Radiation safety for the Cardiologist

Introduction

- Cath lab operators are extensively exposed to ionizing radiation in the form of X-rays used in the cardiac catheterization laboratory

- Unlike patients who receive radiation doses only during their procedure, operators are repeatedly exposed

Understanding the Hazards

- **Brain Tumors**
- Cataracts
- Thyroid Disease
- Reproductive System Effects

- A case report of brain tumors in 2 Canadian interventional cardiologists first raised this concern

- Finkelstein MM. Is brain cancer an occupational disease of cardiologists? *Can J Cardiol* 1998;14:1385-8
- Hardell L, Mild KH, Påhlson A, et al. Ionizing radiation, cellular telephones and the risk for brain tumours. *Eur J Cancer Prev* 2001;10:523-9

- **Left-sided predisposition** of these tumors raised further alarm when four additional cases were reported from France and Israel
- In a study of 11 cardiologists performing invasive (diagnostic and interventional) procedures, radiation exposure to the outside left side and outside center of the head was significantly greater than the outside right side of the head

Understanding the Hazards

- Brain Tumors
- **Cataracts**
- Thyroid Disease
- Reproductive System Effects

- Higher incidence of cataracts (specifically posterior subcapsular) has been reported in interventional cardiologists in a large French multicenter observational study
- Similar results were also noted in a separate study of both interventional cardiologists and CCL nurses and technicians
- Reduced by wearing lead lined glasses

Understanding the Hazards

- Brain Tumors
- Cataracts
- **Thyroid Disease**
- Reproductive System Effects

- Structural and functional changes as a result of radiation exposure have been reported in the thyroid gland.
- The degree of exposure has been correlated with a linear increase in the development of both benign and malignant thyroid neoplasms

Understanding the Hazards

- Brain Tumors
- Cataracts
- Thyroid Disease
- **Reproductive System Effects**

- Although **exposure to ionizing radiation reduces both sperm count and quality**, the occupational effects of this have not been determined
- A study of 56,436 female radiology technicians in the United States revealed 1,050 cases of breast cancer and showed that **daily low-dose radiation** exposure over several years may increase the risk of developing breast cancer
- It is concerning that in the small series reported by the "Women in Innovation" group for safety, two cardiologists and one nurse with breast cancer **had left-sided tumors**

Understanding Adverse Effects of Radiation Exposure

- **Stochastic Effects**
- Deterministic Effects

- The non-threshold biologic effect of radiation that occurs by chance to a population of persons whose **probability is proportional** to the dose and whose **severity is independent** of the dose

Understanding Adverse Effects of Radiation Exposure

- Stochastic Effects

- **Deterministic Effects**
  - A dose-dependent direct health effect of radiation for which a threshold is believed to exist

Dose exposure

- **Fluoroscopic Time**
  - Time during a procedure that fluoroscopy is used but does not include cine acquisition imaging
- Cumulative Air Kerma (Gy)
- Dose-Area Product (Gy.cm2)

Dose exposure

- Fluoroscopic Time

- **Cumulative Air Kerma (Gy)**
  - The cumulative air kerma is a measure of X-ray energy delivered to air at the interventional reference point (15 cm from the isocenter in the direction of the focal spot)

- Dose-Area Product (Gy.cm2)

Dose exposure

- Fluoroscopic Time
- Cumulative Air Kerma (Gy)
- **Dose-Area Product (Gy.cm2)**
  - This is the cumulative sum of the instantaneous air kerma and the X-ray field area. This monitors the patient dose burden and is a good indicator of stochastic effects

Minimizing X-ray Exposure

- "**As Low As Reasonably Achievable**" principle
- The level of protection should be the best under the prevailing circumstances, maximizing the margin of benefit over harm
- Imaging requirements depend on the specific patient and the specific procedure

Precautions to Minimize Exposure to Patient and Operator

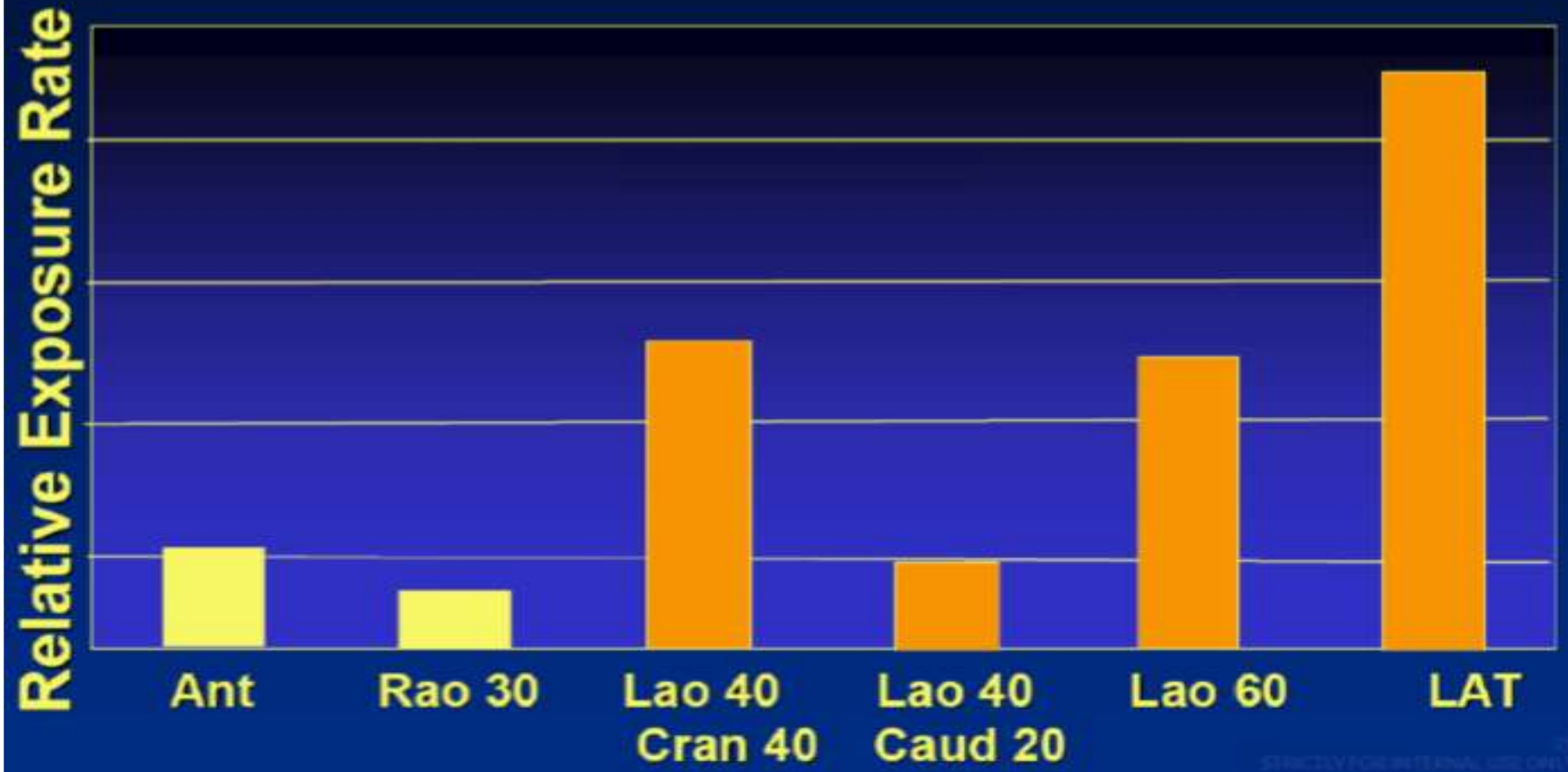
- Utilize radiation only when imaging is necessary to support clinical care
- Avoid the "heavy foot," which steps on the fluoro pedal while not looking at the image
- Minimize use of cine - "Fluoro-save" has a <10% radiation exposure of cineangiography

Precautions to Minimize Exposure to Patient and Operator

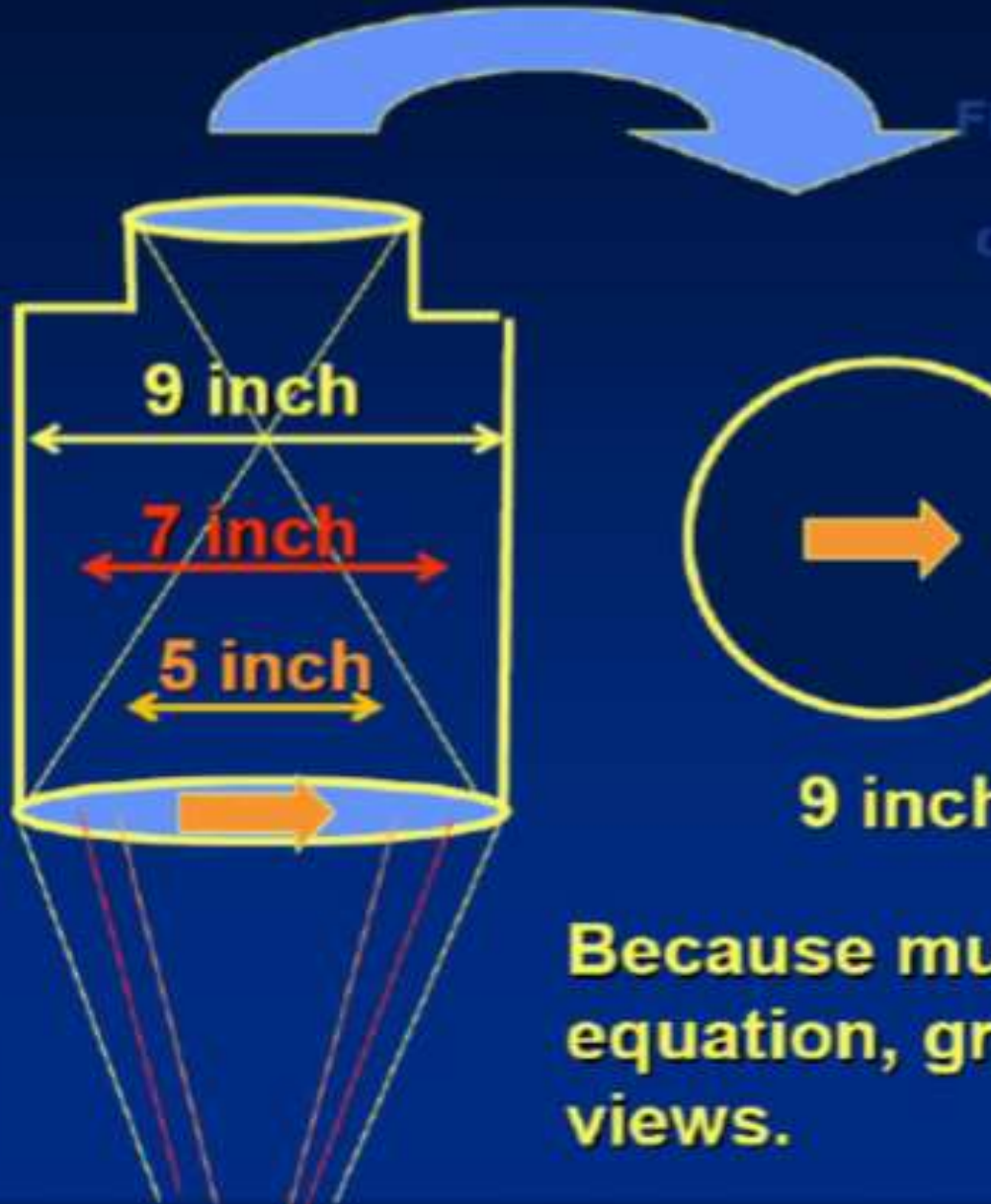
- Minimize use of steep angles of X-ray beam. The left anterior oblique (LAO) cranial angulation has the highest degree of scatter exposure to the operator

- Minimize use of magnification modes. Most modern systems allow for magnification without additional radiation

Physician Radiation Exposure
Effect of Different Projections



Magnification at the I.I.
Effect on Exposure

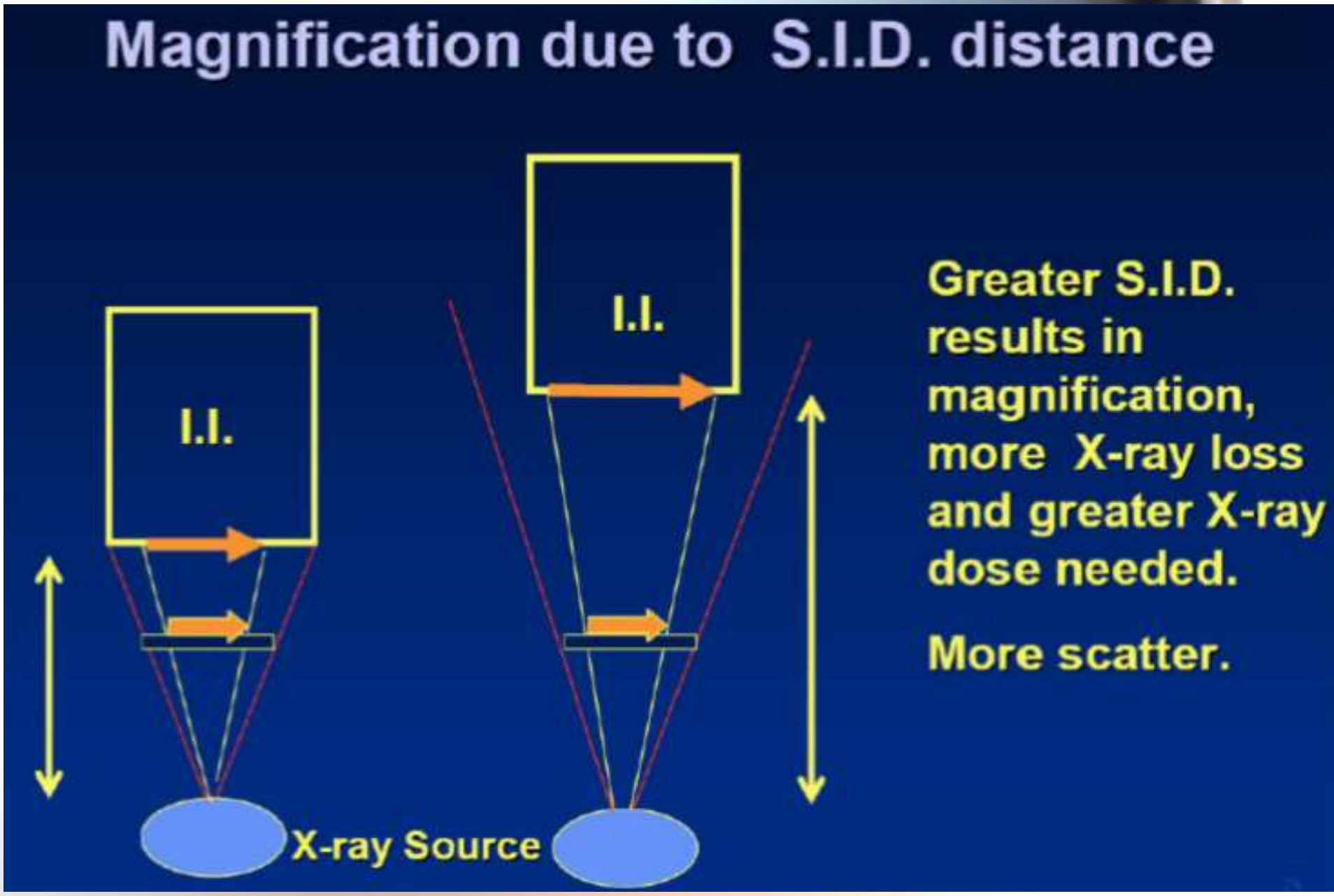


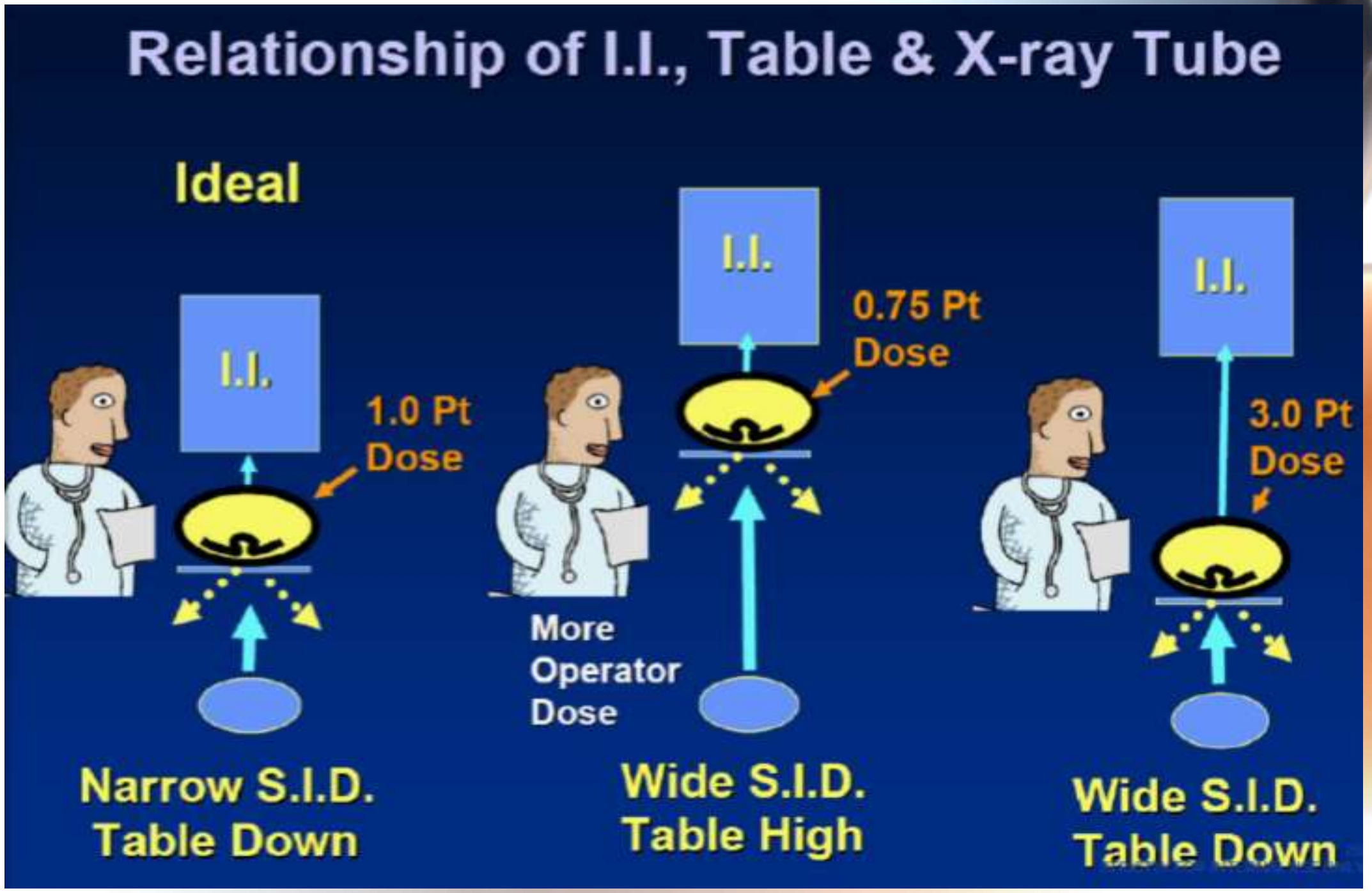
Field size decreases with magnification, therefore, the local patient radiation dose must increase to compensate for the loss of brightness

9 inch 7 inch 5 inch

Because must optimize exposure equation, greater x-ray dose at magnified views.

- Keep the image detector close to the patient (low subject-image distance – S.I.D)




Relationship of I.I., Table & X-ray Tube
Ideal
I.I.
1.0 Pt Dose
Narrow S.I.D.
Table Down
I.I.
0.75 Pt Dose
More Operator Dose
Wide S.I.D.
Table High
I.I.
3.0 Pt Dose
Wide S.I.D.
Table Down

Precautions to Minimize Exposure to Patient and Operator

- Minimize frame rate of fluoroscopy and cine. Ensure that CTOs and other long cases are performed on the 7.5 frames/sec fluoroscopy setting
- A reduction of the fluoroscopic pulse rate from 15 frames/sec to 7.5 frames/sec with a fluoroscopic mode to low dose reduces the radiation exposure by 67%

Precautions to Minimize Exposure to Patient and Operator

- Utilize collimation to the fullest extent possible
- Monitor radiation dose in real time to assess the patient's risk/benefit ratio during the procedure

Precautions to Specifically Minimize Exposure to Operator

- Use and maintain appropriate protective lead garments
- Ideally, a full protective suit with thyroid collar and additional head protection
- Ceiling suspension or floor-mounted personal radiation shielding for enhancing radiation protection and preventing orthopedic issues
- For women, additional protection to the breast with sleeves, which ensure full coverage of this area, in addition to dedicated breast shields
- In view of the concern about brain tumors, protective hats are recommended, especially for the primary operator

Precautions to Specifically Minimize Exposure to Operator

- Maximize distance of operator from X-ray source and patient
- Keep above-table (hanging) and below-table shields in optimal position at all times. A larger ceiling-mounted shield with attached lamellae, used in combination with a drape, decreased exposure to the operator by half
- Keep all body parts out of the field of view at all times. When it is unavoidable that a body part would be exposed to radiation, consider usage of radiation attenuating gloves

Keep detector close to patient.

Collimate.

Position shield in between patient and operator.

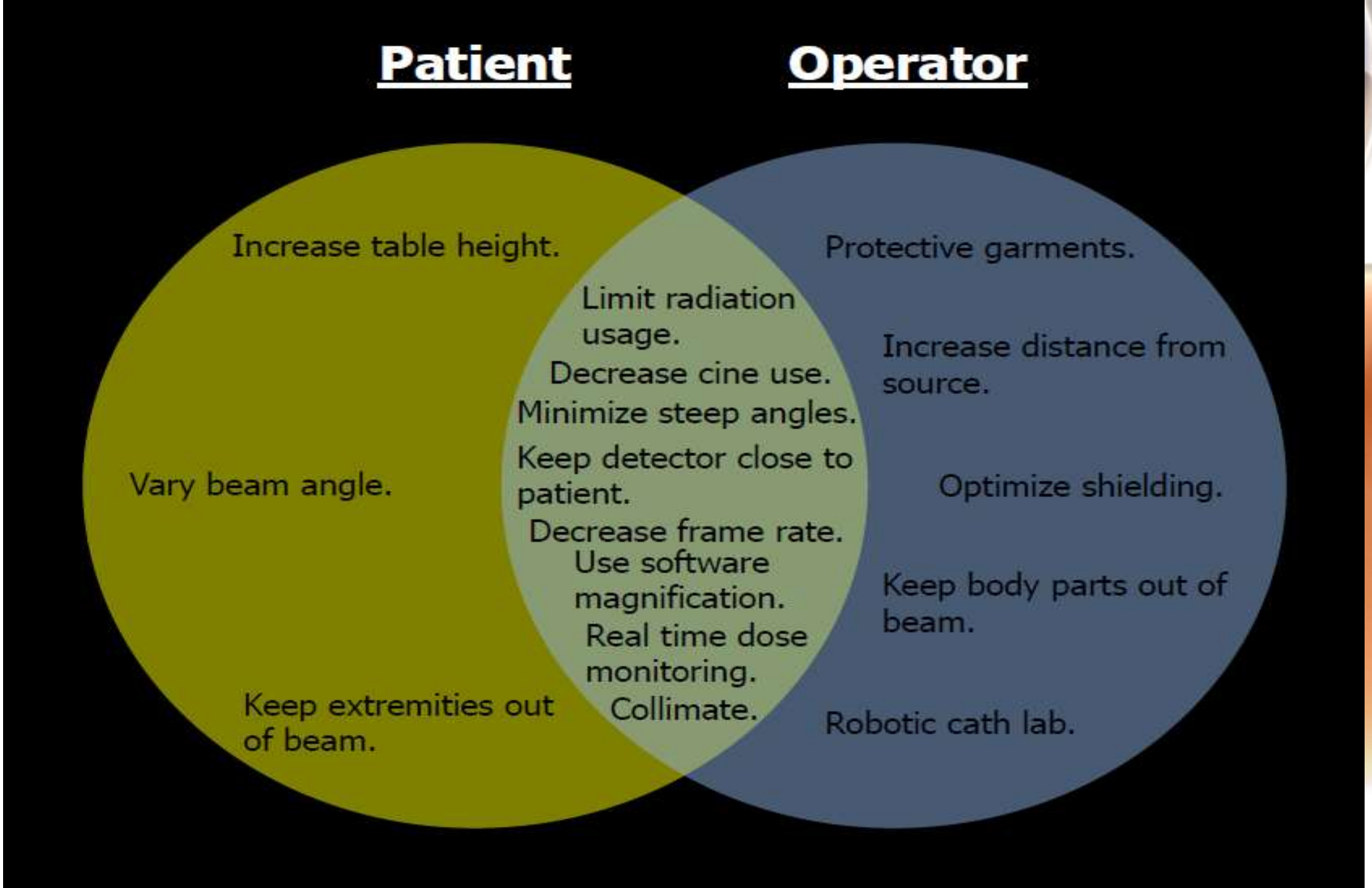
Radiation safety cap.

Radiation safety glasses (with side panels).

Lead skirt and vest with thyroid collar.

Movable lead skirt.

Disposable shielding.


Patient
Operator
Increase table height.
Vary beam angle.
Keep extremities out of beam.
Limit radiation usage.
Decrease cine use.
Minimize steep angles.
Keep detector close to patient.
Decrease frame rate.
Use software magnification.
Real time dose monitoring.
Collimate.
Protective garments.
Increase distance from source.
Optimize shielding.
Keep body parts out of beam.
Robotic cath lab.

Robotic PCI

- Robotic percutaneous coronary intervention (PCI) system may be considered as a viable alternative for both radiation protection and occupational hazard mitigation because lead shielding need not be worn when seated in the interventional cockpit during PCI procedures

Conclusions

- A radiation safety program is an essential part of the quality administration for the catheterization laboratory
- Should be a collaborative effort involving physicians, staff, medical or health physicists, quality assurance personnel, and hospital administration
- Interventional cardiologists are an essential part of this process
- Interventional cardiologists need to be conscious of their own radiation safety