BMC2 Best Practices to Enhance Cath Lab Radiation Safety

Use of ionizing radiation during fluoroscopically-guided procedures can adversely impact patients and medical personnel. Reducing radiation exposure during cardiac catheterization is of paramount importance. Advances in fluoroscopic equipment and application of radiation safety protocols can significantly reduce radiation doses to patients, physicians, and laboratory staff, yet recent data from catheterization laboratories across the state of Michigan suggests radiation safety practices are not uniformly applied. By no means a comprehensive review of radiation safety, this document is intended to provide catheterization laboratories a list of practical tips and best practices for enhancing radiation safety in the catheterization laboratory.

I. Best Practices to Reduce Patient Radiation Doses

- Radiation safety education: Radiation safety training has been shown to increase operator awareness and reduce exposure. BMC2 recommends radiation safety education for all catheterization laboratory personnel at the time of initial hire and then annually at least every 3 years.

- Limit fluoroscopy intensity and time: Fluoroscopy should only be used when the operator is looking at the monitor. Modern fluoroscopy systems offer low (7.5 frames/sec), medium (10 frames/sec), and high-intensity (15 frames/sec) modes. Decreasing the fluoroscopy rate from 15 to 7.5 f/s has been shown to significantly reduce patient radiation exposure. Catheterization laboratories that have set the default fluoroscopy rate to 7.5 frames/second have noticed a decline in total radiation dose with no untoward patient outcomes and BMC2 recommends such an approach. In addition to lower the frame rate, the max R of the fluoroscopy system should be set as low as possible to achieve adequate image quality.

- Limit cineangiography: The radiation dose during cineangiography is up to 10 times higher than during fluoroscopy. Cineangiography should only be used when necessary. When higher resolution images are not required, use of "fluoroscopy save" function can be used to store fluoroscopy images and reduce the need for cineangiography.

- Table position: In order to minimize the patient's radiation dose, the table should be raised to the maximal height that still allows the operator to comfortably perform the procedure. By increasing the table height and moving the patient further from the X-ray tube, the patient's radiation dose will be decreased. The optimal table height to minimize physician and staff radiation exposure requires further study.

- Image intensifier position: The image intensifier should be positioned as close as possible to patient's chest. This will result in a lower patient dose.

- Image angulation: Image projections characterized by steep angulations are associated with higher radiation doses. Images with steep angulations should be avoided when possible.

- Collimators and shutters: Use of collimators and shutters should be used frequently to reduce patient radiation dose.

- Imaging equipment: Advances in fluoroscopic systems incorporate novel technology to minimize radiation doses and allow for many adjustable radiation dosing parameters. Given the potential of novel fluoroscopy systems to reduce radiation doses, catheterization laboratories should recognize that older fluoroscopy systems may not provide the same image quality and the lowest possible dose compared to newer systems.

- Case selection: Whenever possible, procedures typically associated with longer procedure duration (i.e. CTO interventions) should be performed in laboratories with the most up to date fluoroscopy equipment.

II. Best Practices to Reduce Physician Radiation Dose

* Because the largest source of physician radiation exposure is scatter radiation emitted from the patient, most practices listed above intended to reduce patient radiation dose will also result in lower radiation doses to the operating physician.

- Protective lead apparel: All operators should wear a protective lead apron, thyroid collar, and protective lead glasses that are at least 0.25 mm lead equivalent. Exception to use of protective lead apparel exists when using a robotic system to perform PCI or when utilizing a suspended lead suit.

- Distance: When possible, operators should increase their distance from the patient.

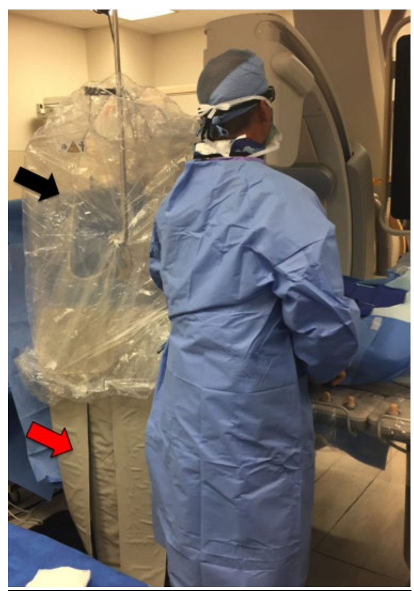
- Imaging projections: Imaging projections wherein the X-ray tube is closer to the operator are associated with higher operator radiation doses. Consequently, operators should minimize use of left anterior oblique (LAO) projections, especially the LAO cranial and lateral projections as this projection is associated with the highest operator radiation dose.

- X-ray system program settings: The programmed settings within the X-ray system may significantly impact radiation dose to the patient and operators. Cath lab medical leadership should work closely with the cath lab vendor on a regular basis to adjust settings that achieve acceptable image quality while minimizing dose.

- Shielding: Operators should maximize the use of a ceiling-suspended acrylic lead shield and a table-suspended lead curtain (Figure). Optimal positioning of the ceiling-suspended lead shield has been previously reported. Novel radiation shielding technologies, including radiation absorbing pads, robotic systems, suspended lead suits have also been demonstrated to be effective means of reducing operator radiation doses.

- Dosimeters: Operators should wear two dosimeters during each case, one at the thyroid collar and one under the protective apron, to monitor their occupational radiation exposure. Real-time dosimeters, which provide operators with data on radiation exposure occurring in real-time during the case, have been associated with reduced operator radiation doses.

Figure: Accessory Lead Shields
Shown are the appropriate positions of a ceiling-suspended acrylic lead shield (black arrow) and table-suspended lead curtain (red arrow).



III. Best Practices to Reduce Staff (Nurses and Technologists) Radiation Doses

* Because the largest source of staff radiation exposure is scatter radiation emitted from the patient, most practices listed above intended to reduce patient radiation dose will also result in lower radiation doses to the laboratory staff members.

- Protective lead apparel: All staff should wear a protective lead apron, thyroid collar, and protective lead glasses that are at least 0.25 mm lead equivalent.

- Distance: When possible, staff should increase their distance from the patient. Staff should not approach the patient when fluoroscopy or cineangiography is in use. Operators should not use fluoroscopy or cineangiography when staff members approach the patient. If a vendor is required in the cath lab to support a case, the vendor should stand behind the physicians and avoid standing on the opposite side or end of the cath lab table.

- Dosimeters: Staff should wear two dosimeters during each case, one at the thyroid collar and one under the protective apron, to monitor their occupational radiation exposure.

- Shielding: Use of dedicated lead shields for staff members have been associated with significant reductions in staff radiation doses.

IV. Other Best Practices to Promote a Culture of Radiation Safety

- Record patient radiation dose: Patient radiation doses including dose area-product and air kerma should be recorded in the medical record after each case.

- Patient radiation dose ≥5 Gy: Patient radiation doses characterized by an air kerma (AK) of ≧5 Gy should be disclosed to the patient. The performing physician, cath lab manager, and radiation safety officer should also be notified. Patients having a dose ≥5 Gy should be monitored for the development of skin injury within the first 30 days of follow up.

- Patient radiation dose 10 Gy: In addition to items listed above for doses ≥5 Gy, cases having an AK ≥10 Gy should have a peak skin dose calculated by a qualified physicist. Patients should undergo a skin examination at 2-4 weeks to evaluate for skin injury. Consideration should be given to reporting cases with an AK ≥10 Gy to the hospital's risk management group for investigation and follow up.

- Patient radiation dose 15 Gy: In addition to items listed above for doses ≥5 Gy and ≥10 Gy, cases having an AK ≥15 Gy should be reported to organizational risk management. Depending on the calculated peak skin dose, risk management should evaluate the need to report the case to the Joint Commission.

- Physicians and staff radiation dose: Physician and staff members should have their occupation radiation doses monitored to ensure they do not exceed occupational dose limits. A mechanism should be in place to regularly monitor doses and provide education as needed for those having high doses.

- Monitoring lead garments: Catheterization laboratories should institute programs to have the lead garments worn by their physicians and staff screened with fluoroscopy at least annually to detect damage, cracks, or holes in the lead protection. When such defects are detected, these damaged garments should be replaced.

- Quality Assurance Meeting: Radiation dose data should be presented/discussed at a Department meeting at least annually.

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