Radiation protection during endovascular procedures - Focus on the eye lens

Alexander Gangl, MSc.
Department of Radiology
University Hospital Graz
Radiation induced cataract is not an effect that emerged newly:

Ionizing radiation exposure to the lens of eye is a known cause of cataractogenesis.

<table>
<thead>
<tr>
<th>DOSE THRESHOLD AND DOSE LIMITS FOR THE LENS OF EYE</th>
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<tbody>
<tr>
<td><strong>Once...</strong></td>
<td><strong>5 Gy</strong></td>
<td><strong>0.5 Gy</strong></td>
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<td><strong>... since 2012 (ICRP 118)</strong></td>
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<td><strong>Acute irradiation of the eye lens:</strong></td>
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<td><strong>Annual dose limit occupational exposure:</strong></td>
<td><strong>150 mSv/a</strong></td>
<td><strong>20 mSv/a (on average)</strong></td>
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</table>

In the year 1896, Thomas Edison suffered from sored eyes after experimenting with X-rays.
... but several recent studies are querying the existence of dose thresholds !!!

(Commission, Protection and Reasoning, 2009), (Jacob et al., 2010), (Hamada and Fujimichi, 2014), ...

Radiation induced cataract:

? stochastic <-> deterministic ?

... increased awareness is recommended !!
Strategies to reduce dose exposure to the lens of eye:

To decrease scattering dose emitted from the patient

- Active (radiation time, irradiated volume, low-dose programs)... Reduction of emitted radiation dose
- Passive (shielding, distance)... Protection against occurring scattering radiation dose
ACTIVE APPROACH:

Radiation time:

• Pulsed fluoroscopy (pulse rate)
• DSA-acquisition (frame rate)
• Last image hold (LIH)
• ... less documentation

Irradiated volume:

• Collimating the irradiated field
• Minimize C-arm angulations
• Reduced field of view (FOV) by using magnification
Magnification - dose reduction

Decreased FOV (diagonal length 48, 42, 32, 16, 11 cm)

... smaller penetrated cross section

... lower scattering dose
Impact of magnification on the scattering dose

**FOV 32:** -40%

**FOV 11:** -80%

Reduction of occupational dose!
Dose exposure to the patient:

**Correlation: KAP - effective Dose**  
(M. Brambilla et al., 2017)

Effective Dose ≈ stochastic health risk to the whole body

... but higher magnification level = higher patient entrance dose

Surface dose must not exceed the dose threshold for deterministic effects

-> Dosimetry !!
Radiation time – pulsed fluoroscopy

Pulse rate – Dose rate:

- No direct proportion
- Halved pulse rate ≠ Halved dose rate
PASSIVE APPROACH:

Shielding

Distance
X-ray protection glasses
Ceiling mounted shields
Distance: Inverse-square law

Patient is not an isotropic point source placed in an ideal environment!
X-ray protection glasses

Level of protection - Predefined testing conditions:

Laboratory conditions

Realistic conditions
X-ray protection glasses

Level of protection - Predefined testing conditions:

- DRF: 1.9 – 2.4
- DRF: 1.9 – 1.07
- DRF: 4.2 – 1.02

A literature review focusing on parameters dealing with eye lens protection published a range of dose reduction factors from 1.2 up to 10.2 determined in course of various test setups (Seals et al., 2016).
Ceiling mounted shields

- Reduction of dose exposure from 50% to 80%
- Protection for other present people (in contrast to protection glasses)

How to place ceiling shields?

- Reduce the gap to patient’s skin
- Place the shield as close as possible to the X-ray field. (Koukorava et al., 2014)
Conclusion:

Radiation production: No „Single Recipe‟

! Act situation related!

• At first, try to reduce arising scattering dose (Active approach)

  „Reducing the patient doses will lower staff dose too“ (IAEA.org)

• Secondly, use any kind of shielding devices (Passive approach)
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