ESR EUROSAFE IMAGING

Ask EuroSafe Imaging
Tips & Tricks

CT Working Group

Organ Based Tube Current Modulation to Reduce Radiation Dose to Superficial Radiosensitive Organs

Eileen Kelly (Galway University Hospitals, IE)
Matthias Stefan May (University Hospital Erlangen, DE)
Robert Bujila (Karolinska University Hospital, SE)

© European Society of Radiology

Introduction

- Superficially located radiosensitive organs (breast, thyroid & lens of the eye) can receive a relatively high radiation dose during CT
- Radiation dose to those organs should be kept to a minimum where possible
- Organ based tube current modulation reduces dose to superficial radiosensitive organs [1]
- Organ based tube current modulation provides better image quality compared to bismuth shielding while reducing radiation dose to superficially located radiosensitive organs [2]

© European Society of Radiology

Background: Tissue Weighting Factors

- The tissue weighting factor is a relative measure of the risk of stochastic effects that might result from irradiation of that specific tissue
- It accounts for the variable radiosensitivities of organs and tissues in the body to ionising radiation
- The breasts are considered one of the most radiosensitive organs in the body (see table across)

	W_T ICRP-103 (2007)
Bladder	0.04
Bone	0.01
Brain	0.01
Breasts	0.12
Colon	0.12
Gonads	0.08
Oesophagus	0.04
Liver	0.04
Lungs	0.12
Red bone marrow	0.12
Salivary glands	0.01
Skin	0.01
Stomach	0.12
Thyroid	0.04
Remaining tissues	0.12

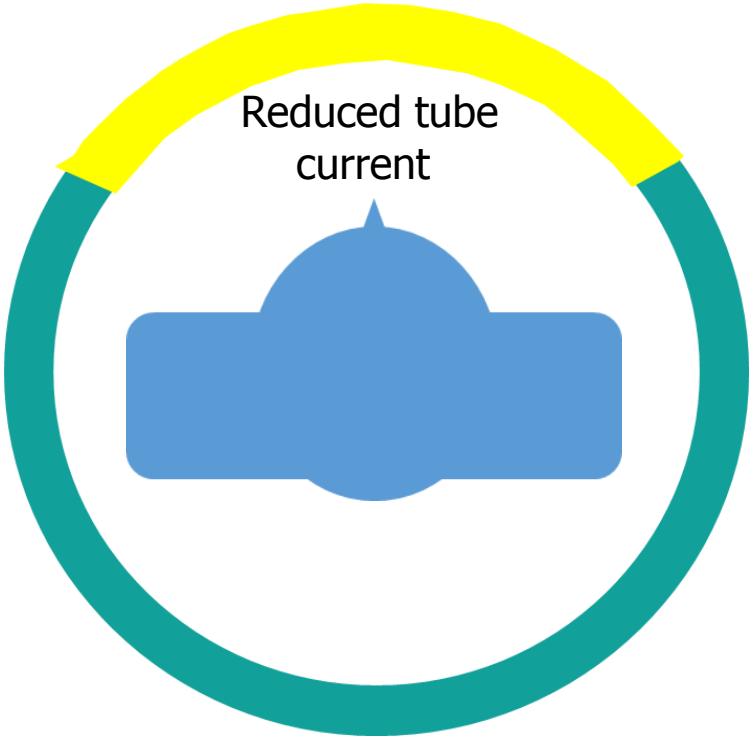
© European Society of Radiology

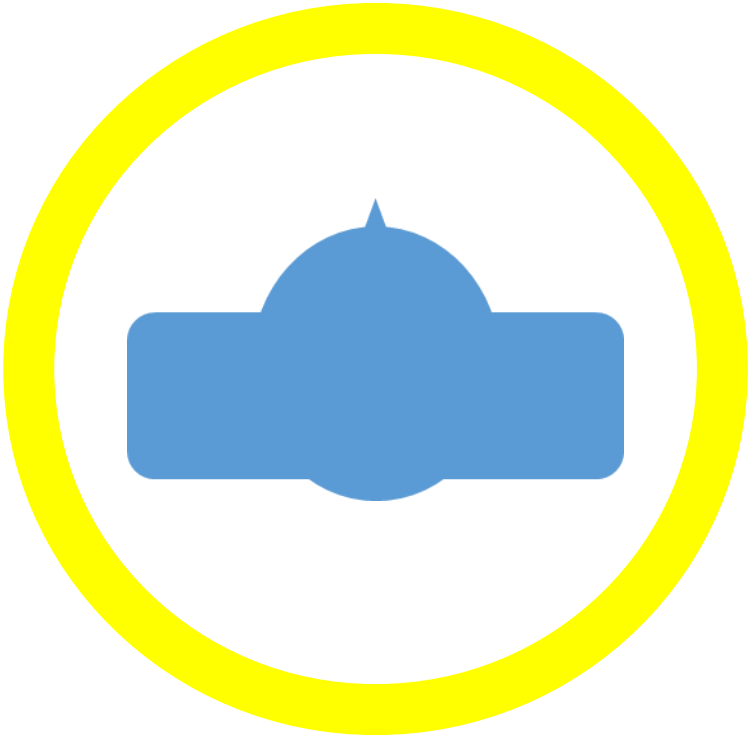
Principles Organ Based Tube Current Modulation

- Tube current is reduced for a defined anterior arc of the gantry rotation
- Thus reducing dose to superficially located radiosensitive organs such as breast, thyroid and lens of eyes
- Tube current may be increased for the remainder of the gantry rotation to maintain image quality (Siemens X-Care)
- Tube current may not be changed for the remainder of the gantry rotation which may result in an increase in image noise (GE Organ Dose Modulation)

© European Society of Radiology

Principles Organ Based Tube Current Modulation





Siemens X-Care
Low tube current for anterior 120° radial arc with compensatory increase in tube current for the remaining 240° of the rotation

GE ODM
Low tube current for 90°/180° radial arc without tube current increase for remainder of rotation[3]

© European Society of Radiology

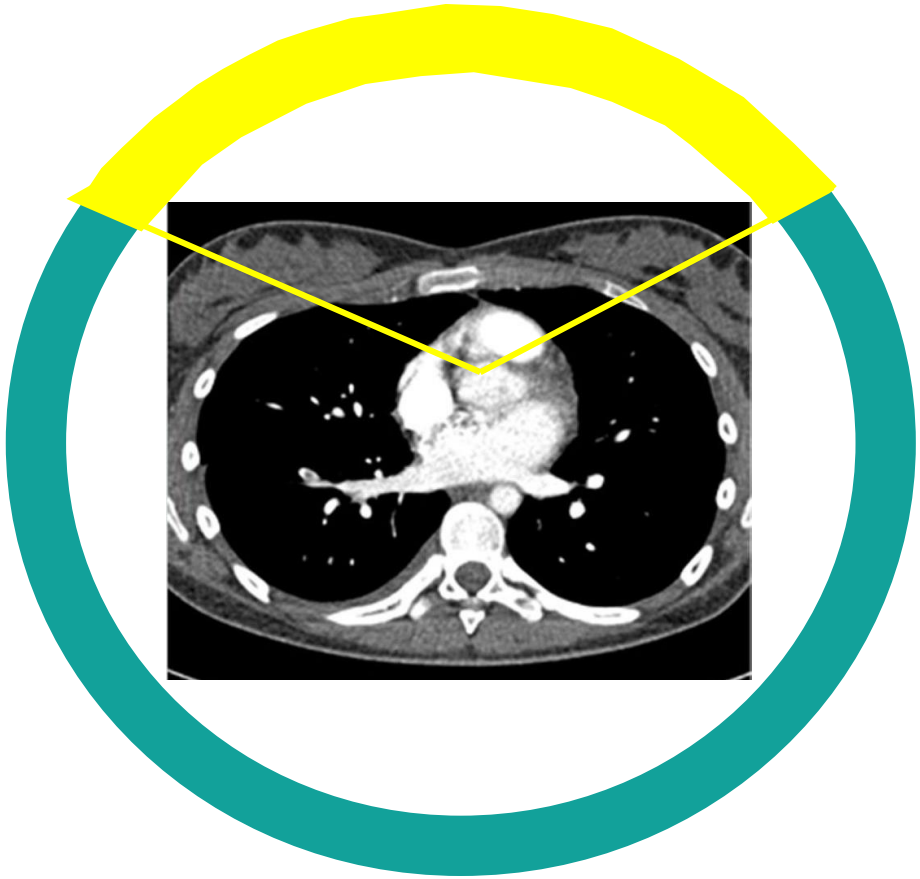
Principles Organ Based Tube Current Modulation

	Siemens X-Care	GE ODM
Low tube current anterior radial arc	120° (all protocols)	90° (head protocols) 180° (body protocols)
Radiation dose to superficial radiosensitive organs	Reduced	Reduced
Overall radiation dose	Unchanged (due to compensatory increase in mA for remaining 240° rotation)	Reduced
Image quality	Unchanged	Increased noise

© European Society of Radiology

Principles Organ Based Tube Current Modulation

- Compared with conventional acquisition Siemens X-care results in reduced tube current by 75% in the reduced current region [1]
- With compensatory increase in tube current by 25% outside the reduced current region [1]
- Total radiation dose delivered equivalent to conventional method



© European Society of Radiology

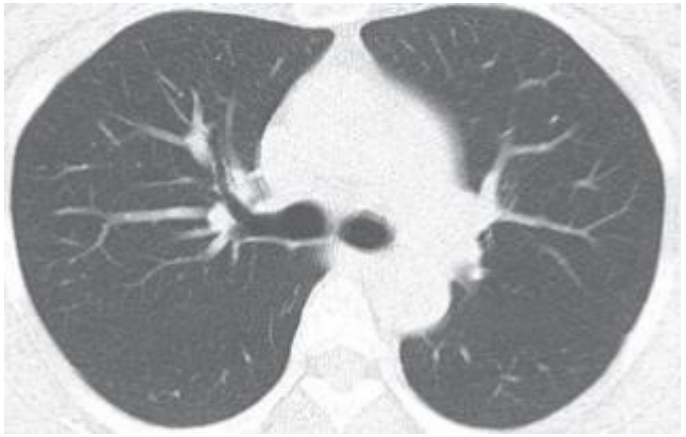
Benefits of Organ Based Dose Modulation

- Bismuth shielding is an effective method for reducing radiation dose to superficial radiosensitive organs
- Incorrect use of bismuth shielding, as placing on patient prior to localiser acquisition, can result in increase in dose to patient
- CT number inaccuracy, streak artefacts and increased noise have been reported with use of bismuth shielding [2]
- Compared with bismuth shielding organ based dose modulation reduces radiation dose to superficial radiosensitive organs without compromising image quality [5]

© European Society of Radiology

Benefits of Organ Based Dose Modulation

Organ based tube current modulation
Scored as no artefacts



With breast shielding
Scored as mild artefacts

Reduction in radiation dose to breast compared with control

	Organ based tube current modulation	Breast Shielding
Breast Surface	20%	16%
Breast deep portion	18.8%	28.1%
Posterior chest wall	5.5%	16.6%

Kim et al, 2013

© European Society of Radiology

Benefits of Organ Based Dose Modulation

a. Reference scan *b. Scan with bismuth shield* *c. Scan with organ based TCM*

- Use of organ based tube current modulation reduces dose to the eye
- Organ based tube current modulation provides superior image quality to that of bismuth shielding (image b versus c)

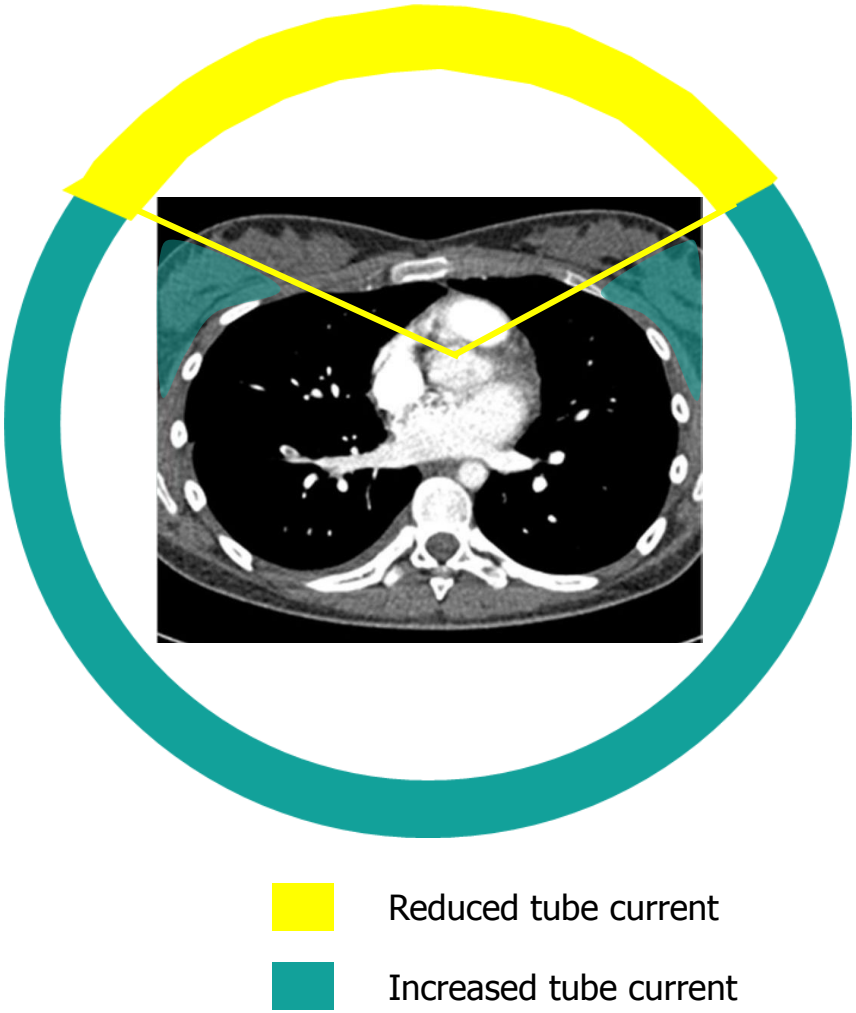
Scan Technique	CTDIvol (mGy)	Dose to eye (mGy)
Reference	38.18	32.16 ± 1.62
Bismuth Shield	38.18	23.66 ± 0.41
Organ based TCM	37.57	22.39 ± 0.47

Wang et al, 2012

© European Society of Radiology

Considerations When Using Organ Based Tube Current Modulation

- The reduced current 180° arc for body scanning with GE ODM ensures that all/most of breast tissue is within the reduced current arc
- With Siemens X-care laterally located breast tissue lying outside the reduced current arc (shaded region of breast across) receives higher organ dose than medially located breast tissue [4]
- Use of positioning aids to ensure all of breast tissue is within the reduced current arc is recommended
- Increase in tube current for remaining 240° arc results in increased radiation exposure to dorsal body parts as lung & bone marrow [5]



© European Society of Radiology

Summary

- Organ based tube current modulation reduces the radiation dose to superficial radiosensitive organs including breast, thyroid & lens of eyes
- Radiation doses to superficial radiosensitive organs are comparable to that of bismuth shielding
- Organ based tube current modulation results in superior image quality to bismuth shielding
- The use of organ based tube current modulation can increase the radiation dose to dorsal body parts
- Risks associated with increased dose to breast tissue located outside the reduced current arc
- Positioning aids recommended to ensure breast tissue is within the reduced current arc

© European Society of Radiology

References

1. Duan X, Wang J, Christner JA, Leng S, Grant KL, McCollough, CH. Dose reduction to anterior surfaced with organ based tube current modulation: Evaluation of performance in a phantom study. *American Journal of Roentgenology* 2011; 197:689-695

2. Wang J, Duan X, Leng S, Grant KL, McCollough, CH. Bismuth shielding, organ based tube current modulation, and global reduction of tube current for dose reduction to the eye at head CT. Radiology 2012; 262(1):191-198

3. Dixon MT, Loader RJ, Stevens GC & Rowles NP. An evaluation of organ dose modulation on a GE optima CT660-computed tomography scanner. *Journal of Applied Clinical Medical Physics* 2016 17(3): 380-391

4. Lungren MP, Yoshizumi TY, Brady SM, Toncheva G, Anderson-Evans C, Lowry C, Zhou XR, Frush D, Hurwitz LM. Radiation dose estimations to the thorax using organ based dose modulation. *American Journal of Roentgenology* 2012; 199:65-73

5. Kim YK, Sung YM, Choi JH, Kim EY, Kim HS. Reduced radiation exposure of the female breast during low dose chest CT using organ based tube current modulation and a bismuth shield: Comparison of image quality and radiation dose. *American Journal of Roentgenology* 2013; 200:537-544

© European Society of Radiology