Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Medical staff exposure and monitoring in interventional practices

EAN - ALARA for interventional radiology & nuclear medicine

Vienna 2nd – 4th October 2023

Ferrari Paolo (ENEA – IRP, Radiation Protection Institute, Italy)

EURADOS European Radiation Dosimetry Group

The European Radiation Dosimetry Group (EURADOS) is a network of 83 European institutions (Voting Members) and more than 650 scientists (Associate Members)

Working Groups
WG2 – Harmonisation of individual monitoring
WG3 – Environmental dosimetry
WG6 – Computational dosimetry
WG7 – Internal dosimetry
WG9 – Radiation dosimetry in radiotherapy
WG10 – Retrospective dosimetry
WG11 – High energy radiation fields
WG12 – Dosimetry in medical imaging
Pilot Group – Dosimetry in nuclear medicine

- promote technical development and its implementation in routine work
- contribute to compatibility/ harmonization within Europe and conformance with international practices
- organization of scientific meeting, and training activities
- organization of intercomparisons and benchmark studies

https://eurados.sckcen.be/

ENEA

EURADOS WG-12 – Current Task Groups

STAFF DOSIMETRY
T.G. 1.1 Report on individual monitoring in interventional radiology and cardiology
T.G.1.2 Dose constraints DCs in interventional cardiology
T.G.1.3 EURADOS practical worksheets
T.G.1.7 Interventional practices in complex procedures
T.G 1.8 Radiation exposure in nuclear medicine evaluation of finger doses and influence of new isotopes

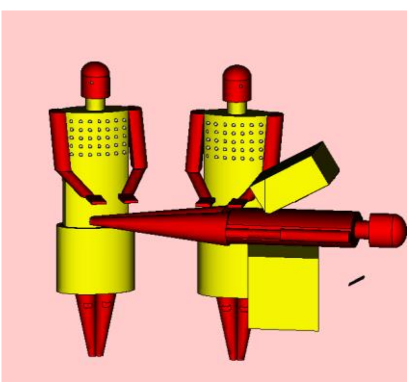
PATIENT DOSIMETRY
T.G.2.2 Total dose in radiotherapy
T.G.2.4 Dosimetry in pregnancy related to medical exposure
T.G.2.5 Organ Dose in Interventional Radiology

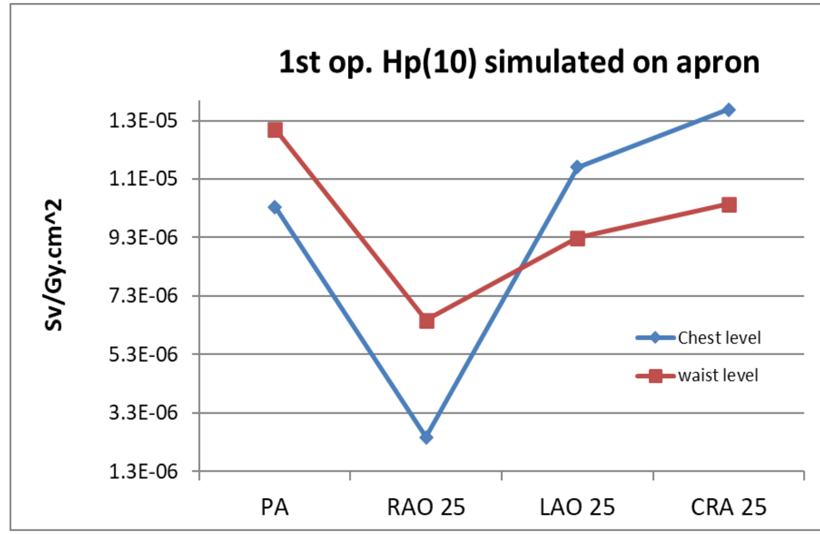
Joint Task: Operator exposure in nuclear medicine during radiopharmaceutical administration

Scattering field variation in interventional procedures

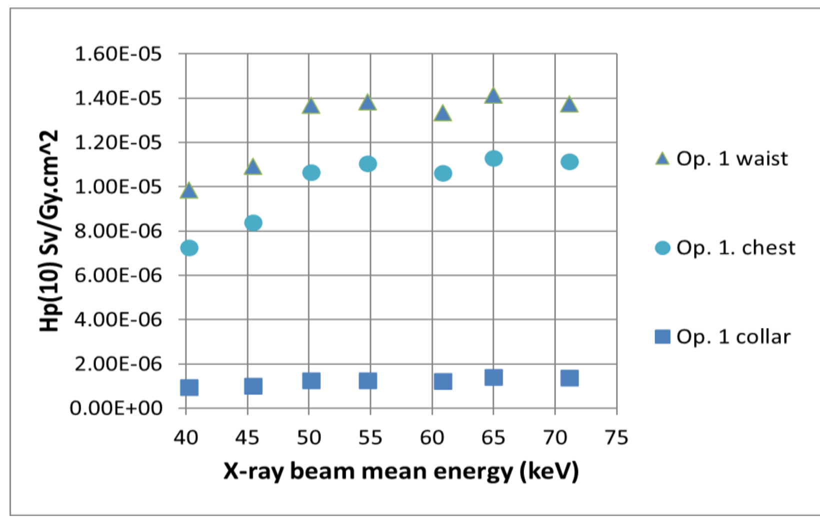
Different parameters affect the variability of the scattered field reaching the operator in interventional practice.
Such variability has been studied in EURADOS WG-12 through simulations with Monte Carlo code MCNP, modified MIRD models and specific measurements in interventional theaters.

Reference:
Simulation of H p (10) and effective dose received by the medical staff in interventional radiology procedures.
P Ferrari et al 2019 J. Radiol. Prot. 39 809





Different beam projections, same enrgy



PA projection, different beam energies

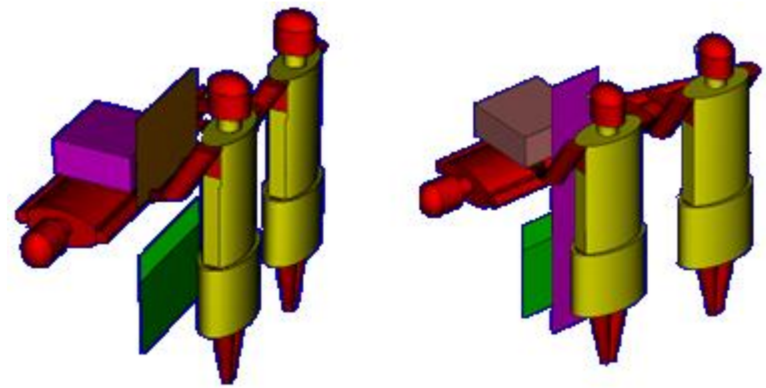
ENEA EURADOS

Shielding - interventional radiology

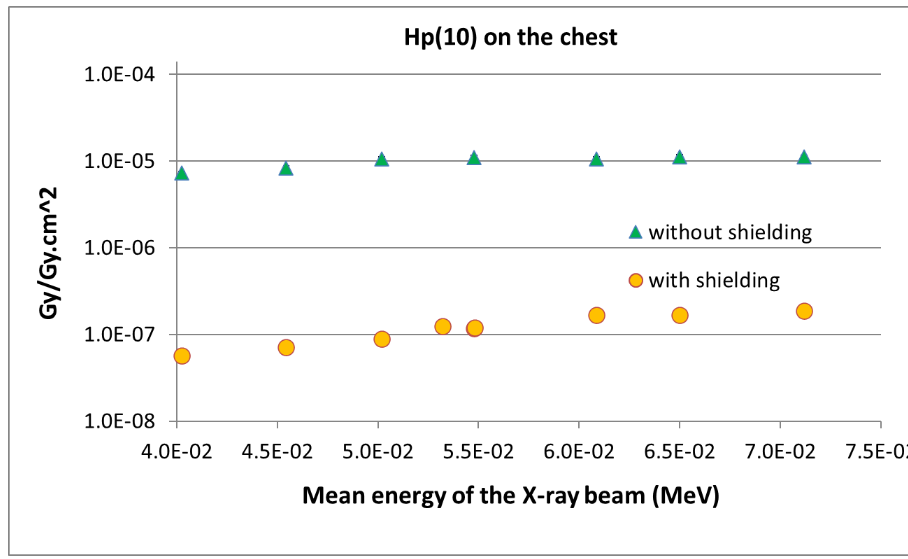
Notwithstanding the intrinsic variability of the exposure, it can be efficiently reduced through a proper shielding

Procedure	KAP Gy.cm^2	Measured Hp(10) µSv
PTC no shielding	80	749
PTC no shielding	35	456
PTC no shielding	19	216
PTA + 0.5 mm Pb	49	11
PTC + 0.5 mm Pb	22	13
PTBD + 1 mm Pb	84	3
PTBD + 1 mm Pb	30	2

PTC Percutaneous transhepatic cholangiography
PTA-Percutaneous Transluminal Angioplasty
PTBD-Percutaneous transhepatic biliary drainage and/or stenting



Simulation of 1 mm Pb mobile barrier



Shielding efficiency (LAO 90° IC) – positioning

The barriers should be properly positioned to preserve their effectiveness in reducing operator's exposure

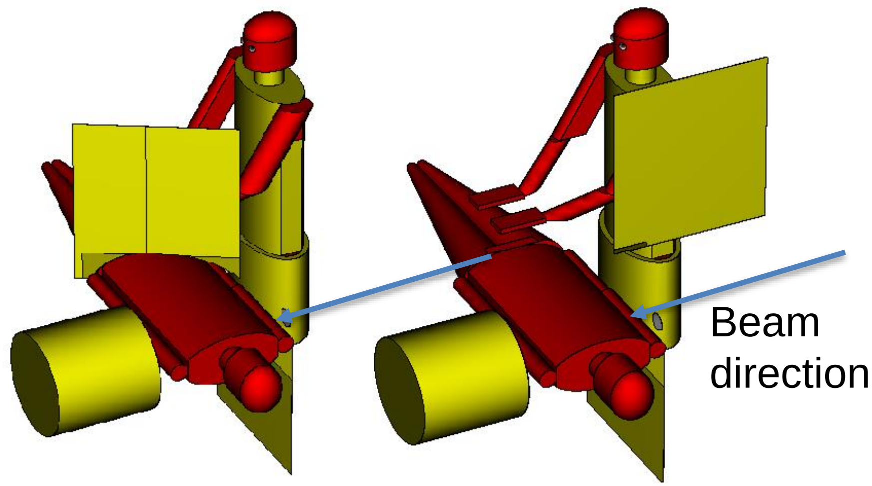
References:

Study of the parameters affecting operator doses in interventional radiology using Monte Carlo simulations.
C. Koukorava et al 2011 Radiation Measurements 46 (2011) 1216 -1222

Monte Carlo study of the scattered radiation field near the eyes of the operator in interventional procedures
P. Ferrari et al 2016 J. Radiol. Prot. 36 (2016) 902–921

Interventional cardiology, LAO 90° beam WITH CEILING SHIELDING (pos A)

Interventional cardiology, LAO 90° beam WITH CEILING SHIELDING (pos B)



No shielding	Shielding Pos.A	Shielding Pos.B
1	0.8	0.1

Dose normalized to the left eye (most exposed)

Shielding efficiency (LAO 90°) – eye lens protection

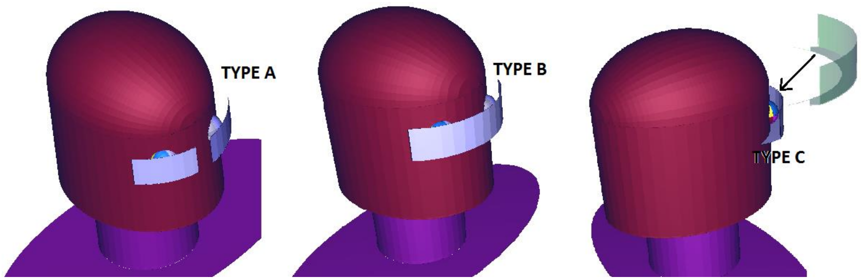
In case of protective glasses, the shape is an important parameter that can affect their radiation attenuation properties

References:

The effectiveness of lead glasses in reducing the doses to eye lenses during cardiac implantation procedures performed using x-ray tubes above the patient table
J. Domienik et al 2016 J. Radiol. Prot., 36

Monte Carlo study of the scattered radiation field near the eyes of the operator in interventional procedures
P. Ferrari et al 2016 J. Radiol. Prot. 36 (2016) 902–921

Operator head – eye lens protection



DOSE TO THE LEFT EYE (THE MOST EXPOSED) NORMALIZED TO «NO GLASSES» CASE:

No glasses	Type A (simple)	Type B (laterally ext.)	Type C (lat. & lower protections)
1	0.9	0.8	0.15

ENEA EURADOS

Simulation of brain exposure in IR

Recently some papers put the attention on the possible long terms effects of medical staff head exposure during interventional practices in developing malignancies (in particular for the left hemisphere of the brain).

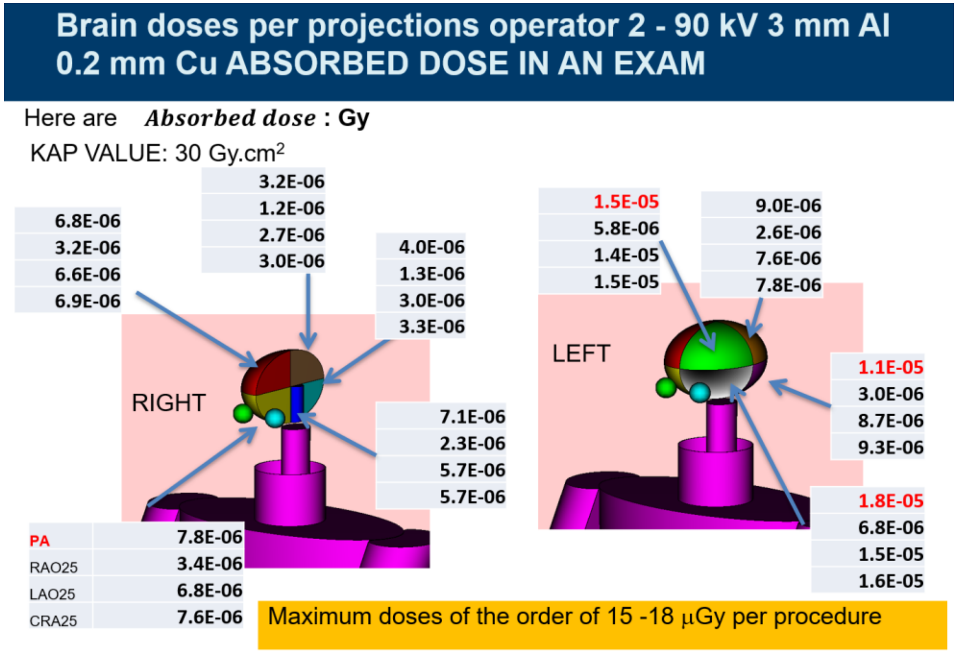
References:

Brain and neck tumours among physicians performing interventional procedures.
A. Roguin et al 2013 Am J Cardiol 2013;111:1368–72

Occupational radiation exposure and deaths from malignant intracranial neoplasms of the brain and CNS in U.S. radiologic technologists
C.M. Kithara et al. 2017 Am J Roentgenol 2017;208:1278–84

Absorbed dose in the operator’s brain in interventional radiology practices: evaluation through KAP value conversion factors
P: Ferrari et al. 2020 Physica Medica 76 (2020) 177–181

A study was undertaken in WG12 to assess the doses to the brain.



Monitoring the extremities

- ring dosemeters at the base of the little or middle fingers
- wrist dosemeters may be used (possible underestimate of the skin dose)
- The sensitive part of the detector should point in the direction of the radiation (patient)
- The proper use of table shield (0.5 mm Pb) can reduce the leg doses from 2 to 5 times.

Data taken from:
ORAMED:
Optimization of Radiation Protection of Medical Staff
Vanhavere et al.
EURADOS Report 2012-02

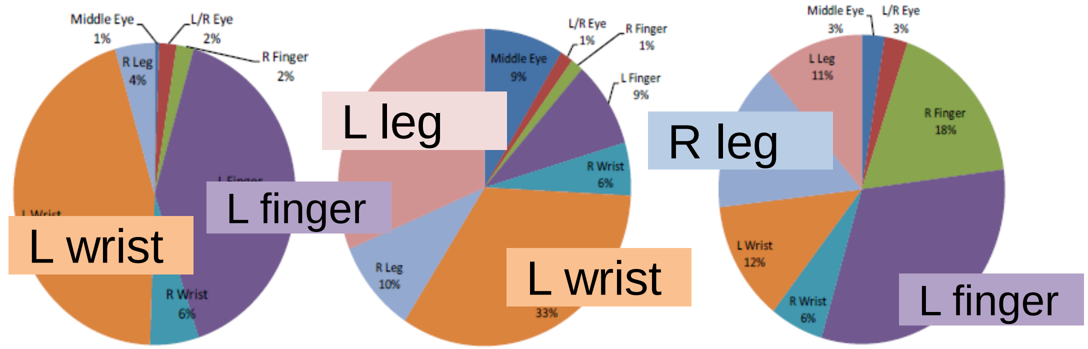


Figure 1.25: Pie Chart showing the frequency of the location of the maximum dose for the IC procedures (a) CA/PTCA (b) RF Ablations and (c) PM/ICDs

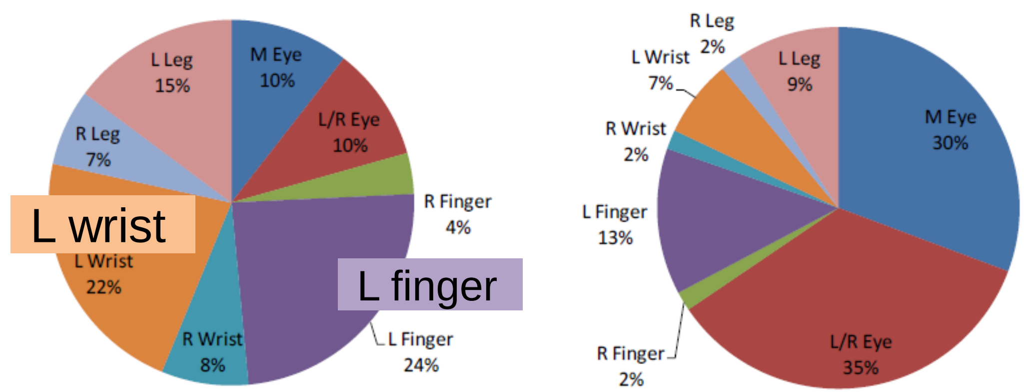


Figure 1.26: (a) Pie Chart showing the frequency of the location of the maximum dose for the IR procedures (b) Pie Chart showing the position of the maximum dose when the respective annual limits are taken into account

Monitoring the eye lens

- One dosemeter worn over the protection, measuring Hp(10) or Hp(10) and Hp(0.07, when the eye lens exposure is expected to be low, can give an estimation of the dose to the lens of the eye.
- One specific eye lens dosemeter placed close to the eyes and measuring Hp(3) provides the best estimate of the dose to the lens of the eye.

References:

Eye lens monitoring for interventional radiology personnel: dosemeters, calibration and practical aspects of Hp(3) monitoring. A 2015 review
E. Carinou et al 2015 J. Radiol. Prot. 35 (2015) R17–R34

Occupational Exposure of the Eye Lens in Interventional Procedures: How to Assess and Manage Radiation Dose
O. Ciraj-Bjelac et al. 2016 Am J Roentgenol 2017;208:1278–84

Eurados 2016 intercomparison exercise of eye lens dosemeters.
Clairand, I.et al. Radiat. Prot. Dosimetry, 182(3),317–322.

How to establish an adequate system for eye lens dose monitoring: A proposal for typical workplaces
Kollaard et al. Radiat. Prot. Dosimetry 185(3),296-302.

Monitoring the whole body

- Double dosimetry (dosemeter under / dosemeter over apron) provides more accurate results (algorithms are needed to combine the two measuremets)
- One dosemeter over apron needs a corrective factor considering the attenuation
- One dosemeter under apron can be taken as an estimate of E (but may underestiamate the dose received by the unprotected part of the body)

References:

Overview of double dosimetry procedures for the determination of the effective dose to the interventional radiology staff.
Jarvinen, H., et al. 2008. Rad. Prot. Dosim. 129,333–339.

Practical guidelines for personal monitoring and estimation of effective dose and dose to the lens of the eye in interventional procedures
P. Askounis et al 2022 J. Radiol. Prot. 42

On the placement of apron dosemeter and dose assessment in interventional cardiology procedures: preliminary results.
P. Ferrari et al. 2022 Radiat. Prot. Dosimetry 199(4),383

How about the new ICRU 95 quantities in dose monitoring?

- For ideal dosemeter a factor calculated as the ratio of the old and new conversion coefficients for that field is needed.
- In case of a real dosemeter additional angle/energy correction factors should be required
- Because the new quantities, H* and Hp (that will substitute H*(10) and Hp(10)), the measured doses for occupationally exposed workers will change.
- It is likely that for **workplaces where low energy photons are the dominant component** of the radiation field, the protection of the eye lens will become more relevant in the dose assessment and dose limiting than the whole body dose.

Evaluation of the Impact of the New ICRU Operational Quantities and Recommendations for their Practical Application

Gilvin et al.

EURADOS Report 2022-02

Additional references from EURADOS WG-12

Determining the dose rate dependence of different active personal dosemeters in standardized pulsed and continuous radiation fields.
O. Hupe et al Rad. Prot. Dosim. 2019, 187, 345–352.

Effect of the radiation protective apron on the response of active and passive personal dosemeters used in interventional radiology and cardiology.
M. Ginjaume et al. J. Radiol. Prot. 2019, 39, 97–112.

The use of active personal dosemeters in interventional workplaces in hospitals: Comparison between active and passive dosemeters worn simultaneously by medical staff.
F. Vanhavere et al. Rad. Prot. Dosim. 2020, 188, 22–29.

Recommendations for the use of active personal dosemeters (APDs) in interventional workplaces in hospitals
U. O'Connor et al. Phys. Med. 2021, 87, 131–135.

What Is Worth Knowing in Interventional Practices about Medical Staff Radiation Exposure Monitoring: A Review of Recent Outcomes of EURADOS Working Group 12
P. Ferrari et al 2022 Environments 2022, 9, 53. https://doi.org/10.3390/environments9040053

EURADOS REPORT (under preparation, expected release in 2024):
Individual Exposure and Monitoring in Interventional Radiology and Cardiology