Institut de radiophysique

RADIATION EXPOSURE OF CARDIOLOGISTS PERFORMING FLUOROSCOPY-GUIDED PROCEDURES


University Hospital Center of Lausanne, Switzerland
Fluoroscopy-guided procedures in cardiology

- Growing use and increasing complexity
  - higher exposure to both patients and medical staff

- Strategy to manage medical staff exposure
  - Education and training
  - Protective equipments
    - Lead aprons,
    - Thyroid shields
    - Lead glasses,
    - Other shields
  - Monitoring of radiation exposure
Individual monitoring in radiology

• Main goals
  – Compliance with dose limits ($E$, $H_{\text{skin}}$, $H_{\text{lens}}$)
  – Detection of unexpected exposure
  – Optimisation (mainly for fluoroscopy)

• Standard method
  – 1 dosemeter, under the apron
  – But: parts of the body are not protected (head, arms)

• For dose-intensive fluoroscopy procedures
  – 2 dosimeters, 1 under and 1 over the apron
  – Extremity ring dosemeters

(ICRP 85, EU Report n 160 & Swiss regulation)
Objectives of the study

• To assess radiation exposure to cardiologists based on two complementary approaches:
  1. Staff survey based on routine individual monitoring using double dosimetry and extremity dosimetry
  2. Staff dose measurements for specific cardiology procedures
1. Staff survey : method

• Follow up of 30 cardiologists (CHUV) over 5 years (2005-2009)
• Monthly doses were measured using :
  – Whole body dosemeters (TLD-100) under and above the apron
  – Extremity dosemeters (TLD-100)
Swiss algorithm for 2 dosimeters

\[ H_{\text{total}}(10) = H_{\text{under}}(10) + a \cdot H_{\text{over}}(10) \]
\[ H_{\text{total}}(0.07) = H_{\text{under}}(0.07) + H_{\text{over}}(0.07) \]

- If a thyroid shield is worn
  - \( a = w_{\text{remainder}} = 0.05 \)

- If a thyroid shield is not worn
  - \( a = w_{\text{remainder}} + w_{\text{thyroid}} = 0.05 + 0.05 = 0.1 \)

- \( H_{\text{total}}(10) \rightarrow E \);
  \( H_{\text{total}}(0.07) \rightarrow H_{\text{skin}} \)

- \( H_{\text{over}}(0.07) \rightarrow \sim H_{\text{lens}} \)
Calibration of whole body dosemeters

- Standard reference geometry [ISO 4037]
- Influence of the apron on the reading
  - Dosimeters over the apron fixed on the water phantom
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![Graph showing the calibration of dosemeters with different mean energies and apron thicknesses.](image)
2. Staff dose specific measurements: method

- 5 procedures from IC and electrophysiology
  - Percutaneous coronary intervention (PCI)
  - Patent foramen ovale (PFO) closure
  - Atrial septal defect (ASD) closure and paravalvular leak closure
  - Pacemaker (PM) implantation
  - Radiofrequency (RF) ablation

- Monitoring of operators, 1 dosimeter over the apron

- Dosemeters used:
  - TLD (IRA-Rados)
  - OSL (InLight - Landauer)
Results of the staff survey

~60% of monthly doses: Hp(10) = 0 under and over the apron

Annual dose distribution, 2005-2009, (78 person-years)
Results of the staff survey

For a particular cardiologist

Annual dose [mSv]

25.0
20.0
15.0
10.0
5.0
0.0

2005 2006 2007 2008 2009

Hp(10)

HP, under
HP, over
HP, total
Results of the staff survey

Radiation exposure of cardiologists performing fluoroscopy-guided procedures

![Chart showing yearly total dose (mSv) for different years and procedures]

- **Hp(10), tot**
- **Biplane (?)**

Yearly total dose for various years:
- 2005: 20 obs.
- 2006: 22 obs.
- 2008: 23 obs.
- 2009: 20 obs.
Results of the staff survey

### Yearly dose

<table>
<thead>
<tr>
<th></th>
<th>Hp(10),under</th>
<th>Hp(10),over</th>
<th>Hp(10),total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max, mSv</strong></td>
<td>3.7</td>
<td>101</td>
<td>13.7</td>
</tr>
<tr>
<td><strong>Mean, mSv</strong></td>
<td>0.3</td>
<td>7.9</td>
<td>1.0</td>
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</table>

### Monthly dose

<table>
<thead>
<tr>
<th></th>
<th>Hp(10),under</th>
<th>Hp(10),over</th>
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</thead>
<tbody>
<tr>
<td><strong>Max, mSv</strong></td>
<td>1.1</td>
<td>16.8</td>
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</table>
Results of the staff survey

Yearly dose to extremity

Mean: 14.2 mSv
Results for specific measurements

66 measurements:
mean = 52 μSv
Does this fit with the survey results?

- **Over the lead apron**
  - 200 procedures per year times $\sim 50 \, \mu\text{Sv}$ per procedure = 10 mSv over the apron
  - From the survey: mean yearly dose: 7.9 mSv

- **Under the lead apron**
  - Mean yearly dose
    - 10 mSv over the apron / attenuation factor of 20 = 0.5 mSv
    - From the survey: 0.3 mSv
  - Monthly dose: 0.5 mSv / 12 $\rightarrow$ 0 mSv
Double dosimetry: yes or no?

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<tbody>
<tr>
<td><strong>Only 1 dosemeter under-apron</strong></td>
<td>- Simple (no risk of inversion)</td>
<td>- Often zero dose</td>
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<tr>
<td></td>
<td></td>
<td>- underestimate E</td>
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<tr>
<td></td>
<td></td>
<td>- No optimisation incitement</td>
</tr>
<tr>
<td><strong>Only 1 dosemeter over-apron</strong></td>
<td>- Simple (no inversion)</td>
<td>- No more relevant without apron</td>
</tr>
<tr>
<td></td>
<td>- good estimate of E with apron</td>
<td>- Incident detection ?</td>
</tr>
<tr>
<td></td>
<td>- Estimate of $H_{\text{lens}}$</td>
<td></td>
</tr>
<tr>
<td><strong>Double dosimetry</strong></td>
<td>- Good estimate of E with and without apron</td>
<td>- Complex (inversion)</td>
</tr>
<tr>
<td></td>
<td>- Estimate of $H_{\text{lens}}$</td>
<td>- Bad interpretation</td>
</tr>
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Conclusions

• Both routine and procedure-specific measurements showed that yearly doses over the apron can be high.

• Wearing only the dosemeter under apron underestimates the effective dose since large parts of the body are not protected by the apron.

• Cardiologists performing fluoroscopy-guided procedures should wear both under and over apron dosimeters to better estimate E (standard algorithm in the future?)

• Increased awareness of cardiologists on occupational exposure and radiological risk → good opportunity to set up double dosimetry