EXTREMITY EXPOSURE IN NUCLEAR MEDICAL THERAPY WITH Y-90 LABELLED SUBSTANCES

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ORAMED work packages WP4 “Extremity dosimetry in nuclear medicine”

OBJECTIVES

Global aim: Optimisation of radiation protection standards and individual dose monitoring of staff in nuclear medicine

Method: Evaluation of extremity exposure of nuclear medical staff and analysis of the impact of protective measures/tools such as syringe and vial shield

- Methods and general aspect
  - Donadille et al.

- Measurements in diagnostics with Tc-99 and F-18
  - Carnicer et al.

- Measurements in therapy procedures with Y-90
  - this presentation

- Results from Monte Carlo simulations
  - Ferrari et al.

- Guidelines and recommendations
  - Sans Merce et al.
### Scope of measurements in preparation (P) and administration (A) of Y-90 in NM therapies

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Procedures</th>
<th>Labs</th>
<th>Hospitals</th>
<th>Workers</th>
<th>Data sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIRS</td>
<td>P+A</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>PRRT</td>
<td>P</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>RIT</td>
<td>P</td>
<td>6</td>
<td>16</td>
<td>20</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>6</td>
<td>15</td>
<td>22</td>
<td>45</td>
</tr>
</tbody>
</table>

**Results presented:**
- **PRRT:** ✓ Classification of workers (not enough data for more !)
- **RIT:** ✓ Classification of workers (max. skin dose mean/median + range)
  ✓ ‘Dose history’ for subsequent measurements
  ✓ Ratio of maximum dose to dose on potential dosemeter positions
Classification of workers for PRRT with Y-90/Dotatoc

**Preparation *)**

<table>
<thead>
<tr>
<th>Worker</th>
<th>Mean dose</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>T5HC7</td>
<td>2.1 mSv/GBq</td>
<td>0.1 – 7.4</td>
</tr>
</tbody>
</table>

*) mean activity: 10.3 GBq

**Administration *)**

<table>
<thead>
<tr>
<th>Worker</th>
<th>Mean dose</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1HC7</td>
<td>1.9 mSv/GBq</td>
<td>0.4 – 4.9</td>
</tr>
</tbody>
</table>

*) mean activity: 5.5 GBq

- Mean
- Median
- Min
- Max

*) no shielding used (yellow)
RESULTS

Classification of workers for RIT with Y-90/Zevalin, Preparation

Maximum skin dose quartiles on both hands

Outliers:
T5HG2, T1HG1, T2HG1: different technique (semiautomatic)
T1HF1 (n=4) extreme dose range (bad RP standard)
T6HF2 (n=1) severe exposure (no shielding, direct vial contact)
RESULTS

Classification of workers for RIT with Y-90/Zevalin, Preparation

Maximum skin dose on both hands

Example of bad RP practice:
Outlier T6HF2

[Bar chart showing maximum skin dose in mSv/GBq for different workers]

ORAMED 2011
Barcelona, 20-22 January

6/21
RESULTS

Maximum skin dose on both hands

Classification of workers for RIT with Y-90/Zevalin, Preparation

Maximum dose in mSv/GBq *)

<table>
<thead>
<tr>
<th>All workers with outliers</th>
<th>Mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>39.2</td>
<td>8.9</td>
<td>0.1</td>
<td>571</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Without outliers</th>
<th>Mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.0</td>
<td>9.5</td>
<td>0.7</td>
<td>63.7</td>
<td></td>
</tr>
</tbody>
</table>

*) usual labelling activity per patient: 1.5 GBq
RESULTS

Maximum skin dose in Y-90/Zevalin preparation

<table>
<thead>
<tr>
<th></th>
<th>Maximum dose in mSv/GBq</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-dominant hand</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>All workers with outliers</td>
<td>37.0</td>
</tr>
<tr>
<td>Without outliers</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Non-dominant hand is higher exposed than dominant hand

Highest exposed positions: tip of index finger and thumb
RESULTS

Classification of workers for RIT with Y-90/Zevalin, Administration

Maximum skin dose quartiles on both hands

Outliers: T5HF6 unlikely low dose (0.3 mSv/GBq) despite working without syringe shield
T6HG2 (n=3) large dose range, no shielding used
T7HF2 (n=1) high dose bad RP standard

- Mean
- Median
- Min
+ Max

+ 46
- 78

Worker
RESULTS

Classification of workers for RIT with Y-90/Zevalin, Administration

Maximum skin dose on both hands

Example of bad RP practice: Outlier T7HF2

Worker

Mean
Median
Min
Max

Outlier

Classifications:

- Mean
- Median
- Min
- Max

Outliers
RESULTS

Classification of workers for RIT with Y-90/Zevalin, Administration

Maximum skin dose on both hands

<table>
<thead>
<tr>
<th>Mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>All workers with outliers</td>
<td>9.0</td>
<td>3.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Without outliers</td>
<td>4.8</td>
<td>2.9</td>
<td>0.7</td>
</tr>
</tbody>
</table>

*) usual therapy activity per patient: 1 GBq
### RESULTS

Maximum skin dose in Y-90/Zevalin administration

<table>
<thead>
<tr>
<th></th>
<th>Maximum dose in mSv/GBq</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-dominant hand</td>
<td>Dominant hand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Min</td>
</tr>
<tr>
<td>All workers</td>
<td>7.7</td>
<td>3.4</td>
<td>0.1</td>
</tr>
<tr>
<td>with outliers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without outliers</td>
<td>4.3</td>
<td>2.8</td>
<td>0.1</td>
</tr>
</tbody>
</table>

- Non-dominant hand is higher exposed than dominant hand
- Highest exposed positions: tip of index finger and thumb
Dose history of workers in RIT with Y-90/Zevalin

Preparation

Administration

Maximum skin dose [mSv/GBq]

274 mSv/GBq (T1HF1)

No syringe shield!
CONCLUSIONS - STAFF EXPOSURE

- Wide ranges of individual exposures (min/max) reflect different practices, equipment, RP means and tools used in NM therapy with Y-90

- Exposures in preparation of radiopharmaceuticals are higher than in administration (e.g. Zevalin: 17 mSv vs 5 mSv per patient on average)

- Shielding of vials and syringes is essential and a precondition but not a guarantee for low exposures

- Other RP tools and measures which were not registered in the protocol (e.g. pincers, forceps etc.) significantly affect exposures

- Use of shielding and protective tools can not be compensated by increased working speed

- Also subjective factors e.g. risk awareness and training affect exposures

- Exposure of staff members has reduced in the course of the project due to the feedback of the measurement results on the RP standard
RESULTS

Ratio of maximum dose on both hands to dose on dosemeter positions.

Y-90/Zevalin preparation

TLD position

Nondominant hand

Dominant hand

Ratio

ring base
wrist
index base
index tip
index 2nd phalanx
thumb 2nd phalanx
ring base
wrist
index base
index tip
index 2nd phalanx
thumb 2nd phalanx
## RESULTS

### Y-90/Zevalin preparation

<table>
<thead>
<tr>
<th>Ratio to dose maximum</th>
<th>Non-dominant hand</th>
<th>Dominant hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ring base</td>
<td>wrist</td>
</tr>
<tr>
<td>Mean</td>
<td>11.5</td>
<td>15.1</td>
</tr>
<tr>
<td>Median</td>
<td>10.6</td>
<td>12.0</td>
</tr>
<tr>
<td>Max</td>
<td>50.8</td>
<td>42.1</td>
</tr>
<tr>
<td>Min</td>
<td>2.2</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Ratio of maximum dose on both hands to dose on dosemeter positions
RESULTS

Y-90/Zevalin administration

Ratio of maximum dose on both hands to dose on dosemeter position
## RESULTS

### Y-90/Zevalin administration

<table>
<thead>
<tr>
<th>Ratio to dose maximum</th>
<th>Non-dominant hand</th>
<th>Dominant hand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ring base</td>
<td>wrist</td>
</tr>
<tr>
<td>Mean</td>
<td>18.6</td>
<td>27.1</td>
</tr>
<tr>
<td>Median</td>
<td>12.5</td>
<td>21.4</td>
</tr>
<tr>
<td>Max</td>
<td>88.5</td>
<td>102.0</td>
</tr>
<tr>
<td>Min</td>
<td>1.0</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Ratio of maximum dose on both hands to dose on dosemeter positions

![Diagram of hands showing dose ratios](image-url)
The tip of the index finger or thumb of the non-dominant hand receive most often the highest exposure

Ring dosemeters should be worn on these fingers, preferably on the base of the index finger

Even if the dosemeter is worn on the base of the index finger, the skin dose maximum is considerably underestimated by a factor of about 6–7

The ringfinger base of the dominant hand, where ring dosemeters are often worn, is not a proper position in routine monitoring

Wrist dosemeters are not appropriate for monitoring NM staff
The ORAMED project has provided the most comprehensive data on staff exposure in NM therapies so far.

Local skin dose can exceed the limit (500 mSv/a) by numerous workers in hospitals where RP standard is low.

There is adequate potential to further improve RP and decrease exposures.

Adequate skin dose monitoring is urgently needed in NM therapy.

Thank you for your attention!