

GE Healthcare

DoseWatch

Radiation Dose in
Interventional Radiology



Introduction

Since the advent of modern interventional radiology procedures in 1977,¹ there has been significant growth in fluoroscopically-guided interventional (FGI) procedures.² In 2008, approximately 5 million FGI procedures were performed in the United States.³

FGI procedures are performed for several reasons:

- localize a lesion or treatment site;
- monitor a procedure; or
- control or document therapy.⁴

Compared to conventional radiography and fluoroscopic examinations, FGI procedures require increased exposure to radiation. FGI procedures with potential for high skin doses include:

- TIPS creation
- Embolization (any location, any lesion)

- Stroke therapy
- Biliary drainage
- Angioplasty with or without stent placement
- Stent-graph placement
- Chemoembolization
- Angiography and intervention for gastrointestinal hemorrhage
- Carotid stent placement
- RF cardiac ablation
- Complex placement of cardiac EP devices
- PCI (single or multiple vessel)

Radiation Health Effects

The biological effects of ionizing radiation can be divided into two broad categories:

1. **Stochastic Effects**
2. **Deterministic Effects**

Stochastic Effects include potential long-term effects such as cancer. Risk of stochastic radiation effects depends upon many variables:

- Demographic indices (patient age, patient gender and patient weight); and
- Patient medical history (prior x-ray exams).

Deterministic Effects are short-term effects observed in the portion of the patient's body receiving direct exposure to radiation. Deterministic effects can be characterized by threshold doses below which the effect is not observed. The severity of deterministic effects increases with increasing dose.

Deterministic effects (skin) have been observed in patient's undergoing FGI procedures. The observed effects may result from a single FGI procedure or a series of procedures. When tissue reactions occur, they are observed in localized areas correlating to the portion of tissue receiving the highest dose.

For FGI procedures, the tissues of interest include:

- Hair follicles
- Skin
- Subcutaneous tissue
- Lens of the eye

Radiation Dose

When a patient is exposed to radiation, energy is transferred to the tissues of the patient's body. Estimates of **radiation dose** are an attempt to describe the amount of energy deposited in a small well-defined portion of a patient's body. In FGI procedures, radiation dose is non-uniform and wide variations in absorbed dose are observed from one region of the patient's body to another. For this reason, uncertainty exists in all estimates of patient dose.

There are several useful parameters for describing patient radiation dose estimates in FGI procedures.

Peak Skin Dose ($D_{\text{skin, max}}$)

Peak Skin Dose is the highest absorbed dose in any portion of the patient's skin accumulated during a procedure. Peak Skin Dose includes contributions from the primary x-ray beam, leakage radiation and scattered radiation.

The National Council on Radiation Protection recommends the use of Peak Skin Dose to evaluate the potential for **deterministic** effects in specific tissues.² It is possible to estimate peak skin dose by tracking the radiation output of the x-ray tube.

Cumulative Air Kerma ($K_{A,R}$)

Cumulative Air Kerma is an estimate of peak skin dose – described in units of **milligray (mGy.)** $K_{A,R}$ is determined for a specific point in space – **the air kerma reference point**. The reference point approximates the location on the patient's skin at the point where the x-ray beam enters the body. The U.S. Food and Drug Administration (FDA) defines the reference point as a point 15 cm on the tube side of iso-center.⁵

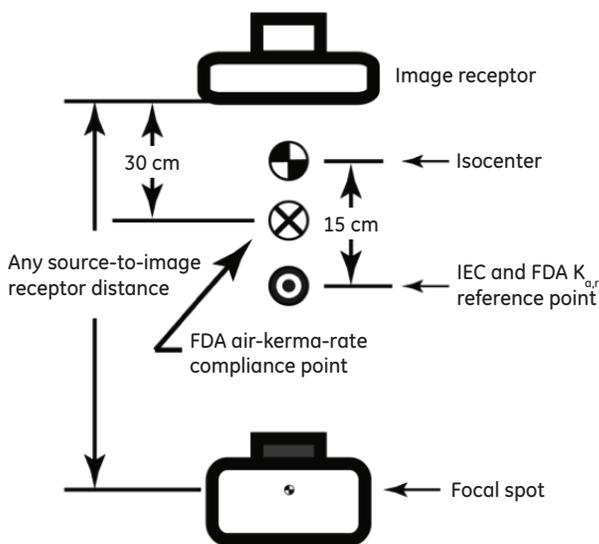


Figure 1. Air Kerma Reference Point⁶

Dose Area Product (DAP)

Dose Area Product (DAP) or **Air Kerma Area Product (P_{KA})** describes the total energy delivered by the x-ray tube. DAP is measured at a point close to the source of X-rays – often within the collimator housing. DAP is related to stochastic risk since it describes the total energy absorbed by all tissues in the patient. DAP is less useful for estimating deterministic risk.

Fluoroscopy Time (FT)

Fluoroscopy Time indicates the total time the x-ray beam was active during the patient procedure. Fluoroscopy time should not be used as the only dose indicator during potential high-dose procedures.² FGI procedures of relatively short duration (< 60 minutes) are still capable of delivering peak skin doses of concern.

Effective Dose (E)

Effective Dose is a single dose index describing risk of a non-uniform radiation exposure in terms of an equivalent whole body uniform exposure. The units of effective dose are millisieverts (mSv). The effective dose describes a relative whole-body dose for a specific protocol and scanner.

Effective Dose is not a direct measurement; rather it is derived by applying a tissue-weighting factor to estimates of organ dose.

NCRP Report No. 168 recommends “Effective Dose shall not be used for quantitative estimates of stochastic radiation risk for individual patients or patient groups”.²

Dose Reduction Techniques

The following strategies have been effective at lowering patient radiation dose in FGI procedures:

1. **Monitor Cumulative Dose**
Establish dose thresholds – possibly based on accepted standards.
2. **Minimize duration of X-ray**
Do not image longer than necessary. Consider modification of X-ray tube angle to lower dose for frequent anatomical views.
3. **Maximize X-ray tube-to-patient distance**
For under-table X-ray tubes, elevate patient imaging table as far above the tube as is consistent with acceptable work practices.
4. **Collimate**
Limit primary X-ray beam to organ or area of interest.
Use largest acceptable image receptor field of view with collimation as opposed to magnification.
When magnification is required, use lowest acceptable dose rate.
5. **Remove grid**
Only for infants up to 1 year old at field of view smaller than 20 cm.
6. **Lower the overall dose level**
Use RDLStandard or RDLPlus AutoEx settings if image quality is acceptable.
7. **Use LOW vs. NORMAL detail**
Use LOW detail if image quality is adequate.
8. **Use lowest acceptable frame rate**
Lower frame rates can reduce dose rate. There is approximately a 50% dose rate reduction associated with a 2:1 frame rate reduction.
9. **Use larger field of view**
A small field of view typically requires additional dose to maintain magnified detectability.
When possible, consider a larger field of view with collimation.
10. **Keep detector close to patient**
Bring image receptor as close to patient as possible – consistent with procedural requirements.
11. **Adjust collimation without radiation**
12. **Store fluoro / Use last image hold**

Conclusion

Fluoroscopically-guided interventional procedures have proven beneficial for use by physicians for patients with certain indications. These procedures, however, require increased exposure to radiation, increasing the need for facilities to develop and implement a comprehensive dose optimization strategy. To be effective, this strategy should combine strong leadership, solid processes and dose optimization technology that enables compliance, improves clinical and quality outcomes, and also enhances a facility's reputation in its community.

References

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- [5] U.S. Food and Drug Administration. "Performance Standards for ionizing radiation emitting products. Fluoroscopic equipment." 21 CFR Part 1020.32, 2009, <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cdcfr/CFRSearch.cfm> U.S. Government Printing Office, Washington, D.C.
- [6] National Council on Radiation Protection Report No.

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