Eye lens doses for medical staff performing interventional procedures

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Overview

- Introduction
- Overview of eye lens doses for medical staff
- Radiation Protection of the eye
- Monitoring of eye lens doses
- Conclusion
Introduction

- Cataract: “loss of transparency of the eye lens”
  - Light not properly focused on the retina
  - Starts with lens opacities: no visual impact

- Associated with aging and metabolic conditions, like diabetes
- Also radiation-induced
Introduction

- Previous status radiation protection ICRP
  - Cataract induction = deterministic effect with definite threshold
    - Acute exposure: 0.5 – 2 Gy
    - Prolonged exposure: 5-6 Gy
  - Latency period that can last for decades
  - Dose limits
    - 150 mSv/year for occupational exposure

- Recent developments*: epidemiological studies
  - A-bomb survivors, Chernobyl clean-up workers, radiological technologists, ...
  - High probability that threshold dose < 0.8 Gy
  - Not certain there is a threshold
  - Current limit is too high

ICRP recommendations

- **ICRP-103** (2007): recommends review of and evaluation of non-cancerous effects of ionising radiation on normal tissue

Cataract:
- **Threshold dose of 0.5 Gy** irrespective of the rate of dose delivery
- Dose limits: **20 mSv/year for occupational exposure** (averaged over 5 years, with not more than 50 mSv/year)

Potentially serious implications for some health care professionals
- medical staff performing interventional procedures
Eye lens doses for medical staff

- EU funded ORAMED project (2008-2011) "Optimization of Radiation protection for Medical staff"

- Overview of eye lens dose measurements
  - Interventional radiologists and cardiologists (>1300 interventional procedures)
  - 6 different countries

   - Eye lens doses from 10 μSv to 4 mSv per procedure (median value of 60 μSv)
   - Cumulative annual eye lens doses from < 1 mSv to 150 mSv

   - Considerable number (24%) exceed the annual dose limit of 20 mSv

Exceeding the annual limit
Eye lens doses for medical staff

- Belgian ExDos project (2008-2011): financed by FANC
  “Overview of extremity doses and eye lens doses for interventional procedures and nuclear medicine in Belgium “

- Overview of eye lens dose measurements
  - 2 Belgian partners: SCK•CEN and UZ-Brussel
  - Belgian extension of ORAMED
    - Extension of measurements from 3 hospitals to 10 hospitals
    - Extra procedure: spine procedures (vertebroplasty and kyphoplasty)

- Eye lens doses from 10 µSv to 836 µSv per procedure (median value of 34 µSv)
- Cumulative annual eye lens doses from < 1 mSv to 61 mSv
Eye lens doses for medical staff

Recent epidemiological studies

- French O’CLOC study*
  - 106 Interventional cardiologists and 99 unexposed individuals
  - Posterior subcapsular lens opacities: 17% vs. 5%, p<0.05


- Finnish study
  - 16 interventional cardiologists + 20 interventional radiologists
  - Cortical and PSC lens opacities

- IAEA study**: survey at cardiology conference
  - 58 cardiologists, 69 technicians
  - Posterior subcapsular lens changes:
    » 50% vs <10% (cardiologists) and 41% vs <10% (technicians)

Radiation protection of the eye

- Medical staff exposed by scattered radiation from the patient

- Protect the eye with
  - lead ceiling-mounted screens

www.oramed-fp7.eu
Radiation protection of the eye

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Radiation protection of the eye

- Medical staff exposed by scattered radiation from the patient
- Protect the eye with
  - lead glasses
Radiation protection of the eye

- Medical staff exposed by scattered radiation from the patient

- Protect the eye with
  - lead glasses

![Diagram of radiation protection]

**Result:**
Ratio with/without lead glasses for any interventional procedure and tube configuration

Left eye = 0.13 (20%)

Right eye = 0.84 (15%)

- www.oramed-fp7.eu
- European ELDO project
Monitoring of eye lens doses

- Need to follow up the eye lens dose
  - for medical staff at risk to exceed annual eye lens dose limit

- ORAMED: development and validation of eye lens dosemeter “EYE-D”
  - Measuring in terms of Hp(3) dose quantity
Monitoring of eye lens doses

● Need to follow up the eye lens dose
  ● for medical staff at risk to exceed annual eye lens dose limit

● ORAMED: development and validation of eye lens dosemeter “EYE-D”
  ● Measuring in terms of Hp(3) dose quantity

  ● Practical problems: ergonomics of the system
  ● Difficult to use in combination with lead glasses

  ● Increase of number of dosemeters per person
  ● Risk of exceeding dose limit, depend on medical speciality

  ● Alternative method to assess eye lens dose??
Monitoring of eye lens doses

- European ELDO project (funded by DoReMi network)
  "Correlation between eye lens dose and whole body dose"

- Measurement of eye lens doses and whole body doses in clinical conditions
  - Operator: Rando-Alderson phantom
  - Patient: PMMA plates
  - Passive and active dosemeters
  - Measurements above the lead apron
    - Eye level
    - Collar level
    - Chest level
    - Waist level
    - Left – middle – right side
Monitoring of eye lens doses

- European ELDO project (funded by DoReMi network)
  
  "Correlation between eye lens dose and whole body dose"

- Clinical conditions
  - Different x-ray beam projections
  - Different operator positions with respect to the x-ray field
  - Different x-ray beam energies
  - Mono-plane and bi-plane x-ray systems

Result = ratio [eye lens dose/whole body dose] and associated uncertainty

- Without protection equipment (lead glasses and ceiling-mounted screen)
### Monitoring of eye lens doses

- **All measurement configurations together (48 cases)**

#### Ratio of average left eye lens dose and whole body dose measured at different locations, considering all projections and operator positions.

<table>
<thead>
<tr>
<th>Location</th>
<th>Collar L</th>
<th>Collar M</th>
<th>Collar R</th>
<th>Chest L</th>
<th>Chest M</th>
<th>Chest R</th>
<th>Waist L</th>
<th>Waist M</th>
<th>Waist R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
<td>3.3</td>
<td>2.1</td>
<td>11.5</td>
<td>0.8</td>
<td>1.2</td>
<td>2.5</td>
<td>1.5</td>
<td>1.8</td>
<td>8.0</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>42%</td>
<td>48%</td>
<td>81%</td>
<td>90%</td>
<td>73%</td>
<td>100%</td>
<td>159%</td>
<td>143%</td>
<td>147%</td>
</tr>
</tbody>
</table>

#### Best correlation

#### Ratio of average right eye lens dose and whole body dose measured at different locations, considering all projections and operator positions.

<table>
<thead>
<tr>
<th>Location</th>
<th>Collar L</th>
<th>Collar M</th>
<th>Collar R</th>
<th>Chest L</th>
<th>Chest M</th>
<th>Chest R</th>
<th>Waist L</th>
<th>Waist M</th>
<th>Waist R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
<td>2.7</td>
<td>1.7</td>
<td>8.6</td>
<td>0.7</td>
<td>0.9</td>
<td>1.8</td>
<td>1.3</td>
<td>1.6</td>
<td>6.2</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>42%</td>
<td>45%</td>
<td>73%</td>
<td>90%</td>
<td>58%</td>
<td>101%</td>
<td>164%</td>
<td>153%</td>
<td>155%</td>
</tr>
</tbody>
</table>
## Monitoring of eye lens doses

### Measurement per type of procedure

Ratio of average **left eye** lens dose and whole body dose measured at different locations, considering projections and operator positions for **CA&PTCA and RF ablations**.

<table>
<thead>
<tr>
<th>Location</th>
<th>Collar L</th>
<th>Collar M</th>
<th>Collar R</th>
<th>Chest L</th>
<th>Chest M</th>
<th>Chest R</th>
<th>Waist L</th>
<th>Waist M</th>
<th>Waist R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
<td>4.0</td>
<td>2.6</td>
<td>12.8</td>
<td>0.7</td>
<td>1.0</td>
<td>1.9</td>
<td>0.5</td>
<td>0.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>41%</td>
<td>40%</td>
<td>56%</td>
<td>52%</td>
<td>56%</td>
<td>50%</td>
<td>46%</td>
<td>64%</td>
<td>101%</td>
</tr>
</tbody>
</table>

Ratio of average **left eye** lens dose and whole body dose measured at different locations, considering projections and operator positions for **pacemaker procedures**.

<table>
<thead>
<tr>
<th>Location</th>
<th>Collar L</th>
<th>Collar M</th>
<th>Collar R</th>
<th>Chest L</th>
<th>Chest M</th>
<th>Chest R</th>
<th>Waist L</th>
<th>Waist M</th>
<th>Waist R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
<td>3.4</td>
<td>2.4</td>
<td>8.2</td>
<td>0.7</td>
<td>0.9</td>
<td>1.7</td>
<td>0.5</td>
<td>0.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>36%</td>
<td>52%</td>
<td>70%</td>
<td><strong>23%</strong></td>
<td>41%</td>
<td>35%</td>
<td>40%</td>
<td>52%</td>
<td>87%</td>
</tr>
</tbody>
</table>
Monitoring of eye lens doses

- Influence of **the use of protection equipment** on these ratio’s

- Monte Carlo calculations
  - Variation of eye lens dose and whole body dose with
    - Shape of lead glasses
    - Thickness of lead
    - Position and shape of ceiling-mounted lead screen
  - For all possible x-ray projections, operator positions and x-ray tube configurations

**Result** = correction coefficients considering effect of protection and associated uncertainty
Monitoring of eye lens doses

- **Effect of ceiling shield (19 cases)**

  Ratio of dose *with/without ceiling-mounted lead screen*, considering all projections and operator positions.

<table>
<thead>
<tr>
<th></th>
<th>Eyes</th>
<th>Collar</th>
<th>Chest</th>
<th>Waist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
<td>0.51</td>
<td>0.63</td>
<td>0.75</td>
<td>0.82</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>70%</td>
<td>54%</td>
<td>34%</td>
<td>22%</td>
</tr>
</tbody>
</table>

- **Effect of lead glasses (27 cases)**

  Ratio of dose *with/without lead glasses*, considering all projections and operator positions.

<table>
<thead>
<tr>
<th></th>
<th>Left Eye</th>
<th>Right Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
<td>0.13</td>
<td>0.84</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>20%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Large influence of glasses shape
- Rounded model: 0.17
- Squared model: 0.63

More calculations on-going !!!
Monitoring of eye lens doses

Summary

- The correlation between eye lens and whole body dose depends on
  - Type of procedure
  - The position of the whole body dosemeter (always ABOVE lead apron)
  - The working practice
    - position of operator
    - The use of protective equipment

- Assessing eye lens dose from whole body dose can introduce large uncertainties
  (40% to 160% without protection; additional 15% to 70% for use of protection)
  - This method is first evaluation of eye lens dose
  - If assessed dose is high: specific person can benefit from wearing eye lens dosemeter routinely

- Useful for future retrospective epidemiological study of this population
Conclusion

- Medical staff performing interventional procedures is at risk of exceeding annual dose limit for the eye lens (20 mSv)
  - Measured eye lens doses are high, especially if no protection is used
  - Recent epidemiological studies show increased prevalence of lens opacities for this population

- Monitoring eye lens dose is crucial
  - First evaluation possible from whole body dose records (above the lead apron)
  - Lack of practical eye lens dosemeter
    - Also to be used in combination with lead glasses

- At least as important is the awareness from the medical staff of the risk and the implementation of protection tools
  - Eye lens doses can be significantly reduced if lead glasses and ceiling-mounted shields are properly used
More research is continuously performed related to the dose-response of radiation-induced lens opacities in the low-dose range

Currently preparing an **European** epidemiological study on radiation-induced cataract for interventional cardiologists

- Several European countries are preparing the creation of a national cohort using the same protocols (ELDO project)
- Joined analysis of the pooled European cohort
- To elucidate further the reduction of the threshold for cataract (ICRP-118)
- To confirm if there is a threshold

Belgium is also participating in this study and in preparation of creating a national cohort of interventional cardiologists

- Retrospective assessment of eye lens doses
- Performance of ophthalmological examinations
Questions?

Thank you for your attention !!!