Dose at an interventional reference point: Comparison between displayed values of X-ray units and actual measured values

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Learning objectives

- To understand the importance of dose at the interventional reference point (reference dose) in interventional radiology (IR).
- To discuss the accuracy of displayed reference doses in IR X-ray equipment.
- To show the importance of evaluating the patient radiation dose in IR.
Background

Because protection from radiation is important in IR, the radiation dose should be measured. Today, IR X-ray units are required to display doses at IR (reference dose) to the operator (physician). However, no detailed report has evaluated the accuracy of the reference doses displayed on X-ray equipment.
Interventional reference point (IRP)

It is calculated as a defined target point for radiation, a fixed distance from the gantry isocenter along the central ray of the X-ray beam, termed the interventional reference point (IRP), defined by the International Electrotechnical Commission (IEC). Today, IR units are required to display doses at IR (reference dose) to the operator at the operator’s working position (Fig. 1).

The IRP is located 15 cm from the isocenter of an IR X-ray unit and at the focus point of the central beam (Fig. 2). Modern X-ray machines for IR display the dose at the IRP (reference dose). The reference dose is calculated and estimated, based on the definition of the IRP as described in the IEC standard. The reference dose does not include backscatter.

Measurement of reference dose

This study examined 15 X-ray systems in nine cardiac catheterization laboratories in and around Sendai, Japan (Table 1). Of the 15 X-ray systems measured, 13 used a flat-panel detector (FPD) and two used an image intensifier (II).

Figure 2 shows the measurement geometry used in this study. The actual reference doses at 15 cm from the X-ray tube side of the isocenter (on the central axis of the X-ray beam) were measured for the 15 X-ray systems with digital cineangiography (duration time: 10 s) and fluoroscopy (duration time: 1 min), using 20-cm thick acrylic plates and a calibrated, thimble-type, 6-cm³ ion chamber. The ion chamber was placed at the IRP (Fig. 2).

The distance of the source from the II or FPD was 100 cm. The entrance exposure area on the acrylic phantom was associated with the actual diameter setting of the FPD or II.

Displayed reference doses on 15 IR X-ray units were compared with actual measured values from each X-ray unit.

Results

Fluoroscopy Dose of the 15 X-ray Systems
For fluoroscopy with nine X-ray systems (units A, B, H, I, J, L, M, O, P) among the 15 X-ray systems, the displayed reference doses agreed with the measured actual values within approximately 15% (Fig. 3). However, in the other X-ray systems (C, D, E, F, G, K), displayed reference doses that disagreed with the measured actual values, and the displayed reference doses were approximately one-half that of measured actual values.

Cineangiography Dose Fig. 4 on page 9

Similarly, for cineangiography, nine X-ray systems displayed reference doses that approximately agreed with the actual measured values (Fig. 4). However, in the other X-ray systems, the displayed reference doses in units C, D, E, F, G, and K, also were approximately one-half that of the actual measured values.

Discussion

Currently, many IR X-ray units can display a dose at the IRP in real-time. For many cardiac IR procedures (oblique view), the IRP approximates to the location of the skin at the beam entrance point. The cumulative dose at the IR (i.e., the reference dose) is the sum of the doses at the IRP for all segments of an IR procedure. That is, the reference dose is an approximation of the total radiation dose applied to the patient's skin in IR.

The reference dose is expressed in Gy, which is easy to use for IR physicians.

Thus, the displayed reference dose of an X-ray unit has been reported to be helpful for characterizing patient exposure in real-time. However, to our knowledge, no detailed report has evaluated the accuracy of the reference doses displayed on X-ray equipment. Thus, in this study, we compared the displayed reference doses to the actual measured value in many IR X-ray systems.

More than half the X-ray units (including those made in Japan) that we assessed displayed reference doses that were quite close to the actual measured values. In a few X-ray units (e.g., unit J) the displayed reference dose disagreed by approximately 20% from the actual measured value. Furthermore, IR X-ray systems with close fluoroscopy doses between the displayed reference dose and the actual measurement value did not necessarily have a close cineangiography dose. Thus, periodically verifying the displayed reference doses of IR X-ray equipment will be necessary for both cineangiography and fluoroscopy.

In contrast, units C, D, E, F, G, and K (all made in Japan) displayed reference doses quite different from the actual measurement value. A likely reason for the large differences is that the IRP of the displayed reference doses of the units (C, D, E, F, G, K) is not located
15 cm from the isocenter of the X-ray tube side. In the Japanese Industrial Standards (JIS), IRP is defined basically in the same way as the IEC (on the central axis of the X-ray beam, 15 cm on the X-ray tube side of the isocenter). However, JIS states that a specific point defined by the manufacture (but different from the point defined by the IEC) is acceptable as an exception. The specific point of those units (C, D, E, F, G, K) may have been defined at the catheter table (patient support table) height on the central X-ray beam. Thus, the displayed reference doses of these units (C, D, E, F, G, K) were approximately one-half of the actual measured values.

When using IR X-ray units made in Japan, IR physicians should pay attention to the IRP of the displayed reference doses, whether the point is located 15 cm from the isocenter on the X-ray tube side.
Fig. 1. This Example shows the television (display) monitor in the IR angiography room. The reference dose in this case was 331 mGy. Modern IR X-ray machines display the dose at the IRP (reference dose) to the operator at the operator’s working position.

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Fig. 2. Schematic of the geometry used for the measurements in this study.
I.I.: Image intensifier, FPD: Flat-panel detector,
SID: Source to image receptor (I.I. or FPD) distance

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Fig. 3. Displayed reference doses and measured actual values for fluoroscopy in 15 X-ray machines
Fig. 4. Displayed reference doses and measured actual values for cineangiography in 15 X-ray machines

Fig. 4: Fig.4. Displayed reference doses and measured actual values for cineangiography in 15 X-ray machines

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Table 1: Table 1. Characteristics of 13 IR X-ray systems. FPD: flat-panel detector, I.I: image intensifier

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Conclusion

In many IR X-ray systems, the displayed reference doses agreed with the measured actual values within approximately 15%. However, for some X-ray systems, the values of displayed reference doses and the measured actual doses disagreed. Therefore, physicians should be aware of the accuracy of the displayed reference dose of the X-ray system they use for IR. Thus, regular checks of the displayed reference dose of the X-ray system are important.
Personal Information

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