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Tips & Tricks

CT Working Group

Breast Bismuth Shields: Should they be used?

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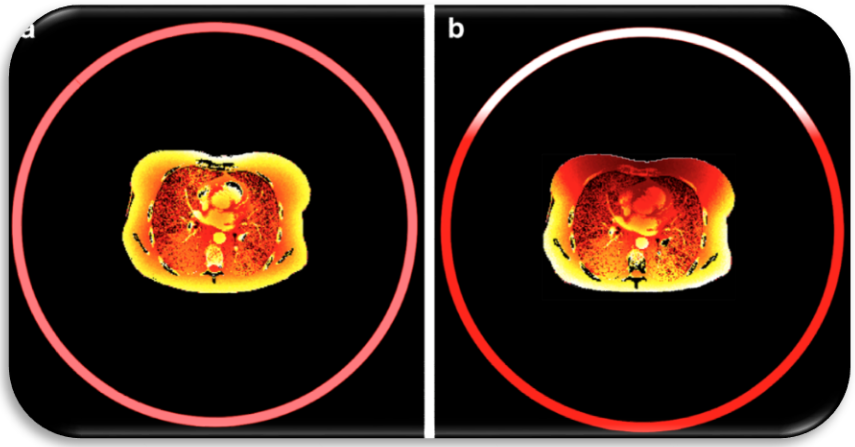
Background

- In the past decades, the use of CT has grown exponentially
- The increased number of CT examinations has lead to concerns about the associated population-based radiation dose
- Significant efforts have been made to minimize unnecessary radiation exposure and maximize patient benefits through the development of dose reduction techniques
- These techniques generally aim to reduce the unnecessary exposure to major radiosensitive organs while maintaining the required image quality level
- Breast tissue is one of the most radiosensitive tissues in the human body, particularly during adolescence
- In thoracic CT examinations, breast tissue is directly irradiated even though it is rarely the organ of interest

Organ Dose Tube Current Modulation

X-ray beam can be turned off when the beam is impinging on a superficial radiosensitive organ but alternatively increased when the beam is on the other side of patient



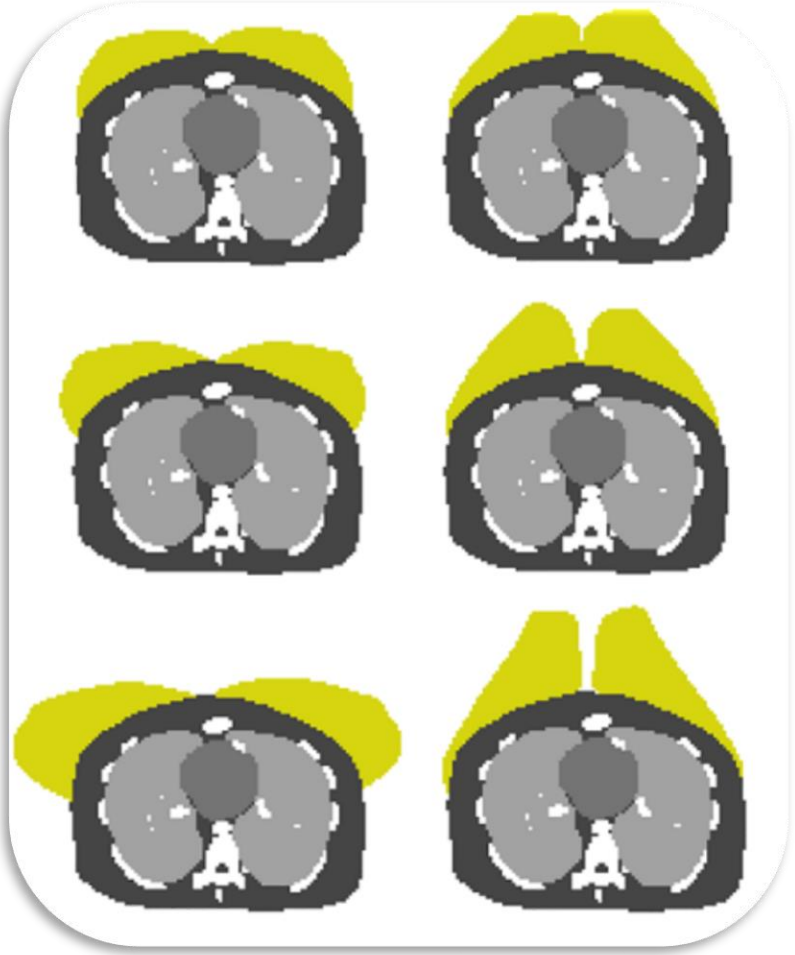
"X-Care"
Courtesy: Siemens Healthcare, Erlangen,Germany"

Dose Reduction Strategies

- This technology can reduce the dose to the target organ, combining appropriate reconstruction without a major impact on overall dose or image quality
- The major disadvantage is the fact that the technique it limited to certain models made by just a few manufacturers
- It is less effective for breast dose reduction in adults who have large breasts

Dose Reduction Strategies

- When the patient is supine, the breast tissue extends within an average angular dose of 155 degrees
- The dose reduction angle is 120 degree
- The tube current (mA) is reduced by 80% in the anterior region of the patient with a corresponding increase in the posterior region
- Correct breast positioning is important in order to place the entire breast in the dose reduction area



Fu W et al, CT breast dose reduction with the use of breast positioning and organ based tube current modulation' Med Phys 2017;44:665-678

Dose Reduction Strategies

- Alternatively, breast bismuth shields can be used
- The shields are typically made of bismuth-impregnated latex
- These bismuth shields are meant to be applied within the imaging field of view and while offering a modest level of protection, they still allow enough X-ray penetration to enable image formation
- Its use is controversial and, in 2012, the AAPM (American Association of Physicists in Medicine) released a position statement about the use of bismuth shields and recommended that ”alternatives to bismuth shielding be carefully considered and implemented when possible”

Dose Reduction Strategies-Bismuth Shields

Disadvantages with use of Bismuth Shields

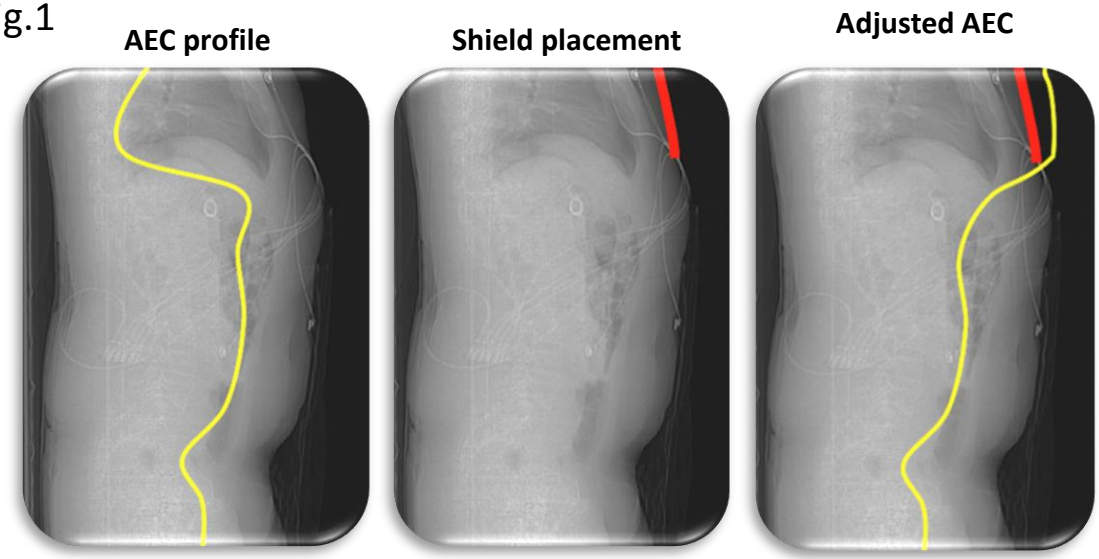
- Improper use may result in over-exposure of the patient (fig.1 next slide)
- The presence of a bismuth attenuating layer in the field-of-view increase the CT numbers, particularly in the proximity of the shield (fig.2 next slide)
- Ineffective use of radiation (fig.3)

Advantages with use of Bismuth Shields

- Bismuth shields are simple to use
- Patient's perception of safety

Disadvantages of Bismuth Shields

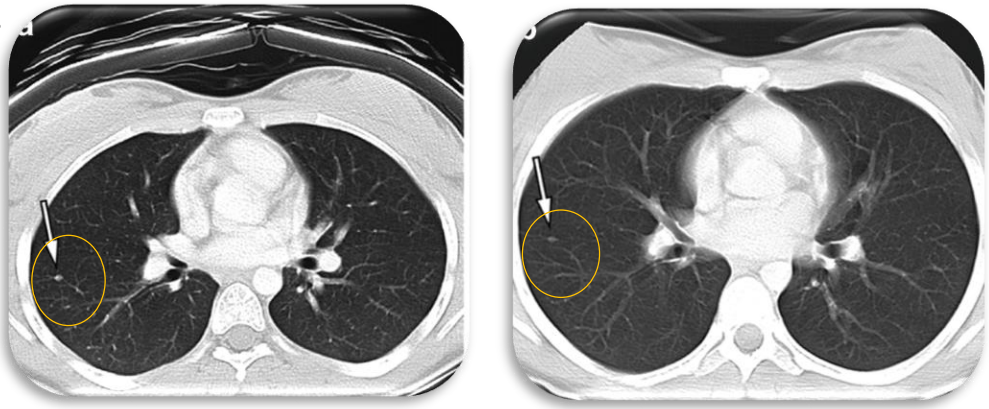
Fig.1



Samei, E., "Pros and cons of organ shielding for CT imaging", Pediatric Radiology (2014) 44(3), 495-500

1. If the shield is placed before the localizer acquisition, the system adaptively increases the tube current in response to the attenuation of the shield

Fig.2

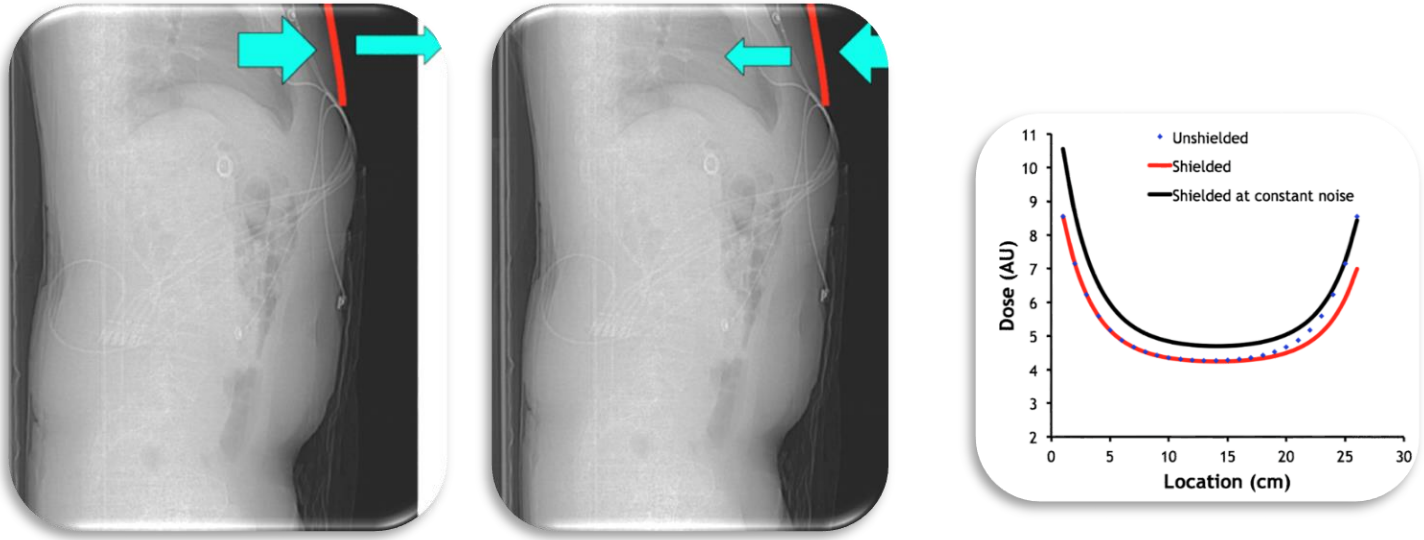


Fricke et al "In plane bismuth breast shields for pediatric CT: effects on radiation dose and image quality using experimental and clinical data" 2013 AJR

2. The presence of a bismuth attenuating layer in the field-of-view increases the CT numbers, particularly in the proximity of the shield

Disadvantages of Bismuth Shields

. Fig.3



Samei, E., "Pros and cons of organ shielding for CT imaging", Pediatric Radiology (2014) 44(3), 495-500

3. When the X-ray beam is anteriorly oriented, the shield reduces dose but the detector receives less photon flux so the image noise is increased. If the beam is posteriorly oriented, the X-ray beam fully exposes the patient but a considerable part of the beam is blocked by the shield. In that case, the dose is the same but the image quality is worse

Bismuth Shields and Dual Energy CT (DECT)

- In-plane bismuth breast shield has been used to selectively reduce radiation exposure to the breast
- In DECT a smaller reduction in radiation dose is expected using breast shielding than in single energy CT because of the higher tube voltage used in DECT.
- The increased CT attenuation differs depending on the distance to the shield and the X-ray energy
- At 100 kV we can observed an increase of CT numbers in the anterior position but not in the posterior
- At 140 kV an increase of CT number at both anterior and posterior positions occurs

Bismuth Shields and DECT

- Iodine can be differentiated and quantified with the DECT technique based on material decomposition.
- Theoretically, iodine enhancement is presented by a vector of fixed direction, but the length depends on iodine attenuation at 100 kV and 140 kV
- The increased CT attenuation values after using bismuth breast shielding, especially at 140 kV, might affect iodine quantification

Conclusions

- Bismuth shields reduce dose to targeted superficial organs
- The dose reduction is associated with a corresponding increase in image noise in the area covered by the shield
- Bismuth shields increase CT numbers and induce noise in a limited part of body
- For tube current modulation techniques that dynamically change during the rotation based on the attenuation level of the patient, bismuth shields should never be used because they inevitably increase the patient dose
- Bismuth shields should not be used in DECT because they affect iodine quantification due to artifacts
- Bismuth shields can degrade image quality and partly waste patient's exposure and, therefore, alternative methods for peripheral organ dose reduction should also be considered

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