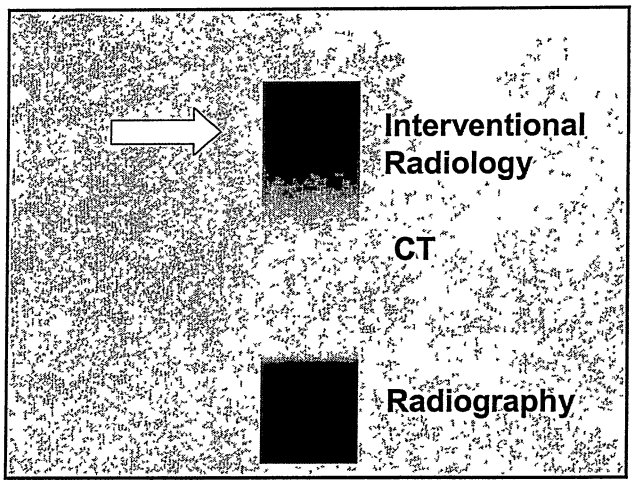
IAEA Standard syllabus course on Radiation Protection in diagnostic and interventional radiology

RADIATION PROTECTION IN DIAGNOSTIC RADIOLOGY

Part 17.2 : Optimization of protection in Interventional Radiology

J. DAMILAKIS, Assistant Professor of Medical Physics



Principle of Interventional Radiology

- Interventional radiology (fluoroscopically-guided) techniques are being used by an increasing number of clinicians not adequately trained in radiation safety or radiobiology
- Patients are suffering radiation-induced skin injuries due to unnecessarily high radiation doses.
- Younger patients may face an increased risk of future cancer

Add module code number and lesson title 3

Skin Injuries

Reports Received by FDA of Skin Injury from Fluoroscopy.

Procedure with Report of Injury	Number of Injuries Reported from Procedure
RF cardiac catheter ablation	12
Catheter placement for chemotherapy	1
Transjugular interhepatic portosystemic shunt	3
Coronary angioplasty	4
Renal angioplasty	2
Multiple hepatic/biliary procedures (angioplasty, stent placement, biopsy, etc.)	3
Percutaneous choloangiogram followed by multiple embolizations	1

Add module code number and lesson title 4

Why do they occur?

No training in radiation protection for those performing these studies, like

- Cardiologist
- Urologist
- Gastro-enterologist
- Orthopedic Surgeon
- Vascular Surgeon
- Traumatologist
- Pediatrician
- Anesthesiologist

ANGIOGRAPHY

Over 50 reports appeared in 1990's

Over 100 cases



Likely thousands of unreported

Many of these injuries are AVOIDABLE – all of the serious ones are!

Acute radiation doses, delivered to tissues during a single procedure or closely spaced procedures, will cause:

1. **Erythema at 2Gy**
2. **Cataract at 2Gy**
3. **Permanent epilation at 7Gy**
4. **Delayed skin necrosis at 12 Gy**

For protracted exposures to the eye e.g. those experienced by interventionists:

5. **Cataract at 4 Gy if dose received in less than 3 months, (5.5 Gy), if received over a period exceeding 3 months**

Principle of Interventional Radiology

- Interventionists are having their practice limited or suffering injury, and are exposing their staff to high doses.
- Occupational doses **can be reduced by reducing unnecessary patient dose**, the correct use and procurement of equipment (including the use of shielding devices).

The IR environment

- ♦ Lengthy and complex procedures
- ♦ Operating staff very close to the patient
- ♦ Prolonged exposure time
- ♦ No shielding

One must look for

- ■ Modern sophisticated x-ray systems
- ■ Use of protection tools, goggles, specific shielding, etc
- ■ Suitable knowledge of the system
- ■ Skill, rational (shared) workload

Requirements for equipment (Joint WHO/IRH/CE workshop 1995 (1))

RECOMMENDED TECHNICAL SPECIFICATION (1) :

- ☒ Additional filtration
- ☒ Removable Grid
- ☒ Pulsed fluoroscopy modes
- ☒ Image hold system
- ☒ Flexibility for AEC

Requirements for equipment (Joint WHO/IRH/CE workshop 1995 (3))

RECOMMENDED TECHNICAL SPECIFICATION (2):

- ☒ **Overcouch** image intensifier
- ☒ **Concave couch** top for patient comfort
- ☒ **Dose-area product** meter
- ☒ Provision of **Staff protective shielding**
- ☒ **Display** of fluoroscopy time, total dose-area product (fluoroscopy and radiographic) and estimated skin entrance dose.

Requirements for equipment (Joint WHO/IRH/CE workshop 1995 (4))

RECOMMENDED TECHNICAL SPECIFICATION (3):

- ☒ Computer interface for **dosimetric information**
- ☒ Provision of **iso-scatter distribution** diagrams for normal and boost modes
- ☒ All instrumentation and switches **clearly labeled**
- ☒ Minimum size of **image store**
- ☒ Means of **patient immobilization**

Requirements for equipment (Joint WHO/IRH/CE workshop 1995 (8))

CONSTANCY TESTS (monthly):

- ☒ Reference dose, dose rate values
- ☒ Resolution
- ☒ Collimation
- ☒ Contrast resolution
- ☒ Tube and generator parameters
- ☒ Hard copy devices

X–Ray Systems - Safe Design

Fluoroscopy Systems used in Interventional Radiology

- shall **comply with national regulations;** should meet the specific needs of each type of interventional procedures and its performance should be appropriate for the that procedures
- should be **regularly updated** to incorporate cost effective features for better dose reduction or, when required, to improve image quality.
- should **indicate and record dosimetry information** i.e. give a continuous indication of patient dose e.g. by the use of a dose-area product meter.

Dosimetric parameters

Useful quantities for patient and staff risk evaluation :

- **Dose area product** (for stochastic effect)
- **Entrance surface dose** (for deterministic effect)
- **Staff dose per procedure** (in more than one localization)

Risks of interventional radiology for the patient:

- While fluoroscopy is commonly used for this purpose, computed tomography (CT) and ultrasound may also be used.
- Compared to other x-ray examinations, interventional radiology can involve prolonged fluoroscopic exposure times together with extensive radiographic exposure. Patient and staff radiation doses can be high resulting in very high doses to patients and can carry the potential risk for detrimental (including deterministic) effects on health.

Risks of interventional radiology for the patient:

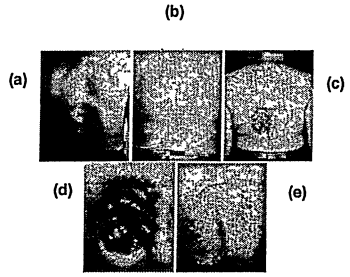
- The majority of deterministic effects result from irradiation of the skin.
- The appearance of a skin injury is dependent on :
  - cumulative dose
  - dose rate
  - fractionation of the dose
  - the age of the patient, and
  - characteristics of the patient.

Risks of interventional radiology for the patient:

- Interventional radiology shall only be performed with x-ray equipment and facilities designed for that purpose.
- Users of such equipment (interventional radiologists, cardiologists, urologists etc.) shall have specific training in radiation protection on the safe use of interventional radiography equipment.
- Strict dose control procedures shall be included in the quality assurance programme as the risk of deterministic effects (in both patients and medical staff) can be significant.
- Real time dose rate measurement shall be displayed for all interventional radiology procedures and the total dose for the procedure recorded.
- Facilities using interventional radiology should have protocols for dealing with cases of suspected high doses to patients.

Add module code number and lesson title 19

Coronary angioplasty twice in a day followed by bypass graft because of complication. Dose ≈ 20 Gy (ICRP 85)



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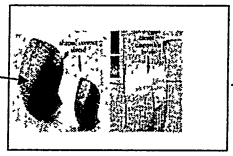
Fluoroscopic guidance of placement of spinal stimulation electrodes illustrating practices which can result in direct x-ray exposure of the hands of the physician performing the procedure: (a) physician's hand in the area of the x-ray beam. If exposures are made in this circumstance, the hands receive direct exposure and are visible in the resulting images (b). (Photographs courtesy of S. Balter.)

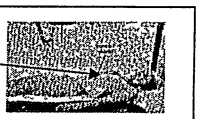
Add module code number and lesson title 21

Patient Protection

Lead protective devices (half aprons or gonad shields) must be used to cover the pelvic region on all males and pre-menopausal females.



The protection must be provided on the patient surface facing the primary (useful) x-ray beam.



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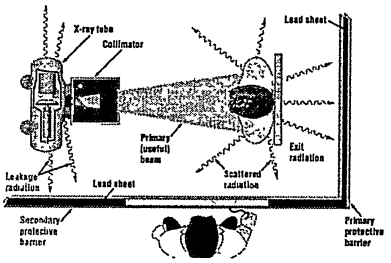

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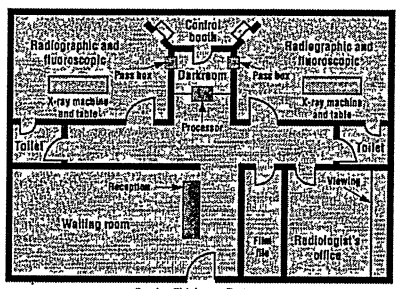

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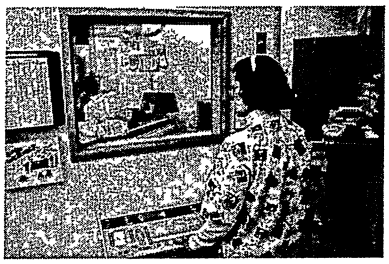
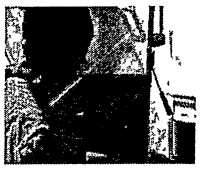
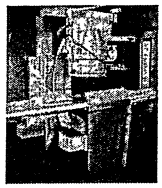


Add module code number and lesson title 25

Protection tools (I)



SCREEN AND GOGLES



CURTAIN



THYROID

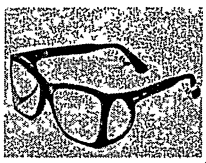
Add module code number and lesson title 26











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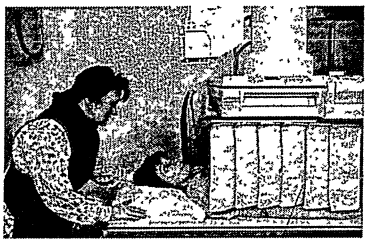

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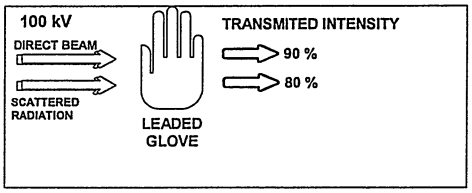
Protection tools (II)



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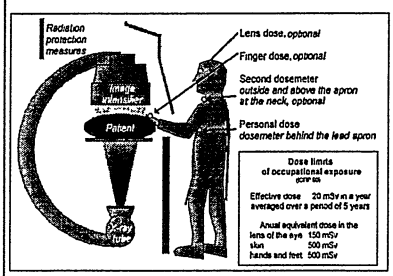
Personal dosimetry



Several personal dosemeters are recommended



From: Avoidance of radiation injuries from interventional procedures. ICRP draft 2000

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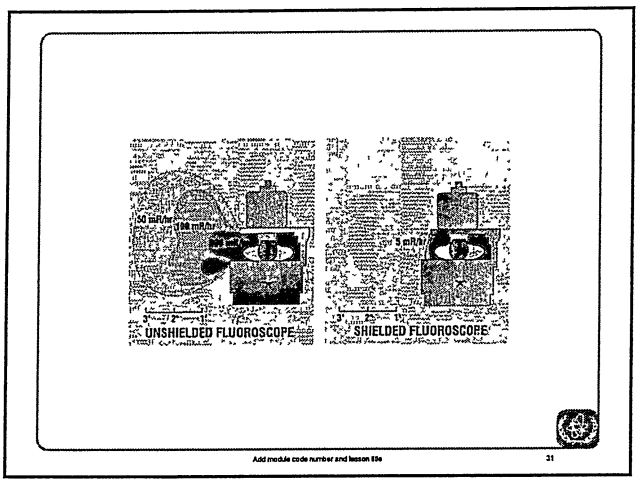
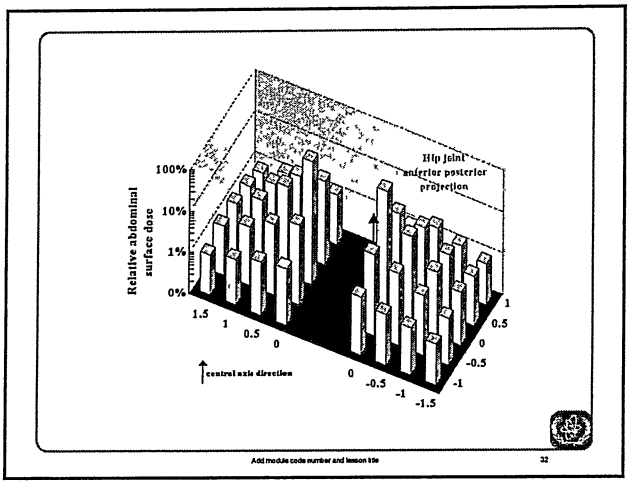
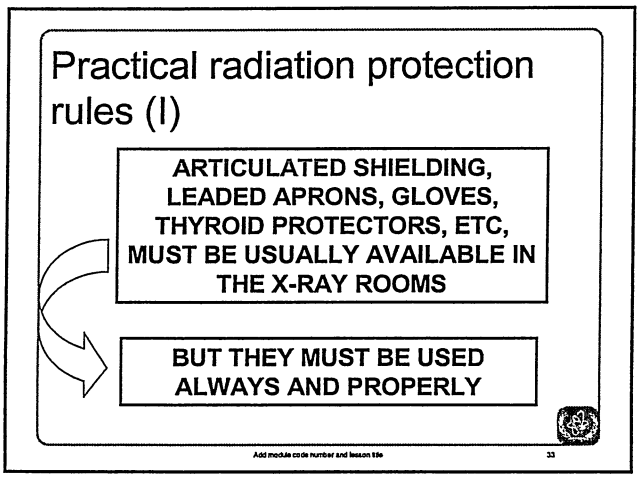

UNSHIELDED FLUOROSCOPE
SHIELDED FLUOROSCOPE
Add module code number and lesson title
31


Relative abdominal surface dose
100%
10%
1%
0%
Hip joint anterior posterior projection
central axis direction
Add module code number and lesson title
32


Practical radiation protection rules (I)
ARTICULATED SHIELDING, LEADED APRONS, GLOVES, THYROID PROTECTORS, ETC, MUST BE USUALLY AVAILABLE IN THE X-RAY ROOMS
BUT THEY MUST BE USED ALWAYS AND PROPERLY
Add module code number and lesson title
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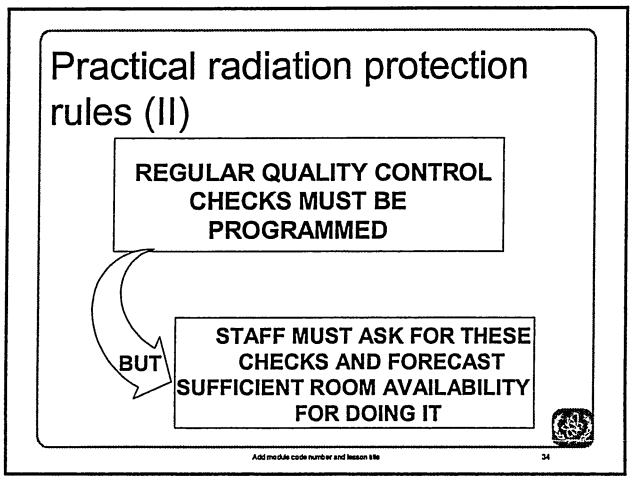
Practical radiation protection rules (II)
REGULAR QUALITY CONTROL CHECKS MUST BE PROGRAMMED
BUT
STAFF MUST ASK FOR THESE CHECKS AND FORECAST SUFFICIENT ROOM AVAILABILITY FOR DOING IT
Add module code number and lesson title
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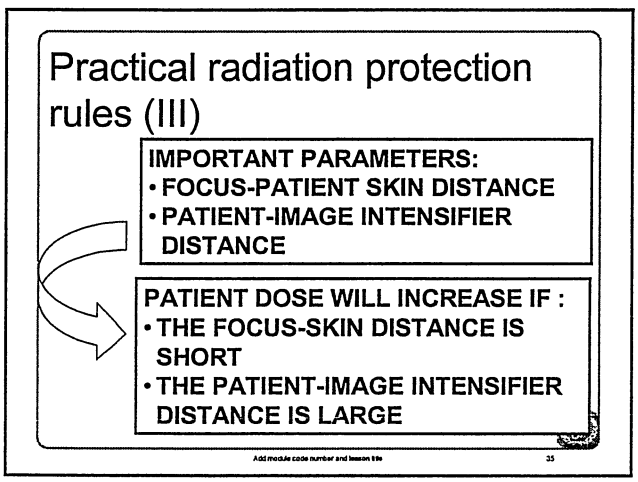
Practical radiation protection rules (III)
IMPORTANT PARAMETERS:
• FOCUS-PATIENT SKIN DISTANCE
• PATIENT-IMAGE INTENSIFIER DISTANCE
PATIENT DOSE WILL INCREASE IF :
• THE FOCUS-SKIN DISTANCE IS SHORT
• THE PATIENT-IMAGE INTENSIFIER DISTANCE IS LARGE
Add module code number and lesson title
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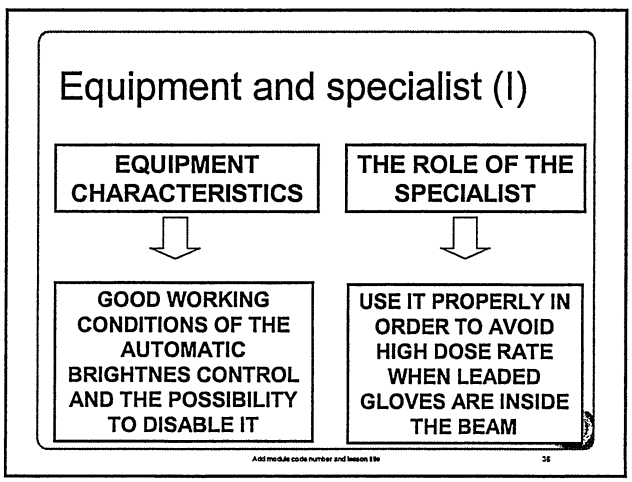
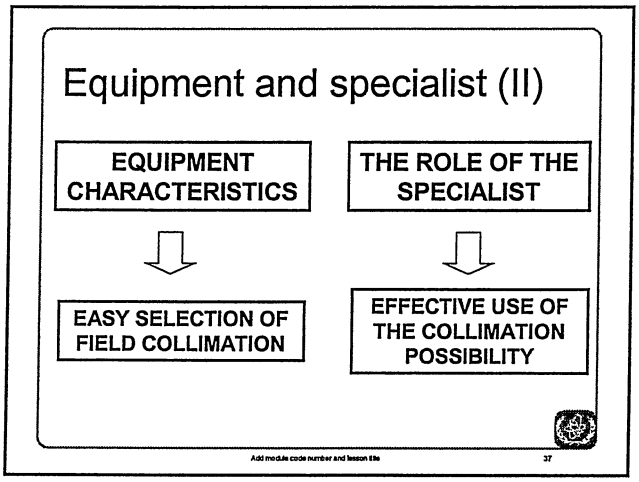
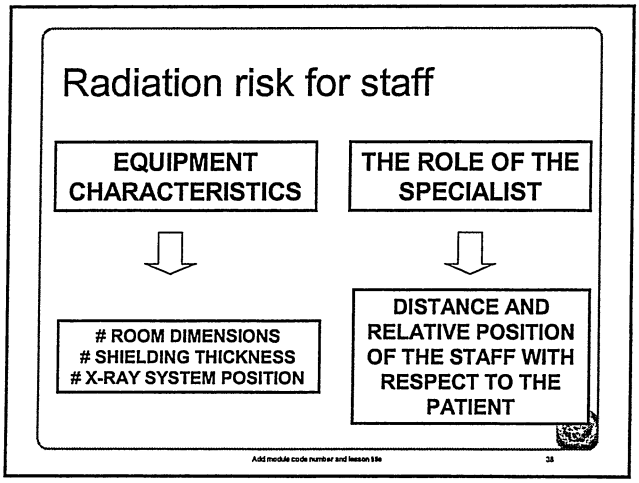

Equipment and specialist (I)
EQUIPMENT CHARACTERISTICS
THE ROLE OF THE SPECIALIST
GOOD WORKING CONDITIONS OF THE AUTOMATIC BRIGHTNES CONTROL AND THE POSSIBILITY TO DISABLE IT
USE IT PROPERLY IN ORDER TO AVOID HIGH DOSE RATE WHEN LEADED GLOVES ARE INSIDE THE BEAM
Add module code number and lesson title
36


Equipment and specialist (II)
EQUIPMENT CHARACTERISTICS
THE ROLE OF THE SPECIALIST
EASY SELECTION OF FIELD COLLIMATION
EFFECTIVE USE OF THE COLLIMATION POSSIBILITY
Add module code number and lesson title
37


Radiation risk for staff
EQUIPMENT CHARACTERISTICS
THE ROLE OF THE SPECIALIST
ROOM DIMENSIONS
SHIELDING THICKNESS
X-RAY SYSTEM POSITION
DISTANCE AND RELATIVE POSITION OF THE STAFF WITH RESPECT TO THE PATIENT
Add module code number and lesson title
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