

Steps for Radiation Safety in Pediatric Interventional Radiology

Plan, prepare and communicate.

Measure, record and review.

1. Equipment

- a. Qualified medical physicist (i.e., one who is board certified in diagnostic radiological physics) consultation at equipment selection, set up, and in equipment maintenance and quality assurance (QA).
- b. Both the maximum radiation output (for largest adult-size patients) and routine radiation output as a function of varying patient size to be measured and documented.
- c. At installation, "child-size" angiographic protocols created, with dose reduction, appropriate lengths of runs, and different frame rates for slow vs. high flow, infant, small child and teenager sized patients
- d. CT guided procedures: "child size" protocols for CT guidance, using as low an mA as possible
- e. Dose recording and reduction technologies installed in equipment

2. Pre procedure consultation

- a. Ask about previous radiation
- b. Answer questions about radiation safety

3. During procedure:

- a. Appropriate communication between in room personnel: Don't be afraid to ask the necessary questions to ensure you are working as a team to keep the radiation dose as low as possible
- b. Use US if possible
- c. Plan and communicate in advance: plan number of runs, injection parameters, contrast, pump, digital subtraction angiography (DSA) frame rates and optimize patient position timing with anesthesia and the radiologist carefully, so as to avoid improper or aborted runs and the need to repeat a run.
- d. For machines with removable grids, remove for infants under 20 kg and use air gap technique.
- e. Lower the number of exposures: use fluoro save when possible.
- f. View and save images with last image hold, decreasing acquisitions/exposures as much as possible when that level of detail is acceptable.
- g. Step lightly: tap on pedal and examine still image on monitor, minimize live fluoroscopic time
- h. Position with fluoroscopy off
- i. Use pulse fluoroscopy when possible. Use a low pulse rate rather than high pulse rates or continuous fluoroscopy; for example, decrease from 7.5 pulses to 3 pulses a second whenever possible.
- j. Collimate tightly. Decreasing the area of patient exposure directly decreases patient dose. Collimate to avoid dose to the eyes, thyroid and gonads whenever possible

- k. Minimize overlap of fields in repeated acquisitions
 - l. Decrease the dose rate setting to the lowest level that provides adequate image quality during either fluoroscopy or the recording of images.
 - m. Minimize use of electronic magnification. Use fluoroscopic zoom whenever possible instead. Switch back to zero magnification whenever possible.
 - n. Move table away from x-ray tube in both planes to maximize distance between source and patient. Maintain an appropriate source to table top distance throughout the procedure. This shall be no less than 15 inches at any time. Lower the image intensifier (or flat panel detector) as close to the patient as possible, to minimize patient to detector distance, while still allowing room for manipulation of needles, wires catheters. Remember these principles in the lateral position.
 - o. Avoid radiosensitive areas (breast, eyes, thyroid, gonads) when possible. Evidence on the need/advisability for shielding of areas outside of the beam is unclear. There is some concern that patient shielding may increase the patient's internal backscatter dose. Additionally, as the table needs to be moved during many procedures, there is a chance that a portion of the shield may enter the field of view, which will automatically increase the dose. Therefore, although shielding is not routinely recommended, the decision is at the discretion of the operator and patient family.
 - p. Audible periodic fluoroscopy time alerts during case. Acknowledge the cumulative timing device. A reminder of the elapsed fluoroscopy time can be given to the operator during the procedure.
 - q. Image acquisition limited only to needed (frames per second, lower dose protocols, magnification, length of run)
4. After procedure:
- a. Review dose
 - b. Counsel if skin dose greater than or equal to 2 Gy or cumulative dose of greater than or equal to 3 Gy (NCI)
5. Education
- a. All operators receive comprehensive training in radiation physics, biological effects and safety.
 - b. Ongoing yearly training after initial certification
 - c. Audit radiation doses for all operators
 - d. Specific feedback and additional training when needed
 - e. All operators and team members, including non-radiology users be taught, tested and credentialed in radiation physics principles, radiation biology and radiation safety.
6. Measurement and QA
- a. Record available indications of patient radiation dose including DAP, cumulative air kerma, etc. If these indices of radiation dose are not available, record

fluoroscopy time and an estimate of the total number of recorded images, so that patient dose could be estimated in the future if necessary.

- b. Patient dose record (Medical Imaging Record)
 - c. QA measures: Participate in or support radiation awareness undertakings in your department
 - d. In house radiation dose database of patients, procedures and dose information
 - e. Review radiation dose database to flag patients with doses greater than 2 Gy for follow up
 - i. Notes to primary care physician about procedure, dose and possible short and long term effects.
 - ii. Counsel patient and primary care to call if erythema develops at beam entrance site
 - iii. Establish follow up procedures including skin examination at 30 days
7. Minimize cumulative dose over time for radiology operator and staff
- a. Remember that reducing patient dose reduces scatter and dose to personnel also: they are tied together
 - b. Personal protective equipment:
 - i. Lead eyewear
 - ii. Well fitted lead apron
 - iii. Thyroid shield
 - c. Use hanging lead shields to protect lower extremities and movable overhead shields for face and neck protection. Set up the room at the start of the case with lead table skirts and all shielding. Don't be hesitant to remind the operator of their use.
 - d. When using lateral fluoroscopy, position personnel on same side as the image receptor/detector to decrease operator scatter dose from X-ray source
 - e. Step away during fluoroscopy or image acquisition if possible
 - f. Operator hands out of beam
 - g. Use power injector when possible. If hand injection, use extension tubing.
 - h. Distance: Advise the personnel in the room of the inverse square law (nurses, anesthesia, physicians)