Extremity doses in nuclear medicine – influence of new radionuclides

Robert Kollaard, NRG, Netherlands
Ann McCann, St. Vincent’s University Hospital, Ireland
Nicolas Cherbuin, HUG-CHUV, Switzerland
Jérémie Dabin, SCK.CEN, Belgium
Peter Covens, VUB, Belgium
Alessandra Zorz, Istituto Oncologico Veneto IOV - IRCCS, Italy
Lidia Cunha, IsoPor Azores, Portugal

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Introduction

• Exposure of the fingers is a major concern in the protection of nuclear medicin (NM) workers
• Large projects (ORAMED, CONRAD) investigating extremity dose in nuclear medicine
  – ORAMED study: about 20% of the exposed workers in NM might receive a maximum extremity (finger) dose of more than 500 mSv
• Developments since 2011:
  – The introduction/increased use of certain radioisotopes
  – A change in the practices

• EURADOS Working Group 12 task (2018) established to:
  – Find out current status of extremity dosimetry in NM
  – Identify and fill in gaps in knowledge – influence of new isotopes
Overview of presentation

- Overview of extremity doses in Europe
  - Results of 2 surveys
- Extremity doses evaluated in 2 pilots:
  - PET procedures with Ga-68
  - Therapeutic procedures with Lu-177
- Summary and conclusions
Measured extremity doses in Europe - distribution

National Dose Registries (2018)
(4938 workers, > 5 mSv)

EANM Survey (2020)
(780 workers)

Registered dose (mSv/year)

# Workers

<5  5-50  50-150  150-500  >500

3703  1030  119   6

Reported dose (extrapolated to mSv/year)

# Workers

<5  5-50  50-150  150-500  >500

31   179  377  143   0
Estimated fingertip doses (EANM survey)

ORAMED (2011): potentially 20% of population > 500 mSv
EANM survey (2018): potentially 13% > 500 mSv
Pilot results - normalized Ga-68 ring dose

- Pilot in 8 centres (122 Ring/TLD dosimeters)
- Index finger of non-dominant hand
- Period of 1 – 3 months
- 61 workers monitored

<table>
<thead>
<tr>
<th>Task</th>
<th>Normalized ring dose (mSv/GBq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep / dispensing/QC</td>
<td>0.23 (0.01 – 3.34)</td>
</tr>
<tr>
<td>Patient administration</td>
<td>0.26 (0.06 – 2.86)</td>
</tr>
<tr>
<td>All</td>
<td>0.25 (0.01 – 3.34)</td>
</tr>
</tbody>
</table>

-> Normalised ring dose similar to F-18
Fingertip to base sub-study

Fingertip to base of the finger data for the index finger of the non-dominant hand (median, range)

<table>
<thead>
<tr>
<th></th>
<th>Ring dose (mSv/month)</th>
<th>Fingertip dose (mSv/month)</th>
<th>Dose ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre 5 (n = 6)</td>
<td>0.5 (0.2 - 0.8)</td>
<td>1.6 (0.7 - 5.0)</td>
<td>4.3 (1.3 - 10.2)</td>
</tr>
<tr>
<td>Centre 8 (n = 4)</td>
<td>1.8 (1.5 - 5.7)</td>
<td>6.9 (3.5 - 25.7)</td>
<td>4.0 (2.1 - 4.7)</td>
</tr>
<tr>
<td>Total</td>
<td>0.7 (0.2 - 5.7)</td>
<td>3.0 (0.7 - 25.7)</td>
<td>4.3 (1.3 – 10.2)</td>
</tr>
</tbody>
</table>
Extrapolated annual Ga-68 dose

Median:
- Ring dose: 5.3 mSv/y
- Fingertip dose: 23 mSv/y
Ga-68 fraction of total extremity dose

Median fraction of 7% (38 workers)
Pilot results - normalized Lu-177 ring dose

- Ring dose multi center pilot
- Index finger of non-dominant hand
- Currently results from 4/11 centers
- 42 measurements

All centers, non dominant, normalized

- Normalised ring dose much lower than Ga-68 or F-18
Lu-177 ring doses (month/year)

Monthly ring doses < 0.4 mSv
Annual ring doses < 5 mSv
=> Fingertip doses < 30 mSv/y?
Next steps for Lu-177 ring dose pilot

- Ring dose data expected from more centers
- Dosimeter intercomparison to validate dosimeters in pilot for Lu-177
## Summary of pilot data

<table>
<thead>
<tr>
<th></th>
<th>Ga-68</th>
<th>F-18 [ORAMED]</th>
<th>Lu-177</th>
<th>Y-90 [ORAMED]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
<td>PET</td>
<td>PET</td>
<td>Therapy</td>
<td>Therapy</td>
</tr>
<tr>
<td><strong>Maximum beta energy</strong></td>
<td>1.9 MeV</td>
<td>0.6 MeV</td>
<td>0.5 MeV</td>
<td>2.3 MeV</td>
</tr>
<tr>
<td><strong>Number of measurements</strong></td>
<td>122</td>
<td>306</td>
<td>42</td>
<td>147</td>
</tr>
<tr>
<td><strong>Number of centers</strong></td>
<td>8</td>
<td>17</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td><strong>Median ring dose (mSv/GBq)</strong></td>
<td>0.25</td>
<td>~0.2 [0.8 fingertip]</td>
<td>0.003</td>
<td>~0.8 [3-9 fingertip]</td>
</tr>
<tr>
<td><strong>Max. ring dose (mSv/y)</strong></td>
<td>69</td>
<td>~5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Median ring to fingertip ratio</strong></td>
<td>4.3</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td><strong>Max. fingertip dose (mSv/y)</strong></td>
<td>295</td>
<td>&gt; 500</td>
<td>~30</td>
<td>&gt; 500</td>
</tr>
</tbody>
</table>
Some words about ALARA

➢ What protection measures can be taken?
➢ How well are protection measures implemented in practice?
## Impact of protection measures on extremity doses – factors in literature

<table>
<thead>
<tr>
<th>Practice</th>
<th>Distance tools</th>
<th>Gloves</th>
<th>Shielding</th>
<th>Automation</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Syringe and/or vial</td>
<td>Cannula</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Factor</td>
<td>Factor</td>
<td>Factor</td>
<td>Factor</td>
<td>Factor</td>
</tr>
<tr>
<td>$^{99m}$Tc</td>
<td></td>
<td></td>
<td>4.3 (P+D) and 1.8 (A), 5-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{18}$F</td>
<td></td>
<td></td>
<td>2.3 (D) and 5.0 (A), 1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{124}$I</td>
<td>3.0</td>
<td></td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{90}$Y RSO</td>
<td>2.2, 27, 53</td>
<td>2.5</td>
<td>5.8</td>
<td>4.9 (D) and 9.6 (A)</td>
<td></td>
</tr>
<tr>
<td>$^{90}$Y PRRT</td>
<td>5.9 (0.2 vs 0.1 mm Pb)</td>
<td>3.8 (shield &amp; forceps)</td>
<td></td>
<td>1.6, 2.7</td>
<td></td>
</tr>
<tr>
<td>$^{90}$Y RIT</td>
<td>1.5-2.7 (3 vs 1 latex)</td>
<td>3.1</td>
<td></td>
<td>2.6-2.8</td>
<td></td>
</tr>
<tr>
<td>$^{177}$Lu PRRT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td>$^{188}$Re RE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.4</td>
</tr>
</tbody>
</table>
Protection measures in practice – EANM survey

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Task</th>
<th>Vial shield</th>
<th>Syringe shield</th>
<th>Distance tool</th>
<th>Automated dose dispenser</th>
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</thead>
<tbody>
<tr>
<td>99mTc</td>
<td>Preparation</td>
<td>100%</td>
<td>84%</td>
<td>87%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Dispensing</td>
<td>100%</td>
<td>87%</td>
<td>68%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Administration</td>
<td>-</td>
<td>98%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>18F</td>
<td>Dispensing</td>
<td>92%</td>
<td>77%</td>
<td>69%</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>Administration</td>
<td>-</td>
<td>81%</td>
<td>-</td>
<td>53%</td>
</tr>
<tr>
<td>68Ga</td>
<td>Preparation</td>
<td>88%</td>
<td>86%</td>
<td>81%</td>
<td>-</td>
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<tr>
<td></td>
<td>Dispensing</td>
<td>88%</td>
<td>70%</td>
<td>79%</td>
<td>21%</td>
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<tr>
<td></td>
<td>Administration</td>
<td>-</td>
<td>77%</td>
<td>-</td>
<td>21%</td>
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<tr>
<td>177Lu</td>
<td>Administration</td>
<td>-</td>
<td>77%</td>
<td>-</td>
<td>44%</td>
</tr>
<tr>
<td>90Y</td>
<td>Administration</td>
<td>-</td>
<td>81%</td>
<td>-</td>
<td>17%</td>
</tr>
</tbody>
</table>
Conclusions

• Surveys (national dose registries, EANM):
  – Current extremity doses lower than estimated by ORAMED study,
  – even with increased workload and new radioisotopes
• Ga-68 procedures
  – Normalized extremity doses and ring to fingertip ratio comparable to F-18
  – Median extrapolated annual dose of 5.3 mSv [ring] and 23 mSv [fingertip]
  – Small group (6%) with estimated fingertip dose > 150 mSv
• Lu-177 procedures
  – Extremity doses are relatively low (< 5 mSv/y) compared to other radionuclides
• Recommendations on protection measures (ICRP and ORAMED) part of daily practice
• Further EURADOS work
  – Complete Lu-177 study
  – Skin dose due to contaminations
Publications of this EURADOS taskgroup

https://doi.org/10.1088/1361-6498/abfff3

Need for harmonisation of extremity dose monitoring in nuclear medicine: results of a survey amongst national dose registries in Europe

Alexandra Kyriakidou1,*, Jeroen Schliefl2,*, Merce Ginjaume2 and Robert Kollaard1,*

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Review: Extremity exposure of nuclear medicine workers: results from an EANM and EURADOS survey

Lidia CUNHA1,*, Jérémy DABIN2, Sigrid LEIDE-SVEGBORN3, Alessandra ZORZ4, Robert KOLLAARD5, Peter COVENS6

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Thanks for your interest

- For more information:
- kollaard@nrg.eu