

# Ancillary Fluoroscopy Safety Training



presented by

RADIOL  OLOGY  
TRAINING ASSOCIATES

Anywhere. Anytime. It's that simple.

# Outline

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- Protecting Yourself (ALARA)
  - Factors That Affect Occupational Exposure and Dose Profiles
  - Use of Distance and Shielding
  - Typical Dose Rates Encountered
  - Occupational Dose Limits and Pregnancy
  - Practical Tips for Minimizing Your Radiation Dose

# Protecting Yourself

## Part III

## 10 Pearls: Radiation protection of **staff** in fluoroscopy

Reducing patient dose always results in staff dose reduction

### 1. Use protective devices!



Advisable skirt type lead apron to distribute weight

0.25 mm lead equivalence but with overlap on front to make it 0.5 mm on the front and 0.25 mm on the back (Provides >90% protection)



Lead glass eyewear with side protection



Thyroid protection

### 2. Make good use of time-distance-shielding (TDS) principle

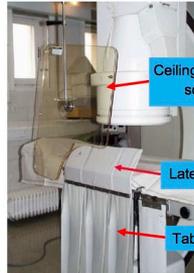
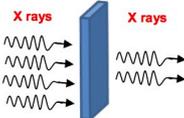
Minimize time



Maximize distance as much as clinically possible



Use shielding



Ceiling mounted screen

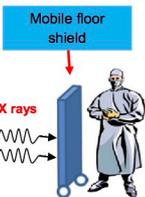
Lateral shield

Table curtain

### 3. Use ceiling suspended screens, lateral shields and table curtains

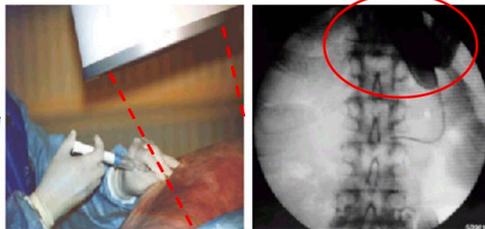
They provide **more than 90% protection** from scattered radiation in fluoroscopy

Mobile floor shielding is advisable when using cine acquisition



### 4. Keep hands outside the primary beam unless totally unavoidable

Hands inside the central area of the primary beam will increase exposure factors (kV, mA) and doses to patient and staff



## 10 Pearls: Radiation protection of **staff** in fluoroscopy

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### 5. Only 1-5% of radiation falling on the patient's body exits the other side

Stand on the side of the **transmitted** beam (i.e. by the **detector**), which contains only 1-5% of the incident radiation and its respective scatter



Right!



Wrong!

### 6. Keep X ray tube under the patient table and not over it

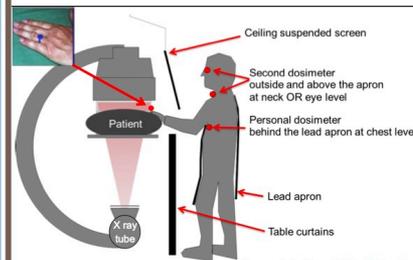
Undercouch systems provide better protection from scattered dose



Right!



Wrong!



\*Image adapted from ICRP Publication 65

### 7. Use personal dosimetry

Use at least **two** dosimeters

- One **inside** the apron at chest level
- One **outside** the apron at neck or eye level
- Additional finger ring dosimeter for procedures requiring hands close to primary beam

Real time dosimetry systems are useful

### 8. Update your knowledge about radiation protection



### 9. Address your concerns about radiation protection to radiation protection specialists (medical physicists)

### 10. REMEMBER!

- Quality control testing of fluoroscopy equipment enables safe and stable performance
- Know your equipment! Using the equipment's features appropriately will help reduce doses to patients and staff
- Use injector devices



RPOP  
Radiation  
Protection of  
Patients

<http://pop.iaea.org>



Information System on Occupational Exposure  
in Medicine, Industry and Research

<http://www-ns.iaea.org/tech-areas/communication-networks/norp/isemir-web.htm>

#### Related Poster!

10 pearls! Radiation protection of **patients** in fluoroscopy  
<http://pop.iaea.org/RPOP/RPoP/Content/Documents/Whitepapers/poster-patient-radiation-protection.pdf>

Page 1 of 2  
Fluoroscopy

Staff Radiation Protection



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Page 2 of 2  
Fluoroscopy

Staff Radiation Protection

# ALARA

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- **As Low As Reasonably Achievable**
  - Reasonable efforts should be made to keep occupational doses as far below regulatory limits as possible
- **Fundamentals of radiation protection**
  - Time, Distance, & Shielding
- **Staff doses are proportional to patient doses**
  - ↑ patient dose ↑ staff dose
  - Protecting your patient protects you!

Time

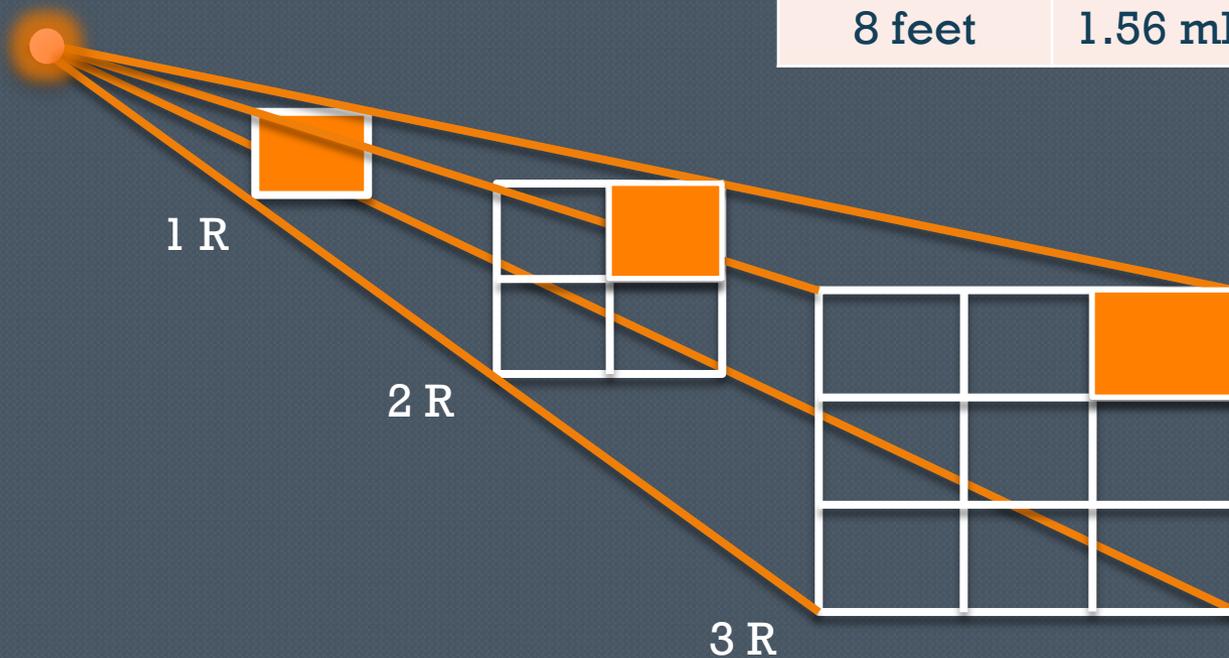
Distance

Shielding

# Distance

$$I_1 D_1^2 = I_2 D_2^2$$

Distance	Dose Rate	% Reduction
1 foot	100 mR/hr	--
2 feet	25 mR/hr	75%
4 feet	6.25 mR/hr	93.75%
8 feet	1.56 mR/hr	98.44%

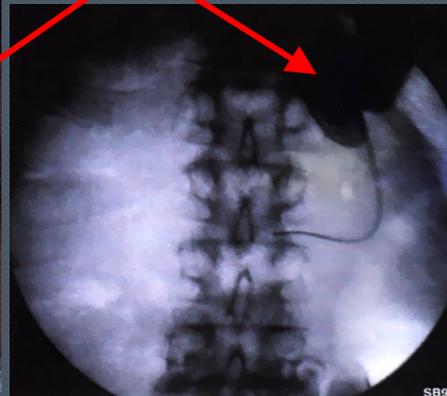


# Stay Out Of The Beam



Dr. Mihran Kassabian, 1903

Physician hands  
in x-ray field



SB96

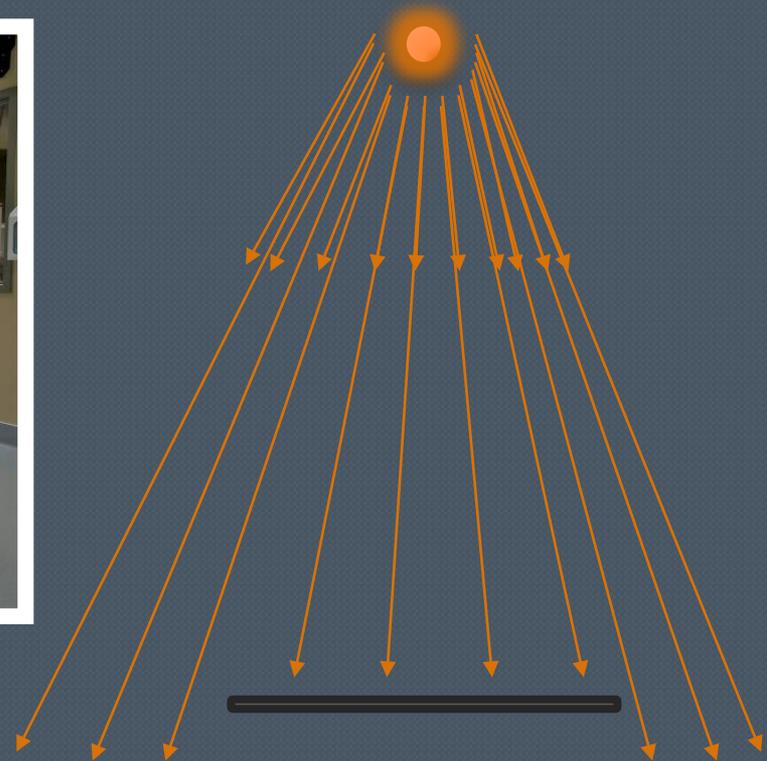
The direct radiation beam  
from a C-Arm is about  
1000x higher than indirect  
or scattered radiation

# Shielding Examples



# Shielding

- Shielding is more effective closer to the source



# Scattered Radiation

On average, only 1% of the X-rays will reach the image intensifier and contribute to image formation. The remaining 99% will be completely absorbed or scattered.

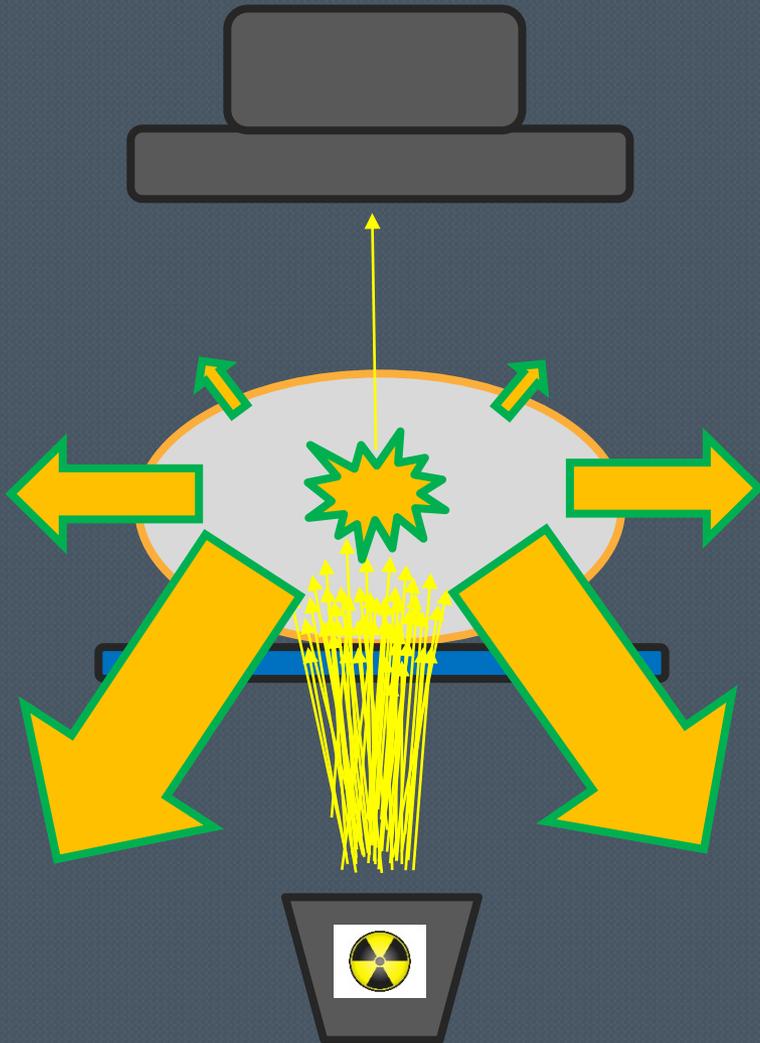
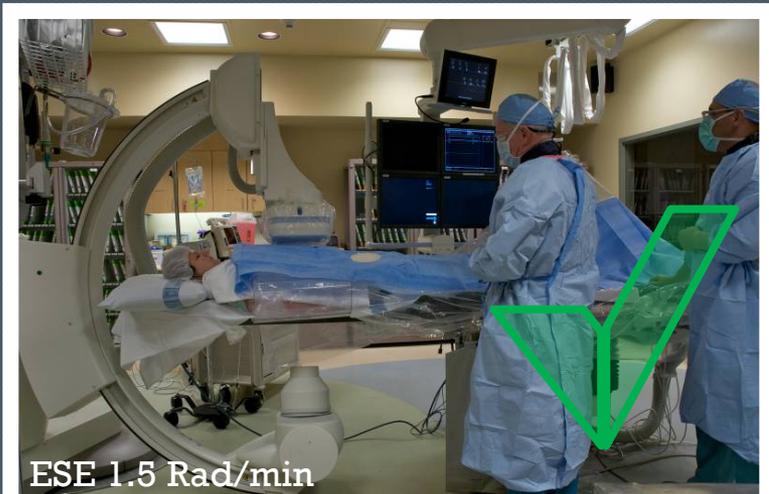


TABLE B-2—Ratio,  $\alpha$ , of scattered to incident exposure<sup>a</sup>

Source	Scattering Angle (from Central Ray)					
	30	45	60	90	120	135
<b>X Rays</b>						
50 kV <sup>b</sup>	0.0005	0.0002	0.00025	0.00035	0.0008	0.0010
<b>70 kV<sup>b</sup></b>	<b>0.00065</b>	<b>0.00035</b>	<b>0.00035</b>	<b>0.0005</b>	<b>0.0010</b>	<b>0.0013</b>
100 kV <sup>b</sup>	0.0015	0.0012	0.0012	0.0013	0.0020	0.0022
125 kV <sup>b</sup>	0.0018	0.0015	0.0015	0.0015	0.0023	0.0025
150 kV <sup>b</sup>	0.0020	0.0016	0.0016	0.0016	0.0024	0.0026
200 kV <sup>b</sup>	0.0024	0.0020	0.0019	0.0019	0.0027	0.0028
250 kV <sup>b</sup>	0.0025	0.0021	0.0019	0.0019	0.0027	0.0028
300 kV <sup>b</sup>	0.0026	0.0022	0.0020	0.0019	0.0026	0.0028
4 MV <sup>c</sup>	—	0.0027	—	—	—	—
6 MV <sup>d</sup>	0.007	0.0018	0.0011	0.0006	—	0.0004
<b>Gamma Rays</b>						
<sup>137</sup> Cs <sup>e</sup>	0.0065	0.0050	0.0041	0.0028	—	0.0019
<sup>60</sup> Co <sup>f</sup>	0.0060	0.0036	0.0023	0.0009	—	0.0006

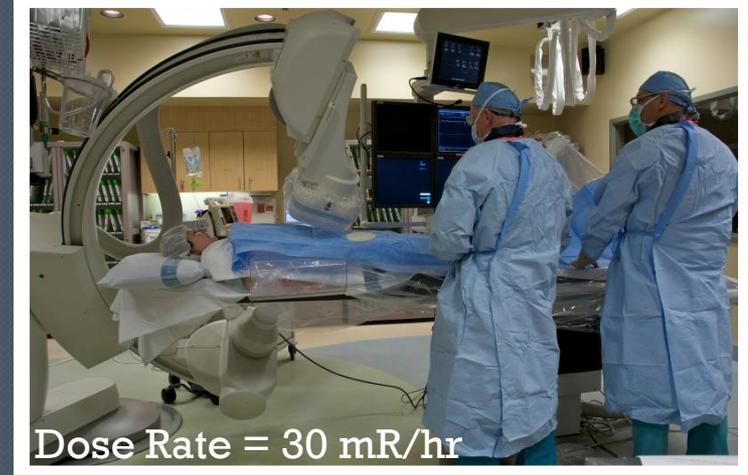
# Positioning Of the C-Arm

- Keep the II as close to the patient as possible and the tube as far from the patient as possible
- The presence of an air gap will always increase the patient/operator exposure and decrease the image quality
- The II intercepts the X-Ray beam earlier
- Make sure no part of the patient is on or near the X-Ray port



# Lateral and Oblique Projections

- X-Ray tube should always be below the table, if possible
- Higher exposure to the operator's head and eyes results during oblique angle projections where the X-ray tube is tilted towards the operator (I-I is tilted away from the operator). Conversely, radiation exposure is decreased when the X-ray tube is tilted away from the operator (I-I tilted towards the operator)
- Lateral and oblique projections are associated with increased radiation exposure as the X-Ray beam must pass through more tissue



# Lead Aprons

## ○ Are they really lead?

- Probably not – most are “lead equivalent”
- Polymers – Pb, Sb, Bi, Ba
- Applicable at certain kVp
- Efficiency changes with changing kVp

(3 layers) .5 mm Regular Lead

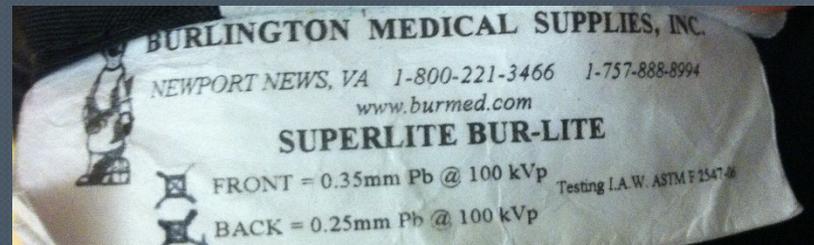
set	kVp		mAs	HVL (mm)	Attenuation %	Pb Eq.
	measured					
74	70.81		32	2.96	99%	0.474
84	80.31		32	3.35	98%	0.473
95	90.72		22	3.78	98%	0.491
105	100.6		15	4.17	97%	0.497
114	110.5		11	4.63	96%	0.504

(2 layers) .5 mm Bur-Lite

set	kVp		mAs	HVL (mm)	Attenuation %	Pb Eq.
	measured					
74	70.81		32	2.96	99%	0.479
84	80.31		32	3.35	99%	0.471
95	90.72		22	3.78	97%	0.482
105	100.6		15	4.17	96%	0.487
114	110.5		11	4.63	96%	0.491

(1 layers) .25 mm Bur-Lite

set	kVp		mAs	HVL (mm)	Attenuation %	Pb Eq.
	measured					
74	70.81		32	2.96	96%	0.267
84	80.31		32	3.35	94%	0.264
95	90.72		22	3.78	91%	0.27
105	100.6		15	4.17	89%	0.272
114	110.5		11	4.63	88%	0.272



# Wearing Lead Aprons

## ○ Lead Aprons

- 1 piece vs. 2 piece
- Lead should fit comfortably and be free of defects

## ○ Thyroid Shield



# Storing Lead Aprons

## ○ Proper storage

- Hanging lead on hangers and hooks prevents the aprons from cracking



# Dosimeters



- Badge Function
- Practical Tips
  - Wear it!
  - Turn it in
  - Store in a low background area
  - Don't take it home
  - Wear outside of your lead, if applicable
  - Only wear your badge!
- Webster Formula
  - Single Badge vs. Double Badge

# Dose Limits

	Annual Limit	
Whole Body (TEDE)	5,000 mrem	50 mSv
Extremities & Skin (SDE)	50,000 mrem	500 mSv
Lens of Eye	15,000 mrem	150 mSv

	Gestational Limit	
Declared Pregnant Workers	500 mrem	5 mSv

	Limits	
Members of the Public	100 mrem*	2 mrem in any 1 hour

Medical X-ray procedures are performed to directly benefit the patient. Note that limits have not been established for how much dose a patient may receive. The regulations properly leave this matter up to the discretion of physicians.

\* Limit goes to 500 mrem when source is an individual administered unsealed byproduct material

# Final Thoughts

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- Think ALARA
- Stay out of the direct radiation beam
- Maintain adequate distance between yourself and the patient
- Limit the amount of time you are near the radiation source
- Use localized shielding
- Ensure the C-Arm is positioned correctly
- Wear your lead and dosimeter correctly
- Limit the dose to your patient
  - Your dose is proportional to the patient dose!