Utilization of Radimetrics to Calculate Peak Skin Dose for Fluoroscopically Guided Interventions: A Guide for Three Manufacturers

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Abstract

Peak skin dose (PSD) estimates are an important dose metric to assess if, when, and how to follow-up with patients who undergo fluoroscopically guided procedures. Radimetrics (Bayer Healthcare LLC, Whippany, NJ) is a commercially-available dose tracking tool that can help gather data for PSD estimations. In this study, we share our recent experience converting reference point air kerma values to PSD estimates using Radimetrics generated data.

Methods

A custom excel tool was developed to estimate PSD values based on corrections made to $K_{a,r}$ measurements with the following equation,

$$D_{tissue,skin} = \sum_i K_{a,r,i} * \left(\frac{d_{source-to-IRP}}{d_{source-to-patient,i}}\right)^2 * f_{tissue,i} * BSF_i * t_i * C$$

where, *i* = an individual acquisition.

Variable	Definition	Data Source
$K_{a,r}$	Air Kerma at the Interventional Reference Point (IRP)	Reported by the machine
$d_{source-to-IRP}$	Distance from the source to the IRP	Can be found in the machine manual
$d_{source-to-patient}$	Distance from the source to the patient	Must be determined from values reported by the machine
f_{tissue}	Tissue f-factor	Calculated as a function of half value layer (HVL) using data from Jones et al. (2011)
BSF	Backscatter factor	Calculated as a function of HVL and field of view (FOV) using data from Jones et al. (2011)
t	Table and pad transmission	Measured by physicist as a function of kVp and beam filtration
C	Air Kerma correction factor	Measured by physicist

Two types of calculation methods were used to perform PSD estimations:
Piecemeal – the PSD calculation is performed using individual data from each fluoroscopic and digital acquisition run performed during the scan.
Semi-piecemeal – the PSD calculation is performed using (1) individual data from each digital acquisition run performed during the exam, and (2) the summed reference point air kerma of all the fluoroscopic series throughout the exam.

Figure 1 demonstrates an example of a possible interventional radiology setup. The air kerma is reported at the Interventional Reference Point, however, the PSD should be calculated where the beam enters the patient.

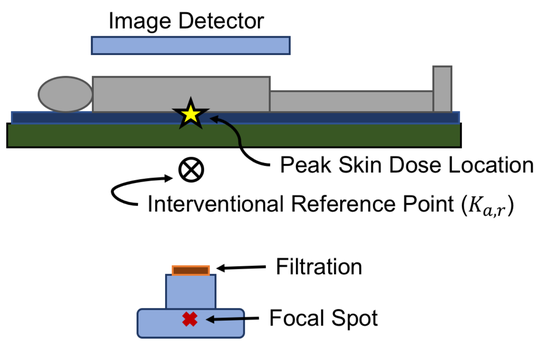

Figure 1. Diagram of a possible interventional radiology procedure setup. In order to calculate the peak skin dose, the air kerma at the IRP must be inverse square corrected to the correct height. Please note that the IRP may alternatively be further from the focal spot than the location of the patient's skin.

Results

A majority of required input data is easily exported using the *Study Exporter* tool in Radimetrics; however, this export tool is missing key information required for complete PSD calculations. **Table 1** displays the location that data can be found (independent of manufacturer) by using the Radimetrics (ver. 2.7a and 2.8.1) *Study Exporter* tool. **Tables 2-5** summarize the location where certain data can be found (manufacturer specific) within the export as well as alternative data sources when the *Study Exporter* tool does not contain information for all needed variables.

Table 1. All Systems

	Location	Name or Tag Number	Notes
Reference Air Kerma	Study Exporter	Reference_Point_Dose_mGy	Gives the air kerma at IRP for a single acquisition
Dose Area Product	Study Exporter	DAP_Gy_cm2	DAP is used in combination with reference point air kerma and table position to calculate field size
kVp	Study Exporter	kVp	

General Electric

- All of our GE equipment are capable of producing RDSRs and sending them to Radimetrics
- Beam filtration data is not exported in the *Study Export* tool
- Complete piecemeal calculations may be computed

Table 2. GE Systems Sending RDSR

	Location	Name or Tag Number	Notes
Type of Acquisition	Study Exporter	rfdosereportentry.irradiationev	This field will list "Fluoroscopy" or a type of digital acquisition
Table Height Position	Study Exporter	Table_Height_Position	Definition: The offset of the table origin to isocenter (mm) Ex. If the table is located at the IRP, a value of approximately 150 should be reported
Beam Filtration*	Study Exporter	Acquisition_Protocol_(RF)	The beam filtration can be found in the Operators manual for each acquisition protocol

Philips

- All of our Philips equipment are capable of producing RDSRs and sending them to Radimetrics
- Beam filtration and table height are not exported in the *Study Export* tool
- Complete piecemeal calculations may be computed

Table 3. Philips Systems Sending RDSR

	Location	Name or Tag Number	Notes
Type of Acquisition	Study Exporter	rfdosereportentry.irradiationev	This field will list "Fluoroscopy" or a type of digital acquisition
Table Height Position	RDSR PDF	Height of System	We convert the PDF to an excel file and extracted the table height data. Approximately the distance from floor to table top (mm)
Beam Filtration	RDSR PDF	X-Ray Filters	We convert the PDF to an excel file and extracted the filter data

Siemens (Sending RDSR)

- Some of our Siemens equipment are capable of producing RDSRs and sending them to Radimetrics
- These machines export all needed information in the *Study Export* tool
- Complete piecemeal calculations may be computed

Table 4. Siemens Systems Sending RDSR

	Location	Name or Tag Number	Notes
Type of Acquisition	Study Exporter	Acquisition_Protocol_(RF)	This field will list "Fluoroscopy" or a type of digital acquisition
Table Height Position	Study Exporter	Table_Height_Position	Definition: The offset of the table origin to isocenter (mm) Ex. If the table is located at the IRP, a value of approximately 150 should be reported
Beam Filtration	Study Exporter	Xray_Filter_Min_Thicknesses	Gives filter thickness in mm of copper

Siemens (Sending Dose Sheet and DICOM images)

- Some of our Siemens equipment do not have RDSR capabilities. These machines send Dose Sheets and DICOM images
- Beam filtration and table position are stored in the DICOM meta-data of saved images
- The Dose Sheet sums all the fluoroscopic acquisitions into a *Remainder so o*nly semi-piecemeal calculations may be computed

Table 5. Siemens Systems Sending Dose Sheet and DICOM Images

	Location	Name or Tag Number	Notes
Type of Acquisition	Study Exporter	Acquisition_Protocol_(RF)	This field will list "Remainder" for the summed fluoroscopy or a type of digital acquisition
Table Height Position	DICOM	Distance Source to Patient (0018,1111)	**Approximately the distance from the FS to the top of the table (mm)
Beam Filtration	DICOM	<No Name> (0021,100A)	** If the value is reported as 6, it means 0.6 mm of copper filtration was used

** Data is not available for fluoroscopic acquisitions unless the image was saved.

Figure 2 displays table and pad transmission data collected at all available filters. We observed that nearly twenty percent more radiation was transmitted through the table and pad for a high kVp beam with up to 0.9 mm of Cu than with a low kVp beam with no additional filtration.

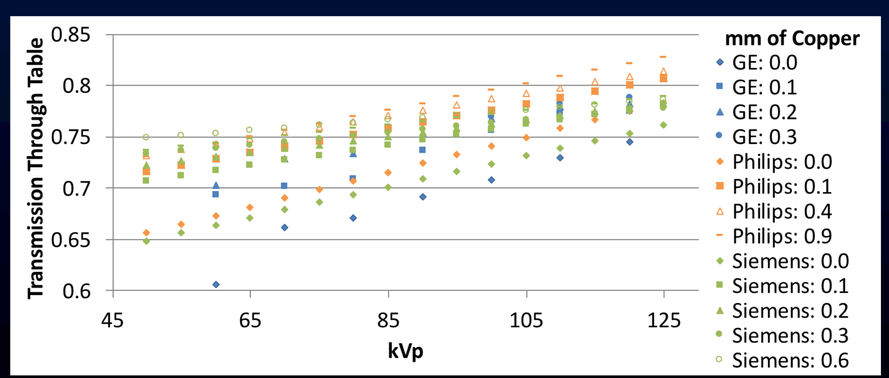

Figure 2. Plot of table and pad transmission for different levels of copper filtration for three different machines. Philips 0.1, 0.4, and 0.9 mm Cu settings all include an additional 1.0 mm of Al filtration.

Conclusions

Radimetrics can be a useful tool for piecewise PSD estimates. However, there are some limitations and vendor-specific intricacies. Easily locating the variables needed to adjust for acquisition setup and technique is often non-trivial, and therefore the development of a vendor-specific process is needed for reasonable PSD calculations.

References
Jones, A. K. and Pasciak, A. S. (2011), Calculating the peak skin dose resulting from fluoroscopically guided interventions. Part I: Methods. Journal of Applied Clinical Medical Physics, 12: 231–244.