levels for Nuclear Medicine CT

CT Users Group Meeting
20th October 2016, Manchester Conference Centre

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**NB:** This work will be submitted for publication imminently
Background

- Diagnostic Reference Levels (DRLs) provide a useful tool for monitoring patient doses
- It is a legislative requirement to establish Local DRLs (LDRLs) (UK\(^1\) and Europe\(^2\))
- DRLs (Local and National) are well established in diagnostic radiology but not a common practice in Nuclear Medicine (NM) CT
- NDRLs are available for NM in terms of administered activity\(^3\) (no information on CT component)
- Previous work has been carried out to establish DRL for PET/CT\(^4,5\)
**Background (cont…)**

**Table 1: IPEM Working Party Proposed NDRLs\(^6\) for common NMCT examinations**

<table>
<thead>
<tr>
<th>Examination Type</th>
<th>CT Purpose</th>
<th>Proposed NDRLs</th>
<th>CTDIvol (mGy)</th>
<th>DLP (mGycm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET half body</td>
<td>Localisation</td>
<td></td>
<td>4.3</td>
<td>400</td>
</tr>
<tr>
<td>Parathyroid</td>
<td>Localisation</td>
<td></td>
<td>5.6</td>
<td>170</td>
</tr>
<tr>
<td>Bone</td>
<td>Localisation</td>
<td></td>
<td>5.6</td>
<td>180</td>
</tr>
<tr>
<td>Octreotide/MIBG</td>
<td>Localisation</td>
<td></td>
<td>5.4</td>
<td>240</td>
</tr>
<tr>
<td>Thyroid post ablation</td>
<td>Localisation</td>
<td></td>
<td>5.9</td>
<td>210</td>
</tr>
<tr>
<td>SPECT/PET cardiac</td>
<td>Attenuation Correction</td>
<td></td>
<td>2.0</td>
<td>34</td>
</tr>
</tbody>
</table>
The aim of this work was to establish a system for NMCT in terms of

- patient dosimetry audit
- setting up LDRLs

Patient dosimetry for NMCT presented a number of difficulties which may not be encountered for diagnostic radiology CT
Background (cont…)

• For diagnostic radiology CT, data are divided according to body region only (e.g. Lumbar Spine)

• For NMCT, data were divided according to:
  ✓ examination type (e.g. Bone)
  ✓ body region
  ✓ dose modes

• Obtaining sufficient patient numbers proved challenging for NMCT due to the above data division
Background (cont…)

**Table 2:** CT dose modes developed for Nuclear Medicine at the Queen Elizabeth Hospital Birmingham

<table>
<thead>
<tr>
<th>Dose Mode</th>
<th>CT Purpose</th>
<th>kV</th>
<th>Quality Reference mAs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Attenuation Correction</td>
<td>130</td>
<td>10-16</td>
</tr>
<tr>
<td>Moderate</td>
<td>Localisation</td>
<td>130</td>
<td>40</td>
</tr>
<tr>
<td>Standard</td>
<td>Diagnostic CT</td>
<td>130</td>
<td>150</td>
</tr>
<tr>
<td>Metal</td>
<td>Patients with Orthopaedic Implants</td>
<td>130</td>
<td>330</td>
</tr>
</tbody>
</table>

*values are approximate as actual value depends on body region
Methods

• Data have been collected from examinations performed on
  ✓ Two SPECT/CT scanners (Siemens Symbia T16 and T)
  ✓ PET/CT scanner (Siemens Biograph mCT Flow)
• Data collection periods
  ✓ SPECT/CT (November 2014 to July 2016)
  ✓ PET/CT (April to August 2016)
• Examination data capture
  ✓ Computed Radiological Information System (CRIS)
  ✓ Paper records (manually recorded by NM Technologists)
Methods (cont…)

- CRIS downloads provided information on the
  - examination type
  - date of birth
  - date of examination
  - Dose Length Product (DLP)

- CRIS provided sufficient information to perform dose analysis for
  - PET/CT examinations
  - Cardiac SPECT/CT examinations

(as these are not associated with different dose modes and body regions)
Methods (cont..)

- The mean and standard deviation of DLPs for common NMCT examinations were then calculated.
- Data were subjectively assessed and any obvious outliers removed before analysis.
- Paediatric data were also identified and removed before analysis.
- Only examinations with 10, or more, patients were analysed.
- LDRLs will be set based on the mean DLP.
Methods (cont…)

• Paper records provided additional information for SPECT/CT (excluding Cardiac) examinations
  ✓ body region
  ✓ dose mode
  ✓ scanner

• The CRIS data and paper records were matched using the patient identification number and examination date found on both records

• For common SPECT/CT examinations, data were divided in terms of the
  examination type, body region, scanner and dose mode
# Results

**Table 3**: Comparison between mean DLP and IPEM WP proposed NDRLs\(^6\) for Bone SPECT/CT examinations for different body regions and dose modes

<table>
<thead>
<tr>
<th>Examination Type</th>
<th>Body Region</th>
<th>Scanner</th>
<th>No. of Patients</th>
<th>Dose Mode</th>
<th>DLP (mGy cm)</th>
<th>Mean DLP</th>
<th>Standard Deviation</th>
<th>Proposed NDRLs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bone</strong></td>
<td>Pelvis</td>
<td>T</td>
<td>15</td>
<td>Moderate</td>
<td>105</td>
<td>40</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>T-Spine</td>
<td>T</td>
<td>13</td>
<td>Moderate</td>
<td>133</td>
<td>40</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>T-Spine/L-Spine</td>
<td>T</td>
<td>15</td>
<td>Moderate</td>
<td>124</td>
<td>26</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>L-Spine</td>
<td>T</td>
<td>47</td>
<td>Moderate</td>
<td>107</td>
<td>33</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>L-Spine</td>
<td>T16</td>
<td>24</td>
<td>Moderate</td>
<td>170</td>
<td>70</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>L-Spine</td>
<td>T16</td>
<td>33</td>
<td>Standard</td>
<td>634</td>
<td>226</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>L-Spine</td>
<td>T16</td>
<td>11</td>
<td>Metal</td>
<td>1045</td>
<td>426</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Feet/Ankles</td>
<td>T</td>
<td>10</td>
<td>Standard</td>
<td>153</td>
<td>44</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Feet/Ankles</td>
<td>T16</td>
<td>32</td>
<td>Standard</td>
<td>221</td>
<td>39</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Pelvis</td>
<td>T16</td>
<td>11</td>
<td>Standard</td>
<td>558</td>
<td>111</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Pelvis</td>
<td>T16</td>
<td>34</td>
<td>Metal</td>
<td>1359</td>
<td>322</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Knees</td>
<td>T16</td>
<td>10</td>
<td>Standard</td>
<td>230</td>
<td>130</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Knees</td>
<td>T16</td>
<td>111</td>
<td>Metal</td>
<td>913</td>
<td>285</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>T-Spine/L-Spine</td>
<td>T16</td>
<td>24</td>
<td>Standard</td>
<td>704</td>
<td>306</td>
<td></td>
<td>180</td>
</tr>
</tbody>
</table>

**Moderate** - Localisation, **Standard** - Diagnostic CT, **Metal** - Patient with orthopaedic implants
Results (cont..)

Table 4 : Comparison between mean DLP and proposed NDRLs for different examination types
body region and dose modes

| Examination Type | Body Region   | Scanner | No. of Patients | Dose Mode | DLP (mGy cm) |  |
|------------------|---------------|---------|-----------------|-----------|--------------| |
|                  |               |         |                 |           | Mean DLP     | Standard Deviation |
|                  |               |         |                 |           | Proposed NDRLs |     |
| Parathyroid      | Neck          | T       | 19              | Moderate  | 66           | 20 | 170 |
|                  | Neck          | T16     | 42              | Moderate  | 120          | 36 | 170 |
| Octreotide       | Abdomen       | T16     | 15              | Moderate  | 280          | 97 | 240 |
|                  | Abdo/Pelvis   | T16     | 14              | Moderate  | 204          | 109| 240 |
|                  | Chest/Abdo/Pelvis | T16   | 32              | Moderate  | 377          | 164| 240 |
|                  | Head/Chest/Abdo/Pelvis | T16 | 10              | Moderate  | 373          | 151| 240 |
| Cardiac          | Heart         | T16     | 2889            | Low       | 34           | 1  | 34  |
| PET/CT           | Whole/half body | PET   | 1192            | Moderate  | 346          | 164| 400*|

*Based on half body scan

Low - Attenuation Correction, Moderate - Localisation
Results (cont..)

**Figure 1:** Mean Dose Length Product (DLP) data for Bone SPECT/CT Lumbar Spine examinations in the four dose modes.

![Bar chart showing mean DLP for different dose modes with number of patients indicated for each mode.](chart.png)
Discussion

• The proposed NDRLs\(^6\) specify the examination type and the scan purpose, but the details of the body region are not given

• Only Octreotide scans have mean DLP greater than the proposed NDRL

  ✓ low numbers, patient height/weight

• T16 scanner tends to give higher DLPs than the T scanner

  ✓ further optimisation of doses required

  ✓ technology difference (relative tube capabilities and detector sizes)

• **Figure 1** clearly shows the importance of dividing the data according to dose mode

• Mean DLP PET/CT (half and whole body) was less than proposed NDRLs\(^6\) (based on the half body only)
Conclusion

- Patient dosimetry for NMCT presents a number of difficulties which may not be encountered for Diagnostic Radiology CT
  - Dependence on paper records (CRIS does not provide all information)
  - Limited number of examinations available due to frequency of examinations and division of data
- Further improvements are planned to capture more data electronically through the CRIS system
- This system provides a useful basis for setting up LDRLs and hence a baseline for attempts at optimisation of NMCT doses
References


Acknowledgements

- Erin Ross, Principal Physicist, Nuclear Medicine Department
- Elizabeth Larkin, Consultant Clinical Scientist, RRPPS
- Nuclear Medicine technologists at QEHB (particularly Samantha Holt and Kenneth Parker)
- Sophie Bissel, Trainee Clinical Scientist, Nuclear Medicine Department
Thank you for your attention
Any Questions?

**NB:** This work will be submitted for publication imminently

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