Shielding In Computed Tomography

Student Researcher: Amanda Agne

Faculty Advisor: Dr. Elaine Halesey, Ed.D, R.T. (R)(QM)(ARRT)

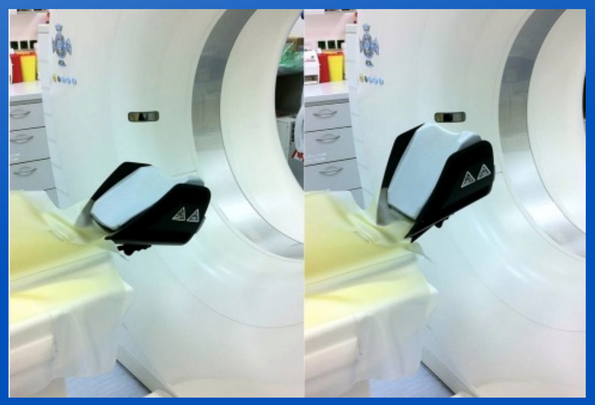
MISERICORDIA UNIVERSITY

Introduction

- Computed Tomography (CT) is ionizing radiation-based imaging that provides a 3D view of regions of interest.
- CT is the imaging modality of choice for trauma and patients needing urgent diagnosis.
- Computed tomography utilizes a higher amount of radiation than diagnostic x-ray.
- Based on the linear non-threshold model, there is no safe dose of radiation.
- The most radiosensitive organs consist of the lens of the eye, thyroid, breasts, and gonads.
- There are two forms in which radiation dissipates to a patient: internally and externally.
- Internal scatter is within the body in scan range and moves transversely.
- External scatter is off-focus radiation from tube to the receptor.
- Shielding patients has been a part of practice in radiology since 1976
- Recent statements and research contends that shielding patients has more risks than benefits. However, this is a heavily debated topic.

Shielding the Eyes

- The risk of radiation-induced cataracts is increased with frequent imaging studies done on the head.
- Annual dose limit to lens of the eyes is 150 mSv (Statkiewicz, Visconti, Ritenour, & Haynes, 2013, p. 191).
- Positioning of the head piece in a tilted orientation removes the lens of the eye out of the direct path of the rays.
- Dose reduction methods are best when the technologist is properly trained, educated & use methods appropriately (Daubner et al., 2022)



The image above demonstrates the appropriate tilted positions of the head piece to remove the primary beam out of the path of lens of eye (Daubner et al., 2022, p. 825).

Table 2
Descriptive statistics of the dose data for different CT scan regions.The median is given with the range within the parenthesis $CTDI_{vol}$:volume CT dose index, DLP:dose length product, $SSDE_{D_w}$:size specific dose estimate based on water equivalent diameter and ESD:entrance surface dose.

Approach	Scan region	$CTDI_{vol}$ (mGy)	DLP (mGy.cm)	$SSDE_{D_w}$ (mGy)	ESD (mGy)
Without shield	Abdomen (NC)	10.6 (7.2–23.1)	635 (416–1228)	15.6 (10.8–25.6)	0.76 (0.21–2.55)
	Abdomen (3–phase)	37.6 (12.8–53.9)	1955 (1317–3090)	52.6 (20.9–90.2)	3.41 (1.65–8.26)
	Abdomen (4–phase)	43.3 (31.0–71.0)	2343 (1494–4605)	63.2 (12.1–112.6)	3.50 (1.52–6.72)
With shield	Abdomen (NC)	10.1 (7.4–15.0)	559 (410–883)	14.2 (12.0–19.2)	0.21 (0.020–0.61)
	Abdomen (3–phase)	36.5 (24.9–55.6)	1848 (1341–2597)	49.7 (37.6–78.4)	0.46 (0.37–0.83)
	Abdomen (4–phase)	41.4 (31.2–74.1)	2224 (1774–3816)	62.6 (43.8–104.6)	1.26 (0.73–2.16)

The table above demonstrates the data of dose indexes for different protocols with and without thyroid shielding. Data shows ESD dose was lower when a shield was used (Jeyasugiththan et al., 2022, p. 707).

The image above shows proper placement of a bismuth shield over the breasts on a phantom (Karim et al., 2019, p. 142)

Bismuth Breast Shielding

- Is more effective than lead.
- Reduce dose to the breasts by 14% (Karim et al., 2019, p. 146).
- May cause inconsistencies with image quality & dose due to the automatic exposure control.
- Optimization for scanning protocols are utilized to reduce dose and provide quality images without using a shield (Kweon, Lee, & Choi, 2022).

AAPM Position Statement

- The American Association for Physicists in Medicine released their statements regarding shielding in radiology.
- The position is in favor of discontinuing the use of shields for diagnostic imaging.
- While they do reduce dose to anterior radiosensitive organs, they may also provide potential problems such as reduced image quality and wasted radiation (American Association of Physicists in Medicine, 2023).

Thyroid Shielding

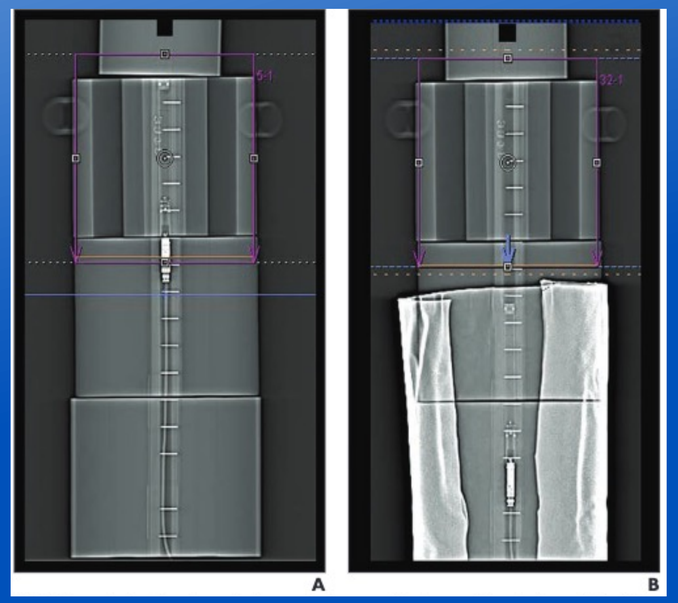
- Dose limit for the thyroid is 150 mSv (Statkiewicz et al., 2013, p. 191). Shielding the thyroid with lead can reduce external scatter by 64%-87% (Jeyasugiththan et al., 2022, p. 704).
- Shielding should be considered when imaging areas of interest that do not include thyroid.
- Contact shielding of the thyroid may reduce primary radiation when it is in the field of view, however, may affect automatic exposure control and image quality.

Should Pediatrics Be Shielded?

- Children are more sensitive to radiation than adults as their cells are reproducing faster and have not fully developed.
- Children pose the challenge of inability to remain still to obtain clear quality images.
- For some pediatric patients, a shield may be intimidating as a heavy weight placed on them.
- May be a challenge for shield to remain in place for duration of procedure. Shield may move to a position where it obscures desired anatomy & repeat imaging may be needed. This results in unnecessary dose to patients.
- Patients who are shielded have a dose reduction of 7% when compared to dose without a shield.
- Scanning protocols for pediatric patients are typically reduced to less than half the mean dose for an adult patient.
- Proper patient positioning, scanning protocols, and faster scanning times can effectively reduce dose to pediatric patients while obtaining quality images.
- There is a reduction in dose when a shield is used properly, however the risks outweigh the benefits for the pediatric population (Yu, Bruesewitz, Vrieze, & McCoullough, 2019)

Alternative Methods

- Consistent advancements in technology in Medical Imaging have allowed for optimization of equipment & protocols to deliver dose as low as possible while obtaining quality images.
- Proper training and education of the technologist is required to apply proper positioning and alignment of the patient to reduce repeat scanning and ensure appropriate anatomy is in the desired field of view.
- Reducing the x-ray tube current to the anterior surface can also reduce dose to the lateral and posterior surfaces.
- Quality management and frequent equipment testing should be performed to review the accuracy of equipment to prevent excess radiation to patients.



The image above demonstrates a scanned projection of a phantom without a lead apron (A) and one with (B). Image B was scanned a few times with varying distances of the shield from the anatomy of interest. Dose was measured for each distance & was most effective closest to anatomy of interest (Yu et al., 2019, p. 152).

Conclusion

- Internal scattered radiation is responsible for potential effects after radiographic imaging.
- Dose is cumulative and patients who have CT imaging done have a higher lifetime dose.
- Radiosensitive organs not in direct field of view are still at risk of being exposed to ionizing radiation.
- Research has been conducted to determine the effectiveness of shielding in CT. Results conclude that shielding reduces dose by a minimal amount.
- The risks outweigh the benefits when deciding to shield patients for CT imaging.