RETROSPECTIVE EVALUATION OF LENS INJURIES AND DOSE (RELID) – IAEA STUDY

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IAEA

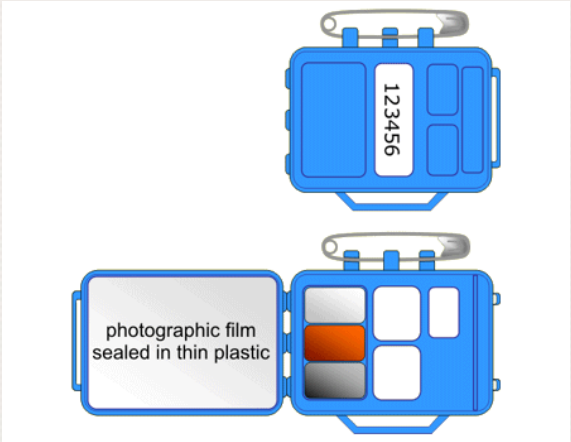
Atoms for Peace: The First Half Century
1957–2007

Objective

- **To examine the prevalence of radiation-associated lens opacities among interventional cardiologists and technical staff and correlate with occupational radiation exposure**
  - **Not purely a doismetry study**
  - **Dose and effect**

Background

- Since we are concerned with determination of effect, we need doses incurred in past, not prospective
- Non-availability of records of measured values from routine individual monitoring
- Non-availability of widely accepted methods for retrospective estimation



Question regarding Radiation Protection (RP)	Vienna 2004 (25 countries inter-regional)	Singapore 2005 (8 countries of Asia)	Addis Ababa 2006 (9 countries of Africa)	Teheran 2006 (6 countries of West Asia)	Bangkok 2006 (8 countries of Asia)	San Jose 2007 (11 countries of Latin-America)	Yerevan 2008 (7 countries of Eastern Europe)
Is this 1st time you are attending a structured program on RP. Ans. Yes	88%	84%	93%	100%	93%	70%	75%
Any cardiologists conference you attended with lecture on RP. Ans. No	85%	100%	100%	100%	100%	85%	92%
Do you measure radiation dose to patient. Ans. No	96%	100%	87%	89%	71%	100%	50%
Do you use badge to monitor your personal exposure Ans.Yes	77%	74%	33%	48%	57%	-	75%

Interventional procedures

- Limited occupational dose data
- 20-30% of cardiologists do not use dosimeter routinely (Vano et al, BJR, 2006, 79:383-388)
- Errors in use of dosimeters:
  - Identification
  - Interchange
  - Simultaneous use of protective devices

IAEA Cataract

Home » News

IAEA Cataract study - List of Eye testing exercises conducted

No	Place (City, Country)	Dates	Regional/National organization	Links
1	Bogota, Colombia	25-26 Sept.2008	SOLACI[1]	RELID report Colombia [English], [Español]
2	Kuala Lumpur, Malaysia	17-19 April 2009	NAHM[2]	RELID report Malaysia
3	Montevideo, Uruguay	16-17 April 2009	SOLACI[1]	RELID report Uruguay [English], [Español]
4	Varna, Bulgaria	11-12 July 2009	NCRRP[3]	RELID report Bulgaria
5	Sofia, Bulgaria	13-15 July 2009	NCRRP[3]	RELID report Bulgaria
6	Bangkok, Thailand New!	23-24 December 2009		RELID report Thailand
7	Buenos Aires, Argentina New!	11-13 August 2010	SOLACI[1]	RELID report Argentina [English], [Español]

Eye Lens Exposure to Radiation in Interventional Suites: Caution Is Warranted[1]

Radiology: Volume 248: Number 3—September 2008

Vano et al, Radiology, 2008:

Results: Mean scattered radiation doses to the lens during fluoroscopy were 6.0 and 34.5 μSv/min in the low- and high-dose scenarios, respectively. For DSA, typical doses to the lens ranged from 0.77 to 3.33 μSv per image. Operation modes involving increasing or decreasing radiation doses were quantified. For hepatic chemoembolization, iliac angioplasty, pelvic embolization, and transjugular intrahepatic portosystemic shunt creation, lens doses ranged from 0.25 to 3.72 mSv per procedure when protection was not used. Lens doses in the neuroembolization procedures could exceed 10 mSv per procedure.

Conclusion: With typical reported workloads, radiation doses to eye lenses may exceed the threshold for deterministic effects (ie, lens opacities or cataracts) after several years of work if radiation protection tools are not used.

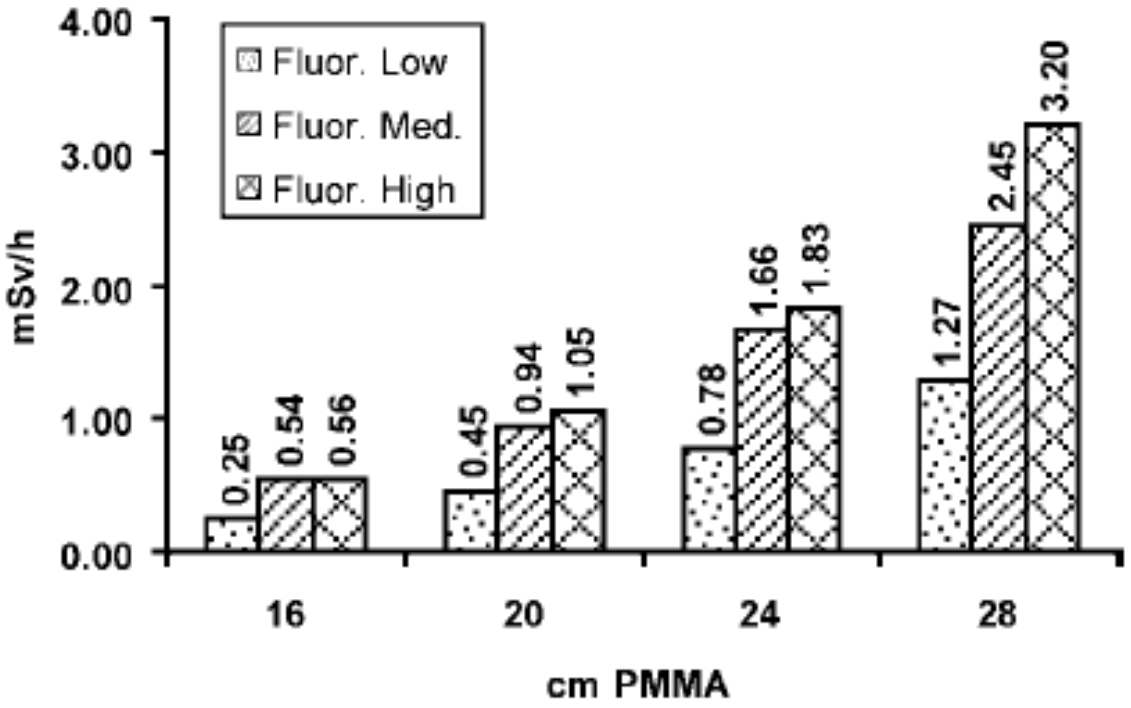


Figure 2: Graph shows scattered radiation doses (at eye position) measured by using different PMMA thicknesses in a fluoroscopy *(Fluor.)* system equipped with an image intensifier. The Leeds test object was in the beam field (in the center of the PMMA phantom) during the measurements.

Dose information for various studies (I)

Model	Value	Unit	Source	Remark
n/a	59	µSv/proc	Tsapaki ate all, PMB, 2004	CA, 5 countries, shoulder dose
n/a	89	µSv/proc	Tsapaki ate all, PMB, 2004	PTCA, 5 countries, Shoulder dose
Philips Optimus M 200 Poly C	260	mSv/y	Vano, et al, BJR, 2006	5000 procedure/y
Philips Integris HM 300	31	mSv/y	Vano, et al, BJR, 2006	5000 procedure/y
Philips Integrtis N-5000	18	mSv/y	Vano, et al, BJR, 2006	5000 procedure/y
Philips Integrtis Allura	3.5	mSv	Kuipers et al, Cardiovas Int Rad, 2008	4 weeks, TLD above the apron
Philps Polydiagnost C2	0.21-0.37	mSv/proc	Steffino, et al BJR 1996	Ceiling screen in place
Not available	0.11	mSv/proc	Pratt and Shaw, BJR, 1993	Ceiling screen and Goggles in place
CGR DG 300	0.014	mSv/proc	Marshall et al, BJR 1995	Eye dose, lead shield
Siemens Angioskop D	0.28	mSv/proc	Calkins et al, circulations, 1991	Eye, Ceiling screen in place
Philips Alura 10FD/20FD. GE Advantix, Philips Intergris 3000/5000, Siemens Axiom bip A	Table 1	Sv//h	Vano et al. Radiology 2008.	Dose rate at 1 m. h=1.6 m for different modes (fluoro. cine..)

Dose information for various studies (II)

Model	Value	Unit	Source	Remark
Philips Integris Allura	3.85	mSv/4 weeks	Kuipers et al, J Inte Card, 2008	TLD dose above the apron, mean value for 7 radiologists
Average 35 institutions	48	mSv/y	Niklason at al, Radiolgy, 1993	972 procedures/y, dose above the apron
Philips Integris 3000, II GE L-U, II	6.55	mSv/month	Williams, BJR, 1997	46 procedures/month, neck dose
Not available	Figure 2.b	µGy/min	Whitby, et al, BJR, 2005	PTCA
Different types of systems, average values	0.5 (IC) 0.15 (nurses)	mSv/proc	Vano et al, BJR , 1998	Without protective tools
Philips Integris V 3000	Figs 3.4,6,7	µGy/min	Whitby, BJR, 2003	Diagrams for PA, RAO, LAO projections
Different units	Table 3	µ Sv/proc	Vano, et al, BJR, 1998	TLD dose, eyes, with and without protective screen
Philips Integris HM 3000	Figs 4.5. 7-11	µGy/min	Morrish et al BJR, 2008	Scatter dose rate for fluoroscopy and acquisition for different projections

Remarks

- Probably other scenarios are possible
- Multiple dosimetry quantities: air kerma, H*(10), Hp(10), Hp(3)…)
- Inaccuracy in dose assessment for nurses due to large variability of location and multiple tasks performed
- Reported eye lens doses:
  - 0.3-11 mGy/study (without use of protective devices)
  - 0.011-0.33 mGy/study (with protective devices)
  - Using dosemeters over the apron a dose of 200-300 mGy/month is possible (Vano, 2006)
  - 0.5 mGy for cardiologists and 0.15 mGy for nurses are good approximations if protective devices are not used

- Typical doses if protective devices are not used
  - *0.5 mGy/procedure for interventional cardiologists*
  - *0.15 mGy/procedure for and nurse*
- This exposure corresponds to a typical procedure of 10 min of fluoroscopy and 800 cine frames

Radiation dose assessment

Typical doses if protective devices are not used:
- *0.5 mGy/procedure for interventional cardiologists*
- *0.15 mGy/procedure for and nurse*

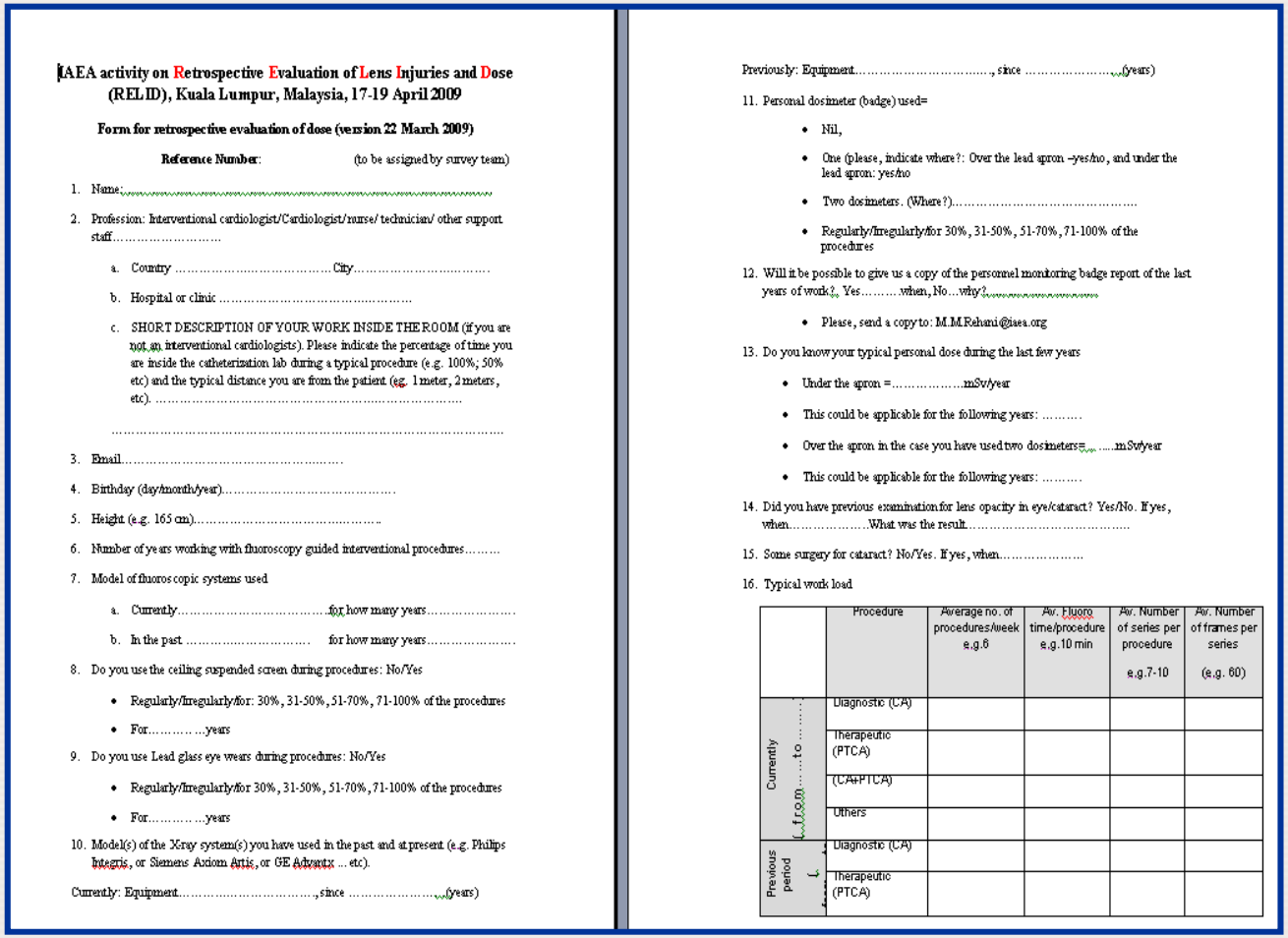
Workload:
- *number of procedures per week*
- *fluoroscopy time*
- *number of cine series per procedure*
- *number of frames per series*

Use of protective devices:
- *ceiling suspended screens (factor: 0.1)*
- *leaded glass eyewear (factor: 0.1)*

Angulations *(factor: 1.8)*
Radial access *(factor: 2.0)*

Materials and methods

- Interventional cardiologists and nurses
- Control group



IAEA activity on Retrospective Evaluation of Lens Injuries and Dose (RELID), Kuala Lumpur, Malaysia, 17-19 April 2009

Form for retrospective evaluation of dose (version 22 March 2009)

Reference Number: (to be assigned by survey team)

1. Name:
2. Profession: Interventional cardiologist/Cardiologist/nurse/ technician/ other support staff……
   a. Country ……City……
   b. Hospital or clinic ……
   c. SHORT DESCRIPTION OF YOUR WORK INSIDE THE ROOM (if you are not an interventional cardiologists). Please indicate the percentage of time you are inside the catheterization lab during a typical procedure (e.g. 100%; 50% etc) and the typical distance you are from the patient (eg. 1 meter, 2 meters, etc). ……
   ……
3. Email……
4. Birthday (day/month/year)……
5. Height (e.g. 165 cm)……..
6. Number of years working with fluoroscopy guided interventional procedures……
7. Model of fluoroscopic systems used
   a. Currently……for how many years……
   b. In the past …… for how many years……
8. Do you use the ceiling suspended screen during procedures: No/Yes
   - Regularly/Irregularly/for: 30%, 31-50%, 51-70%, 71-100% of the procedures
   - For……years
9. Do you use Lead glass eye wears during procedures: No/Yes
   - Regularly/Irregularly/for 30%, 31-50%, 51-70%, 71-100% of the procedures
   - For……years
10. Model(s) of the X-ray system(s) you have used in the past and at present (e.g. Philips Integris, or Siemens Axiom Artis, or GE Advantx … etc).

Currently: Equipment……., since ……(years)

Previously: Equipment……., since ……(years)

11. Personal dosimeter (badge) used=
    - Nil,
    - One (please, indicate where?: Over the lead apron –yes/no, and under the lead apron: yes/no
    - Two dosimeters. (Where?)……
    - Regularly/Irregularly/for 30%, 31-50%, 51-70%, 71-100% of the procedures
12. Will it be possible to give us a copy of the personnel monitoring badge report of the last years of work?. Yes……when, No…why?……
    - Please, send a copy to: M.M.Rehani@iaea.org
13. Do you know your typical personal dose during the last few years
    - Under the apron =……mSv/year
    - This could be applicable for the following years: ……
    - Over the apron in the case you have used two dosimeters=……mSv/year
    - This could be applicable for the following years: ……
14. Did you have previous examination for lens opacity in eye/cataract? Yes/No. If yes, when……What was the result……
15. Some surgery for cataract? No/Yes. If yes, when……
16. Typical work load

	Procedure	Average no. of procedures/week e.g.6	Av. Fluoro time/procedure e.g.10 min	Av. Number of series per procedure e.g.7-10	Av. Number of frames per series (e.g. 60)
Currently (..from..to..)	Diagnostic (CA)				
	Therapeutic (PTCA)				
	(CA+PTCA)				
	Others				
Previous period (..from..to..)	Diagnostic (CA)				
	Therapeutic (PTCA)				

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Dose related parameters (I)

Parameter	Source
Number of years in interventional cardiology	form
Model of fluoroscopy system used (in the past/now)	form
Use of ceiling suspended screens (in % of time period), S	form
Use of goggles (in % of time period), G	form
Workload: number of procedures/week	form
Fluoroscopy time/procedure	form
No of frames/procedure (no of frames/series and series/ procedure)	form

Dose related parameters (II)

Parameter	Source	Value	Factor
Attenuation of goggles, A	literature	90%	$1 - \frac{G\,(1 - A)}{100}$
Attenuation of ceiling suspended screen, B	literature	90%	$1 - \frac{S\,(1 - B)}{100}$
Distance from isocenter	literature	75 cm	ISL
For particular procedure. for different models of interventional systems at eye level scatter dose: • Dose rate [Sv/h] • Normalized dose rate [Sv/mAs] • Total dose for typical procedure [Sv/study]	literature; different sources to match the model of the system		
Angulations	literature: Vano, 2006 Batsou, 1998 Morrish, 2008	1.8	
Radial access	literature: IAEA, 2004 Vano, 2008	2	

Dose assessment

Scenario	Calculation
Information about model of the unit, workolad and typical procedure parameters are available	•Scattered dose rate •Correction for distance, use of protective devices, angulation, radial access •Dose ate eye level for typical procedure •Annual dose/dose for the whole period use of a particular system
Information about model and workload is available (procedure parameters are not available)	•Typical exposure parameters from the literature for a particular or similar type if system (10 min fluoroscopy time and 800 cine frames) •Same a previous

Angulation for typical procedure (CA)

	Betsou et al. BJR, 1998	Vano et al. Radiology, 2008.	Average
PROJECTION	TIME (%)	mSv/h	mSv/h
PA	11.50	1.00	0.12
PA CD	0.50	1.00	0.01
PA CR	5.90	1.00	0.06
RAO	7.50	1.00	0.08
RAO CD	15.80	1.00	0.16
RAO CR	4.20	1.00	0.04
LAO	26.30	2.00	0.53
LAO CD	11.90	2.50	0.30
LAO CR	15.10	3.00	0.45
L LAT	1.30	5.00	0.07
	100.00		**1.8**

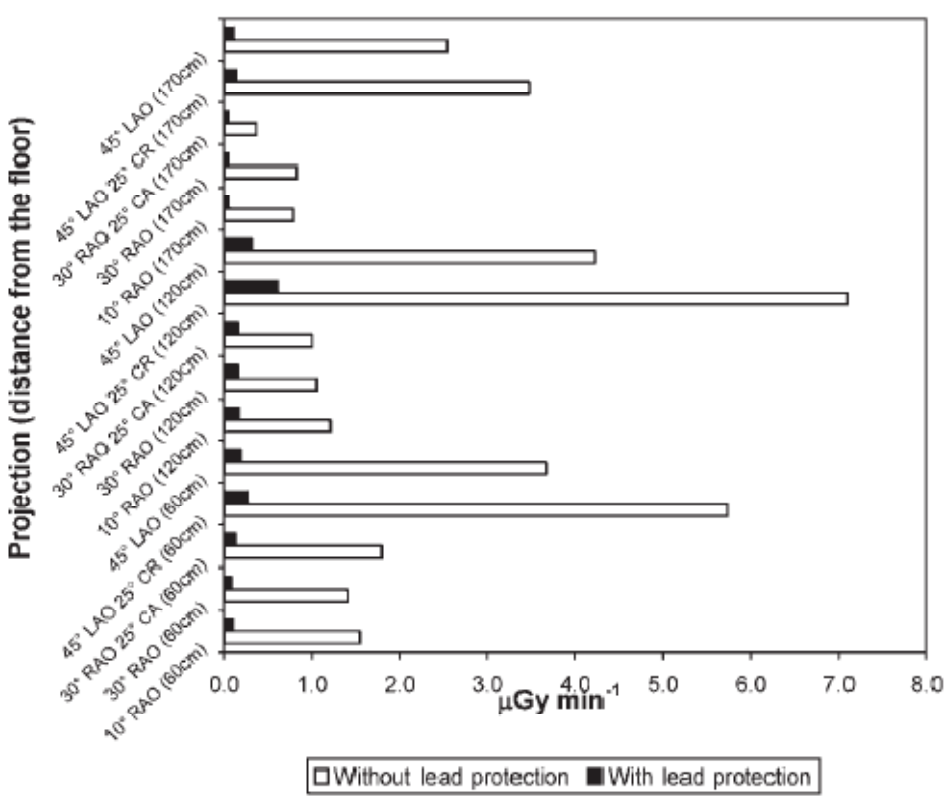


Figure 4. Measurements during fluoroscopy at the 210° position (cardiologist's position) with and without lead protection. RAO, right anterior oblique; LAO, left anterior oblique; CA, caudal; CR, cranial.

Figure 8. Distribution of scattered radiation from digital acquisition on the 10° right anterior oblique (RAO) projection at 68 kVp. The radial axis shows the dose in µGy min^{-1}, whereas the ionization chamber position is indicated on the circumference. The figure shows the patient position from above, and the arrow shows the direction of the primary beam. Data for points not measured at 90°, 180° and 150° at 60 cm have been interpolated.

O W E Morrish and K E Goldstone

The British Journal of Radiology, January 2008

1957–2007

Example of dose assessment (I)

Parameter	Source	Value	Period I	Period II
Number of years in IC	form	20	10 y	10 y
Model of fluoroscopy system (in the past/now)	form	CGR DG 300, for 10 years Philips Integris 3000, for 10 years	CGR DG 300	Philips Integris 3000
Use of ceiling suspended screens in %, with time period	form	50%, for 10 y 100% for 10 y	0.55	0.1
Use of goggles in %, with time period	form	0%	1	1
Workload: no of procedures/week	form	20	20x50 weeks/y	20x50 weeks/y
Fluoroscopy time/procedure	form	15 min	na	0.25 h
No of frames/procedure (no of frames/series and series/ procedure)	form	500	na	500

Example of dose assessment (I)

Parameter	Source	Value	Period I	Period II
Attenuation of goggles	literature	A=0.1 90%	100	
Attenuation of ceiling suspended screen	literature	B=0.1 90%		
Distance from isocenter	literature	75 cm	1	1.8 (dose at 1 m is avaliable)
Scattered dose rate in mSv/proc, assuming no protective tools	literature	0.5	0.5	0.5
Angulation	literature		1	1.8
Radial access	literature		2	2
			=3080 mSv/y	=66 mSv/y
		For 10 y	**30.8 Sv**	**0.7 Sv**
		TOTAL	**32 Sv**	

Assessment of lens change

- Dilatated slit lamp examination
- Merriam-Focht scoring system
- Scores: 0-3.0
- Scores >2.0 correlate with visual acuity

A CLINICAL AND EXPERIMENTAL STUDY OF THE EFFECT OF SINGLE AND DIVIDED DOSES OF RADIATION ON CATARACT PRODUCTION*

BY *George R. Merriam, Jr.*, M.D.† AND (BY INVITATION) *Elizabeth F. Focht*, M.A.**

TR. AM. OPHTH. SOC., vol. 60, 1962

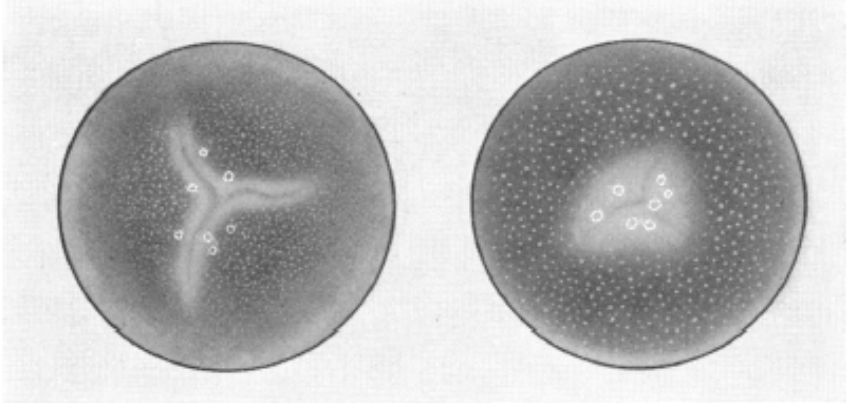


FIGURE 3

Two characteristic 1+ cataracts showing the early central posterior subcapsular vacuoles and dots with widening of the suture lines and an increase in the light reflex.

Results

Subjects and lifetime cumulative radiation dose to the lens of the eye

Subjects	No	Age* (y)	No of years in interventional cardiology	Cumulative dose to the lens (Gy)*
Interventional cardiologists	56	42 ± 7 (31-64)	9.2 ± 6.9 (1.0-33)	3.7 ± 7.5 (0.02-43)
Nurses	11	38 ± 11 (25-53)	6.0 ± 4.6 (1.0-14)	1.8 ± 3.1 (0.01-8.5)
Control group	22	44 ± 9 (29-57)	n/a	n/a

*mean ± standard deviation; values in parentheses are ranges

PSC changes (score > 0.5)

- IC staff: 34 subjects (51%. 95% CI: 2-95)
- Control: 2 individuals (9%. 95% CI: 1-33)

Interventional cardiologists:

- Prevalence 52% (29/56. 95% CI: 35-73)
- Significance (Fisher exact test): $p<0.001$
- Relative risk: 5.7 (95% CI: 1.5-22)

Nurses:

- Prevalence 45% (5/11. 95% CI: 15-100)
- Significance (Fisher exact test): $p<0.05$
- Relative risk: 5.0 (95% CI: 1.2-21)

Dose response for posterior lens changes in cardiologists and nurses and associated odds ratios (OR). relative risk (RR) and 95% confidence intervals (CI)

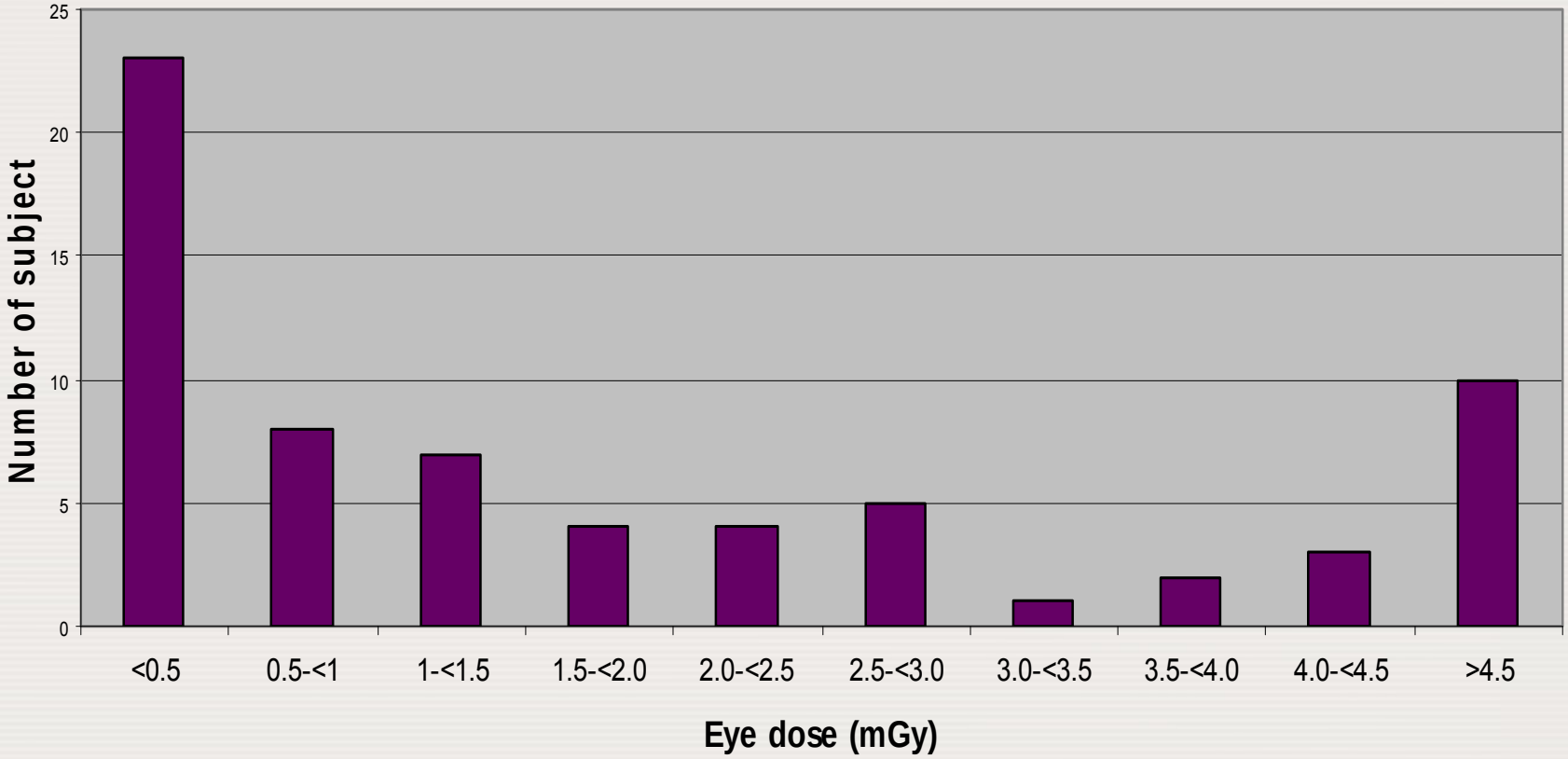
Dose (Gy)	Number of subjects	Number of subjects with posterior lens changes*	OR	95% CI	RR	95% CI
0 (Control)	22	2 (9%)	1.0	n/a	1.0	n/a
<1	31	12 (39%)	6.3	1.2-32	4.3	1.0-17
1<2	11	5 (45%)	8.3	1.3-54	5.0	1.1-22
2-<3	9	5 (55%)	12.5	1.7-89	6.1	1.4-26
≥3	16	12 (75%)	30	4.7-189	8.3	2.1-32
		34 (51%)	**10.3**	**2.2-48**	**5.6**	**1.4-21**

*cataract grade 0.5 or higher in one eye

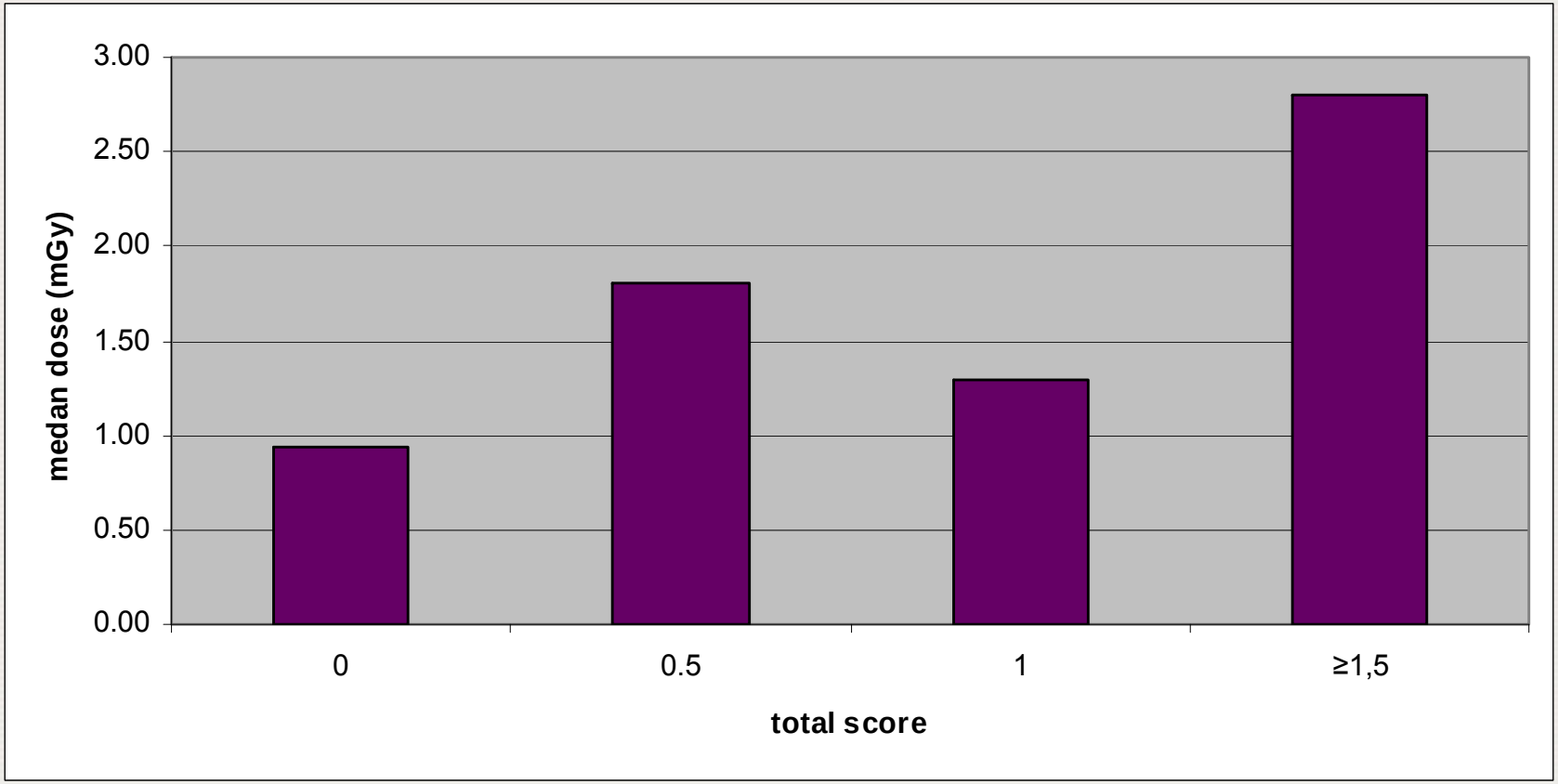
Number of interventional cardiologists with posterior lens changes graded by severity of lens changes with associated cumulative doses to the lens of the eye

Score	N	(%)	Dose (Gy)			
			mean	median	min	max
0 in both eyes	27	48	1.6	0.94	0.02	7.4
0.5 in one eye	8	14	2.4	1.8	0.04	8.4
0.5 in both eyes	18	32	7.4	1.3	0.02	43
>1 in one eye (0.5 or more in the other eye)	3	5	3	2.8	0.24	4.5

Eye dose distribution for IC



Total score vs cumulative eye dose



Summary

- The present study: score range 0-1.5 that had not progressed to cause significant visual disability
- Preliminary investigation of the dose response relationship
- Quantitative risk assessment would require a much larger cohort

Conclusions

- **Dose-response relationship between occupational exposure and the prevalence of radiation-associated posterior lens changes**
- **There is a need to find better means for eye lens dosimetry**
- **Threshold value, if any, is much lower that current guidelines indicate**
- **A study of a larger cohort is needed to confirm these findings**

Future Challenge

Among the future epidemiological research directions, the most important research need is for adequate studies of vision-impairing cataract after protracted radiation exposure

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