ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
Εθνικόν και Καποδιστριακόν Πανεπιστήμιον Αθηνών

Β΄ Εργαστήριο Ακτινολογίας, Ιατρική Σχολή, ΕΚΠΑ
ΕΛΕΝΕΠΥ Ελληνική Εταιρεία Νανοτεχνολογίας στις Επιστήμες Υγείας
ΕΦΙΕ Ένωση Φυσικών Ιατρικής Ελλάδος
Πανελλήνια Ένωση Φυσικών Νοσοκομείων Ακτινοφυσικών Ιατρικής Δημόσιου Τομέα

ΑΤΤΙΚΟΝ

ΕΚΠΑΙΔΕΥΤΙΚΗ ΗΜΕΡΙΔΑ
ΔΙΑΓΝΩΣΤΙΚΑ ΕΠΙΠΕΔΑ ΑΝΑΦΟΡΑΣ (ΔΕΑ):
Ο ΡΟΛΟΣ ΤΟΥΣ ΣΤΗΝ ΙΑΤΡΙΚΗ ΑΠΕΙΚΟΝΙΣΗ

ΔΟΣΕΙΣ ΣΤΟΥΣ ΑΣΘΕΝΕΙΣ: Η ΜΑΤΙΑ ΤΟΥ ΑΚΤΙΝΟΛΟΓΟΥ

ΔΚ Φιλιππιάδης MD, PhD, MSc, EBIR
Επίκουρος Καθηγητής Διαγνωστικής και Επεμβατικής Ακτινολογίας
Β Εργαστήριο Ακτινολογίας, ΠΓΝ "ΑΤΤΙΚΟΝ"
Ιατρική Σχολή ΕΚΠΑ

Why radiation protection is important?

- Harmful effects of ionizing radiation
- Increased frequency of X-ray examinations
- High radiation doses

Why radiation protection is important?

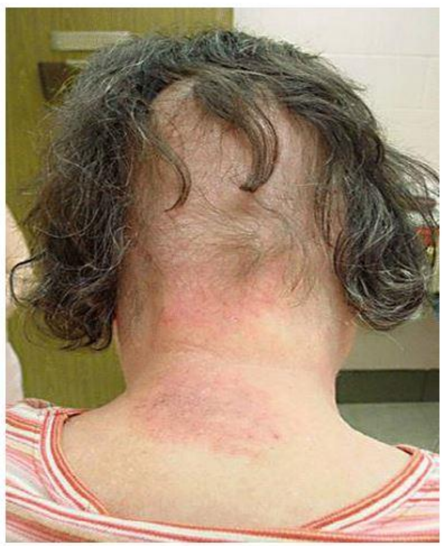
Harmful effects of ionizing radiation

NCI skin toxicity grade 4. **(a)** Central area of deep necrosis surrounded by indurated and depigmented skin within an area of prolonged erythema at 30 weeks after coronary angioplasty **(b)** Same patient 38 weeks after the procedure.

Balter et al. 2010. Fluoroscopically Guided Interventional Procedures: A Review of Radiation Effects on Patients' Skin and Hair

Why radiation protection is important?

Harmful effects of ionizing radiation

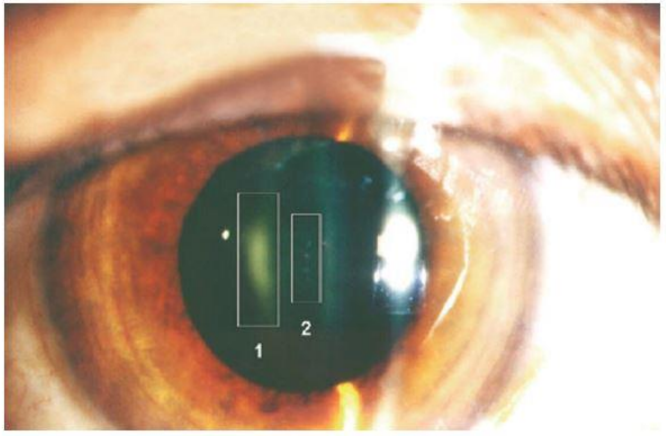


Radiation injury in a 60-year-old woman from neurointerventional procedure for the treatment of acute stroke. Fluoroscopy time > 70 min.

Balter et al. 2010. Fluoroscopically Guided Interventional Procedures: A Review of Radiation Effects on Patients' Skin and Hair

Why radiation protection is important?

Harmful effects of ionizing radiation



Radio-induced crystalline lens opacity in an interventional radiologist submitted to high levels of radiation using an X-ray tube above the table. Region 1 indicates posterior subcapsular opacity; Region 2, perinuclear punctate opacities.

Vano et al. 1998. Lens Injuries induced by occupational exposure in non-optimized interventional radiology laboratories.

- Serious skin injuries have occurred in aa very small percentage of patients (~1/10000)
- Occur when there is lack of:
  - Awareness that the procedure can cause such injuries
  - Real time monitoring of dose
- A case of radiation induced skin injury is filled in US courts every 4-6 weeks currently from IR procedures
  - ~10 cases/year

- If protection is used most skin injuries are avoidable
- Every action taken to reduce patient dose has corresponding effect on staff dose, the reverse is not true

HOW NOT TO MISS AN INJURY

- Any patient with following:
  - Fluoroscopy time >40min
  - DAP/KAP> 20,000 cGy x cm^2
  - Cumulative air kerna >5Gy

- Ask the patient to report back to you if any discomfort with skin till 30 days

- Ask nurse to call around 30 days to check with patient

Why radiation protection is important?

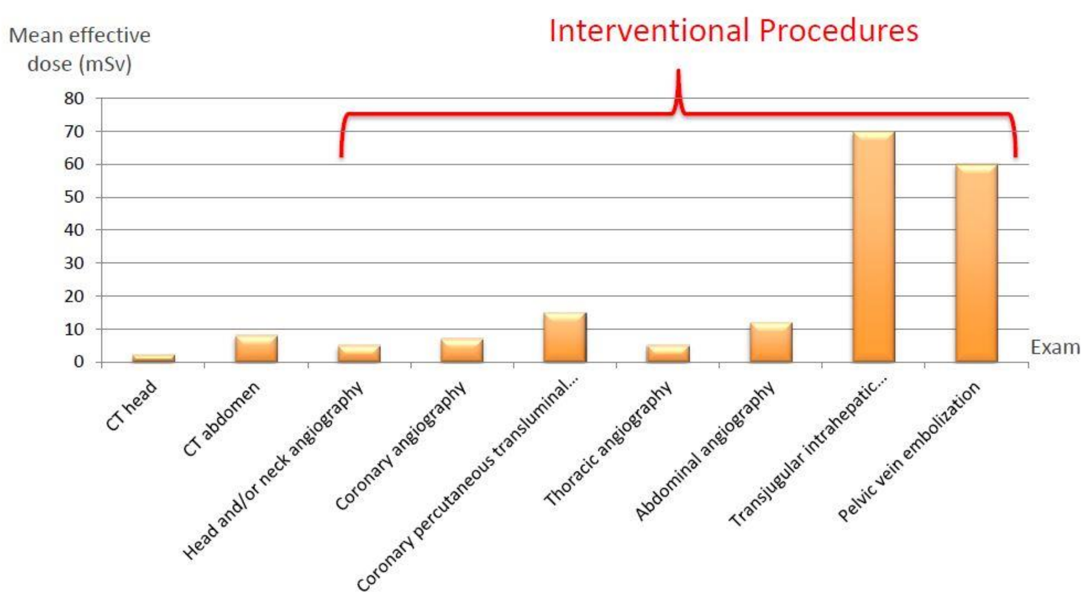
Frequency of X-ray examinations

Examination	No of examinations 1998	2008	
Conventional Radiology	39.586,000	41.927,000	
CT	1.387,000	3.421,000	**+ 59%**
Interventional (non-CT)	247,000	442,000	**+ 78%**

Hart et al. Frequency and collective dose for medical and dental X-ray examinations in the UK, 2008. Health Protection Agency. HPA-CRCE-012 (2010).

Why radiation protection is important?

Patient radiation doses



Mettler et al. 2008. Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog.

Dose Limits

Equivalent Dose (mSv/yr)	Occupational	Public
Lens of eye	~~150~~ **20**	15
Skin	500	50
Hands/Feet	500	-
Effective dose	20	1

!!! Dose Limits are not applicable to patients

International Commission on Radiological Protection 2011 Statement on tissue reactions ICRP 4825-3093-1464, April 2011

Fred A. Mettler, Jr, MD, MPH
Walter Huda, PhD
Terry T. Yoshizumi, PhD
Mahadevappa Mahesh, MS, PhD

Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog[1]

Radiology

Table 1

Adult Effective Doses for Various Diagnostic Radiology Procedures

Examination	Average Effective Dose (mSv)	Values Reported in Literature (mSv)
Skull	0.1	0.03–0.22
Cervical spine	0.2	0.07–0.3
Thoracic spine	1.0	0.6–1.4
Lumbar spine	1.5	0.5–1.8
Posteroanterior and lateral study of chest	0.1	0.05–0.24
Posteroanterior study of chest	0.02	0.007–0.050
Mammography	0.4	0.10–0.60
Abdomen	0.7	0.04–1.1
Pelvis	0.6	0.2–1.2
Hip	0.7	0.18–2.71
Shoulder	0.01	. . .
Knee	0.005	. . .
Other extremities	0.001	0.0002–0.1
Dual x-ray absorptiometry (without CT)	0.001	0.001–0.035
Dual x-ray absorptiometry (with CT)	0.04	0.003–0.06
Intravenous urography	3	0.7–3.7
Upper gastrointestinal series	6*	1.5–12
Small-bowel series	5	3.0–7.8
Barium enema	8*	2.0–18.0
Endoscopic retrograde cholangiopancreatography	4.0	. . .

* Includes fluoroscopy.

Fred A. Mettler, Jr, MD, MPH
Walter Huda, PhD
Terry T. Yoshizumi, PhD
Mahadevappa Mahesh, MS, PhD

Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog[1]

Radiology

Table 2

Adult Effective Doses for Various CT Procedures

Examination	Average Effective Dose (mSv)	Values Reported in Literature (mSv)
Head	2	0.9–4.0
Neck	3	. . .
Chest	7	4.0–18.0
Chest for pulmonary embolism	15	13–40
Abdomen	8	3.5–25
Pelvis	6	3.3–10
Three-phase liver study	15	. . .
Spine	6	1.5–10
Coronary angiography	16	5.0–32
Calcium scoring	3	1.0–12
Virtual colonoscopy	10	4.0–13.2

Fred A. Mettler, Jr, MD, MPH
Walter Huda, PhD
Terry T. Yoshizumi, PhD
Mahadevappa Mahesh, MS, PhD

Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog[1]

Radiology

Table 3

Adult Effective Doses for Various Interventional Radiology Procedures

Examination	Average Effective Dose (mSv)*	Values Reported in Literature (mSv)
Head and/or neck angiography	5	0.8–19.6
Coronary angiography (diagnostic)	7	2.0–15.8
Coronary percutaneous transluminal angioplasty, stent placement, or radiofrequency ablation	15	6.9–57
Thoracic angiography of pulmonary artery or aorta	5	4.1–9.0
Abdominal angiography or aortography	12	4.0–48.0
Transjugular intrahepatic portosystemic shunt placement	70	20–180
Pelvic vein embolization	60	44–78

* Values can vary markedly on the basis of the skill of the operator and the difficulty of the procedure.

The principles of radiation protection

- **Justification of practices:** Any decision that alters the radiation exposure situation should do more good than harm
- **Optimization of protection:** All exposures should be kept as low as reasonably achievable (ALARA)
- **Limitation of exposure:** The total dose to any individual should not exceed the dose limits recommended by the ICRP

ICRP 103 2007, The 2007 recommendations of the International Commission on Radiological Protection

ΚΙΝΔΥΝΟΙ ΑΠΟ ΤΙΣ ΑΚΤΙΝΟΛΟΓΙΚΕΣ ΕΞΕΤΑΣΕΙΣ

Εργαζόμενοι - Εξεταζόμενοι

<u>Μέτρα περιορισμού της έκθεσης εργαζομένων και εξεταζομένων στα Ακτινολογικά εργαστήρια</u>

1. Γνώση και τήρηση όλων των κανόνων Ακτινοπροστασίας από το προσωπικό των εργαστηρίων. Οι Κανονισμοί Ακτινοπροστασίας επιβάλλουν στο προσωπικό των εργαστηρίων να έχει την κατάλληλη εκπαίδευση (παρ. 1.1.7.α.)

ΚΙΝΔΥΝΟΙ ΑΠΟ ΤΙΣ ΑΚΤΙΝΟΛΟΓΙΚΕΣ ΕΞΕΤΑΣΕΙΣ

2. Στην είσοδο των χώρων που έχουν χαρακτηρισθεί, να υπάρχουν πινακίδες με το σήμα της ακτινοβολίας που να αναφέρουν το χαρακτηρισμό του χώρου, καθώς και την ένδειξη 'ΠΡΟΣΟΧΗ ΑΚΤΙΝΟΒΟΛΙΑ'

3. Να έχει τοποθετηθεί η κατάλληλη θωράκιση, μετά από μελέτη Ακτινοπροστασίας, στους περιβάλλοντες τοίχους

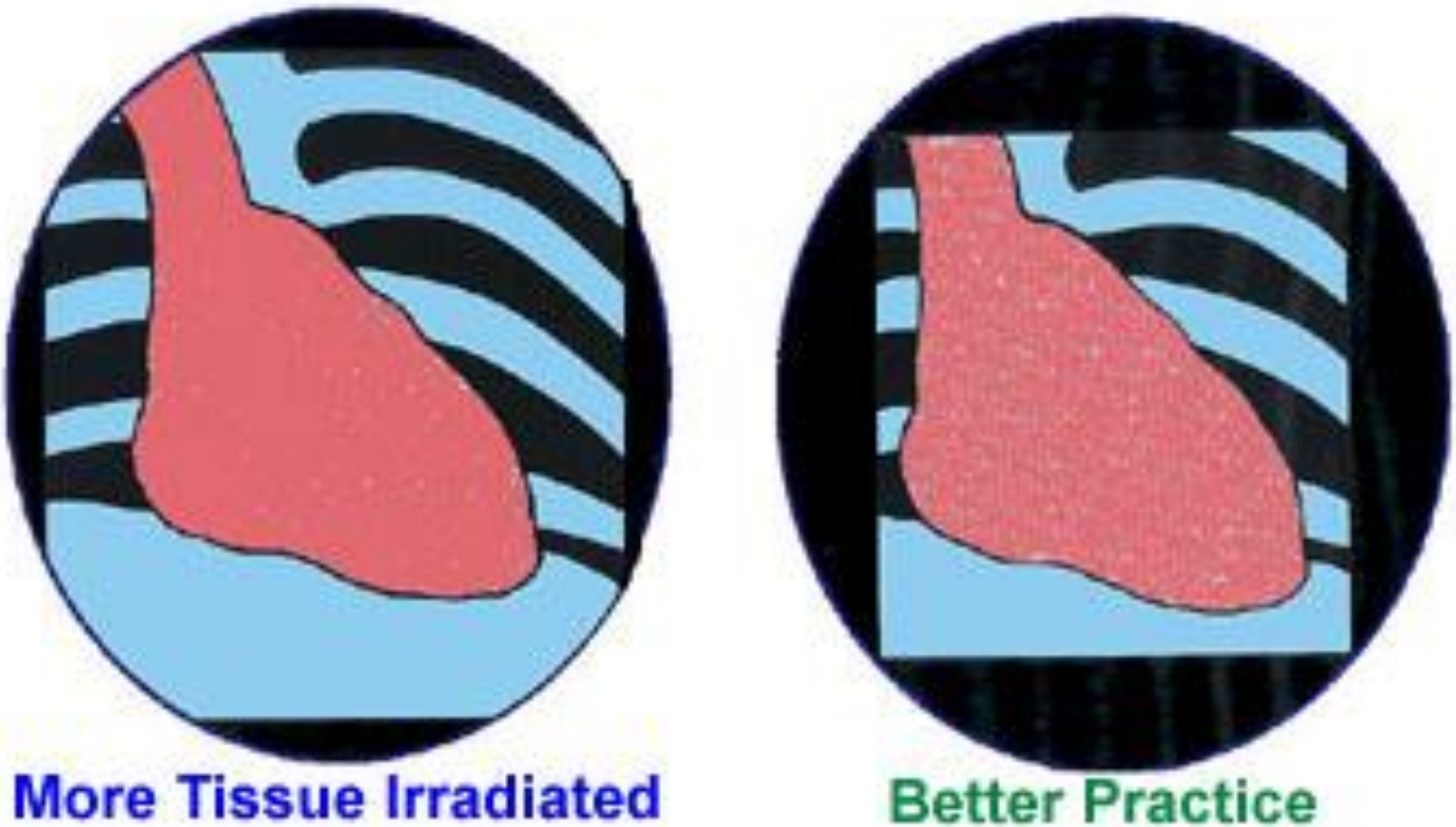
ΚΙΝΔΥΝΟΙ ΑΠΟ ΤΙΣ ΑΚΤΙΝΟΛΟΓΙΚΕΣ ΕΞΕΤΑΣΕΙΣ

4. Κατά τη διάρκεια της εξέτασης πρέπει να ακτινοβολείται μόνο ο εξεταζόμενος, και πιο συγκεκριμένα, μόνο η περιοχή ενδιαφέροντος. Αυτό δεν είναι πάντα εφικτό (π.χ. στις επεμβατικές πράξεις) και επιτυγχάνεται με καλή οργάνωση και σχεδιασμό του εργαστηρίου και εκπαίδευση του προσωπικού

ΚΙΝΔΥΝΟΙ ΑΠΟ ΤΙΣ ΑΚΤΙΝΟΛΟΓΙΚΕΣ ΕΞΕΤΑΣΕΙΣ

5. Κατά τη διάρκεια της εξέτασης πρέπει να προφυλάσσονται όσο είναι δυνατόν τα ευαίσθητα όργανα. Επίσης εάν χρειάζεται βοήθεια στήριξης ο ασθενής, αυτή να δίδεται από μη εργαζόμενο άτομο (π.χ. συνοδός), το οποίο να προστατεύεται το περισσότερο δυνατό

6. Να δίδεται ιδιαίτερη προσοχή στις γυναίκες που βρίσκονται σε αναπαραγωγική ηλικία για την περίπτωση εγκυμοσύνης


More Tissue Irradiated
Better Practice

1. Knowledge of the X-ray and imaging system

- Operation modes available (e.g. fluoroscopy, cine, DSA, roadmap, stent enhacement, CBCT, etc).
- Image quality and patient dose for the different modes.
- Radiation dose information during the procedures (patient and staff doses, if available).
- Radiation dose reports (RDSR in DICOM) and interpretation.
- Radiation dose registries (patients and staff if available).
- Alarm settings for high doses (need of follow-up).

2. Availability and knowledge of the radiation protection tools (patients and staff)

- Active and passive strategies.
- RP tools offered by the X-ray system (e.g. specific low dose protocols, wedge filters, virtual collimation, etc).
- Ceiling suspended screens and protective curtains.
- Disposable protective patient drapes.
- Personal protective devices: aprons, thyroid shield, glasses, gloves, etc.
- Importance of occupational dosimetry (and real time information).

3. Audit of patient dose values and comparison with DRLs

- No limits for patient doses, but Diagnostic Reference Levels (DRLs) should be used (and are required by the European regulations) for optimization and clinical audit.
- DRLs are a form of investigation level, applied to an easily measured quantity.
- Intended for use as a simple test for identifying situations where the levels of patient dose are unusually high or low.
- Objective of DRLs - avoid radiation dose to the patient that does not contribute to the clinical purpose of a medical imaging task (ICRP 105).

5. Are optimization actions necessary?

- Optimization actions are required by European regulations and recommended by most of the international organizations.
- Optimization actions should be included in the quality assurance programme of any IR unit.
- The periodic evaluation of image quality (diagnostic information), patient doses and staff doses, are the key aspects of any radiation safety programme for interventional radiology.

Journal of Vascular and Interventional Radiology
JVIR
Official Journal of the Society of Interventional Radiology

Guidelines for Patient Radiation Dose Management

Michael S. Stecker, MD, Stephen Balter, PhD, Richard B. Towbin, MD, Donald L. Miller, MD, Eliseo Vañó, PhD, Gabriel Bartal, MD, J. Fritz Angle, MD, Christine P. Chao, MD, Alan M. Cohen, MD, Robert G. Dixon, MD, Kathleen Gross, MSN, RN-BC, CRN, George G. Hartnell, MD, Beth Schueler, PhD, John D. Statler, MD, Thierry de Baère, MD, and John F. Cardella, MD, for the SIR Safety and Health Committee and the CIRSE Standards of Practice Committee

J Vasc Interv Radiol 2009; 20:S263–S273

SOCIETY OF INTERVENTIONAL RADIOLOGY
Enhanced care through advanced technology®

CIRSE

CPG

STANDARDS OF PRACTICE

Radiation Management for Interventions Using Fluoroscopic or Computed Tomographic Guidance during Pregnancy: A Joint Guideline of the Society of Interventional Radiology and the Cardiovascular and Interventional Radiological Society of Europe with Endorsement by the Canadian Interventional Radiology Association

Lawrence T. Dauer, PhD, CHP, Raymond H. Thornton, MD, Donald L. Miller, MD, John Damilakis, PhD, Robert G. Dixon, MD, M. Victoria Marx, MD, Beth A. Schueler, PhD, Eliseo Vañó, PhD, Aradhana Venkatesan, MD, Gabriel Bartal, MD, Dimitrios Tsetis, MD, PhD, and John F. Cardella, MD, for the Society of Interventional Radiology Safety and Health Committee and the Cardiovascular and Interventional Radiology Society of Europe Standards of Practice Committee

Journal of Vascular and Interventional Radiology
JVIR
Official Journal of the Society of Interventional Radiology

SOCIETY OF INTERVENTIONAL RADIOLOGY
Enhanced care through advanced technology

CIRSE

Published in: J Vasc Interv Radiol 2012; 23:19–32

Guidelines approved by the members of the SIR Safety and Health Committee and CIRSE Standards of Practice committee, represent experts in a broad spectrum of interventional procedures from both the private and academic sectors of medicine

Aims of Optimisation

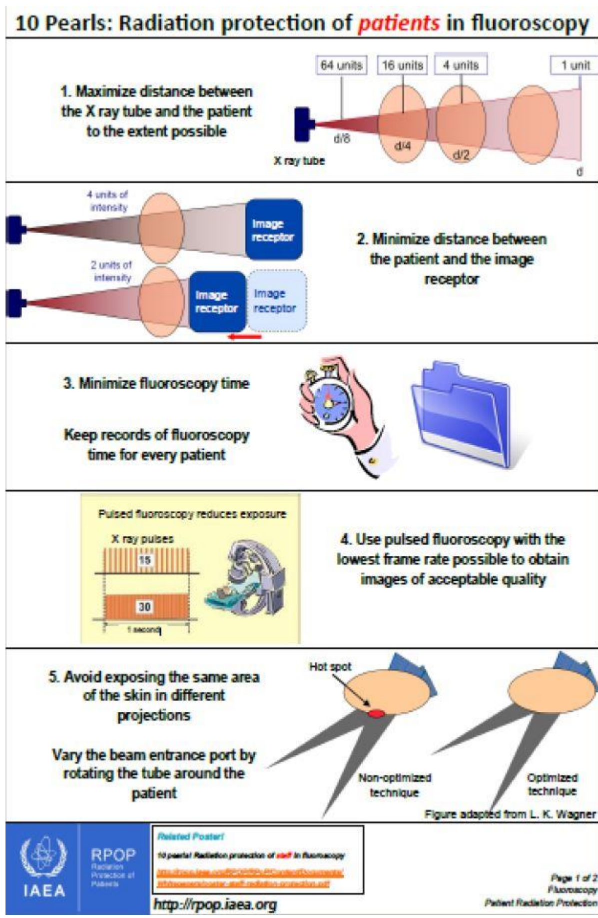
- Use shortest fluoroscopy time
- Always use pulsed fluoroscopy with adequate to the case pulse sequence
- Use Last Image Hold (LIH) and Last Fluoroscopy Hold (LFH) or store Fluoro
- DSA
  - obtain lowest possible number of DSA runs
  - carefully plan each as short as possible DSA runs
  - always ensure optimal DSA parameter selection

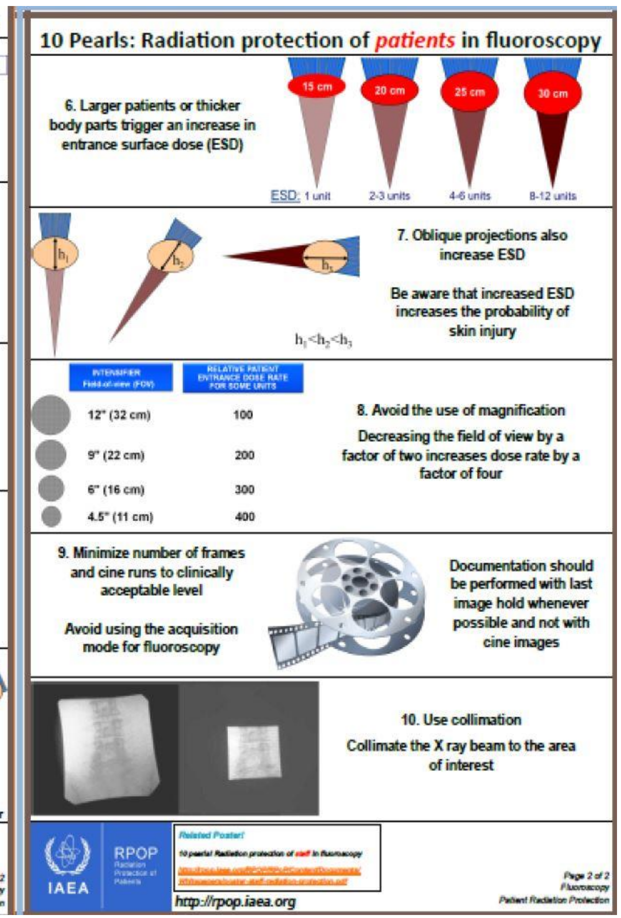
Aims of Optimisation

- Use pre-defined C-arm positions, angulations and iso-position functions
  - it saves fluoroscopy time and consequently procedure time
  - brings the image safely into the same condition as prior to moving the C-arm
- Wisely and carefully use the road-map function
  - remember - Road Map is associated with HIGHER exposures compared to Fluoroscopy!!!

Dose Saving Features

- Major vendors offer very advanced tools that provide
  - significant reduction of patient exposure
  - No image quality compromise
  - We have to make sure that such features will become an integral part of the equipment and not an option


10 Pearls: Radiation protection of patients in fluoroscopy
1. Maximize distance between the X ray tube and the patient to the extent possible
64 units
16 units
4 units
1 unit
d/8
d/4
d/2
d
X ray tube
4 units of intensity
Image receptor
2 units of intensity
Image receptor
Image receptor
2. Minimize distance between the patient and the image receptor
3. Minimize fluoroscopy time
Keep records of fluoroscopy time for every patient
Pulsed fluoroscopy reduces exposure
X ray pulses
15
30
1 second
4. Use pulsed fluoroscopy with the lowest frame rate possible to obtain images of acceptable quality
5. Avoid exposing the same area of the skin in different projections
Vary the beam entrance port by rotating the tube around the patient
Hot spot
Non-optimized technique
Optimized technique
Figure adapted from L. K. Wagner
IAEA
RPOP
Related Poster!
http://rpop.iaea.org
Page 1 of 2
Fluoroscopy
Patient Radiation Protection


10 Pearls: Radiation protection of patients in fluoroscopy
6. Larger patients or thicker body parts trigger an increase in entrance surface dose (ESD)
15 cm
20 cm
25 cm
30 cm
ESD: 1 unit
2-3 units
4-6 units
8-12 units
7. Oblique projections also increase ESD
Be aware that increased ESD increases the probability of skin injury
h1<h2<h3
12" (32 cm) 100
9" (22 cm) 200
6" (16 cm) 300
4.5" (11 cm) 400
8. Avoid the use of magnification
Decreasing the field of view by a factor of two increases dose rate by a factor of four
9. Minimize number of frames and cine runs to clinically acceptable level
Avoid using the acquisition mode for fluoroscopy
Documentation should be performed with last image hold whenever possible and not with cine images
10. Use collimation
Collimate the X ray beam to the area of interest
IAEA
RPOP
Related Poster!
http://rpop.iaea.org
Page 2 of 2
Fluoroscopy
Patient Radiation Protection

Conclusion

Radiation protection….

- Constitutes a very important issue for the safety of occupational, patients and public in every Radiology Department
- Requires education and training of health care workers as well availability of appropriate protection tools and equipment (shielding, personal protective devices)
- Should be an integral part of clinical routine

1837 2017
HELLENIC REPUBLIC
National and Kapodistrian University of Athens

ATTIKON

ΕΥΧΑΡΙΣΤΩ ΠΟΛΥ

The