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DoseWise Portal

Peak Skin Dose

Estimating Peak Skin Dose from fluoroscopic procedures **using DoseWise Portal**

What is Peak Skin Dose and why is it important?

Peak Skin Dose (PSD) is the maximum absorbed dose to skin from exposure to x-rays.[1] This quantity is important to estimate because skin exposed to high levels can result in injury to the skin. These injuries range from a mild form of burn (i.e., erythema) to much more significant injury where the skin is destroyed (i.e., necrosis) causing significant pain and comorbidities to the patient.[2,7]

The outermost layers of skin protect us from the environment. These protective layers are formed by the movement of basal layer skin cells upward as the outermost layer is removed from normal daily activities. The destruction of the basal layer of skin cells by radiation exposure prevents the replacement of the outer. If they cannot be replaced, the result is a lesion exposing underlying tissue structures to the environment. If left untreated, the skin injury can result in infection and serious health complications.[3,7]

Absorption of radiation from x-rays is measured in units of gray – one gray is equal to 100 joules of energy deposited in one kilogram of material. Normal skin is unlikely to experience the damage described above at doses less than about 3 gray. Some people may experience skin injuries at lower doses depending on comorbidities such as diabetes mellitus, or other conditions that may compromise the physiological functioning of live skin cells. Radiation doses greater than 5 gray can cause skin injuries of which severity increases as the absorbed dose increases.[2] Radiation dose to skin has not been correlated with an increase in risk of developing melanoma, a potentially fatal form of skin cancer.[3]

The National Committee on Radiation Protection (NCRP) recommends patients who receive absorbed radiation doses exceeding 3 gray also receive follow up observation for skin injury for at least one year after the procedure.[5] The Joint Commission (JC) recommends hospitals establish a level at which follow up observation will be performed. The JC, however, requires that any exposure exceeding 15 gray be evaluated as a potential "sentinel event." If skin injury is observed, care must be provided. The extent of the injury can take many months to fully manifest. Estimates of the extent and level of skin injury can be made by the clinician if the peak skin dose is known.

Skin doses from x-ray imaging

Radiation doses to skin from x-ray imaging can range from a few milligray (one one-thousandth of a gray), to tens of grays. Most diagnostic imaging does not deliver enough radiation to result in skin injury. This includes radiographs (general x-ray), mammography imaging, and computed tomography (CT) scans. There are some procedures, however, such as perfusion scanning and cardiac catheterization procedures that deliver radiation doses that sometimes exceeds the threshold where skin injuries can occur. Fluoroscopy is the one x-ray imaging modality where skin injuries are possible from routine imaging procedures and therefore require closer attention.[4,5]

X-ray exposure to skin during fluoroscopy procedures

Fluoroscopy is a critical tool used in medicine to provide real-time images of patients' internal structures and functioning. Real-time imaging of patients allows clinicians to identify internal problems, provide visual guidance while performing minimally invasive procedures, and observe in real-time the results of their actions. In order to produce the images needed, x-rays are used to image the region of clinical interest inside the patient and resulting images are displayed on a monitor for the clinician. The clinician adjusts the location of the x-ray tube to obtain the view the clinician needs for optimal observation of the region of interest. The fluoroscopy device and the table the patient is laying on can be adjusted to provide the clinician with the optimal view. When x-rays are generated to produce the needed view, radiation is delivered to the skin the x-ray tube is pointed towards. As the skin absorbs more radiation, the potential for skin injury increases. Once the absorbed dose to the skin exceeds approximately 5 gray, the potential for skin injury is high, and the severity of the injury increases as the dose increases.[2] The table below presents the threshold for different types of skin injuries.[7]

Effect	Approximate threshold doses (Gy)	Time of onset
Early transient erythema	2	2-24 hours
Main erythema reaction	6	≈1.5 weeks
Temporary epilation	3	≈3 weeks
Permanent epilation	7	≈3 weeks
Dry desquamaion	14	≈4-6 weeks
Moist desquamaion	18	≈4 weeks
Secondary ulceration	24	>6 weeks
Late erythema	15	8-10 weeks
Ischaemic dermal necrosis	18	>10 weeks
Dermal atrophy (1st phase)	10	>52 weeks
Telangiectasia	10	>52 weeks
Dermal necrosis (late phase)	>15?	>52 weeks

For any fluoroscopy procedure, there is an area of skin that receives the highest absorbed dose, the "peak skin dose." Clinicians often employ techniques to keep the peak skin dose to levels below that which skin injuries are a high possibility – one such technique is moving the x-ray tube often to prevent any single area of skin from absorbing radiation that exceeds the threshold for skin injury. However, for some patients and procedures, the clinician has limited availability to move the tube to perform the clinical procedure. If such procedures require long exposure times, or require more intense radiation to provide the images needed such as with obese patients, then the probability for absorbed doses sufficient to result in skin injury increases.

Estimating peak skin dose requires calculating the amount of radiation absorbed by exposed areas of skin. Some areas of skin may receive overlapping radiation fields. In these instances, the absorbed skin dose in the overlapping fields is the summation of the two. (See Figure 1.)

Therefore, estimating the peak skin dose for fluoroscopic procedures is critical in determining which patients should receive future observation, and in providing the clinician with some estimation of the level of skin injury the patient may experience if left untreated. Treatments to mitigate severity of a skin injury are available.

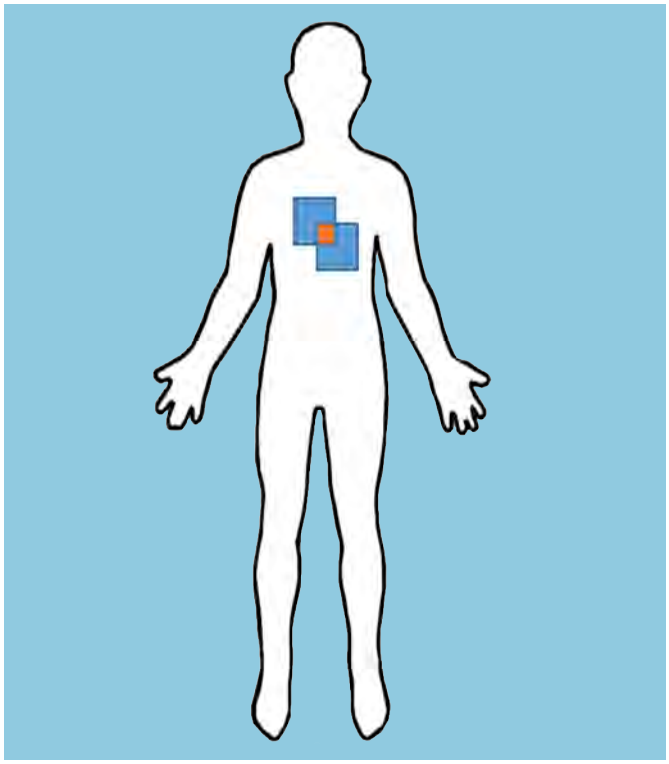
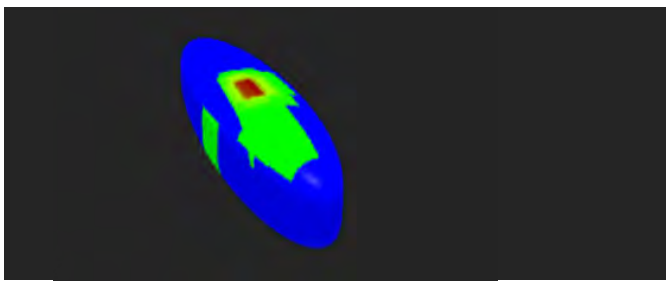


Figure 1: Philips Peak Skin Dose estimation algorithm

The Peak Skin Dose algorithm in Philips Dose Wise Portal uses the following parameters in its calculations:

- The absorbed dose to air at a defined point in space (i.e., Air Kerma at the Interventional Reference Point)
- X-ray tube primary and secondary gantry angle
- Table position and height
- Table thickness and x-ray attenuation factor
- Pad thickness and x-ray attenuation factor
- Correction factor to convert dose in air to dose in tissue
- Correction factor to adjust dose in air as reported by the fluoroscopy machine relative to the dose in air measured by a medical physicist
- Backscatter estimate based on exposed area size

For the purposes of the calculations, DoseWise Portal uses a "modified super ellipse" to approximate the physical shape and size of the patient's torso. If the fluoroscopic procedure is for the patient's head, then a 16cm sphere is used. The exterior surface of the super ellipse or sphere is the patient skin surface. The absorbed radiation dose to the exterior surface is calculated for each radiation exposure "event" conducted during the fluoroscopic procedure, adjusting for each of the factors presented above. The summation of all exposures is plotted on a visual model of the super ellipse, and an estimate of the peak skin dose and approximate location is displayed. The size of the super ellipse changes according to the height, weight and body mass index of the patient. If this information is not available, a standard male or female ellipse is used.



DoseWise Portal allows the user to calculate the peak skin dose for fluoroscopic procedures stored in the DoseWise Portal database. The user can also receive a printout of the calculation inputs for each individual radiation exposure event upon which the peak skin dose was estimated.

This output allows the medical physicist to see when default values were used and can therefore draw conclusions on their level of confidence in the result.

The visual model of the modified super ellipse shows the areas that were exposed to the various x-ray fields. However, this visual model should not be construed to identify the exact location of the peak skin dose on the patient's body surface. Since the actual location of the patient's body on the table is not known, precise matching of the peak skin dose location displayed on the model to the actual location on the patient body is not recommended. The algorithm, however, takes into account the general body regions where exposures occur, and provides an approximate location of where the peak skin dose occurred.

Overlaps between exposure fields down to one centimeter are possible, if the dimensions of the modified super ellipse closely approximate the actual dimensions of the patient. Overlaps on the head of one centimeter are possible.[6]

The accuracy of the skin dose calculations are generally accurate to within 20% for Philips fluoroscopy devices if all configuration settings, patient physical size, and correction factors are applied. For other manufacturers, an accuracy of 40% is expected.[6]

For additional details on DoseWise Portal, please visit philips.com/dosewise or contact your Philips representative.

References

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