Ocular Effects of Optical Radiation - Cataract

Per Söderberg

Ophthalmology, Dept. of Neuroscience, Uppsala university, Sweden
Dept. of Biomedical Engineering, University of Miami, Florida
Dept of Ophthalmology, Dalian University, China
College of Optometry, University of Houston, Texas
Take Home Message

- Effects of optical radiation in the eye strongly depends on exposure conditions and transmittance characteristics in the eye.
- Ultraviolet radiation causes photochemical damage in the eye lids, the conjunctiva, the cornea, the uvea and the lens.
- Light causes photochemical damage in the retina.
- There may be a photochemical effects of near infrared radiation in the lens.
Spectral irradiance (W/m²/nm)

Wavelength (nm)

Wester, 1996
Coroneo effect
Above threshold, short delay onset
Below threshold, chronic exposure
Below threshold, chronic exposure
Below threshold, chronic exposure
Above threshold, short delay onset

Wavelength (nm)

Biological eff. (rel.)

ACGIH, 2005
Below threshold, chronic exposure

Courtesy Sliney D
Above threshold, short delay onset
Above threshold, short delay onset

Pitts et al, 1977

Merriam et al, 2000
Rel. sensitivity as a function of age

Pigmented C57Bl6 mice, Zhang et al, manus

Albino SD rat, Dong et al. 2005
Wavelength additivity
Albino SD rat (6 w), postexposure int. 1 w.

300 nm 1.9 W/m², 35 min +
300 nm 1.9 W/m², 35 min
4 + 4 kJ/m² Abs dose
8 kJ/m² Biol. eff. Dose

300 nm 1.9 W/m², 35 min +
310 nm 20.0 W/m², 35 min
4 + 42 kJ/m² Abs dose
8 kJ/m² Biol. eff. Dose

Light scatt. diff. (tEDC)

300 nm

300+310 nm

Strategy

Li et al, manus

n = 20

n = 20
MTD dependence on fractionation interval
SD rat, albino, 6 weeks, UVR 300 nm, latency 1 weeks

\[ MTD_{2.3:16} = 5.14 + 0.90(1 - e^{-0.13 \times IntExpInt}) \]

Repair rate
\[ \tau = 1/0.13 = 8 \text{ days} \]

Repairable damage = 0.90
\[ 0.90/5.14 = 18 \% \]

No repair threshold 5.14

Dong et al, 2005
Cataract Chronic Daily Exposure Threshold Vs Cumulation period

MTD: 2.3:16

Cumulation period (days)

Galichanin et al, draft
Below threshold, chronic exposure

Cataract, cortical, risk factors

Age > 40 yrs

(UVR > 0.02 MSY, McCarty, VIP, Melbourne, IOVS 2000)

Risk factor:
- Age 70+
- Gender, female
- Family history
- Artrit
- UVR > 0.02 MSY
- Myopi > 1D
- Diabetes > 5 yrs
- Struma > 10 yrs

PAR (%)
Above threshold, short delay onset

Biological eff. (rel.)

Wavelength (nm)

Aphasic
Phasic, Typ II
Type I
Immediate onset
Thermal retinal hazard (Lund 2006)

Biological eff. (rel.)

Wavelength (nm)

300 400 500 600 700 800

0 0.5 1

Photocoagulation
Chronic subthreshold exposure to light

Macular degeneration?
IRR and cataract?
Epidemiological association between chronic exposure to IRR and cataract (Lydahl, 1984)

Photochemical effect?
Infrared radiation cataract

Albino SD rat, 1090 nm, 6.2 W within (3 mm), exp time 8 s
Summary

- Ultraviolet radiation exposure of ocular structures is determined by ambient scattering and transmittance characteristics of the eye.

- Ultraviolet radiation causes photochemical damage in the eye lids, the conjuctiva, the cornea, the uvea and the lens.

- Light causes photochemical damage in the retina.

If there is a photochemical effect of near infrared radiation, additive effects of chronic subthreshold exposures has to be considered.