Ask EuroSafe Imaging
Tips & Tricks

CT Working Group

To shield or not to shield?

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What is the rationale for using shields?

- During CT examination of the head and thorax, radiosensitive organs such as the eye, thyroid and breast, are always included in the scanning field
- Typical doses to patients' eyes from routine head CT range from about 30 mGy to about 70 mGy
- Typical doses to patients' breasts from routine chest CT range from about 20 mGy to about 50 mGy

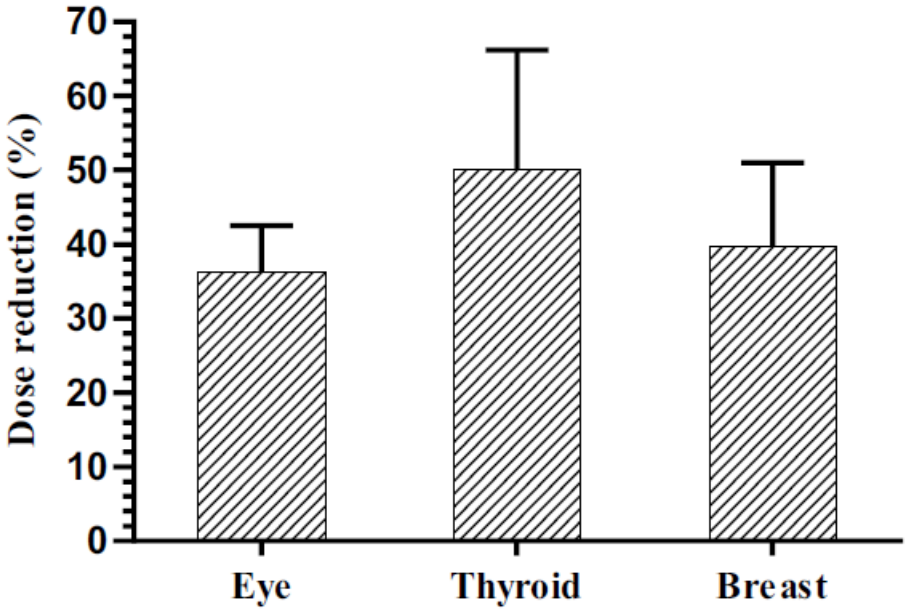
What is the rationale for using shields?

- The risk associated with exposure to radiation is much higher in individuals <18 years of age and pregnant women

- Repetitive CT scanning in trauma and oncology may expose patients to significant cumulative radiation doses

The benefits using shields

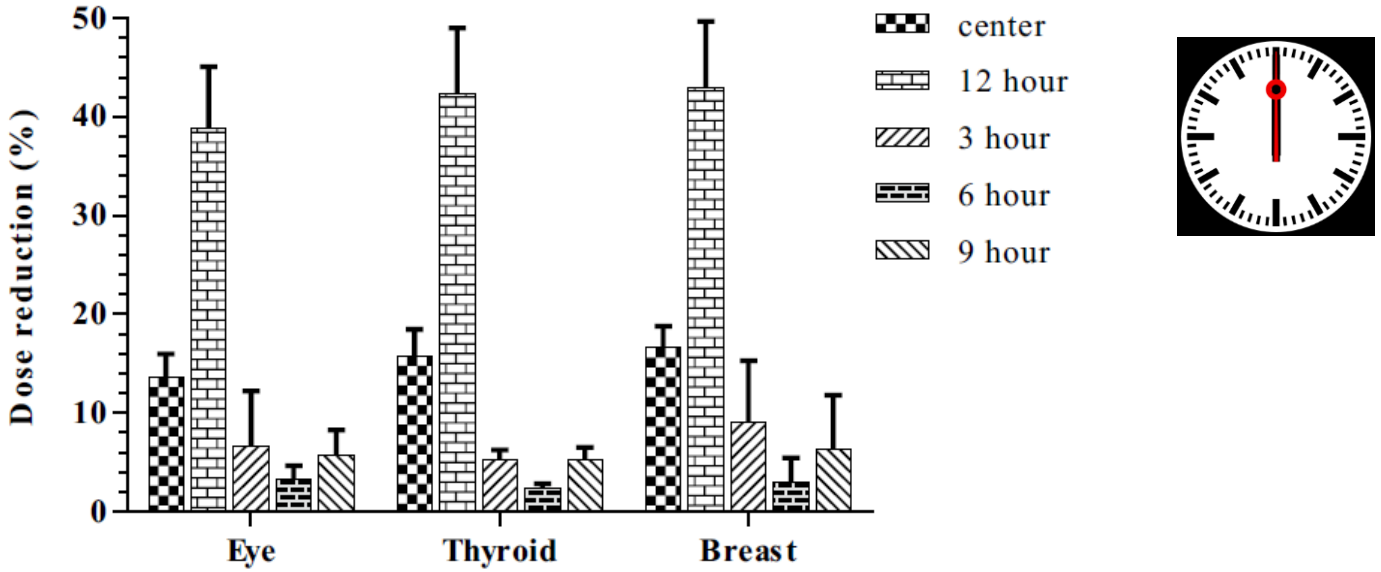
- Shield placement over the surface of the protected area causes an approximately twofold attenuation of the primary X-ray beam before it reaches the patient



Mehnati et al. *Use of bismuth shield for protection of superficial radiosensitive organs in patients undergoing computed tomography: a literature review and meta-analysis.* Radiol Phys Technol. 2019 Mar;12(1):6-25.

The benefits using shields

- The highest percentage of dose reduction occurs at the 12-o'clock position, the lowest at the 6-o'clock position, and there is gradual decrease in the dose reduction with increases in the distance from the shield



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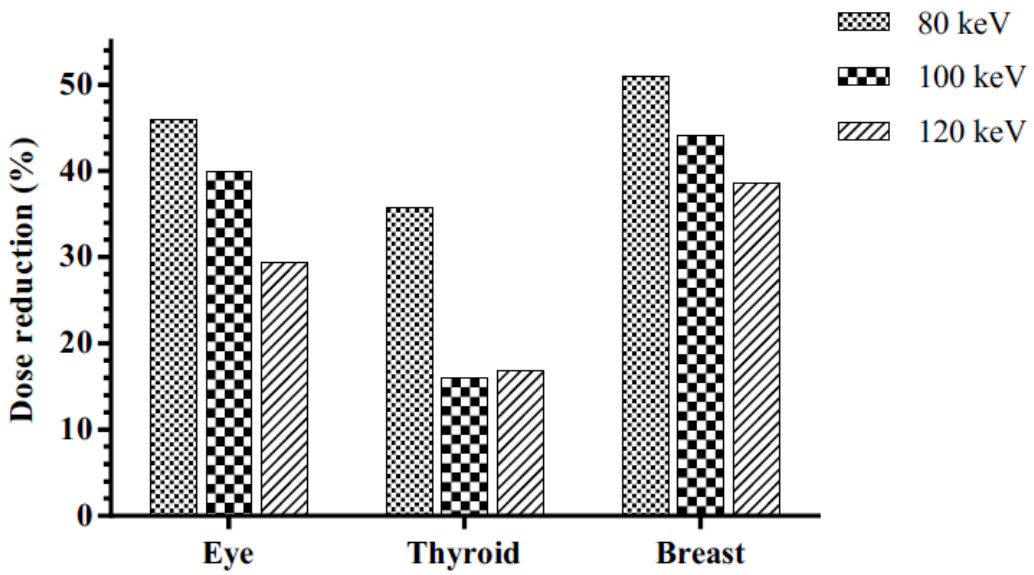
The benefits using shields

- At low beam energy, shielding is more effective, which may be explained by the variation in shape of the X-ray spectrum at increasing value from 80 to 120 keV



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Recommendation by the German Commission on Radiological Protection

Exmination type	Patient radiation protection equipment	Possible dose reduction (organ-equivalent dose)
Head CT	Eye lens protection when the eyes are in the direct radiation field	Eye lens: approx. 20 mSv (Bulla et al. 2012, Keil et al. 2008)
	Thyroid protection	Thyroid: approx. 0.5 mSv (Beaconsfield et al. 1998, Ngaile et al.2008)
	Breast protection (covering the breast in female patients)	Breast: approx. 0.15 mSv (Beaconsfield et al. 1998, Ngaile et al. 2008)

Because the dose reduction strongly depends on the examination device, the examination technique, and the situation, the application of the radiation protection equipment should be clarified on site with a medical physics expert.

Recommendation by the German Commission on Radiological Protection

Exmination type	Patient radiation protection equipment	Possible dose reduction (organ-equivalent dose)
CT and CBCT of paranasal sinuses and visceral cranium	Thyroid protection Eye lens protection when the eyes are in the direct radiation field	Thyroid: approx. 0.6 mSv (Goren et al. 2013) Eye lens: approx. 20 mSv
CBCT in dentistry	No protection necessary	Thyroid: < 0.02 mSv (Rottke et al. 2013a, Rottke et al. 2013b)

Because the dose reduction strongly depends on the examination device, the examination technique, and the situation, the application of the radiation protection equipment should be clarified on site with a medical physics expert.

Recommendation by the German Commission on Radiological Protection

Exmination type	Patient radiation protection equipment	Possible dose reduction (organ-equivalent dose)
CT of thorax	Thyroid protection (not for paediatric examinations) Lead shield around the abdomen in pregnant women	Thyroid: approx. 2.5 mSv (Buchgeister et al. 2012) Uterus: approx. 0.02 mSv (Danova et al. 2010, Iball und Brettle 2011)

Because the dose reduction strongly depends on the examination device, the examination technique, and the situation, the application of the radiation protection equipment should be clarified on site with a medical physics expert.

Recommendation by the German Commission on Radiological Protection

Exmination type	Patient radiation protection equipment	Possible dose reduction (organ-equivalent dose)
CT of pelvis/abdomen	Males: Testicle pouch if artefacts are not disturbing	Gonads: approx. 1 mSv (Price et al. 1999, Hohl et al. 2005, Hidajat et al. 1996, Dauer et al. 2007) in the direct radiation field > 1 mSv (Price et al. 1999, Hohl et al. 2005, Hidajat et al. 1996, Dauer et al. 2007)

Because the dose reduction strongly depends on the examination device, the examination technique, and the situation, the application of the radiation protection equipment should be clarified on site with a medical physics expert.

Recommendations in the Nordic region - Bismuth shielding

- The Nordic health authorities follow the recommendations of the American Association of medical physicists (AAPM) and do not recommend bismuth shielding to be routinely used in CT

- The main arguments against in-plane shielding are that radiation in the PA direction is absorbed by the shields before it reaches the detectors and that shields cause noise and artifacts

- Instead reduced kVp over radiation sensitive areas, automatic exposure control or organ-based tube current modulation is recommended

Tips and Tricks

- **Be aware of the recommendations in your country:** Different countries and regions may recommend not to use bismuth shielding etc.
- **Shield placement:** Place the shield after acquiring the scout image because the algorithm for current adjustment may be offset by the attenuation due to the shield
- **Scout image:** Use p.a. direction, in order to expose the radiation-sensitive organs to a lower radiation dose
- **Shield artifacts:** Shields may cause beam-hardening artifacts, and may also increase the CT numbers recorded under the shield (may be a problem in evaluation of the orbital and peri-orbital area, and the upper mediastinum)
- **CBCT:** Use a 180° rotation so that the eye lenses are not exposed to the unattenuated beam

Tips and Tricks

- **Eye lenses:** Position eye lenses outside the primary beam path by means of gantry tilting or slight elevation with a foam wedge and bending of the head. Use tube current modulation, in which no direct radiation reaches the eye lenses.
- **Thyroid:** Shields may not be practical in all paediatric age groups because of the proportions of the very short neck. A narrow lead blanket may be put over the thyroid in children < 8 years of age.
- **Breast:** Use an organ-based tube current modulation* or a sectoral switch-off/reduction of the tube current in the anterior angle range
- **Gonads:** Use an organ-based tube current modulation. Patient radiation protection equipment should not be in the path of radiation, especially when assessing the pelvis.

* slide n.15

Tips and Tricks

- **Out-of plane shielding:** A recent a study by Ryckx et al. deemed the need for abdominal lead aprons in chest CT obsolete with the introduction of modern CT scanners. Instead the authors state that reducing the scan length by 3 cm will reduce the radiation dose to the uterus similarly while avoiding the potential negative consequences of the shield.
- **Scanner specific recommendations:** Follow the recommendations of the respective CT manufacturer when using patient radiation protection equipment in the examination area or in the immediate vicinity in CT examinations. Use automatic exposure control and organ-based tube current modulation.

ORGAN-BASED TUBE CURRENT MODULATION

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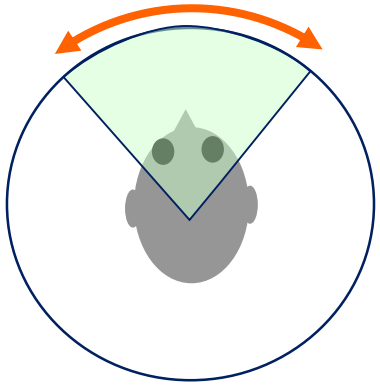
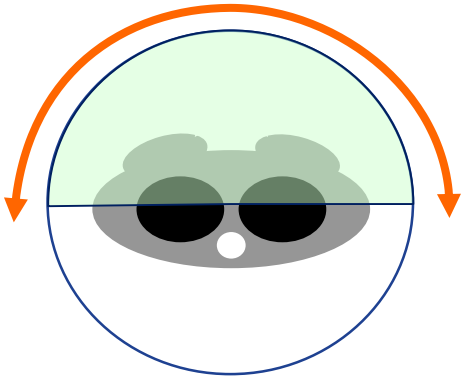
Head



Body



mA reduction rate in front side	Up to 30%	Up to 40%
mA reduction range (tube angle)	90°	180°
SFOV type	Ped Head, Head	Ped body, Small body Large body

ORGAN-BASED TUBE CURRENT MODULATION

- Provides a mode to reduce X-ray tube current (mA) in anterior direction of the patient where the most radiation sensitive organs are located while aiming to maintain image noise constant by modulating X-ray tube current (mA) according to the X-ray tube angle
- Siemens X-care increases tube current for the remainder of the gantry rotation to maintain image quality (Siemens X-Care). This may lead to dose increase to posterior organs (Franck et al.)
- GE organ-based tube current modulation does not change tube current which may result in an increase in image noise.

References

- Mehnati P, Malekzadeh R, Sooteh MY. **Use of bismuth shield for protection of superficial radiosensitive organs in patients undergoing computed tomography: a literature review and meta-analysis.** Radiol Phys Technol. 2019 Mar;12(1):6-25.

- **Use of patient radiation protection equipment in the diagnostic application of X-rays on humans.** Recommendation by the German Commission on Radiological Protection. Adopted at the 297th meeting of the German Commission on Radiological Protection on 13. and 14. December 2018.

- **Nordic position statement on the use of bismuth shielding for the purpose of dose reduction in CT scanning** https://www.sst.dk/-/media/Nyheder/2015/Nordic-statement-bismuth-shielding.ashx?la=da&hash=BEAFD7D47544199F13BAD57D65CB94AA5ED6640C

- **AAPM position statement: Use of Bismuth Shielding for the Purpose of Dose Reduction in CT Scanning. 2012.** https://www.aapm.org/publicgeneral/BismuthShielding.pdf

- Ryckx N, Sans-Merce M, Schmidt S et al: **The use of out-of-plane high Z patient shielding for fetal dose reduction in computed tomography: Literature review and comparison with Monte-Carlo calculations of an alternative optimisation technique.** Physica Medica, 2018,48,156-61.

- Franck C, Smeets P, Lapeire L, Achten E, Bacher K. **Estimating the Patient-specific Dose to the Thyroid and Breasts and Overall Risk in Chest CT When Using Organ-based Tube Current Modulation.** Radiology. 2018 Jul;288(1):164-169.