Radiation Effect on Eye Lens

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Major international organizations
• More BASIC that the Basic Safety Standard,
• More BASIC than the basic recommendation
HOT Topic in Occupational Radiation Protection

- Cataract
Unlike Patients where........
Goal

• 100% protection of staff against cataract
• Is it achievable: Yes
• Is it documentable: Yes
Is there any other goal that is achievable with this much success?

Goal in effect, not in steps & actions
Radiation effects- 100% success

• Carcinogenic: No
• Genetic: No
• Skin injuries: May be ??
What is cataract

Clouding or opacification of the natural lens of the eye and obstructing the passage of light
What effect does it have?

• When light passes through the cataractous lens, it is diffused or scattered, resulting in blurred or defocused vision.

Easily treatable condition - surgery
Cataract - Age related

- Most cataracts appear with advancing age after 45 years.
- Smoking, diabetes, and excessive exposure to sunlight.
Localized effects of microwave radiation on the intact eye lens in...
by A Dowrat - 2005 - Cited by 7 - Related articles
A novel experimental system was used to investigate the localized effects of microwave radiation on bovine eye lenses in culture for over 2 weeks. ...
www.ncbi.nlm.nih.gov/pubmed/15887253

WHO | Health effects of UV radiation
Acute effects of UV radiation exposure include photokeratitis and ... Proteins in the eye's lens unravel, tangle and accumulate pigments that cloud the lens ...
www.who.int ... Health effects of UV radiation - Cached - Similar

[PDF] Localized effects of microwave radiation on the intact eye lens in...
File Format: PDF/Adobe Acrobat - Quick View
2005 - Cited by 7 - Related articles
properties of intact bovine lens in long-term culture conditions, we developed a system to determine the effect of microwave radiation on the eye lens. ...
webee.technion.ac.il/people/schachter/human/3.pdf

Student's Guide - Effects of UV Radiation on You
What is known, however, is that cumulative exposure to UV rays is one of the causes of opacity of the eye's lens, called cataract, a condition that displays ...
www.biospherical.com/nsf/student/page4.html - Cached - Similar

The Effects Of Radiation On The Eyes | LIVESTRONG.COM
The toxic effects of ultraviolet radiation, or UVR, can injure the ocular tissues of the eye, including the cornea, lens and macula lutea, ...
www.livestrong.com/.../199031-the-effects-of-radiation-on-the-eyes/ - Cached
Mechanism: Photochemical or Thermal

• High frequency microwave electromagnetic radiation from mobile phones and other modern devices has the potential to damage eye tissues, but its effect on the lens epithelium is unknown at present.

Fig. 6. The distribution of temperature rises within the anterior part of the eye after an exposure of 10 min for radiation of 1200°C, normal lens, pupil diameter of 2 mm and brown iris, expressed by isothermal contours. The incident irradiance is 200 mW cm$^{-2}$. This distribution will not vary if the exposure continues further.
Major Cataract Subtypes

- Cortical
- Nuclear
- Posterior SubCapsular (psc)
- Mixed
Eye Lens

• It is a unique organ in that it is nonvascular
• Has no loss of cells over the lifetime,
• Thus there is no mechanism for the removal of damaged cells.
History of radiation cataract

- Documented within 1 year of Roentgen’s discovery of X rays
• However, cataract was long thought to result from only high doses of radiation to the lens of the eye.

• This was based on data from early cyclotron workers with cataract after substantial neutron doses and

• with early Japanese A-bomb studies that reported excess cataracts among those who received over 2–3 Gy.
Up to early 1950’s


Radiation can cause cataract at High dose

Beliefs based on data in late 1950’s

- Cataract has a dose threshold
- The severity increased and the latency decreased as the radiation dose increased above that threshold
- Latent period was strongly inversely correlated with dose and that there was no cataract induction below 2 Gy.
Other major papers that influenced


ICRP Guidelines on Minimal Lens Doses for Cataract Induction (15, 16)

<table>
<thead>
<tr>
<th>End point</th>
<th>Brief exposures (Sv)</th>
<th>Fractionated or protected exposures (Sv)</th>
<th>Annual dose rate (Sv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detectable opacities</td>
<td>0.5–2</td>
<td>5</td>
<td>&gt;0.1</td>
</tr>
<tr>
<td>Visual impairment</td>
<td>5</td>
<td>&gt;8</td>
<td>&gt;0.15</td>
</tr>
</tbody>
</table>
What is New?

Lens opacities being reported at dose levels below the currently mentioned threshold in ICRP
• Inspection of the Merriam and Focht papers shows that the observation periods after irradiation were mostly quite short (average of 8 years)

• They studied only 20 individuals who had estimated lens doses under 2 Gy,
More Recent Studies


More Recent Studies


• a second AHS study examined the prevalence of cataract surgeries among 3,761 study subjects 55–57 years after the bombings, in which 479 surgical-cataract cases were documented (33). The study subjects were primarily 0–35 years old at exposure
Strength of newer studies over earlier ones

- Negative aspects of earlier studies:
  - short follow-up periods,
  - failed to take into account increasing latent periods with decreasing doses,
  - relatively few subjects with doses below a few Gy.
- Positive aspects of newer studies: Long follow-up, larger numbers, lower doses
Why longer follow-up?

• The latent period is dependent on the rate at which damaged epithelial cells undergo aberrant differentiation (fibrogenesis) and accumulate in the PSC region of the lens cortex.
IONIZING RADIATION

Damage to the Lens Epithelium

[ dividing cells ]  [ differentiating cells ]

ABNORMAL LENS FIBERS

Loss of Transparency
CATARACT
IAEA Cataract study

The lens of the eye is one of the radiosensitive tissues in the body. Radiation induced cataract has been demonstrated among staff involved with interventional procedures using X rays [ICRP 85; Vano et al., 1998]. A number of studies suggest there may be significant risk of lens opacities in populations exposed to low doses of ionizing radiation. These include those undergoing CT scans [Klein et al., 1993], astronauts [Cucinotta et al., 2001; Rastegar et al., 2002], radiologic technologists [Chodick et al., 2008] radiotherapy [Hall et al., 1999] besides data from atomic bomb survivors [Nakashima et al., 2006; Nerishi et al., 2007] and those exposed in Chernobyl accident [Day et al., 1995].

These observations have clear implications for those working in interventional rooms. Interventionalists and paramedical staff (nurses and to some extent radiographers) remain near the X ray source and within a high scatter radiation field for several hours a day during interventional procedures. During typical working conditions and if radiation protection tools are not routinely used, X-ray exposure to the eyes of interventional physicians and paramedical personnel working in interventional and catheterization laboratories can be high.

The cataract has so far been considered to be a deterministic effect with threshold. The International Commission on Radiological Protection (ICRP) and the U.S. National Council on Radiological Protection
Active collaborators
## IAEA Cataract Study - List of Eye Testing Exercises Conducted

<table>
<thead>
<tr>
<th>No</th>
<th>Place (City, Country)</th>
<th>Dates</th>
<th>Regional/National Organization</th>
<th>Links</th>
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<tr>
<td>1</td>
<td>Bogota, Colombia</td>
<td>25-26 Sept. 2008</td>
<td>SOLACI¹</td>
<td>RELID report Colombia [English], [Español]</td>
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<td>2</td>
<td>Kuala Lumpur, Malaysia</td>
<td>17-19 April 2009</td>
<td>NAHM²</td>
<td>RELID report Malaysia</td>
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<td>Montevideo, Uruguay</td>
<td>16-17 April 2009</td>
<td>SOLACI¹</td>
<td>RELID report Uruguay [English], [Español]</td>
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<td>11-12 July 2009</td>
<td>NCRRP³</td>
<td>RELID report Bulgaria</td>
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<td>RELID report Bulgaria</td>
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<tr>
<td>6</td>
<td>Bangkok, Thailand</td>
<td>23-24 December 2009</td>
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<td>RELID report Thailand</td>
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<td>7</td>
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Overview of studies

- A-Bomb survivors - Not in occupational settings
- Chernobyl workers - acute exposure
- Air Crew
- Medical occupational
  - NIH
  - IAEA studies
  - Unpublished from others
Cataract Staging: Merriam & Focht & 1962

- Anterior 1+
- Posterior 2+
- Anterior 3+
- Posterior 4+
Epidemiological evidences

Risk of Cataract after Exposure to Low Doses of Ionizing Radiation: A 20-Year Prospective Cohort Study among US Radiologic Technologists

Gabriel Chodick\textsuperscript{1}, Nural Bekiroglu\textsuperscript{2}, Michael Hauptmann\textsuperscript{3,4}, Bruce H. Alexander\textsuperscript{5}, D. Michal Freedman\textsuperscript{1}, Michele Morin Doody\textsuperscript{1}, Li C. Cheung\textsuperscript{6}, Steven L. Simon\textsuperscript{1}, Robert M. Weinstock\textsuperscript{1}, André Bouville\textsuperscript{1}, and Alice J. Sigurdson\textsuperscript{1}

and nonoccupational exposures to ionizing radiation and to personal characteristics. A cohort of 35,705 cataract-free US radiologic technologists aged 24–44 years was followed for 22 years (1983–2004) by using two follow-up questionnaires. During the study period, 2,382 cataracts and 2,573 cataract extractions were reported. Cigarette smoking for \( \geq 5 \) pack-years; body mass index \( \geq 30 \); hypertension; hypercholesterolemia, or arthritis at baseline were (1) associated with increased risk of cataract. In multivariate models, self-report of \( \geq 3 \) x-rays to neck was associated with a hazard ratio of cataract of 1.25 (95\% confidence interval: 1.06, 1.47). For workers in the highest category (mean, 50 mGy) versus lowest category (mean, 5 mGy) of occupational dose to the lens of the eye, the adjusted hazard ratio of cataract was 1.18 (95\% confidence interval: 0.99, 1.40). Findings challenge the National Council on Radiation Protection and International Commission on Radiological Protection assumptions that the lowest cumulative ionizing radiation dose to the lens of the eye that can produce a progressive cataract is approximately 2 Gy, and they support the hypothesis that the lowest cataractogenic dose in humans is substantially less than previously thought.

cataract; radiation; technology, radiologic; x-rays
• Lens opacities which may or may not lead to cataract
• Surgically operated cataracts among medical occupational group ??
Epidemiologists
Occupational risks
(difficulty with dose)

Radiation Protection professionals
• Good at dose estimations
• Training to prevent
• Capability to solve the problem
• Monitoring of effectiveness of RP actions
• Regulatory support
• -ve: not good in epidemiological context

Few tens of thousands
Summary

• Clear that cataract is possible at doses below the currently accepted threshold
• Larger scale studies in occupational settings
• Actual cataract demonstration
  • With typical doses in occupational settings
  • With dose estimates
  • Long term follow up

**CHALLENGE to this group!!!!!!**
International Workshop ORAMED 2011, Barcelona 20-22 January 2011
Optimization of Radiation Protection of Medical Staff.
rpop.iaea.org/RPOP/RPoP/.../international-workshop-ormed.htm - Cached

Work in progress / WP5 / Workpackages / ORAMED - SCK•CEN
The venue, scope and general organization of the ORAMED workshop were agreed in September 2009. The workshop will be held in Barcelona, from 20th to 22nd of ...

ORAMED 2011: International Workshop on Optimization of Radiation ...
20 Jan 2010 ... Comments about the event, ORAMED 2011: International Workshop on ...
from 13/07/2011 to 16/07/2011 Workshop in Barcelona TBD (Barcelona) ...
events.emagister.co.uk/congresses/oramed...workshop.../26143 - Cached

International Workshop ORAMED 2011 Optimization of Radiation ...
www.euradnews.org/fullstory.php?storyid=230375 - Cached

Radiation Protection of Medical Staff, ORAMED 2011 — CSOZ SURO
CZ - [ Translate this page ]
9. leden 2011 ... The ORAMED 2011 Workshop will offer an ideal opportunity for the exchange ... We look forward to welcoming you in Barcelona and to receiving ...
csoz.suro.cz/.../radiation-protection-of-medical-staff-ormed-2011 - Cached

SCK•CEN - ORAMED 2011: International Workshop on Optimization of ...
Barcelona, Spain. The ORAMED 2011 workshop will offer an opportunity for the exchange of ideas among professionals from different countries and with ...
www.sckcen.be/.../Events/Related-events - Cached
Thank you

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