PLEASE CLICK ON THE FOLLOWING LINK TO WATCH THE LECTURE ONLINE:-

- https://www.youtube.com/watch?v=6izOihek-Rs&list=PLuBRb5B7fa_eyBVgz4xb_AqlGcXLIEyRA&index=4

Radiation hazards

AO Trauma Basic Principles Course

Learning objectives

- Describe effect of radiation on human organs and cells
- Outline how the radiation exposure will affect the operation room (OR) personnel
- List the various factors for minimizing radiation hazards during intraoperative imaging
- Describe how to use the C-arm to minimize radiation hazards and provide optimal intraoperative imaging

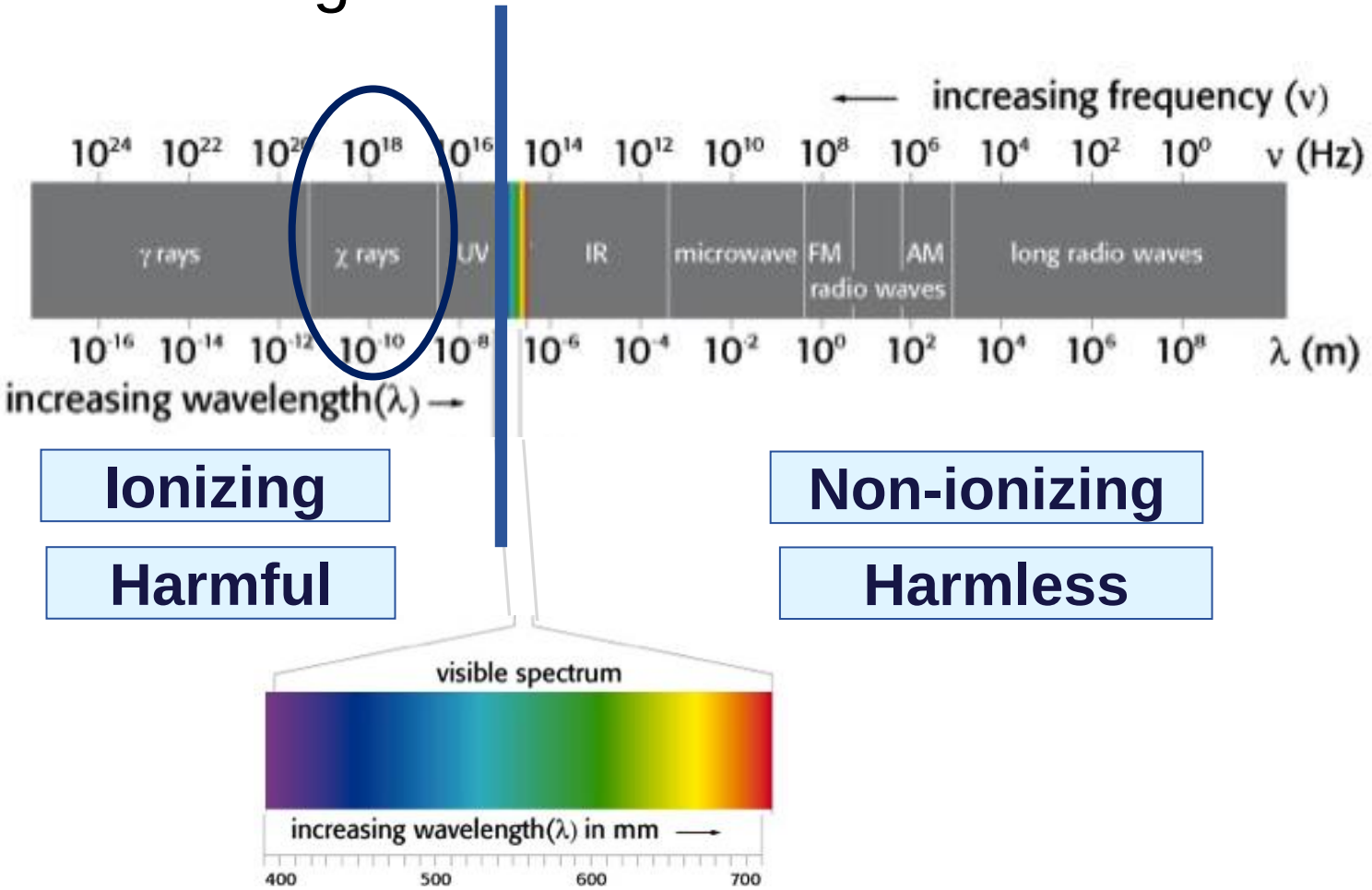
Why discuss radiation hazards?

- A number of orthopedic surgeons have been diagnosed with tumors during their working life
- Some do not take enough care while using x-rays in the OR

What you are about to hear, may affect your life-span!

Physical facts

- Radiation is energy from electromagnetic waves
- X-radiation = ionizing radiation

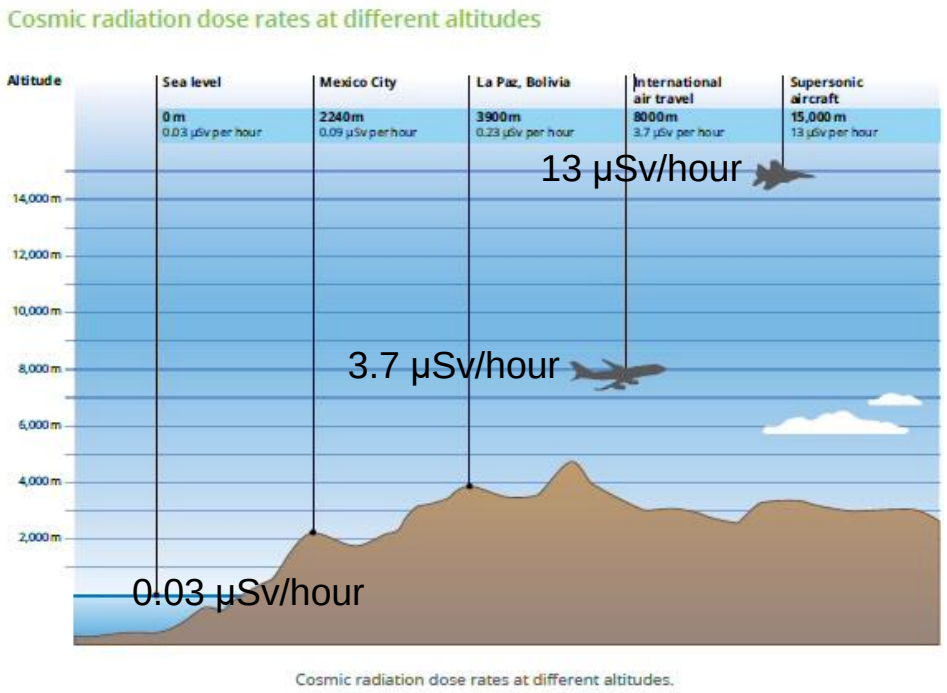


Physical facts

- Unit of measurement: Sievert (Sv)
- 1 Sv = 1 Joule/kg
    - Dose equivalent, reflects the biological effect

Physical facts

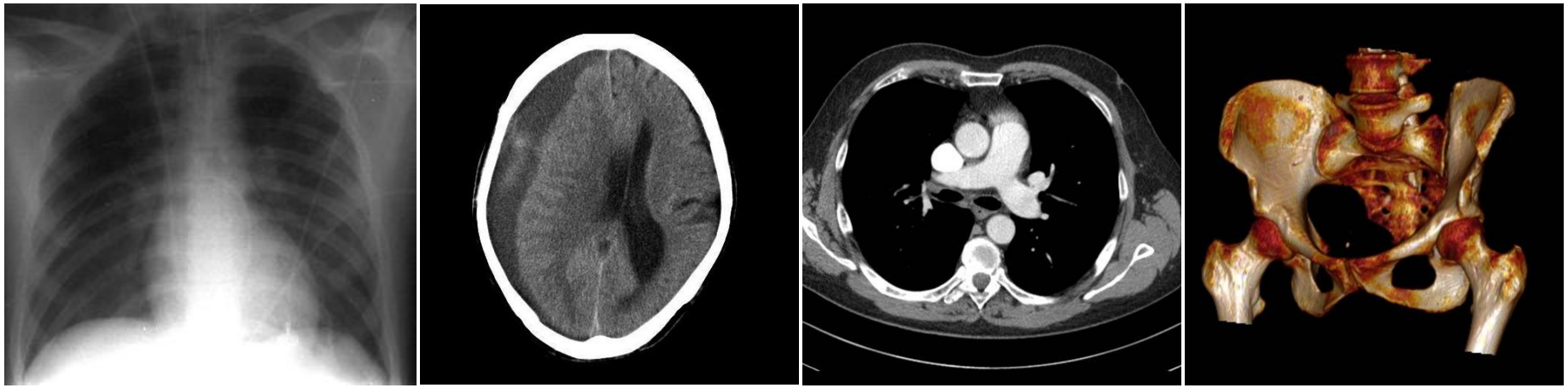
- Normal exposure



Cosmic radiation dose rates at different altitudes.

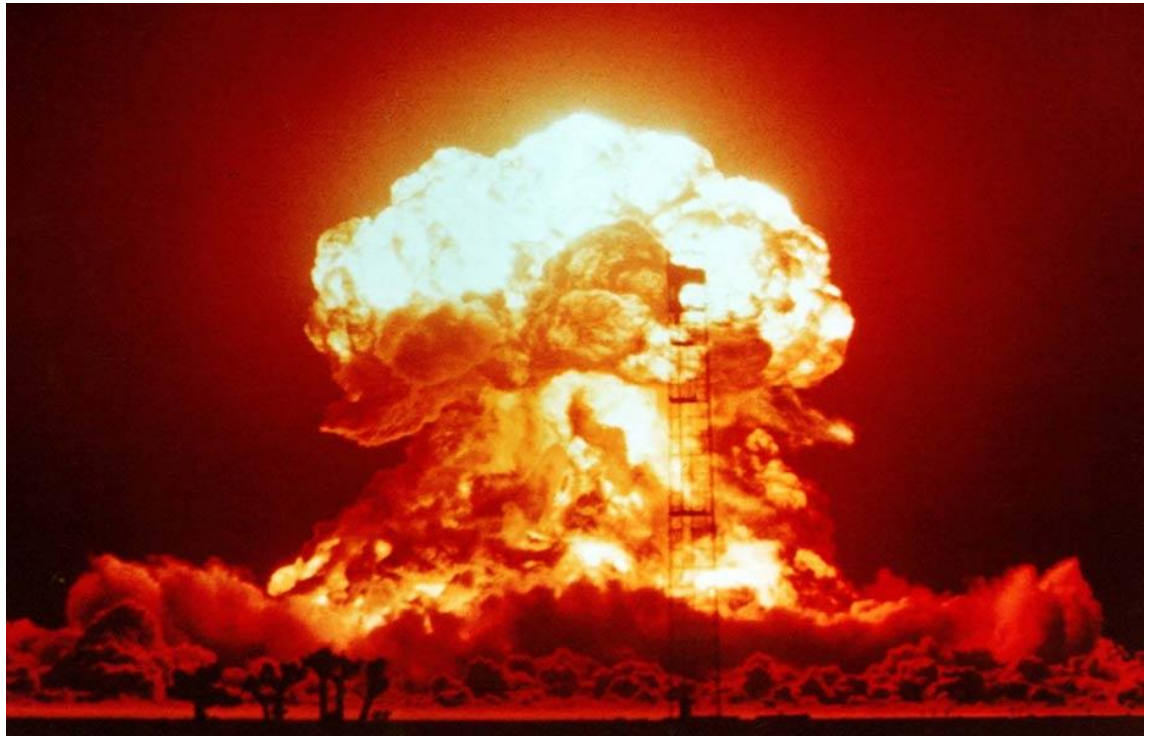
- Cosmic rays in high-altitude flights: 0.001–0.01 mSv/hour
  - Higher altitude = more radiation
- Natural background radiation: 0.01 mSv/day

Physical facts



Medical exposure		
Chest x-ray	0.1 mSv	
CT scan, head	1.5 mSv	15 chest x-rays
CT scan, whole body	9.9 mSv	100 chest x-rays

Physical facts



Radiation from a nuclear bomb: 500–1000 mSv

50–100 whole body CT scans!

Biological facts—ionizing radiation

- Somatic effects (500–1000 mSv):
  - Radiation sickness
  - Radiation cataract
  - Thyroid cancer
  - Leukemia

Directly related to dose
Below certain threshold, no increased risk

Biological facts—ionizing radiation

- Stochastic effects:

  (NOT determined by dose - chance)

  - Thyroid cancer
  - Leukemia

No safe threshold
Cumulative damage with multiple exposures

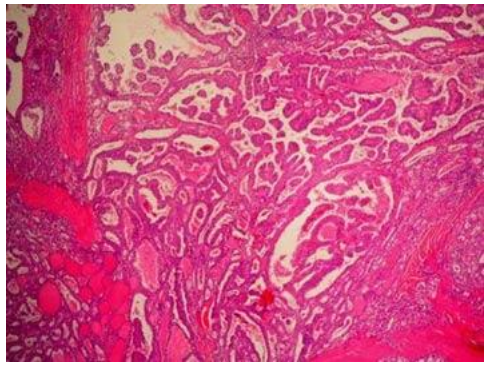
Biological facts—ionizing radiation

- Genetic effects:
  - Mutagenic effects (dose related) proven in animals

- Teratogenic effects:
  - At 18–85 days of gestation provoked by 10 mSv

Specific body exposure

- Hands:
  - Have greatest exposure risk
- Eyes:
  - Radiation cataract
- Thyroid:
  - 85% of papillary carcinoma are radiation induced



Modern orthopedic trauma surgery

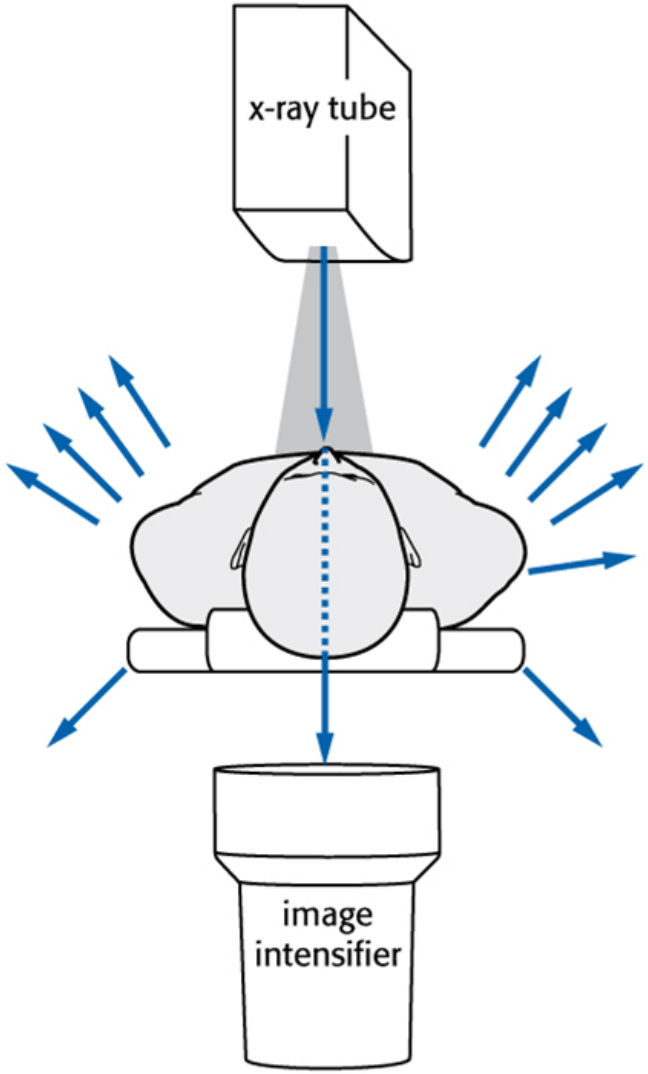
- Increased exposure of surgeon, patient, and team to radiation by minimally invasive procedures
  - Intramedullary (IM) nailing
  - Percutaneous K-wire fixation
  - Minimally invasive plate osteosynthesis (MIPO)
  - Vertebroplasty

How to protect patients, staff, and yourself

Physical facts—absorption and scatter

For every 100 photons reaching the patient:

- ~10–20 are scattered
- ~ 2 reach the image detector
- ~ 80 are absorbed by patient (radiation dose)

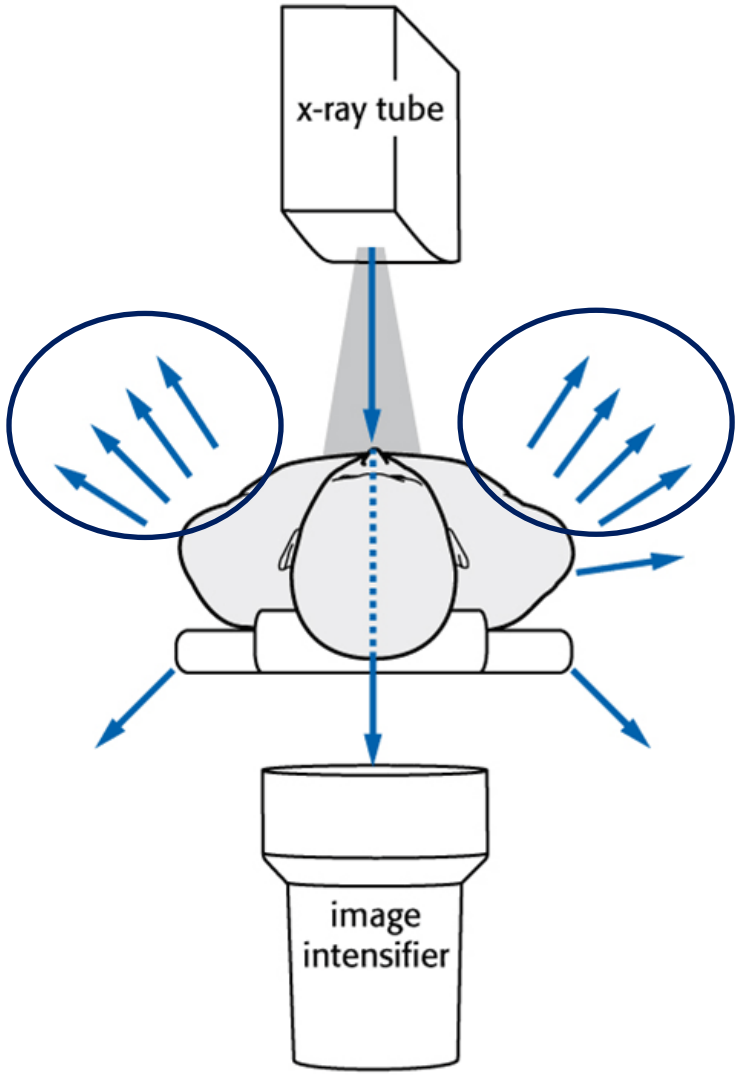


Richter, et al. OA Musculoskeletal Medicine 2013 Jun 01;1(2):11.

Physical facts—absorption and scatter

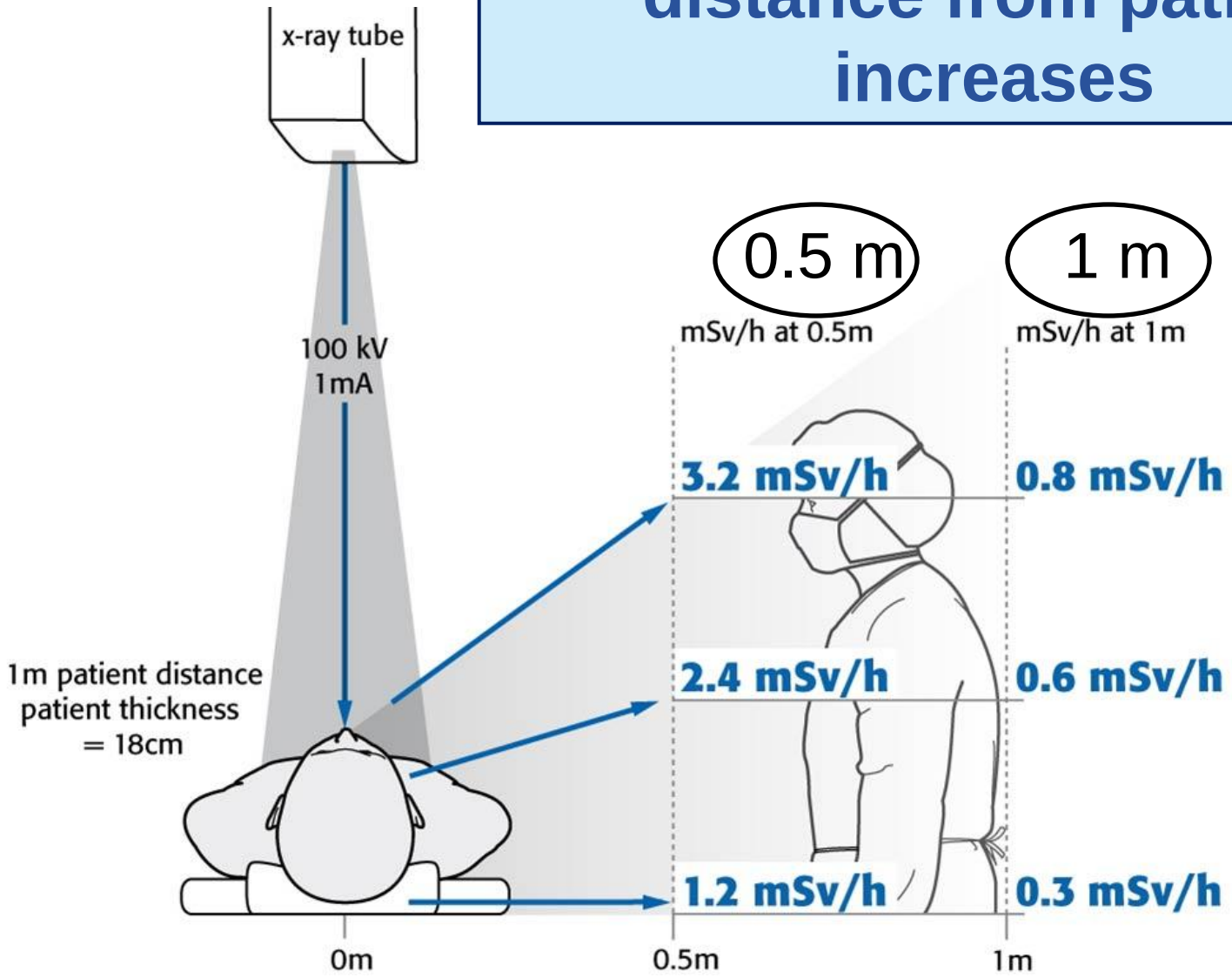
- Radiation scatter is mainly directed toward the source

Main source of radiation for team and surgeon is scattered radiation from patient



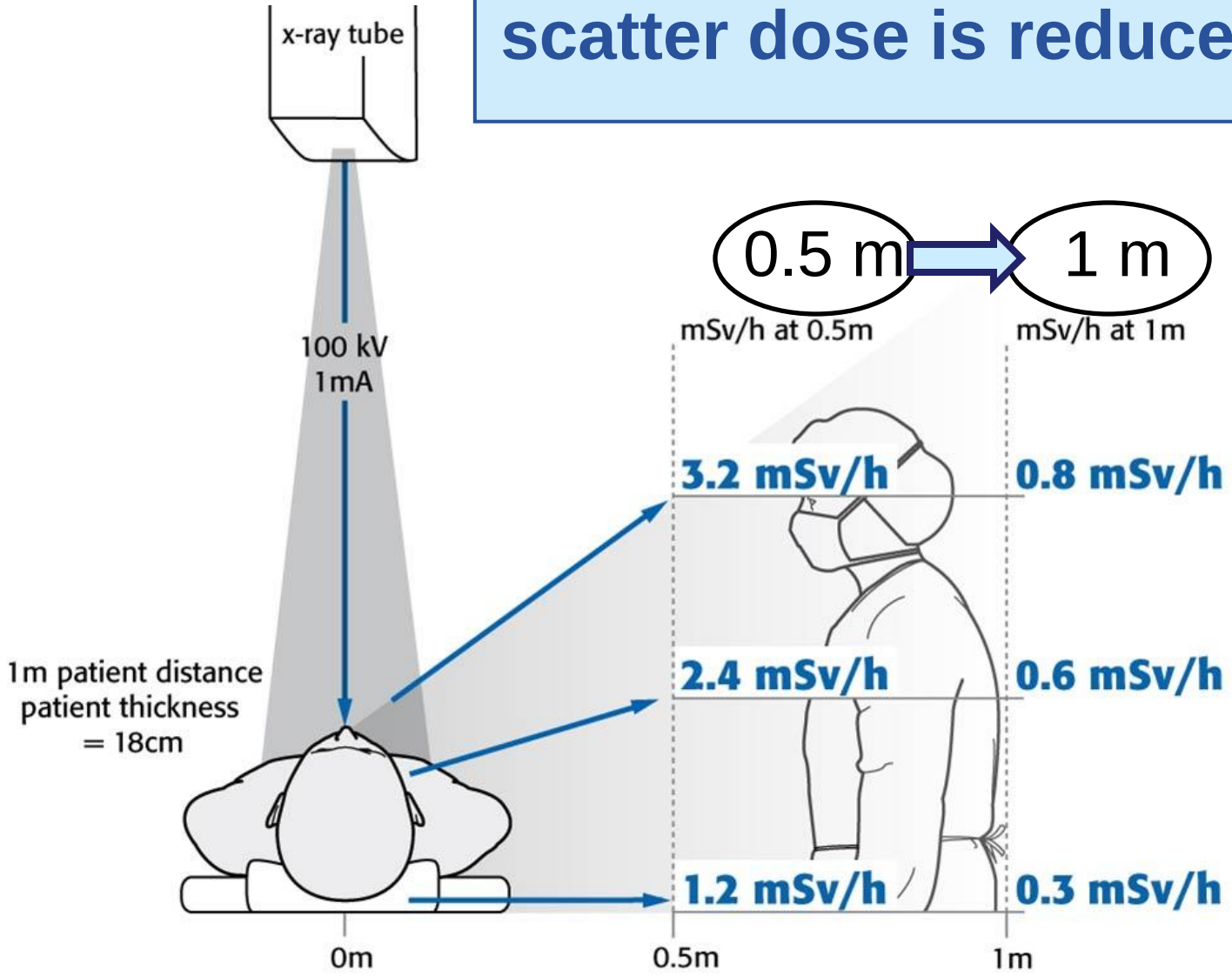
Distance

Scatter-dose is lower when distance from patient increases

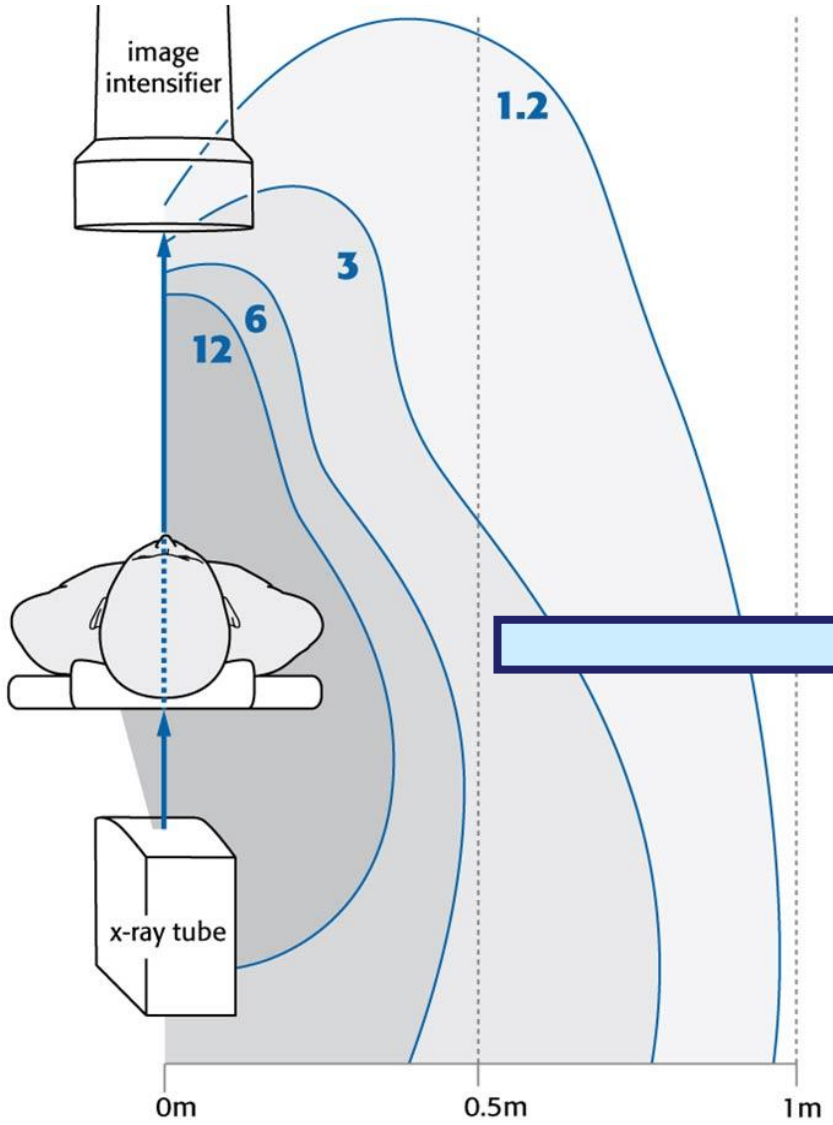


Distance

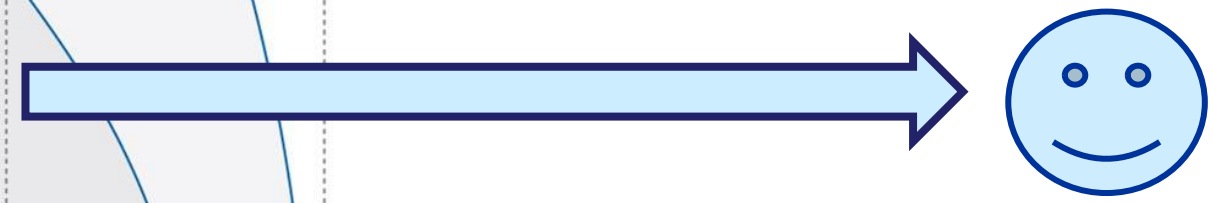
When distance is doubled, scatter dose is reduced to 1/4



Distance



Reasonably safe at 3 m away from source!



Who receives the most exposure?

3-month period: 107 consecutive operations

- Surgeon always >90 cm from beam
- Assistant ~10 cm from beam

- Radiation dose:

Dose measurement	Surgeon	Assistant
Outer dosimeter	**0.0375 mSv**	**0.21 mSv**

Tasbas BA et al (2003) Arch Orthop Trauma Surg

Experience and exposure during IM nailing

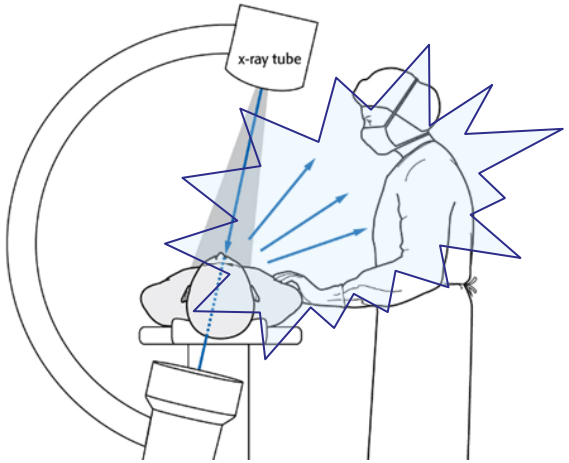
22 procedures of IM nailing of long bones

- Senior group (12) versus junior group (10)

Fluorometric time statistically greater for junior group

Blattert TR et al (2004) Arch Orthop Trauma Surg

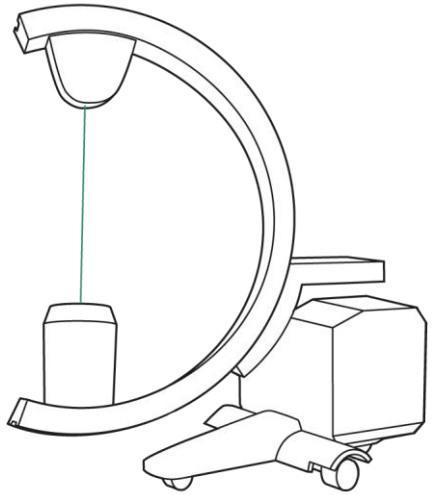
X-ray tube position



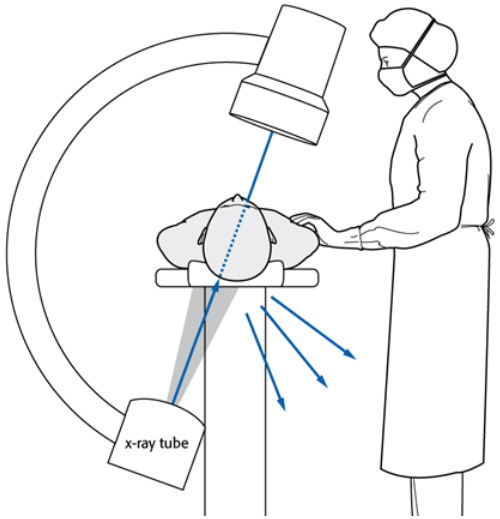
X-ray tube up

✗ ↓ ✗

Intensifier down



Tube position below OR table
reduces radiation dose to eye lens by 3 or more times

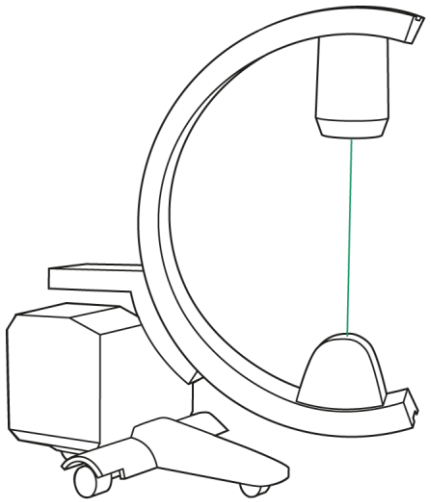


Intensifier up

✓ ↑ ✓

X-ray tube down

Best configuration



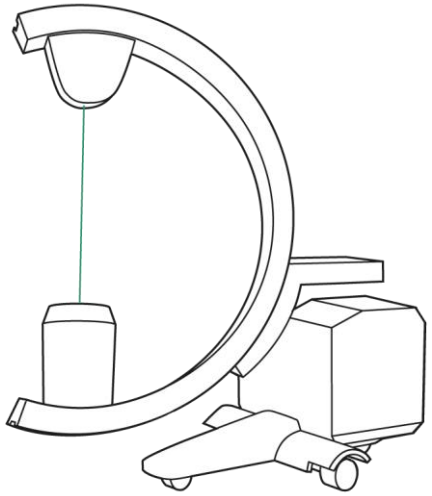
X-ray tube position

Exception:
hand, small-part surgery

Scatter is minimal

X-ray tube up

Intensifier down

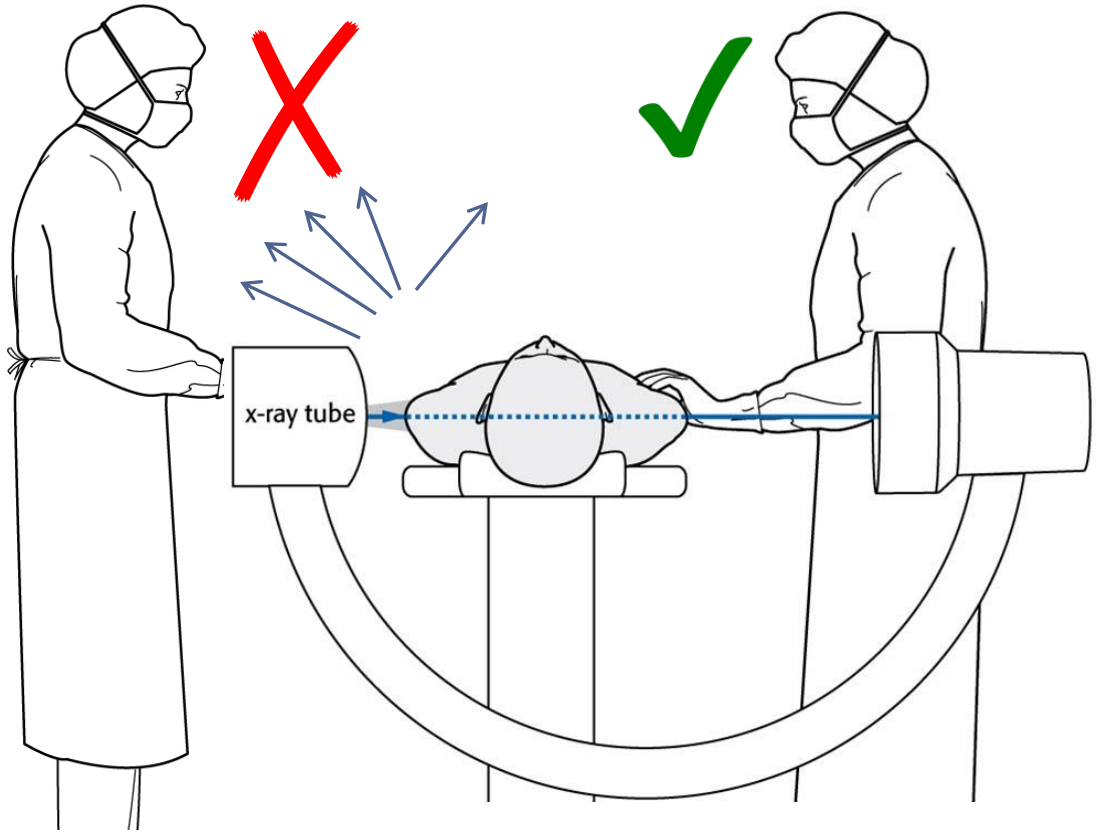


Avoid direct exposure to beam
Stay away as much as possible

Tremains, et al. JBJS-Am, May 2001 - V83 - 5

X-ray tube position

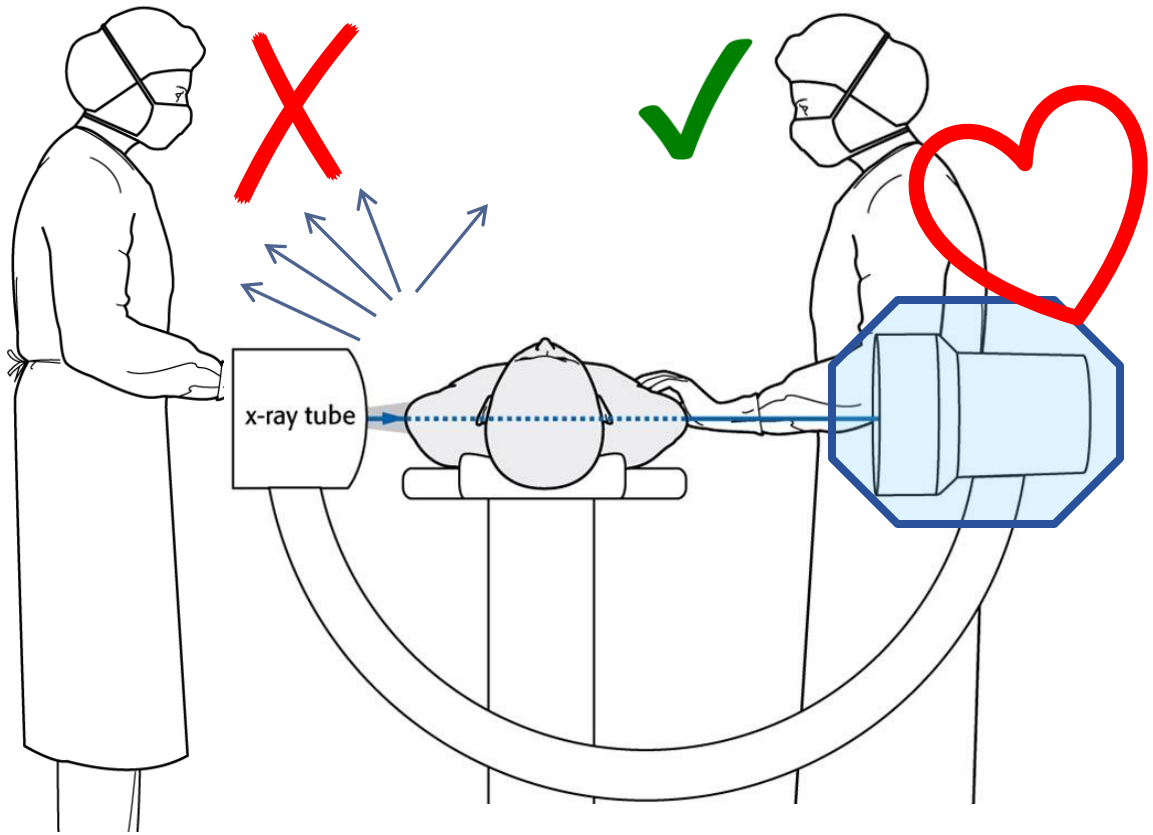
- Exposure at x-ray tube side:
  - Thyroid **X 3–4**
  - Torso **X 25**



Stay away from the x-ray tube side during fluoroscopy

X-ray tube position

- Exposure at x-ray tube side:
  - Thyroid **X 3–4**
  - Torso **X 25**



Hug the intensifier!

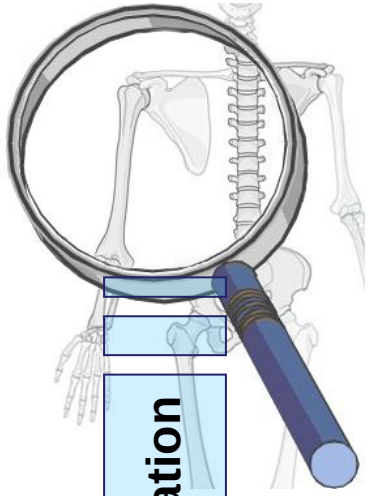
Factors affecting staff and patient doses

Patient size increases skin dose and scattered radiation

- **Use additional protective devices**
- **Keep a safe distance from large patients**

Factors affecting patient doses

Intensifier diameter	Patient entrance dose
32 cm (12 in)	Dose 100
22 cm (9 in)	Dose 150
16 cm (6 in)	Dose 200
11 cm (4.5 in)	Dose 300

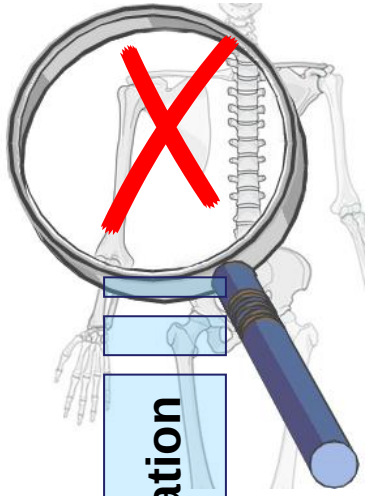


More magnification

More magnification (smaller diameter) increases patient entrance dose

Factors affecting patient doses

Intensifier diameter	Patient entrance dose
32 cm (12 in)	Dose 100
22 cm (9 in)	Dose 150
16 cm (6 in)	Dose 200
11 cm (4.5 in)	**Dose 300**



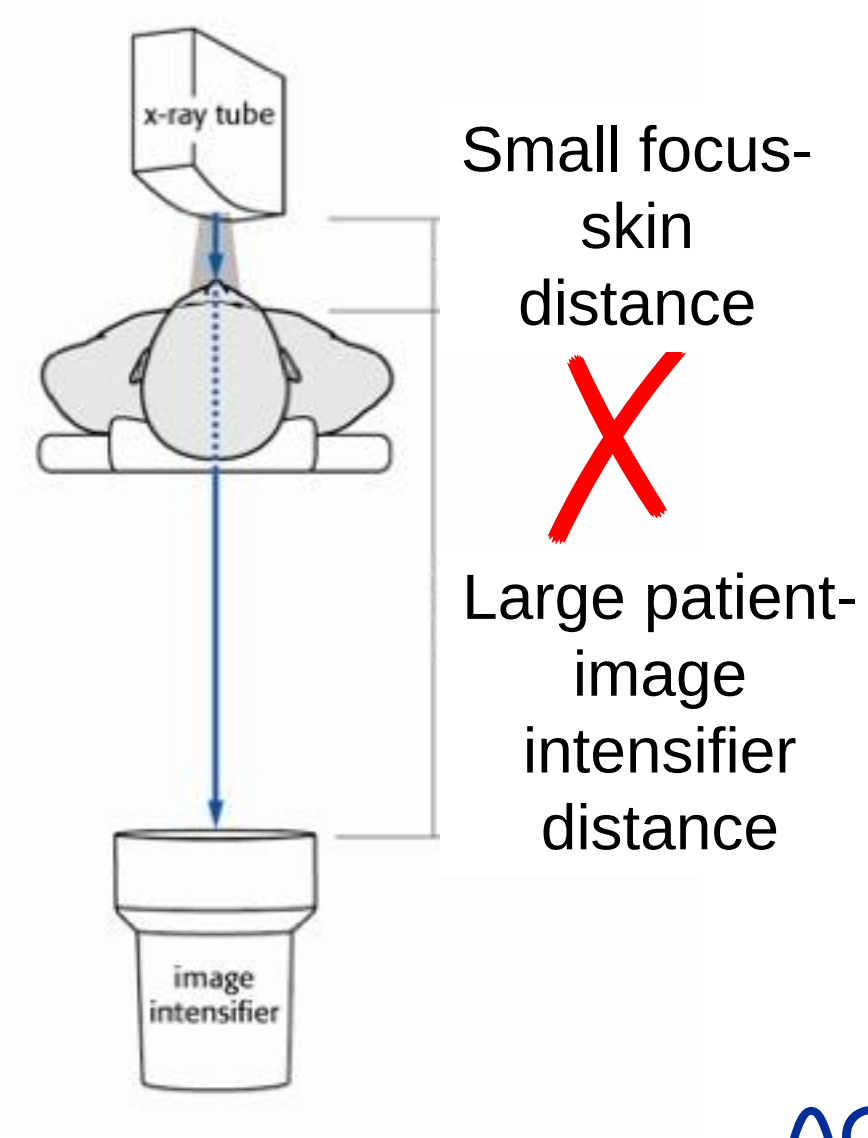
More magnification

Do not use too much magnification

Factors affecting staff and patient doses

Patient dose will **increase** if:

- Focus–skin distance is short
- Patient–image intensifier distance is large



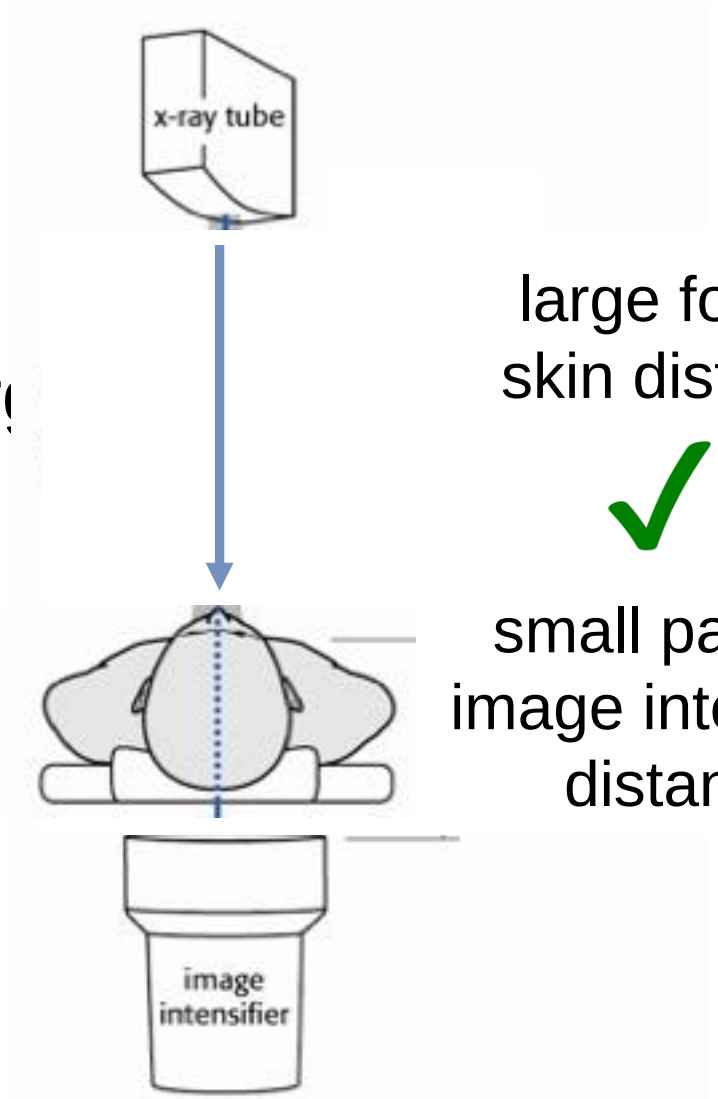
Factors affecting staff and patient doses

Patient dose will **increase** if:

- Focus–skin distance is short
- Patient–image intensifier distance is lar

Reduce patients' dose & scatter:

Place patient close to image intensifier



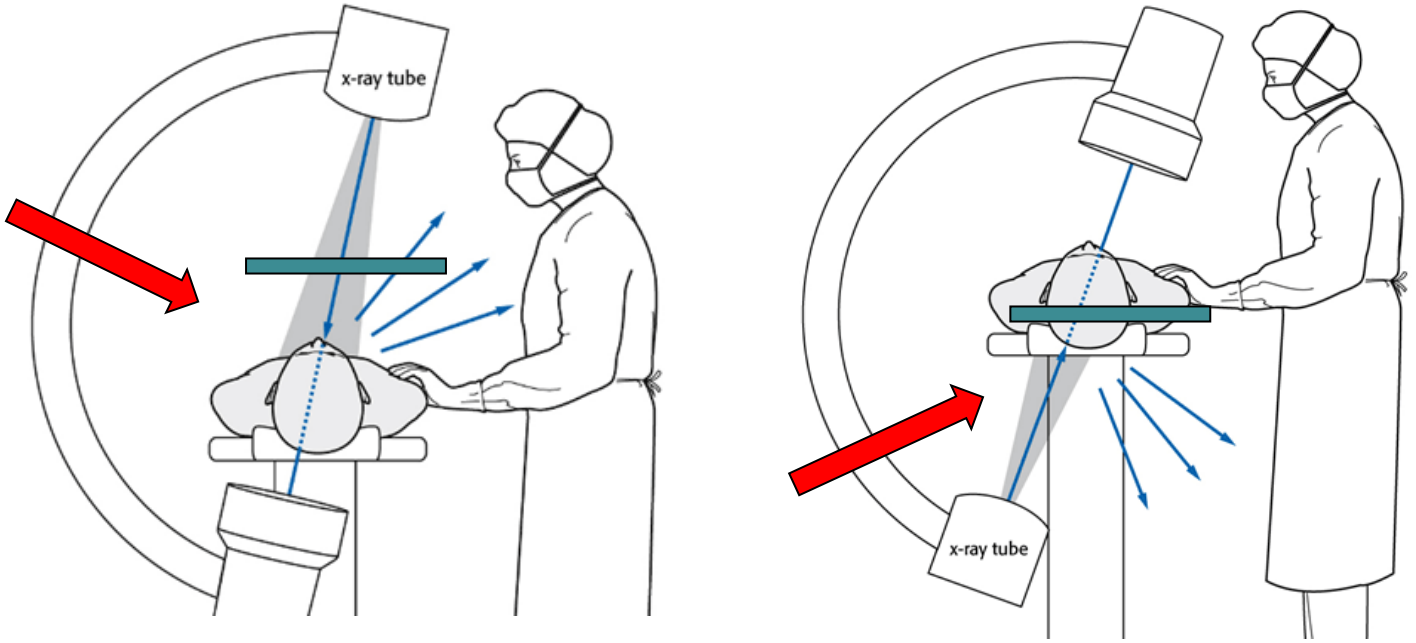
large focus-skin distance

✓

small patient-image intensifier distance

Remember to protect patients

- Away from x-ray tube
- Protective shield for patients must be placed on the side of x-ray tube
  - **On** patient if tube is above
  - **Under** patient if tube is below

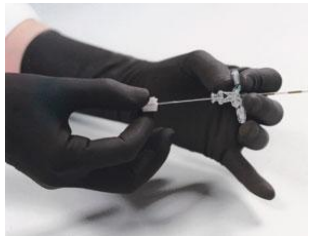


Protect yourself – use protective gear

0.15 mm lead-equivalent goggles
provide 70% attenuation of radiographic beam

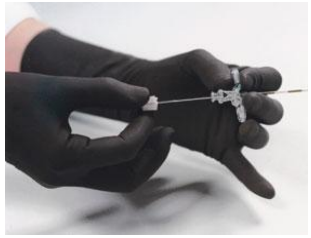
Thyroid collar
2.5-fold further decreases

Apron
AP: decreased 16-fold
Lateral: decreased 4-fold



Protective gloves
60–64% protection at 52–58 KV

Protective gear



If not provided by hospital

Buy your own protection!

Protective gear

Apron and thyroid collar

- Treat them well to get good protection

Protective gear

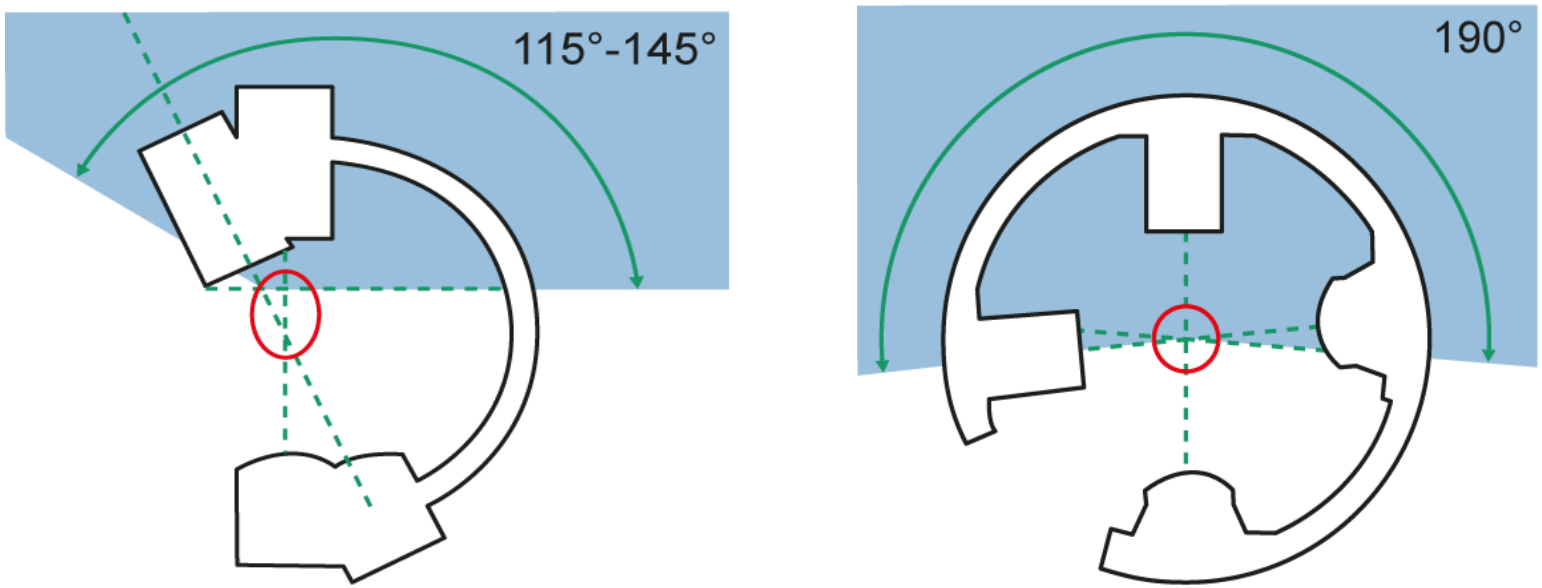
Apron and thyroid collar

- Treat them well to get good protection

Should be routinely checked

Technical contributions to radiation dose reduction

- Iso-centric C-arms:
  - Repositioning of C-arm is not needed when changing from AP to lateral



Technical contributions to radiation dose reduction

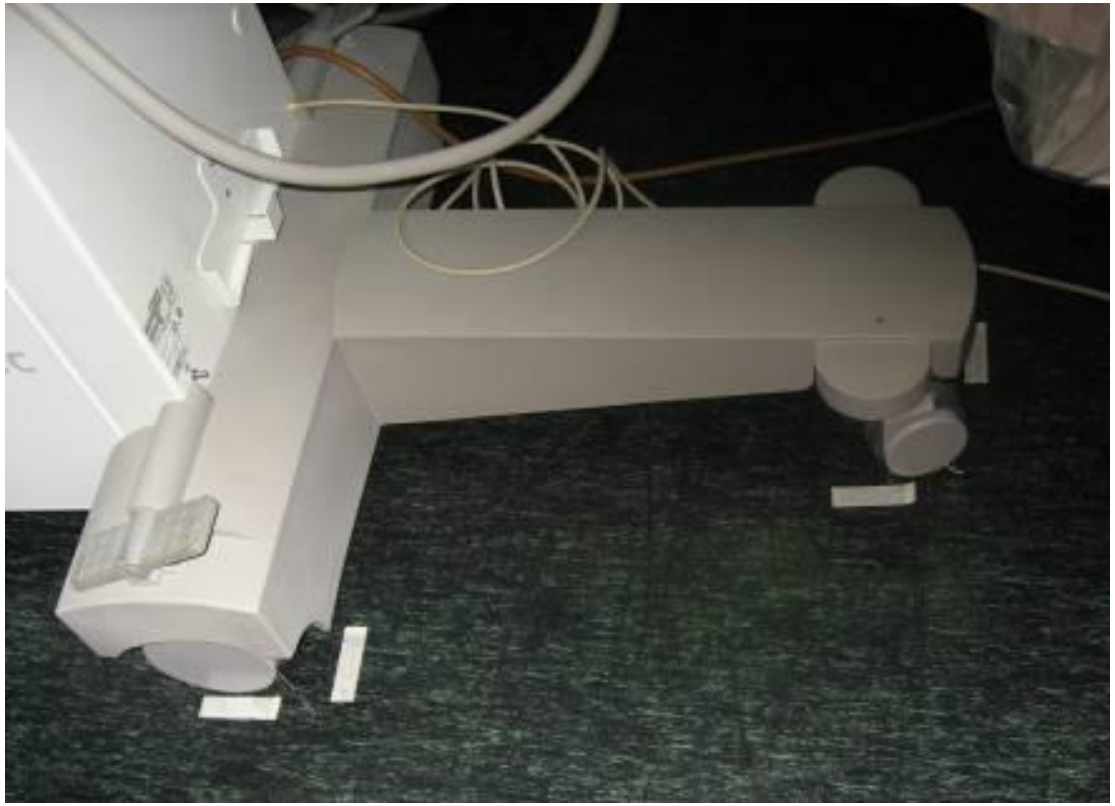
- Good quality off-center imaging
  - No need to repeat exposure

- Remove/reduce metals in the field
  - C-arms automatically increase exposure to improve bone image

Clinical C-arm application: “C-arm attitude”

Clinical C-arm application: “C-arm attitude”

- Landmarks (floor)



Clinical C-arm application: “C-arm attitude”

- Landmarks (floor, body)

Clinical C-arm application: “C-arm attitude”

- Landmarks (floor, body)
- Laser aiming

Clinical C-arm application: “C-arm attitude”

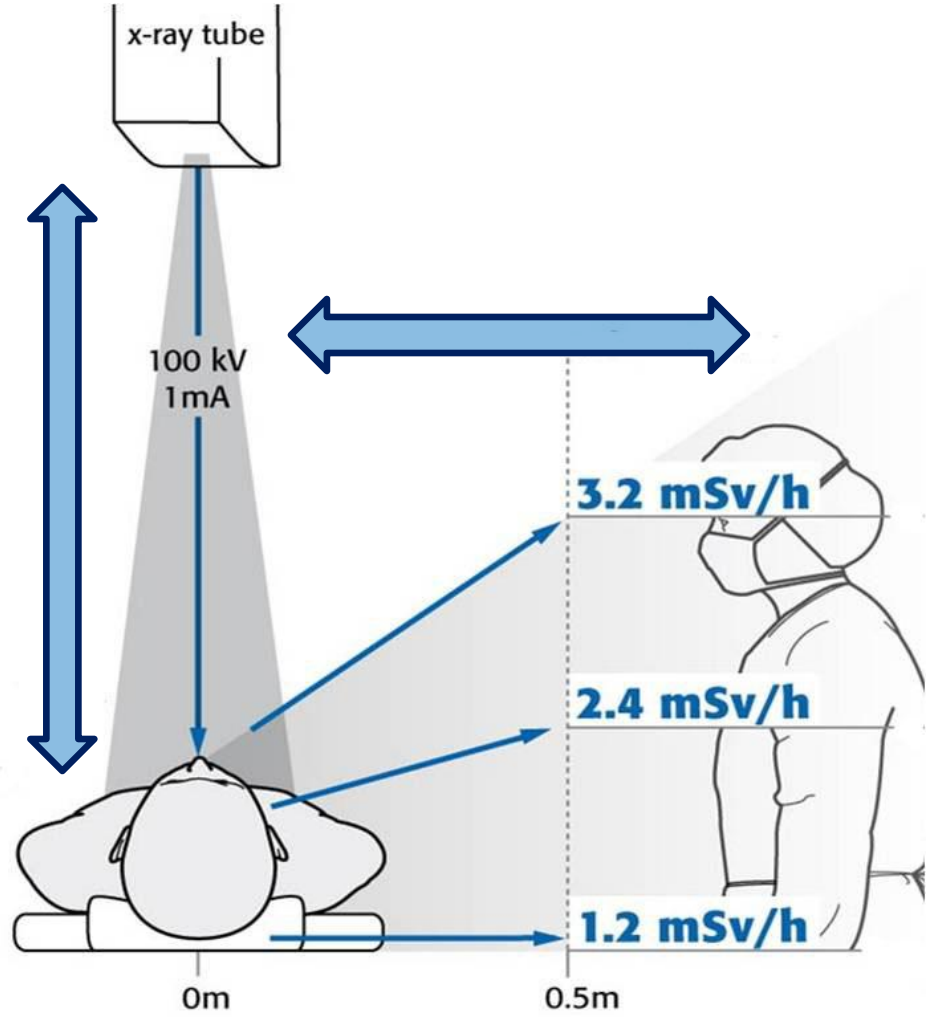
- Landmarks (floor, body)
- Laser aiming
- Pulsed acquisition

1 second of fluoroscopy = 15–25 frames of pulsed acquisition!

Best by a technician!

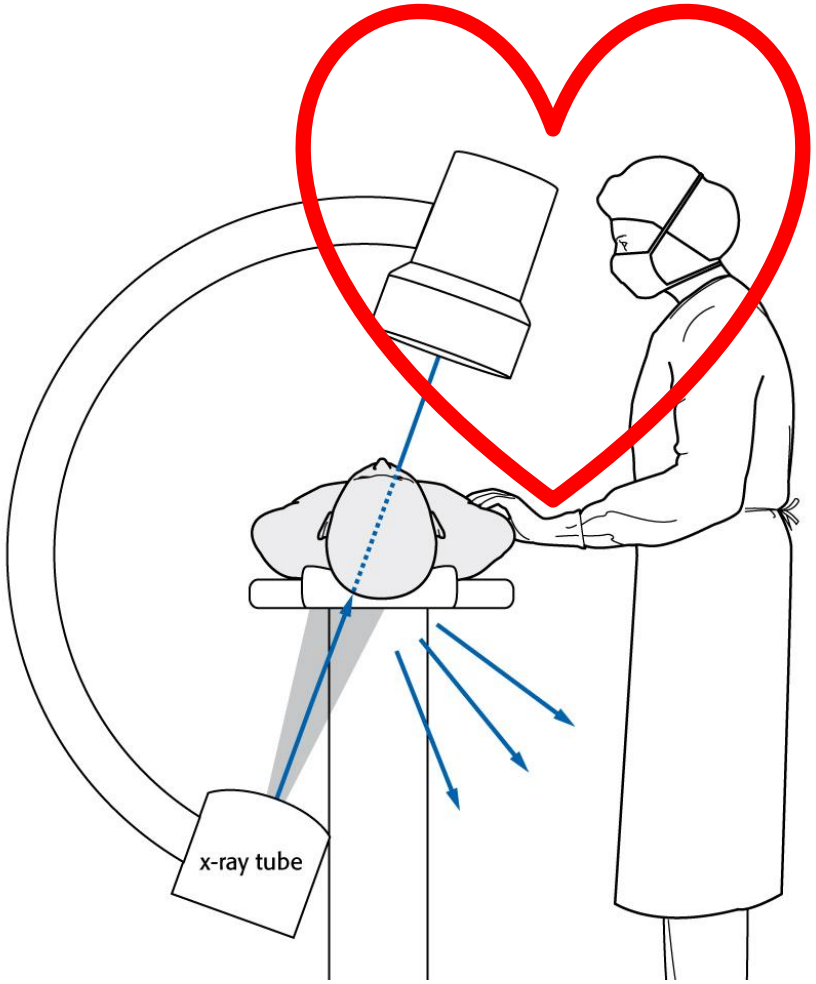
Clinical C-arm application: “C-arm attitude”

- Landmarks (floor, body)
- Laser aiming
- Pulsed acquisition
- Distance



Clinical C-arm application: “C-arm attitude”

- Landmarks (floor, body)
- Laser aiming
- Pulsed acquisition
- Distance
- Position of x-ray tube



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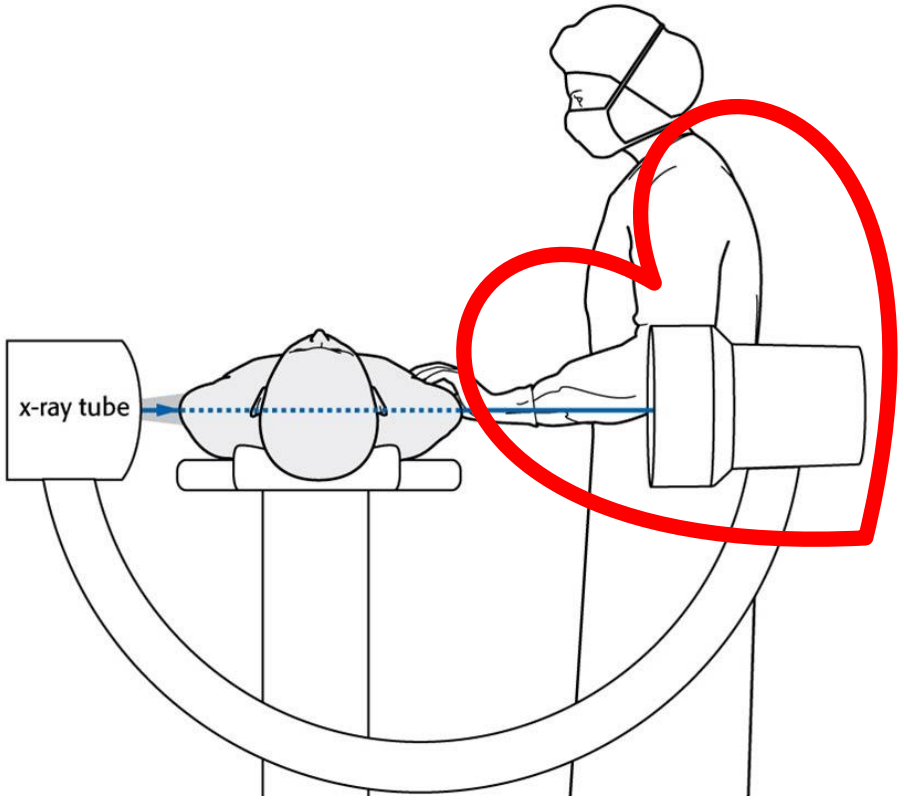
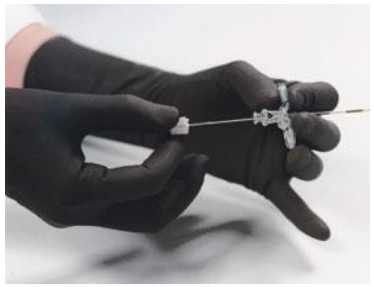


Clinical C-arm application: “C-arm attitude”

- Landmarks (floor, body)
- Laser aiming
- Pulsed acquisition
- Distance
- Position of x-ray tube
- Protective gear



Clinical C-arm application: “C-arm attitude”

- Landmarks (floor, body)
- Laser aiming
- Pulsed acquisition
- Distance
- Position of x-ray tube
- Protective gear
- Keep hands away from the beam

Clinical C-arm application: “C-arm attitude”

- Landmarks (floor, body)
- Laser aiming
- Pulsed acquisition
- Distance
- Position of x-ray tube
- Protective gear
- Keep hands away from beam
- Shout when exposing and scream “Screening!”

Summary

We work in a field of radiation!

Summary

We have an obligation towards the safety of:

- Our patients
- Our staff
- Ourselves

Take-home messages

- Scattered radiation to be avoided
- Keep x-ray tube:
  - Underneath the patient
  - Away from patient
  - Away from you (lateral view)
- Use pulsed acquisition
- Landmarks on the floor/body, use laser aiming
- Use protective gear routinely
- Keep your hands out of the beam
- Shout out when screening

Take-home messages

Hug the intensifier!