SESSION 5: Radiation protection of patients and staff in interventional procedures

Assessing and Reducing Exposures to Cardiology Staff

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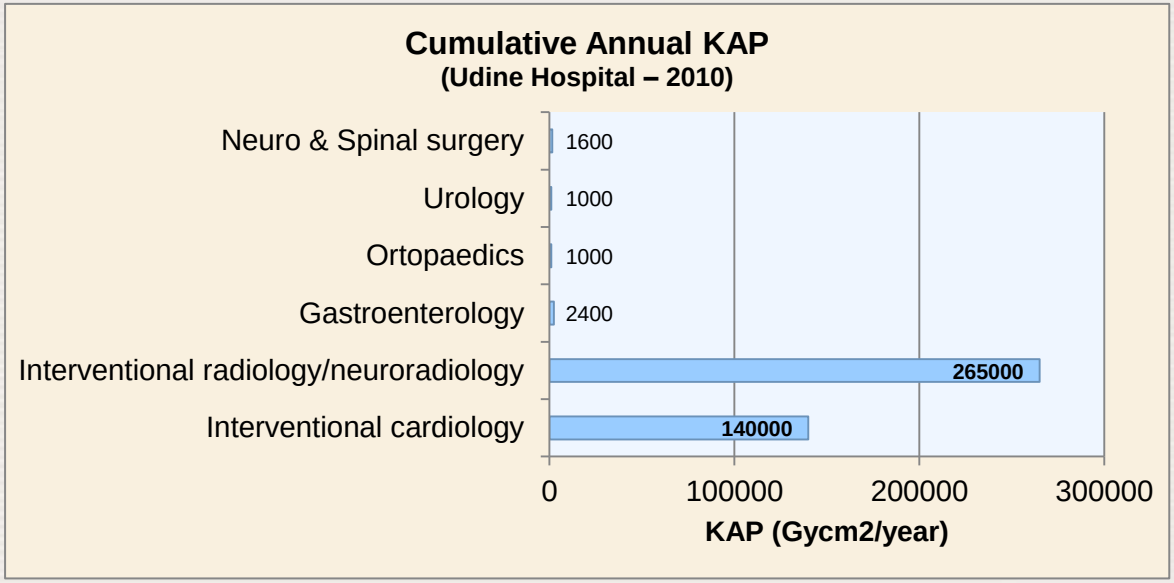
The facts

- Interventional radiology & cardiology are hospital fluoroscopy guided practices with the highest radiological workload

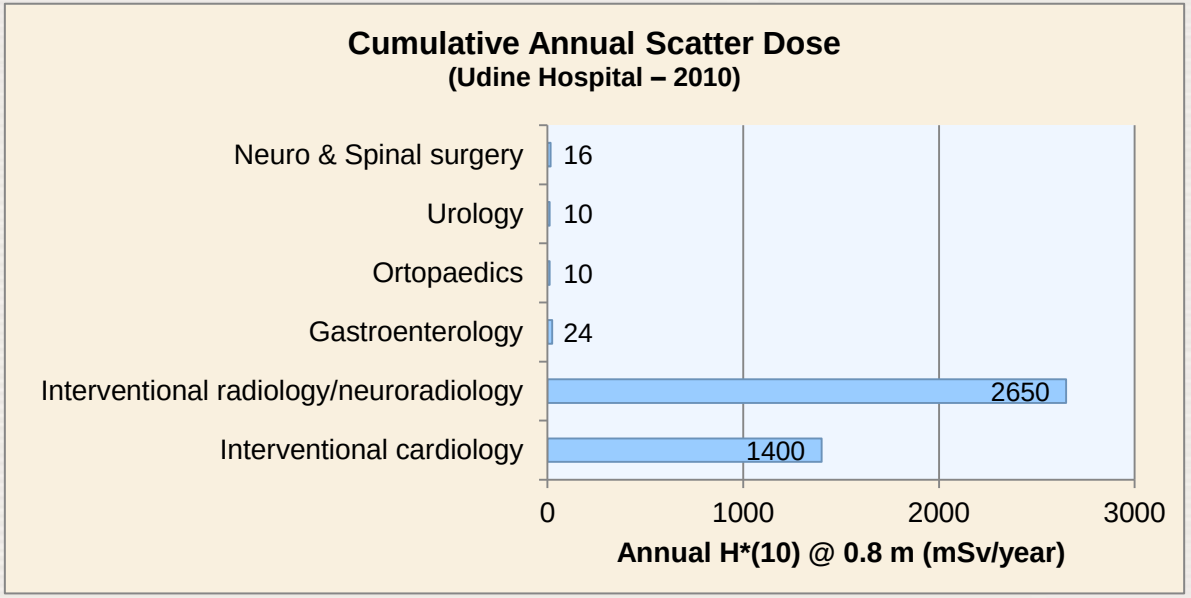
Annual workload of fluoroscopy guided practices



The facts

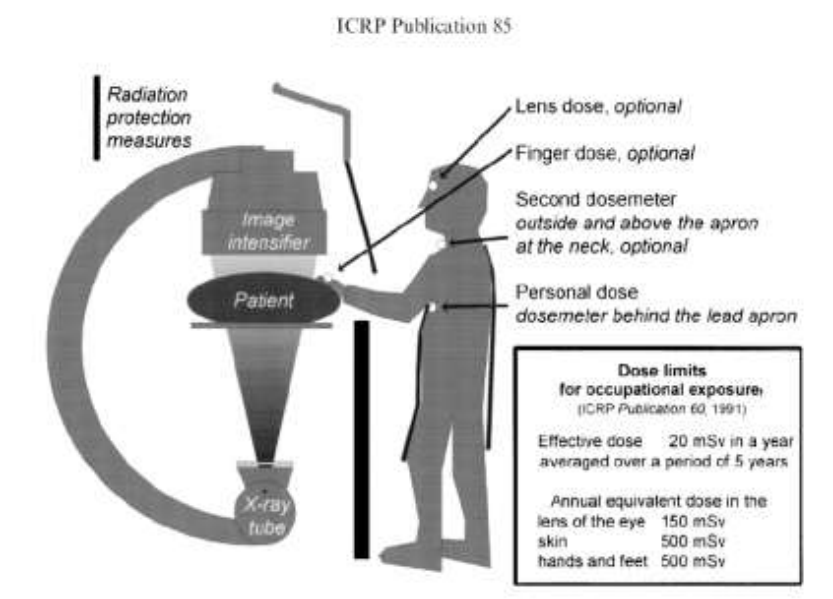
- ... and highest potential exposures to staff

Annual scatter exposures



Staff exposure monitoring

- 50 years of personal monitoring experience
  - Methodologies: dose quantities, protocols
  - Technologies: detectors, dosemeters
  - Practice: guidelines, training, national archives, etc.



Levels of staff exposure in interventional cardiology

ISEMIR (IAEA)

Information System on Occupational Exposure in Medicine, Industry and Research

- Working Group on Interventional Cardiology (IC):
  - World-wide overview of occupational exposures in IC
  - Harmonization of monitoring of staff in IC
  - Establish system for regular collection of occupational doses in IC (International database on staff exposures in IC)

ISEMIR surveys

- Individual interventional cardiologists
  - 201 responses from 32 countries
- Regulatory bodies
  - 136 answers: 24% world population
- Hospitals

Personal monitoring habits

- Interventional cardiologists:
  - 76% claimed that they always used their dosimeter
  - 45% stated they always used 2 dosimeters
    - 50% in Healthcare Level I countries
    - 24% in other countries

Results from the survey probably give an over-optimistic picture

Knowledge of doses

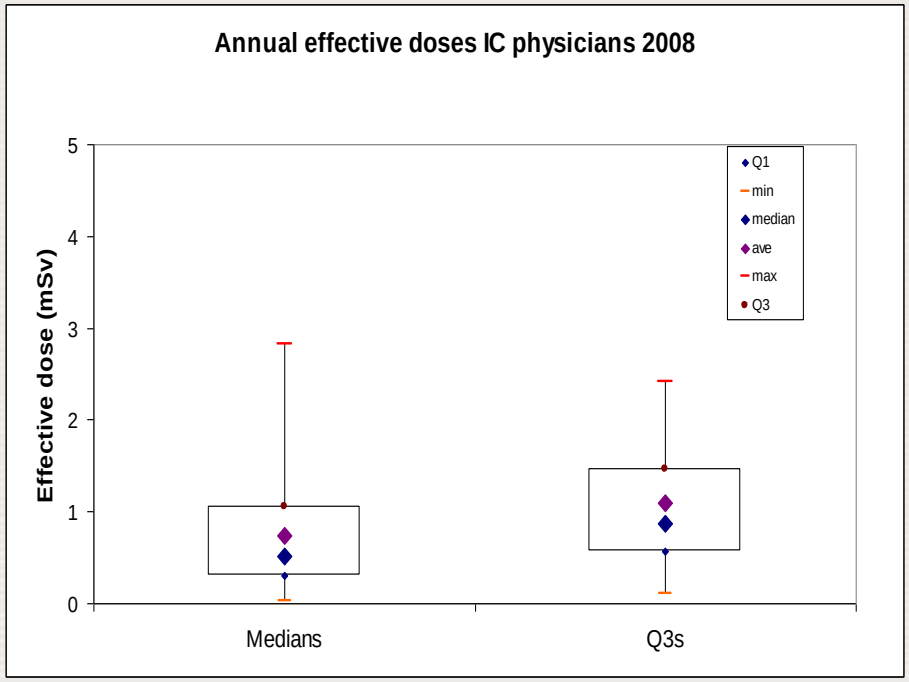
- Interventional cardiologists:
  - 64% said they knew their own personal doses
  - 38% knew both their own and patients' doses

Results from the survey probably give an over-optimistic picture

Regulatory requirements for monitoring in IC

- ~ 60% of RBs stated that they specify the number and position of dosimeters
- Of these:
  - 20% specify 2 dosimeters
    - 1 above and 1 below the apron
  - 40% specify 1 dosimeter
    - Most (~ 80%) above the apron
  - 40% did not provide information

Regulatory Bodies: national archives
Reported doses for 2008 (1080 persons)



Literature reports:

- 0.1 to 30 µSv effective dose per IC procedure
- Average E ~ 10 µSv/procedure

Average workload
~ 400 IC procedures/year

- e.g. 400 x 10 µSv = 4 mSv/year

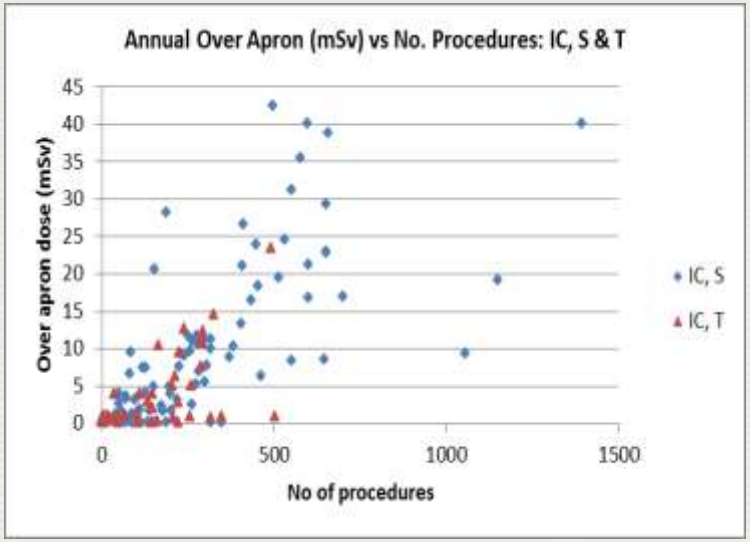
Reported values from survey probably under-estimate true values

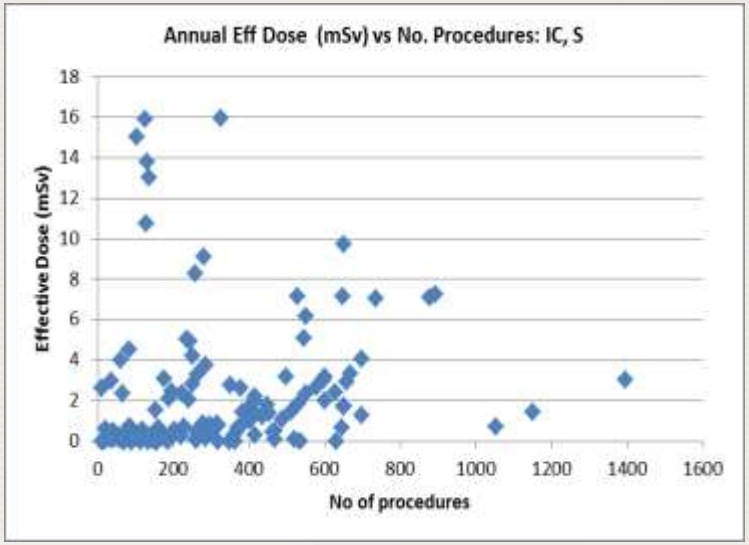
Why might there be an under-estimate?

- Interventional cardiologists may not wear their dosimeter(s) all the time
- Zero doses distort the dose distributions

ISEMIR survey: hospital archives

20 hospitals in 15 countries: annual doses and individual workload (2010)



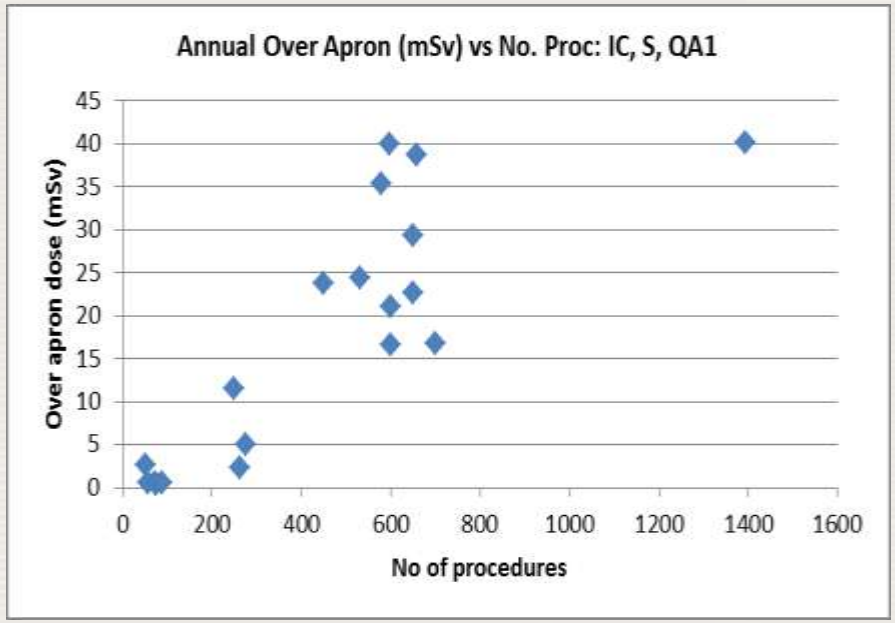


Interventional Cardiologists: Over apron and effective dose versus no. of IC procedures performed in a year (triangle: staff in training)

Great number of unrealistic zero values also at typical workload

ISEMIR survey: eye lens exposure of ICs

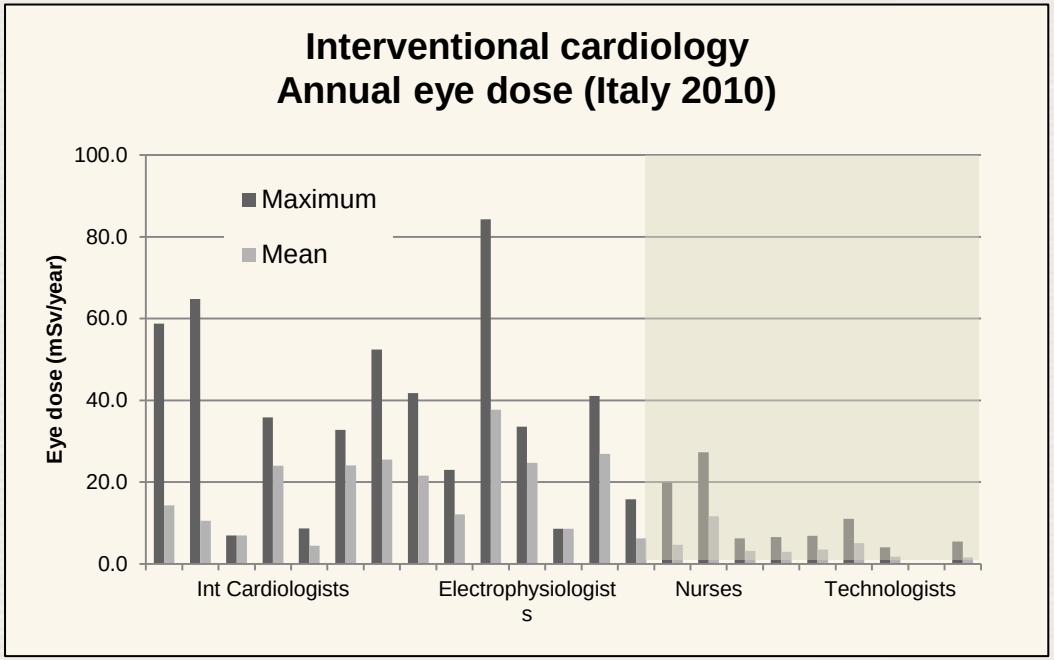
- Over apron Hp(0.07) is frequently used to estimate eye lens doses
- Sample of “good” quality data are showing a great fraction of ICs are receiving doses over the recently ICRP recommended limit.



First operator: mean value 50 µSv/procedure

Italian survey: eye lens exposure of all IC staff

- **ICs & EPs (first operators):**
  - Highest exposures
  - Some hospitals: mean value > 20 mSv/y
- **Nurses & Technologists:**
  - Mean values: << 20 mSv/y
  - Rarely max > 20 mSv/y



Italian survey: 10 hospitals. ISS/AOUD Project (2011)

Large variability. Great number of unrealistic zero values

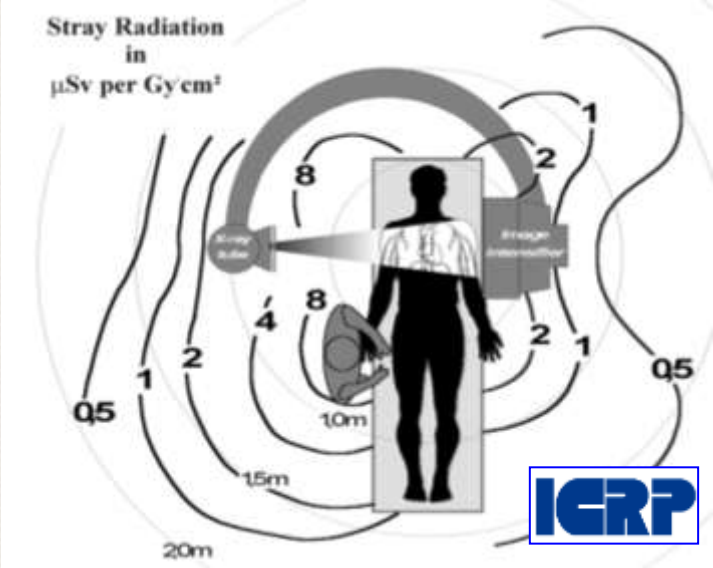
... summarising

- Staff exposure of IC staff:
  - Lack of knowledge of actual doses
  - Large variability of doses
  - Great number of unrealistic zero dose values
  - Individual high dose values are indicating existence of high exposures in IC practice
  - Probably, a large fraction of interventionalists have annual eye doses well over 20 mSv/y

DOSE ASSESSMENT

Dose assessment: effective dose

Non uniform field of radiation, linked to patient exposure



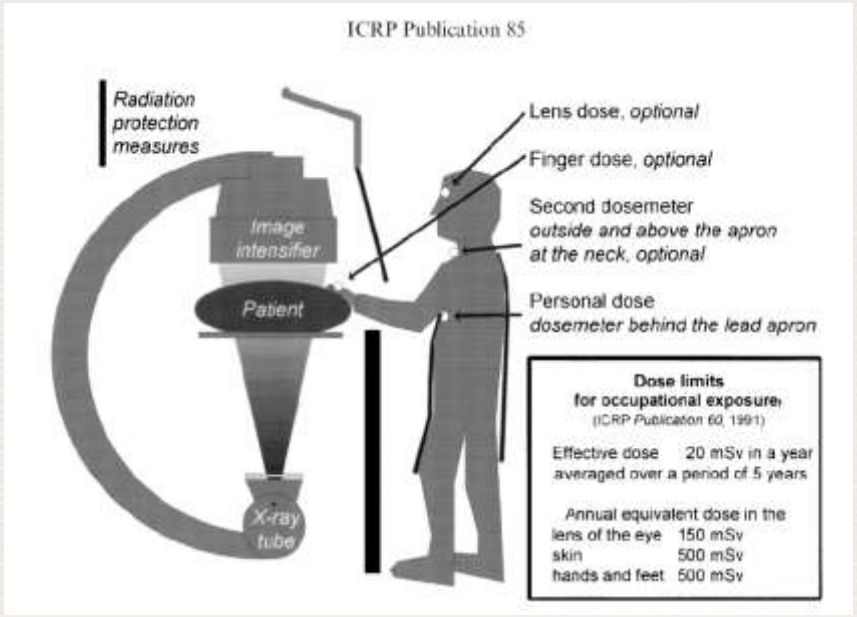
- ICRP 85 Recommendations (2001):
  - *.. interventional radiology requires the use of robust and adequate monitoring ..for staff.*
  - *A single dosimeter worn under the lead apron will yield a reasonable estimate of effective dose.*
  - *Wearing an additional dosimeter at collar level above the lead apron will provide an indication of head (eye) dose.*

Dose assessment: effective dose E

Dosemeter/s reading → $H_P(10)$ → E

- Several factors are influencing dosimeter reading:
  - position of the operator
  - X-ray projection
  - position of dosemeter
  - dosemeter outside apron or under apron
  - dependency on apron thickness/tyroid collar/other protective devises and tube voltage

Correction factor?



Effective dose: Double Dosimetry algorithms

$$E = \alpha H_u + \beta H_o$$

DD algorithm without TS	α	β	Remarks
Wambersie and Delhove (1993)	1	0,1	
Rosenstein and Webster (1994), NCRP Report 122 (1995)	0,5	0,025	
Niklason et al. (1994)	1	0,06	H_o-->H_o-H_u
Swiss ordinance (1999)	1	0,1	
McEvan (2000)	0,71	0,05	
Franken and Huyskens (2002)	1	0,1	
Sherbini and DeCicco (2002)	1	0,07	
Von Boetticher et al. (2003), Lachmund (2005)	0,65	0,074	
Clerinx et al. (2007)	1,64	0,075	

Effective dose: Double Dosimetry algorithms

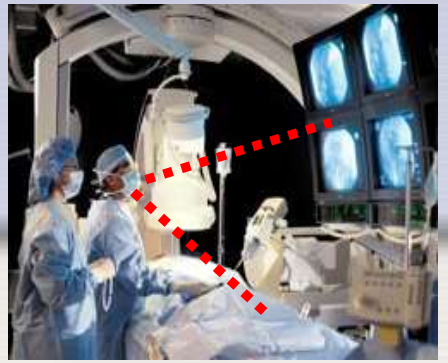
- Most algorithms are overestimating E

  → low accuracy

DD algorithm	Max **over**est.of E by a factor of			Max **under**est. of E by a factor of	
	Ref.	Schulz & Zoetelief	Siiskonen et al.	Ref.	Schulz & Zoetelief
Rosenstein & Webster (1994)	Up to 1,89	2,25	6,7	Up to 3,3	1,2
NCRP 122 (1995)	Up to 2,03		16,7		
Niklason et al. (1994)	< 2	2	5,6		1,3
Franken & Huyskens (2002)	Up to 1,5	3	9,1		
Swiss ordinance (1999)		4,5	13,4		

Schultz, F. W. and Zoetelief, J. Estimating effective dose for a cardiac catheterisation procedure with single and double personal dosemeters. Radiat. Prot. Dosim. 118(2), 196-204 (2006)

Eye lens dose assessment



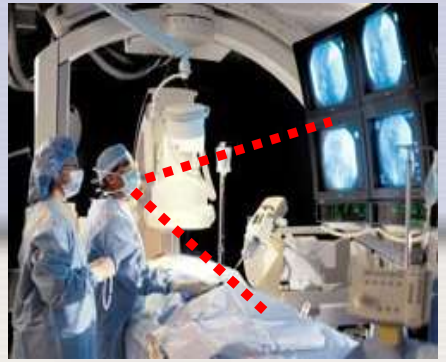
- **Dose quantity: Hp(3)**
  - Hp(0.07) can be properly used
- **Several factors are influencing eye dose:**
  - use of eye shields (suspended lead screen, lead glasses)
  - position of the operator
  - X-ray projection

- Dosimeter position:
  - Above the eye on the side of the x-ray tube
  - Alternative: dosimeter at the neck over the apron
    - Different studies are providing corrective factors from **0.4 to 0.9**
    - **C.Martin is suggesting a factor of 0.75**

→ Uncertainty: very high

Martin C, Personal dosimetry for interventional operators: when and how should monitoring be done?, British J Radiol, 84 (2011), 639–648

Eye lens dose assessment

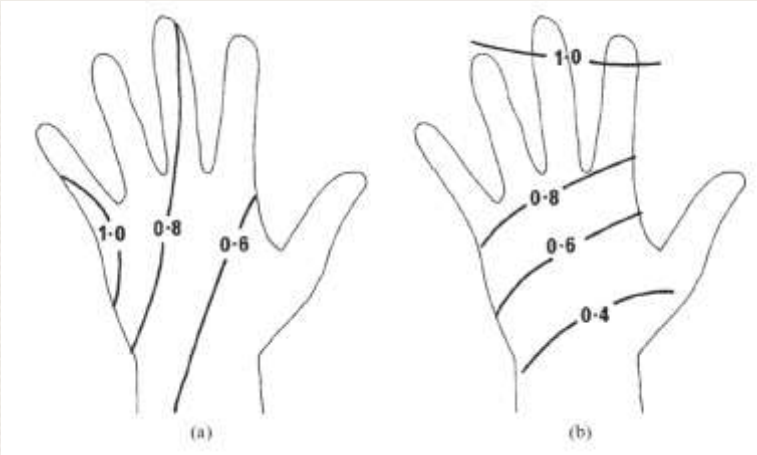


- Use of lead glasses
  - The unshielded dosimeter will overestimate the eye dose
- The present eye dosimetry is not a “robust” method
  - The annual eye dose of the first IC is of the same order of magnitude of the recommended new dose limit
  - The high uncertainty of the available monitoring methods is probably not acceptable

Hand dose assessment

- Typical doses

Type of procedure	Hand dose (μSv/Gycm2)
Percutaneous (PM implantation)	27 (11 ÷ 60)
Non-percutaneous (CA, PCI)	2.8 (0.43 ÷ 6.7)



Dose distribution:
a) femoral, b) percutaneous access

Non uniform field of radiation:

- The ICRP recommends the assessment of the dose to the most exposed area of skin
- The dose limit applied to the dose averaged over an area of 1 cm^2

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Hand dose assessment

- Dosimeter: ring dosimeter on little or ring finger
- Accuracy: underestimation of the maximum skin dose by 10–30%

- For comparison, a dosimeter on the wrist may underestimate the dose by a factor of 3 (range 2-7)

Martin C, Personal dosimetry for interventional operators: when and how should monitoring be done?, British J Radiol, 84 (2011), 639–648

Leg dose assessment

- Typical doses

Table lead drapes	Leg dose (µSv/Gycm2)
Without	6.7 (2.6 – 10)
With	0.6 (0.2 – 1.9)

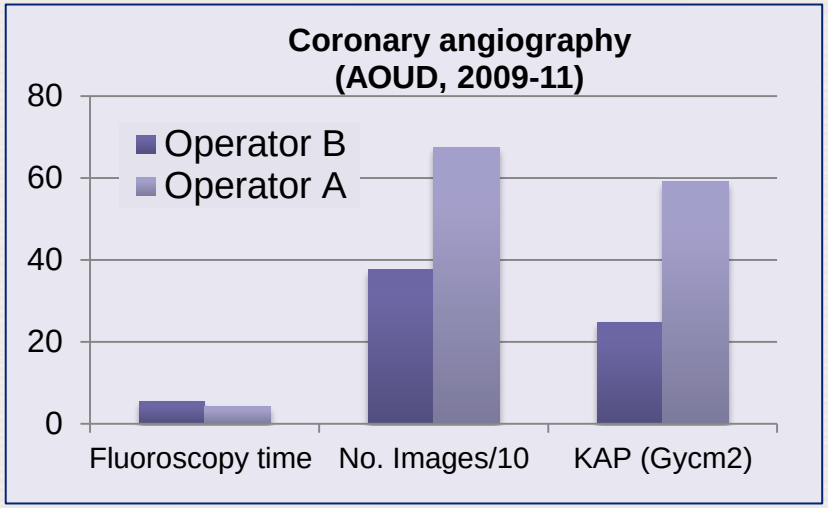
- The doses to the legs should not present a protection issue if appropriate shields are in place
- Personal monitoring is not usually required

Martin C, Personal dosimetry for interventional operators: when and how should monitoring be done?, British J Radiol, 84 (2011), 639–648

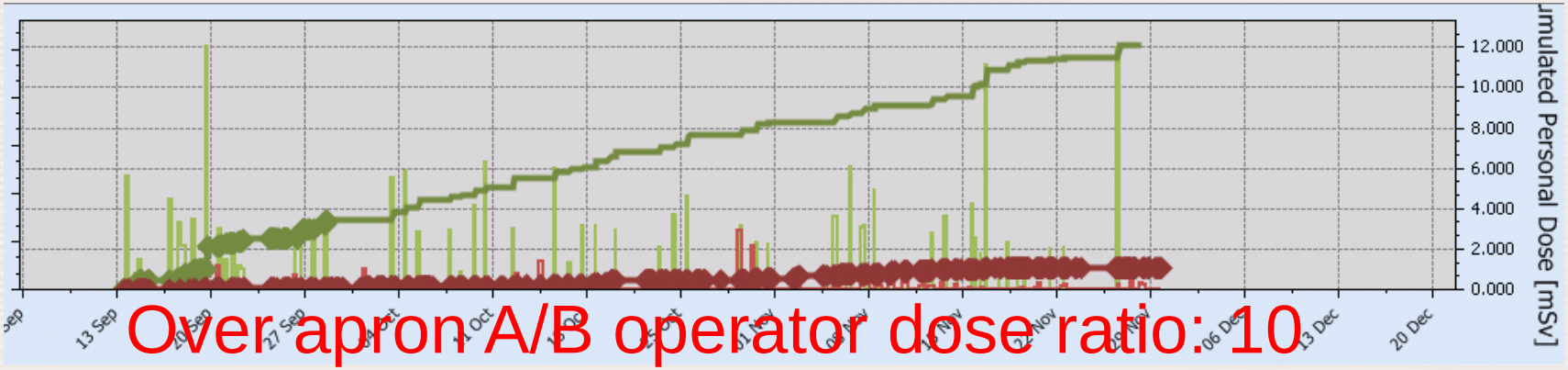
DOSE REDUCTION

Reduce staff exposure: IC procedures

- Optimisation of clinical procedures
  - Staff exposure is correlated to patient exposure



Patient dose A/B ratio: 3



Over apron A/B operator dose ratio: 10

Reduce staff exposure: tools

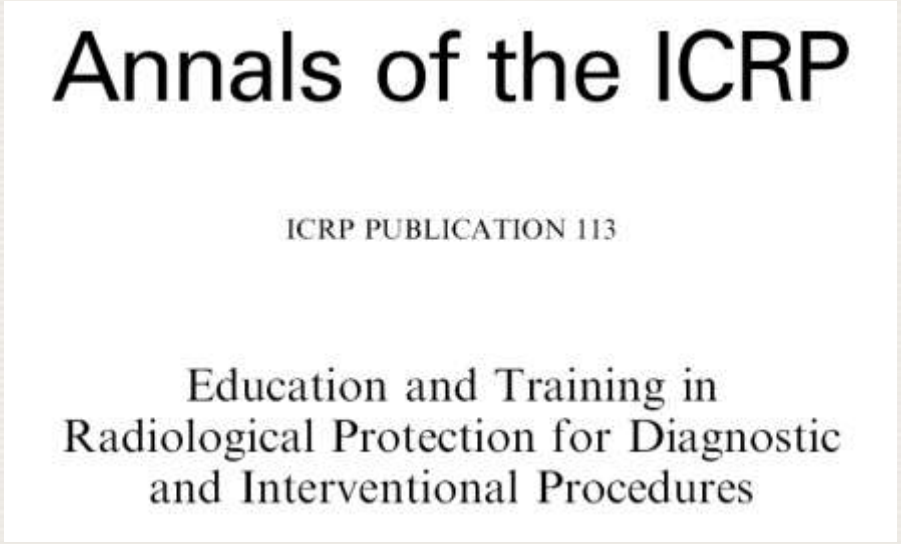
- To assess and use
  - local reference levels for patients
  - Achievable/investigation levels for staff
- Clinical and Dosimetry audits
  - Internal/external
- To develop dose information system
  - To integrate patient and staff dosimetry
    - Active dosimeters can play a role
  - Standards needed (DICOM, IEC)

Reduce staff exposure: equipment

- Imaging technology:
  - Advanced, more efficient imaging detectors
  - To improve image post-processing
- Equipment set-up:
  - To assess maximum dose rates (task related)
- Shielding:
  - Better design of protective tools (eye protectors)
  - To be integrated in the angiography unit

Reduce staff exposure: training

- The training should be theoretical and practical with:
  - a curriculum appropriate to the practice
  - a certification, or formal qualification



Role of international/national bodies and scientific societies

- To develop guidelines and optimise clinical and monitoring protocols
- To promote education and training
- To conduct clinical audits

- To improve national archives of staff doses
- To promote the use of international database of staff doses for benchmarking (ISEMIR iDB)

Useful guidelines

Annals of the ICRP

ICRP PUBLICATION 120

Radiological Protection in Cardiology

Catheterization and Cardiovascular Interventions 00:000–000 (2012)

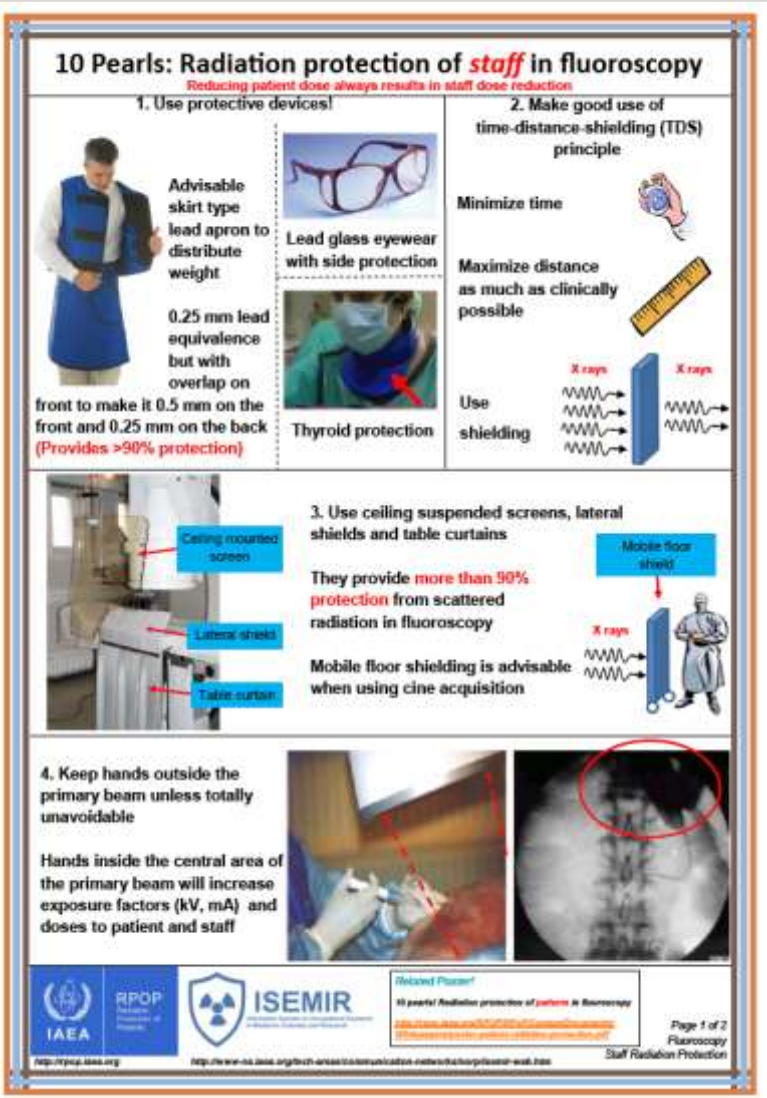
Core Curriculum

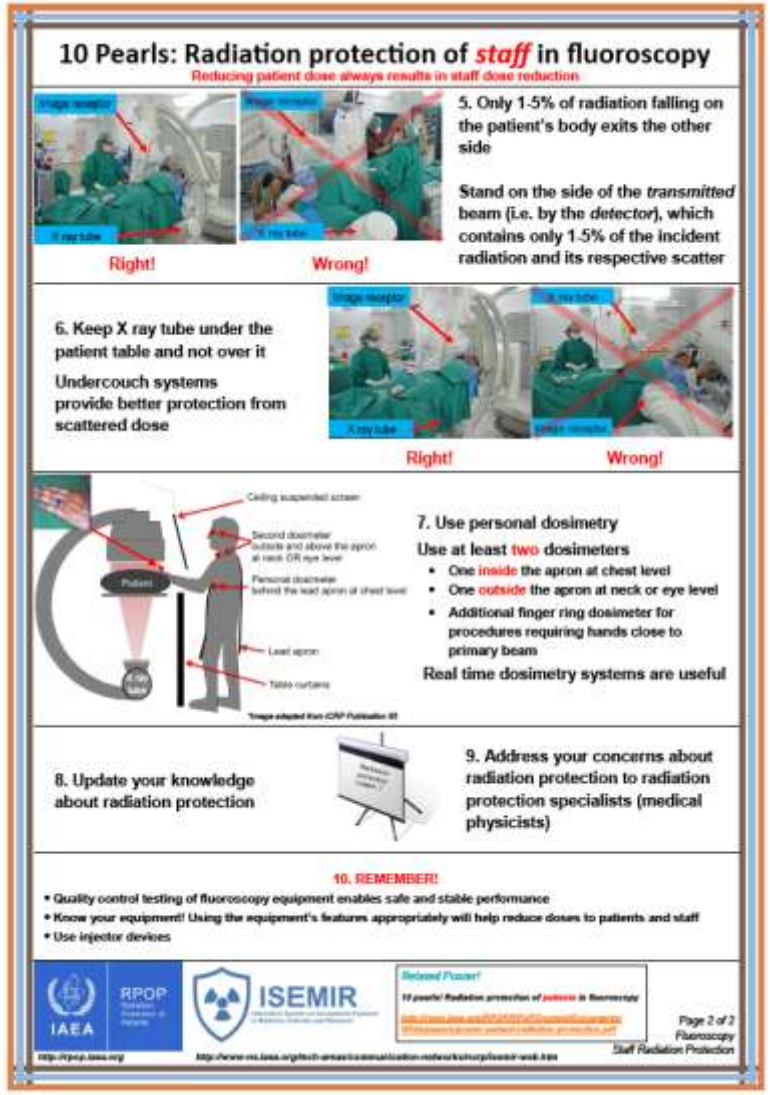
A Summary of Recommendations for Occupational Radiation Protection in Interventional Cardiology

Ariel Durán,[1] MD, FACC, Sim Kui Hian,[2] MBBS, FRACP, Donald L. Miller,[3] MD, John Le Heron,[4*] BSc(Hons), FACPSEM, Renato Padovani,[5] PhD, and Eliseo Vano,[6] PhD

Recommendations of the Working Group on Interventional Cardiology on occupational doses to the lens of the eye in Interventional Cardiology

Useful practical advices





Conclusions: ISEMIR statement

- Given the new occupational dose limit for the lens of the eye, the potential for high doses in IC, and the general lack of knowledge of actual eye doses in interventional cardiology (and other similar interventional practices), it is considered necessary:
  - To improve training in occupational RP
  - To improve monitoring methods for assessing lens doses
  - To urge hospital management to utilize the IAEA iDB for benchmarking occupational doses in IC and hence improving optimization of protection