Methods for Eye Lens Dosimetry and Studies on Lens Opacities with Interventionalists

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Disclosures

• None

What is cataract?
Clouding or opacification of the natural lens of the eye and obstructing the passage of light

Most frequent cause of blindness worldwide

Cataract

What is treatment?
Easily treatable condition - surgery or phacoemulsification

Nothing to match natural
**Radiation & Cataract**

HOT Topic in Occupational Radiation Protection

- Dot Opacities
- Latency depends on rate at which damaged epithelial cells undergo fibrogenesis and accumulate.

**Is Radiation induced cataract different? How?**

- Good news is that “Yes it is different”. How? Let us see... 

**Pre-dominantly, not exclusively**

**Major Cataract Subtypes**
- Cortical
- Nuclear
- Posterior SubCapsular (psc)
- Mixed

**Eye dosimetry**
- Regular eye dosimetry in diagnostic imaging practically does not exist
- Accurate assessment of eye lens dose is one of the most important aspects of:
  - correlating doses with observed lens opacities among workers in interventional suites
  - ascertaining compliance with regulatory limits

**CORnea**
**LENS**
- Anterior Chamber
- PSC Cataract
- Epithelium
- Capsule

**LENS**
- PSC Cataract
- Epithelium
- Capsule

Pre-­‐dominantly,
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- Cortical
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Dose metrics

- The eye lens dose, as organ dose is not directly measurable
- According to ICRU the operational quantity Hp (3) is the most appropriate to monitor the eye lens dose, as the lens is covered by about 3 mm of tissue
- Proposals to use Hp(0.07) for eye lens dose monitoring
- Correlations are being attempted with Hp(10)

Current eye dosimetry challenges

- Which personal dose equivalent quantity is appropriate?
- How it can be used routinely for eye lens dose monitoring?
- What is a suitable dosimeter and calibration procedure?
- How to convert radiometric quantities, as fluence, to equivalent dose to the lens?

Possible approaches

Practical dosimetry:
1. Passive dosimeters
2. Active dosimeters

Passive dosimeters

- Dedicated passive dosimeter designed to provide the dosimetric quantity Hp(3)
- Double dosimetry:
  - If a dedicated eye dosimeter is not available, a collar dosimeter calibrated in terms of Hp(0.07)
  - Some studies that claim that collar dosimeter provide a reasonable and conservative estimate of eye lens dose (within 15%)
  - Other studies claiming that a dosimeter at collar level would underestimate the absorbed dose to the eye lens to about 73 %

Problems with Passive dosimetry

- Large number of operators are not wearing personal dosimeters or wear it irregularly
- No passive dosimeter has been accepted for regulatory purpose

Possible approaches

Practical dosimetry:
1. Passive dosimeters
2. Active dosimeters
3. Retrospective dose assessment using scatter radiation dose levels
4. Correlations between patient dose indices and eye doses to the operators
Measuring scatter dose reduction for different goggles (with correct position of ceiling suspended shielding: Only 4-8 % transmitted)

Vascular surgery procedure % of the scatter dose measured at the C-arm San Carlos University Hospital Madrid

Only 4-8 % transmitted

Measuring scatter dose reduction for different goggles (frontal protection and lateral protection)

Frontal transmission 5 ± 1 %
(max. 7 min. 4)
Lateral transmission 23 ± 16 %
(max. 48 min. 6)

Scatter levels (incorrect position of the ceiling shielding) In this case: 20-90 % transmitted (depending of the shielding position)

Active dosimeters

- Good for
  - educational purpose and
  - for radiation protection
- Not for regulatory compliance

Possible approaches

Practical dosimetry:
1. Passive dosimeters
2. Active dosimeters
3. Retrospective dose assessment using scatter radiation dose levels
4. Correlations between patient dose indices and eye doses to the operators
Retrospective dosimetry

- Reconstruction of the laboratory workload (types and numbers of procedures)
- Usually with questionnaires and the application of many assumptions about past activity (procedures performed, corresponding doses based on previous dosimetric studies and the use of radiation protection tools)
- Currently many times this is the only possible approach

Possible approaches

Practical dosimetry:
1. Passive dosimeters
2. Active dosimeters

Retrospective dosimetry assessment using scatter radiation dose levels
4. Correlations between patient dose indices and eye doses to the operators

Correlation of patient’s dose with operators’ eye lens dose

- No clear consensus on the correlation between the patient dose and the dose to the eyes of the medical staff
- Correlation between the eye dose and kerma-area product strongly depends on two main parameters:
  - X-ray tube configuration
  - Use of radiation protection tools

From our RPD paper

Normalized eye lens doses per unit kerma–area product:
- 0.94 mSv/Gy cm² for the first operator, 0.33 mSv/Gy.cm² for the second operator/nurse and 0.16 mSv/Gy.cm² for radiographers.
- Statistical analysis indicated that there is a weak but significant ($p < 0.01$) correlation between the eye dose and the kerma–area product for all three staff categories.
Recommenda8ons

- Use of active dosimeter is most appropriate option for periodic assessment
- If a dedicated eye dosimeter is not available:
  - estimation of eye dose from patient dose

As per NCRP Report 168, nearly 16 million interventional procedures are performed annually in USA.

Latest changes in dose limits and dose thresholds

ICRP

- Threshold dose: 0.5 Gy (50 rads)
- Occupational dose limit: 20 mSv (2000 m rem) averaged over 5 years.
- NCRP yet to finalize/accept these

ICRP Statement on Tissue Reactions

- Lens of the eye, threshold in absorbed dose is now considered to be 0.5 Gy (against 0.5 to 2 for detectable opacities and 5 for visual impairment).
- Occupational Exposure Lens of Eye Limit — 20 mSv in a y (against 150), averaged over defined periods of 5 y, with no single y exceeding 50 mSv
Interventional Radiologists

Haskal & Worgul, RSNA News 2004:14

- Radiologists
- 5/59 posterior subcapsular cataracts
- 22/59 small dot-like opacities (early signs of radiation damage)
- 1/59 had undergone cataract surgery in one eye

Schueller et al, Radiographics 2006

Active collaborators

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Plus a team of local ophthalmologists
Radiation induced cataract is a major threat among staff working in interventional suites

- 38-53% main operators (1/3rd to half of main operators)
- 21-45% in nurses

Our Publications

• These changes have potential to lead to cataract in future years, as per information from A-Bomb survivors.

Recap

• What is cataract, radiation cataract, PSC
• Eye dosimetry: ICRU [Hp(0.3)]
• Approaches to eye dosimetry
• ICRP recommendations dose threshold of 0.5 Gy & occupational dose limit of 20 mSv/y
• Recent studies on lens opacities among interventionists (1/3rd to half of main operators)

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