Guidelines to optimize extremity monitoring and to reduce skin doses in nuclear medicine. Results of the ORAMED Project

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General overview of the ORAMED project

Optimization of Radiation Protection of MEDical staff
Collaborative FP7 project: 2008 - 2011 - Coordinator: F. Vanhavere (SCK-CEN)

ORAMED aimed at developing methodologies for better assessing and reducing exposures to medical staff in interventional radiology and nuclear medicine.

- Optimization in interventional Radiology and interventional cardiology:
  - See poster P02.25 hall 4, Carinou et al.

- Optimization in nuclear medicine (this presentation)
  - Context
  - Objectives - Material and methods
  - Main results
  - Recommendations

More information:
www.oramed-fp7.eu

**Context:** Occupational exposure of workers in Nuclear Medicine

- Low whole body doses
- Hands particularly exposed
- Fields:
  - $\gamma / \beta / \gamma-\beta$
  - Use of $\beta$ and PET increasing
  - Presence of shields
  - Typically inhomogeneous
- Extremity dosimetry
  - Extremity dosemeters not always used
  - Dosimeter material and design not always appropriate
  - The position of the dosemeter on the hand matters
- Radiation protection
  - Not always appropriate
  - Extremity dosemeters often underestimate $H_p(0.07)$, the annual dose could surpass the dose limit
Objectives

• To evaluate extremity doses and dose distributions across the hands of medical staff working in NM departments.

• To study the influence of protective devices such as syringe and vial shields and to improve such devices when possible.

• To propose “levels of reference doses” for each standard NM procedure and to use these for risk assessment and optimisation of working methods.

• To propose guidelines to reduce doses to NM workers.
Methodology (1/2)

- **Hand dose survey**
  - 735 measurements (x 22 dosemeters) in 7 EU countries, 32 NM departments, for 124 workers
  - Common protocol
  - Diagnostics: $^{99mTc}$, $^{18F}$
  - Therapy: $^{90Y}$-Zevalin®
  - Preparation and administration stages

**Measurement protocol**

- 22 positions across the hands
- At least 2 different NM departments in each country
- Workers: at least 2 workers from the same NM
- Number of measurements per worker: 5
Methodology (2/2)

- Analysis of the parameters influencing the doses

**MCNPx Monte Carlo simulations (~200) for realistic scenarios (voxel phantoms)**

**ADMINISTRATION**

- **I1** The hand pushing the syringe piston
- **I2** The hand holding the syringe

**PREPARATION**

- **PSM1** The hand holding the syringe by the piston
- **PSM2** The hand holding the syringe by the needle
- **PTR** The hand handling the vial

**Working step**

**Hand phantom**

**Simulation geometry**
Main results

- Large spread of doses is observed.
- Bad practices are clearly associated with high doses.
- Preparation leads to higher doses than administration.
- Y-90 leads to higher doses than F-18, and F-18 higher doses than Tc-99m.
- The non-dominant hand receives higher doses than the dominant hand.
- Nature and minimum thicknesses of shields have been defined (through Monte Carlo simulations).
Main results

Extrapolated annual maximum skin dose

Estimated for each monitored worker from the position receiving the maximum average dose

Diagnostics $^{99m}$Tc, $^{18}$F

- 1000 patients/year
- 17% > 500 mSv
- 44% 150-500 mSv
- 39% < 150 mSv

Therapy $^{90}$Y Zevalin®

- 5 patients/year
- 2% > 500 mSv
- 90% < 150 mSv
- 17% 150-500 mSv
Hand dosimetry in nuclear medicine

Main results

- The tip of the index is generally the most exposed position.
- Good correlation are found between the maximum dose and doses at positions used for routine ring dosemeters.

Hand monitoring recommendation

- Routine ring dosemeter shall be located at the base of the index finger of the non-dominant hand with the sensitive part of the dosemeter oriented towards the inside of the hand.
- For estimation of the maximum hand dose: multiply by 6

Ratios between the maximum dose and dose at possible locations for routine monitoring

Diagnostics

- Non-dominant hand: 6
- Dominant hand: 9

Therapy

- Non-dominant hand: 7
- Dominant hand: 31

- Non-dominant hand: 22
- Dominant hand: 18

- Non-dominant hand: 21
- Dominant hand: 21
RECOMMENDATIONS

1.- Extremities should be monitored systematically in NM.

2.- The dosemeter should be worn at the base of the index finger of the non-dominant hand (sensible towards inside of the hand).

3.- The maximum skin dose can be estimated multiplying this value by 6.

4.- Shielding of vials and syringes are essential and a pre-condition but not a guarantee for low exposures.

5.- Recommended minimum shielding:
   - syringe: 2 mm W for $^{99m}$Tc; 5 mm W for $^{18}$F, 10 mm PMMA for $^{90}$Y
   - vial: 3 mm Pb for $^{99m}$Tc; 3 cm W for $^{18}$F, 10 mm PMMA + mm Pb for $^{90}$Y

6.- Training and education on good practice are more relevant parameters than the experience of the workers.

7.- Any tool increasing the distance between hand and source is very effective for dose reduction.

8.- Working fast is not sufficient, the use of shields or increasing the distance are more effective.
Thank you for your attention

Example of good practices:

Example of bad practices:

Available at www.oramed-fp7.eu:
- Recommendation leaflets
- Training materials
- Freeware: dose calculation tool