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Monitoring and Tracking of Fluoroscopic Dose

Handout developed by CRCPD's H-31 Task Force for Monitoring Patient Dose during Fluoroscopy

Protecting our Patients and Ourselves

It is important for operators of fluoroscopic equipment to be aware of the radiation dose that patients and staff are receiving. While it is accepted that the medical outcome of the procedure usually outweighs the radiation risk incurred by the patient, this does not mean that the radiation dose should be anything other than As Low As Reasonably Achievable (ALARA) to obtain the best quality images. Good quality images are imperative for an accurate visualization of the anatomy and abnormalities that may be present and the treatment thereof. Additionally, if you reduce the patient dose, you will reduce the staff dose as well.

Fluoroscopic interventional procedures is an area where high radiation dose risks and deterministic effects are most prevalent. Many procedures of this type are performed in cardiac catheterization labs and other interventional procedure suites. Regardless of what type of procedure if performed, being dose conscious is paramount.

Awareness of fluoroscopic dose during procedures is critical in protecting your patients and staff. Dose monitoring is a necessary part of an effective radiation dose management program. Radiation deterministic effects may be induced with high exposures to radiation. These injuries may be immediately seen or may occur several days to weeks later. With proper dose monitoring and tracking, these injuries may be reduced or eliminated in some cases. Monitoring patients will also help predict which ones might be at risk for injury, and those individuals could be observed more closely.

Suggestions for radiation dose management programs, dose monitoring methods, and patient care will be discussed in this handout.

Topics:

Radiation Dose Management

A comprehensive radiation dose management program should address three main areas specifically. These include training of the fluoroscopist and staff, monitoring and tracking of fluoroscopic dose, and patient follow-up.

Training should include at a minimum:

1. Biological effects of ionizing radiation
2. Radiation protection of patient/staff
3. Use of personal protective equipment (i.e., shields, aprons, etc.)
4. Threshold action levels
5. Personnel dose monitoring

This training should be performed initially and as an annual refresher course.

Each facility should have an orientation/certification system for newly employed fluoroscopists to ensure proficient skill in the safe operation of each fluoroscopic system. Established operators should be oriented when new systems are installed.

Monitoring Methods

Modern fluoroscopy equipment that has been manufactured since 2006 is equipped with a dose monitoring system. These systems monitor dose rate and cumulative dose. By utilizing a dose monitoring system, dose threshold limits can be monitored and notifications can be made so that the fluoroscopist can better manage the radiation prescription.

Air kerma, dose-area product meters, electronic dosimeters, and fluoroscopy time are all examples of methods of monitoring. Facilities with older fluoroscopic systems that are not equipped with monitoring systems should consult with a qualified medical physicist to determine which method of monitoring is best for your particular equipment and facility.

Tracking of Fluoroscopic Dose

A dose monitoring and tracking program should include various threshold level of notifications so that the fluoroscopist is aware of current levels of radiation dose that the patient has received. The dose data should be used during fluoroscopic procedures to adequately monitor radiation dose without compromising medical treatment. Some suggested levels are noted in the following table.

Summary of Radiation Monitoring Dose Notification Thresholds

Parameter	First Notification	Subsequent Notifications
PSD	2000 mGy (200 rad)	500 mGy (50 rad)
$K_{a,r}$	3000 mGy (300 rad)	1000 mGy (100 rad)
P_{KA}	300 Gy·cm² *	100 Gy·cm² *
FT	30 min	15 min

*Assuming a 100cm² field at the patient's skin. The value should be adjusted to the actual procedural field size.

The above table, radiation monitoring dose notification thresholds, and the suggested threshold values table on page 3 are reprinted with permission: Stecker, Michael S., M.D., S Balter, Ph.D., et al. Guidelines for Patient Radiation Dose Management. Journal of Vascular and Interventional Radiology (2009) 20: pp S263-S273.

All available dose data should be recorded for every fluoroscopic procedure. This information should be immediately reviewed to determine if the patient is at risk for deterministic effects.

The entire data log should be periodically reviewed as part of the facility's quality management program.

Deterministic Effects

Single-site Skin Dose Range (Gy)	Prompt < 14 days	Early 14 – 40 days	Mid term 40 – 400 days	Long term > 400 days
0-2	No observable effects expected			
2-5	Transient erythema	Transient hair thinning	Hair recovery	None expected
5-10	Transient erythema	Erythema, epilation	Recovery from previous effects; at higher doses, possible prolonged erythema. Permanent partial epilation	Recovery, with possible permanent skin changes at higher doses in this range.
10-15	Transient erythema	Epilation, erythema. Possible moist desquamation at higher doses, with subsequent healing	Permanent total epilation. Prolonged erythema	Telangiectasia, induration. Skin likely to be weak and more susceptible to secondary injury.
> 15 *	Transient erythema and possibly pain. Edema and acute ulceration after very high doses (> 80 Gy)	Epilation, erythema, moist desquamation. Possible healing of acute ulceration.	Dermal atrophy. Secondary ulceration in areas of prolonged moist desquamation after higher doses. Dermal necrosis. Surgical intervention likely required; should be delayed until viable tissues are defined.	Telangiectasia, dermal atrophy/ induration. Depending on dose and patient characteristics, any persistent wound might progress into a deeper lesion. Healing in absence of surgical correction likely to result in some or all of the following: scarred tissues, weak skin susceptible to injury, skin breakdown reoccurring at later dates.

* Some effects may occur sooner than noted and be more pronounced as dose increases above 20 Gy. Adapted from Balter et al. — Radiology in Press

Patient Notification and Follow-up

Radiation risks should be discussed with the patient as part of the pre-procedure patient consent process. Procedures where the radiation dose may be potentially high should be discussed with the patient, and the patient should be informed of the possible deterministic risks.

In the event that a threshold level has been met or exceeded, the patient should be made aware of symptoms that may occur and be advised that they should notify their physician as well as the facility promptly if symptoms should occur. Facilities should follow up by telephone approximately 3 weeks after the procedure to ascertain whether there is any evidence of a radiation induced injury. This will assure that prompt medical care will be delivered if necessary.

The following table has some suggested threshold values for patient follow-up.

Parameter	Threshold
PSD	3000 mGy
$K_{a,r}$	5000 mGy
P_{KA}	500 Gy·cm^2
FT	60 min

Table reprinted with permission from the Journal of Vascular and Interventional Radiology (2009). See p. 2 for full citation.

It is recommended that the facility radiation safety committee/officer take an active role in reviewing all cases that meet or exceed the dose threshold level. The committee should review the cases to ensure that appropriate notification has occurred and that medical follow-up has been pursued.

NOTE: Currently only a few states have implemented regulations that require dose tracking. The threshold dose values may differ from those used in the table above. Please consult your own state's regulations for what may apply to your facility.

Dose Reduction Techniques

Methods should be employed to help minimize radiation dose during fluoroscopic procedures. These include but are not limited to the following:

1. Minimize beam on time.
2. Vary the site of the entrance port on the patient as clinically possible.
3. Optimal collimation.
4. Use the least amount of machine magnification possible.
5. Position the x-ray source and image receptor optimally.
6. Understand and utilize machine dose reduction features: last image hold, pulsed fluoroscopy.
7. Maintain equipment in good repair and calibration.

Final Notes

All machines manufactured after June 2006 have the ability to track and display patient dose both in real time and cumulatively. Facilities are encouraged to make efforts to incorporate dose display features into fluoroscopic equipment manufactured prior to June 2006. Each facility should consult with a qualified medical physicist and decide which method is best.

It should be noted that radiation dose from medical exams is not solely a fluoroscopic issue. All medical radiation doses should be tracked and considered to determine if an increased deterministic risk exists.

For more information on this topic, a comprehensive paper can be referenced on the CRCPD website at www.crcpd.org.

Common Procedure Skin Doses

Procedure	Skin Dose	Author/Year/Journal
TIPS	~2,168 mGy (217 rad)	Miller et al., 2003, JVIR
Nephrostomy	~258 mGy (25.8 rad)	Miller et al., 2003, JVIR
Neuroembolization—Head (all types)	~1,977 mGy (198 rad)	Miller et al., 2003, JVIR
Neuroembolization—Spine (all types)	~3,739 mGy (374 rad)	Miller et al., 2003, JVIR
IVC Filter Placement	~193 mGy (19.3 rad)	Miller et al., 2003, JVIR
Biliary Drainage	~781 mGy (78.1 rad)	Miller et al., 2003, JVIR
Hepatic Embolization	~1,959 mGy (196 rad)	Dauer et al., 2009, JVIR
Percutaneous Coronary Intervention	~2 Gy (200 rad)	Suzuki et al., 2006, Circulation Journal
PTCA & CA	~1,407 mGy (141 rad)	Balter, et al., 2008, Medical Physics

Ask yourself these questions:

Is your facility prepared?

How knowledgeable is your staff?

How do you compare?

How much dose am I delivering to my patients?

Are my staff properly protected?

Quotable Quote

"...Deterministic effects should never be a post procedure surprise."

Stephen Balter, Ph.D.