Skin dose in interventional radiology

Uncertainty

Jonas Andersson
Medical Physics Expert, Associate Professor
Centre for information technology and biomedical engineering (CIMT)

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Skin dose – what is the uncertainty?

1. 5%

2. 10%

3. 100%

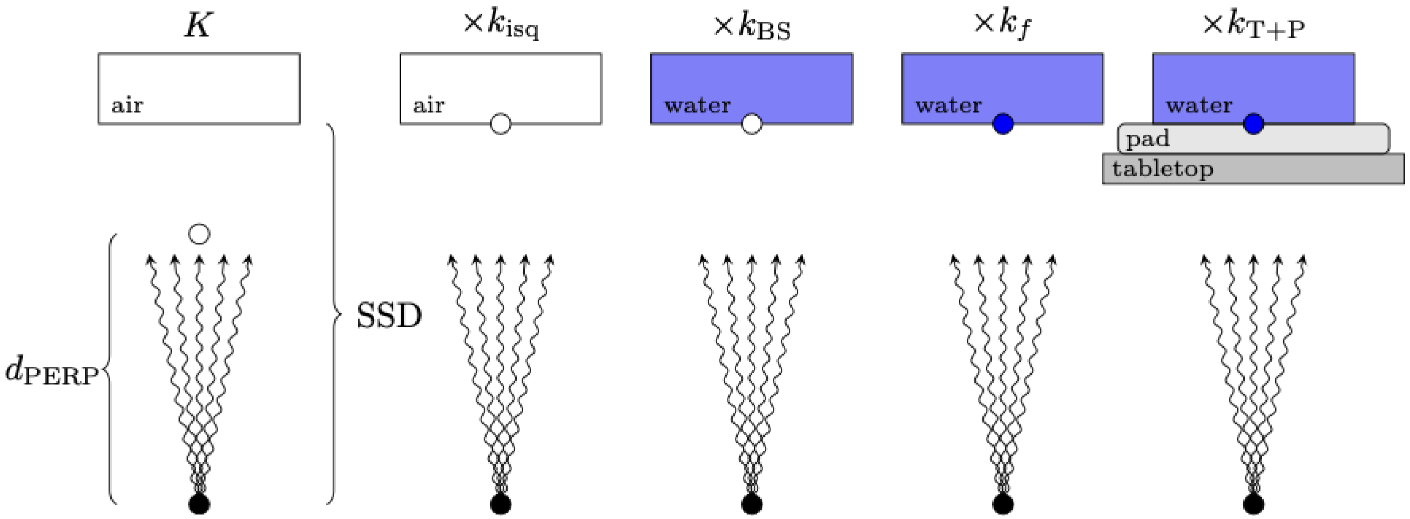

FIG. 4. Step-by-step correction of the FGI device indicated K to a skin dose estimate according to Eq. (5). The location of the measurement point is indicated with a white dot or a blue dot, respectively, depending on whether the measurement point is considered air or water equivalent.[7,8] [Color figure can be viewed at wileyonlinelibrary.com]

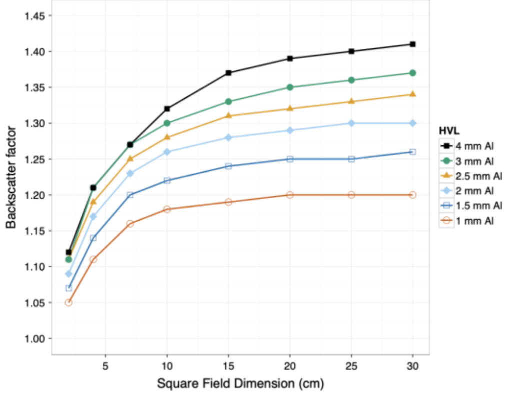

FIG. 5. Backscatter factors as a function of dimension of a square field at the entrance surface of a water phantom for different HVLs.[36] [Color figure can be viewed at wileyonlinelibrary.com]

TABLE III. Mass energy-absorption coefficients relative to air.[47]

Energy (keV)	Soft Tissue	Muscle	Eye Lens	Cortical Bone	Compact Bone
10	1.052	1.047	0.940	5.652	3.937
15	1.051	1.046	0.931	6.288	4.359
20	1.051	1.046	0.926	6.682	4.610
30	1.051	1.047	0.925	6.962	4.792
40	1.056	1.053	0.939	6.596	4.576
50	1.064	1.061	0.967	5.700	4.016
60	1.073	1.071	0.998	4.604	3.320
80	1.087	1.086	1.046	2.865	2.225
100	1.095	1.094	1.071	1.972	1.654
150	1.100	1.100	1.089	1.275	1.221

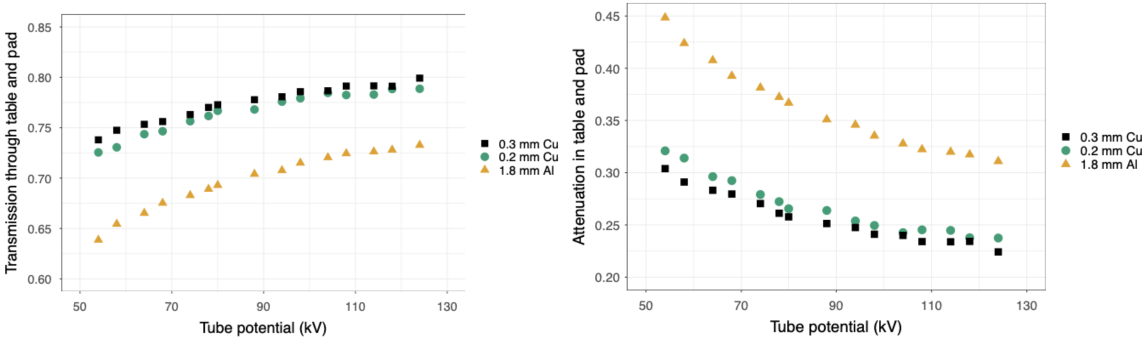

FIG. 8. Examples of measured tabletop and pad attenuation and transmission.[54] Left: the ratio of beam intensity transmitted through the tabletop and pad to the intensity measured in air, as a function of kV for the three spectral filters. Right: $\mu_T t_T + \mu_P t_P$ shown as function of kV for three different spectral filters [Color figure can be viewed at wileyonlinelibrary.com]

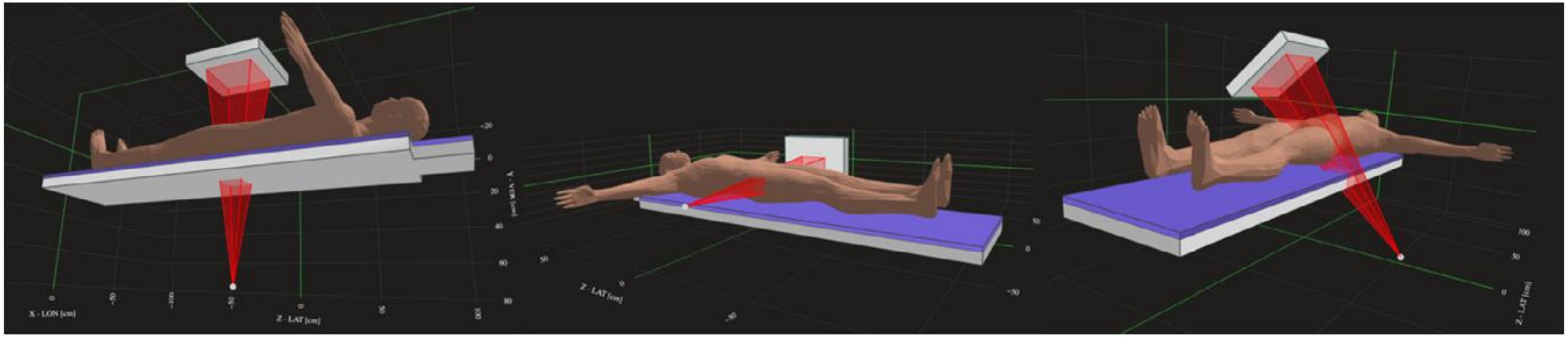

FIG. 16. Illustration of the importance of applying the tabletop and pad correction factors on a skin patch level. Left: Normal incidence posterior projection, in which all irradiated skin patches should be corrected for tabletop and pad attenuation. Middle: LAO projection, where no patches of skin should be corrected for tabletop and pad attenuation. *Right:* RAO projection, where parts of the X-ray beam are covered by the tabletop and pad.[8] [Color figure can be viewed at wileyonlinelibrary.com]

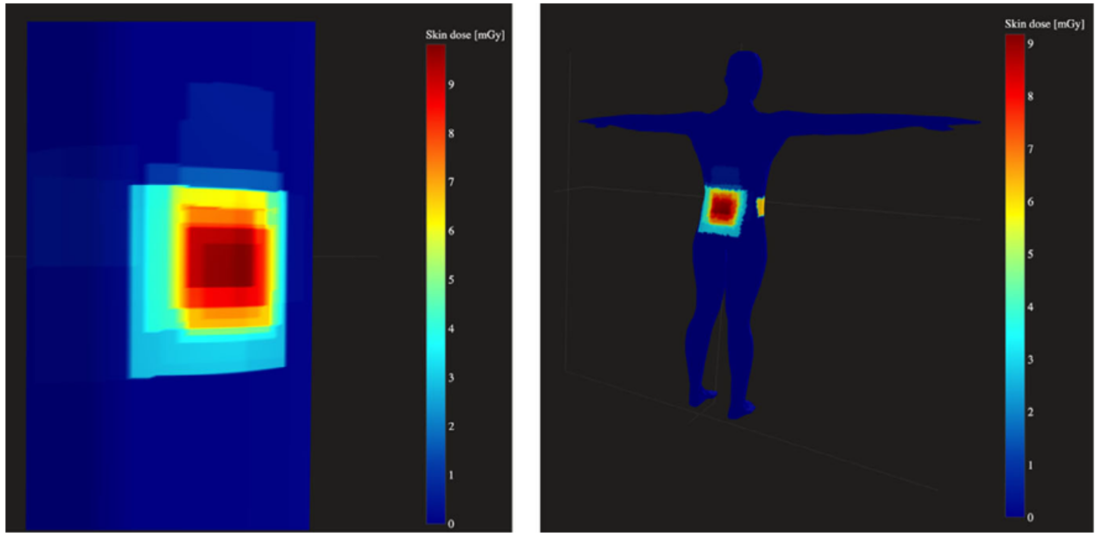

FIG. 18. Illustration of dose maps calculated from RDSR data Left: Calculated with a cylindrical phantom and Right: A human-shaped phantom.[8] The PSD estimate equals maximum absorbed skin dose to any of the skin patches on the patient phantom. [Color figure can be viewed at wileyonlinelibrary.com]

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TABLE IV. Identified uncertainties associated with basic skin dose estimates, employing only physical corrections, from FGI device procedures

Source	Description	Magnitude of Error
Air kerma (K) at the PERP	a. Measurement performed by a medical physicist. b. Required tolerances by IEC and FDA.[15,24]	a. ±5%, inclusive of ±2 standard deviations. b. Up to ±35%, stated tolerances provided by the manufacturers.[15,24]
X-ray Beam Size (Area) at the PERP	Correction for beam size. See the Report of AAPM Task Group 190.[14]	An error with the beam size affects P_{KA}, which propagates to K for FGI devices with KAP-meters. An area that is wrongly stated as too large can cause overlapped irradiated areas when performing skin dose mapping (Section 4.2).
Tabletop and Pad Attenuation	Attenuation of primary beam by the tabletop and pad, which depends upon kV, added filtration, as well as angle of beam incidence on the tabletop.	25% to 45%.
Forward Scatter from Tabletop and Pad	Forward scattered X rays from the tabletop and pad.	8% to 12% of the primary beam.
Backscattered X rays for Soft tissue	X rays that are backscattered to the skin of the patient.	5% to 50%, depending on field size and beam quality. Up to 15% for cortical bone directly beneath the skin.
Backscattered X rays for Phantoms	Differences noted with back scatter corrections obtained using different phantom materials.	Up to 10%, depending on the actual phantom material.
Distance Correction to Skin Surface – Actual Patient versus Computational Model	Inverse square law from the X-ray source to patient. Large patients and lateral projections may be expected to cause the largest variations.	±20%, depending on the relative position of X-ray source and irradiated patient skin area.
Conversion of Skin Exposure to Skin Dose	Conversion of air kerma to absorbed skin dose.	Up to 4%, depending on X-ray beam energy.
Non-uniformity of the X-ray Beam	Correction for non-uniform irradiation of the patient skin, for example, from the heel effect and use of wedge compensation filters.	Up to 15%, depending on incident beam area on patient skin.

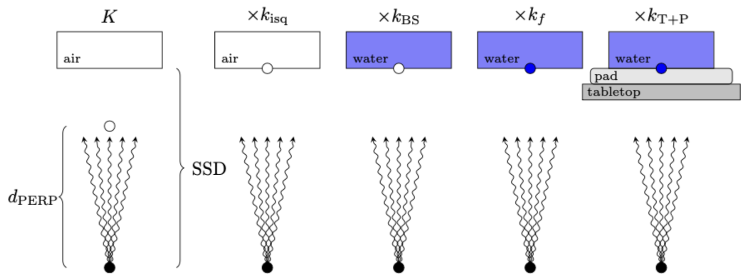

FIG. 4. Step-by-step correction of the FGI device indicated K to a skin dose estimate according to Eq. (5). The location of the measurement point is indicated with a white dot or a blue dot, respectively, depending on whether the measurement point is considered air or water equivalent.[7,8] [Color figure can be viewed at wileyonlinelibrary.com]

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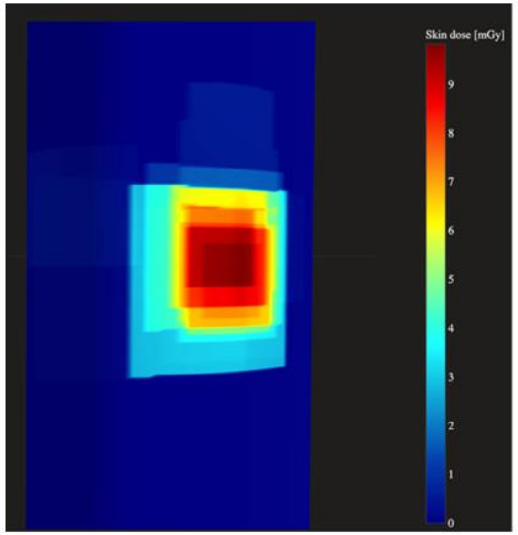
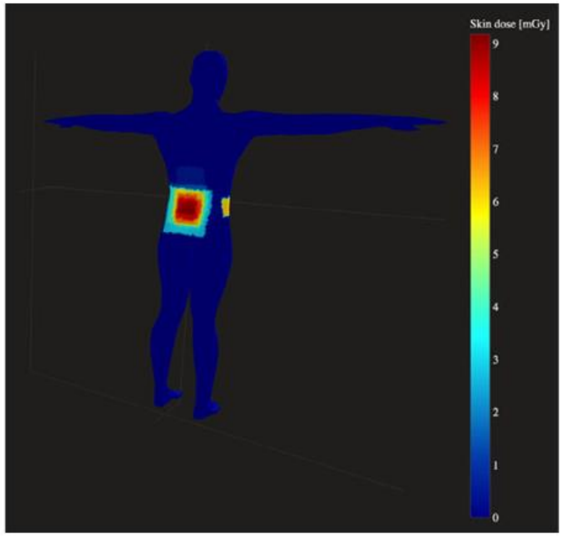
TABLE VI. Identified uncertainties associated with skin dose mapping estimates from FGI procedures

Source	Description	Magnitude of Error
Computational Phantom Type and Format	A statement is needed on which computational phantom was used, together with characteristics: • Human like or cylindrical/ elliptical phantom. • Computational phantom height and weight. • Model number or another descriptor. • Size of the smallest skin patches on the phantom.	Dependent upon phantom agreement with actual patient. If patient is supine and the X-ray tube is under the tabletop, the uncertainty may be described using Table 4.1.
Computational C-arm Models	If a virtual C-arm is used to estimate skin dose, the element matching should be stated. Further important information associated with uncertainty include: • SID matching to the actual FGI device. • Determination of X-ray beam shape (square or rectangular). • Longitudinal and lateral tabletop position movement for locating the X-ray beam on the phantom.	Aspects associated with identifying the irradiated patches of the phantom skin should be noted.
Matching a Patient with a Computational Phantom	Patient size will affect accuracy of skin dose estimates, particularly with angled C-arm projections. Data on patient to phantom match should be presented.	10% to 15%
Patient Location on the Tabletop	A statement on the method used for locating the actual patient on the tabletop, for example, 15 cm from the top of the head to the end of the tabletop. Patient movement or position change during the procedure must also be taken into account.	NA
C-arm Angulation During an Irradiation Event	RDSR provide the start angle for each irradiation event, but not the stop end position. Only images sent to PACS store the C-arm angulation and tabletop locations in DICOM image header tags.	The assumptions used in the beam location on the patient should be stated. For example, all irradiation events list the start location as irradiated during an entire sequence.
Resolution of Skin Dose Regions and X-ray Beam Collimation	No agreement exists for the needed resolution.	NA





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Review of skin dose software

https://www.sciencedirect.com/science/article/pii/S1120179720302398#t0005