CT Dose Optimisation: Tube Current Modulation vs Overall Tube Current Reduction

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BACKGROUND

The COMARE report (2014) suggested Imaging Optimisation Teams including radiographer, radiologist and health physics, should be established within CT depts in order to improve dose optimisation, radiation protection and patient safety [1]. This is particularly prevalent in paediatric practice where there is increased radiation risks due to the developing body and overall lifetime dose[2].

In recent years, the use of Automatic Tube Current Modulation (ATCM) programmes has alleviated the need for bismuth shielding (BS) within CT scanning. ATCM works by reducing the tube current (mA) whilst rotating over the anterior aspect of the patient but maintaining a level mA through the posterior and lateral portions of the body [3]. ATCM has been shown to provide the same anterior dose reduction to the sensitive organs – eyes, thyroid and breast – as achieved by bismuth shielding [4] but with the added benefit of not producing streak artefact or noise that can be seen in scans using BS [5].

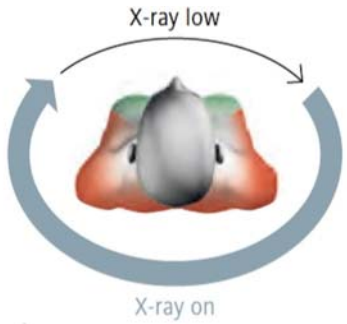

Fig 1. How ATCM Works [6]

Other studies have suggested that an overall tube current reduction can prove to have the same, if not even greater, dose reductions to the patient [7]. An overall tube current reduction of up to 30% has been shown to have a greater effect on patient than that of ATCM in that it decreases mA for the entire rotation thus lowering the dose to the entire area being scanned and not just the anterior portion as with ATCM [7,8,9].

However, as with any factors that are modified whilst scanning, ATCM and overall tube current reduction has the potential to have adverse effects on image quality. The purpose of this study was to assess both the effects on the resulting dose using both ATCM and Overall Tube Current Reduction and the resulting effects – if any – on image quality from both methods and whether there is room for improvement within the scan techniques used.

AIM

To assess which method – Automatic Tube Current Modulation or Overall Tube Current Reduction – successfully provides dose reduction whilst also maintaining image quality.

METHODS

A CT head phantom – pictured below (Image 1) - was scanned under 4 different controlled settings:

- SmartmA (50-500) without ODM (reference scan)
- SmartmA (50-500) with ODM
- Reduced SmartmA (50-350) without ODM
- Reduced Smart mA (50-350) with ODM

ODM – Organ Dose Modulation - is the scanner specific name of the ATCM programme.
The reduced SmartmA range on the 3rd and 4th scan setting was a 30% reduction on the maximum mA on the reference scan. The resulting CTDIvol and DLP from each setting was noted to see which gave the least radiation dose to the patient.

Image 1. CT Head & Neck Phantom

ANALYSIS METHODS

In order to assess whether image quality was effected by either ODM or an overall reduced tube current, 3 x 448.6mm2 areas of interest where selected on the same slice of each scan – in the anterior, central and posterior portion – and the CT number/SD for each scan were compared, as shown in Image 2-5.

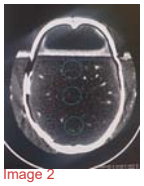

Image 2

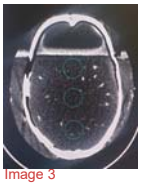

Image 3

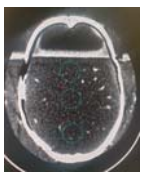

Image 4

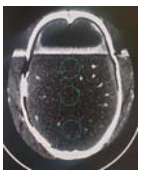

Image 5

RESULTS

The initial scan with the smart mA range of 50-500 without ODM created the base reference level. Repeating the scan with ODM showed a decrease in CTDIvol and DLP with little to no effect on the SD values in the 3 areas of interest. This confirmed that the scanners ATCM programme did not affect the image quality. The repeated scans with a reduced Smart mA range (50-350) produced different results, - a significant decrease in CTDIvol and DLP but increase in CT number SD - as shown in Table 1. These scans were reproduced helically and provided similar results.
The lowest CTDIvol & DLP was shown in the fourth scan variation - Reduced Smart mA (50-350) with ODM. This created a substantial overall dose reduction due to the 30% decrease in tube current as well as additional anterior reduction to the sensitive organs by having the ODM on. However, there was a marked increase (greater than 10% from the reference scan) in CT number, showing increase in noise and decrease in image quality.

CT Dose and Numbers in 3 Brain Regions Using Different Scanning Techniques

	Ant	Cen	Post	Dose	
Scanning Technique	SD	SD	SD	$CTDI_{vol}$	DLP
SmartmA (50-500) no ODM	5.00	4.40	4.50	24.87	348.22
SmartmA (50-500) + ODM	5.10	4.70	4.60	22.65	317.13
Reduced SmartmA (50-350) no ODM	5.90	5.50	5.70	13.94	195.1
Reduced SmartmA (50-350) + ODM	6.50	5.70	5.80	12.62	176.75

Table 1. Effect Tube Current Has on DLP and CT number (SD)

CONCLUSIONS

Although an overall tube current reduction of 30% combined with ATCM, provided the most significant change in dose – 49% reduction compared to reference – the CT numbers/SD were greater than 10% above the reference scan thus showing that this large decrease in mA has an impact on image quality which cannot be maintained. Whereas ATCM alone can maintain image quality whilst also reducing dose.
Reducing the overall mA and thus lowering the dose to the overall area and not solely the anterior aspect would be considered best practice within the paediatric setting where there is increased concerns regarding ionising radiation exposure[6].
Image Optimisation Teams could repeat this study using a lesser tube current reduction - ~15%, SmartmA 50-425 – to see if image quality could be maintained whilst also reducing the overall dose.

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