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Contrast-to-Noise Ratio Improvements with AIDR 3D

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Introduction

Contrast-to-noise ratio (CNR) is commonly cited as one of the single most useful indicators of image quality for optimisation studies in computed tomography[1]. CNR takes into account not only the difference in mean attenuation between tissues, but also the confounding effect of pixel noise, both of which influence the diagnostic confidence of an observer. In general, contrast in CT is affected by factors influencing the relative linear attenuation coefficients of tissues, including X-ray tube kilo-voltage and, if used, concentration of iodinated contrast agent. Factors affecting image noise include those determining the number of contributing X-ray photons: tube current, kilovoltage, slice thickness and patient size, as well as the convolution filter used in reconstruction and electronic noise inherent in the detector system. Reducing patient exposure in CT decreases the flux of X-ray photons to the detector and is generally associated with increased image noise. The recent introduction of iterative reconstruction methods in CT has offered the possibility of significantly reduced noise, hence improved CNR, for a given exposure.

AIDR 3D

The recently introduced AIDR 3D software[2], released with Aquilion software version 4.74, is an advanced iterative reconstruction algorithm in which noise is reduced via two processes. First, quantum noise and electronic detector noise (which dominates at very low levels of photon flux to the detector) are modelled and suppressed in the raw data contributing to the initial input filtered back projection (FBP) image. Secondly, a process of smoothing, combined with edge detection to preserve sharp detail, is employed in the iterative process. Three 'strengths' of AIDR 3D are available, Mild, Standard and Strong, providing a varying blend of FBP and iterative solutions, Mild having the least iterative weighting and Strong the greatest. In order to characterise the performance of the AIDR 3D algorithm for introduction into clinical use at our centre, we performed phantom studies measuring CNR for clinical 320 multi-detector row CT (320 MDCT) protocols, comparing results with previous algorithms.

Phantom measurements

One of the main clinical applications of 320 MDCT at our institution is CT coronary angiography (CTCA). Phantom images were acquired with our clinically used prospectively ECG triggered CTCA protocol, utilising a set-up previously adopted in studies of the AIDR 3D algorithm (Aquilion v4.6)[3]. In order to simulate a contrast filled vessel, the water target of the Catphan 600 phantom[4], replaced with a vial containing 4 % iodinated contrast (Iomeron 400, Bracco UK Ltd.) in isotonic saline, representative of the contrast concentration found in the coronary arteries during CTCA acquisition (Figure 1). The 30 cm diameter Catphan expansion annulus was used to simulate body scanning conditions. Acquisition parameters included simulated ECG

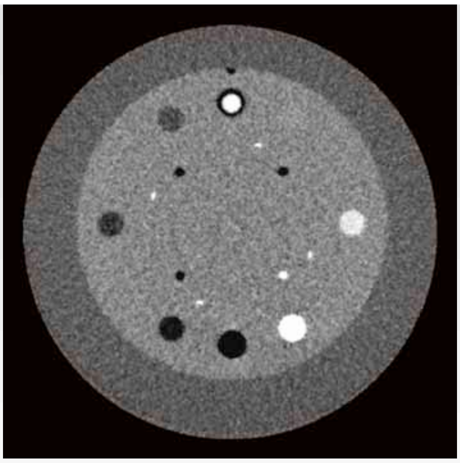

Fig. 1: Cross section through Catphan 600 showing iodinated contrast vial

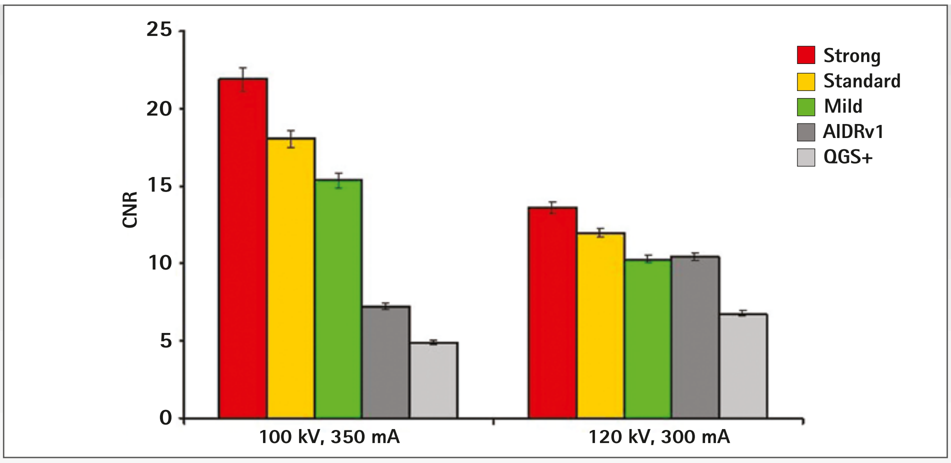

Fig. 2: Contrast-to-noise ratio results for iodinated contrast solution at 100 kV and 120 kV, comparing AIDR 3D, AIDR and QDS+ (filtered back projection) reconstructions

at 60 bpm, 0.35 s rotation, display field of view 200 mm (M), FC03 convolution filter, VolumeXact interpolation and 0.5 mm slices spaced at 0.25 mm. A range of tube current and kilovoltage combinations were acquired.

All scans were reconstructed with AIDR 3D Mild, Standard and Strong. CNR was calculated as the difference in mean Hounsfield Units (HU) for regions of interest (ROIs) placed within the contrast vial and the Catphan background material, divided by the pixel standard deviation in the background material. Figure 2 shows representative CNR results for acquisitions at 100 and 120 kV. These illustrate a general improvement in CNR with AIDR 3D relative to FBP and AIDR algorithm. The CNR gain is seen to increase with increasing iterative blend, from Mild to Strong. The CNR increase is also greater at 100 kV compared to 120 kV. This may be attributed to two factors: i) improved noise modelling and noise reduction at low photon flux, and ii) an increase in HU for high density structures with the new reconstruction software which is greater at 100 kV than 120 kV.

Cardiac applications

Figure 3 shows an MPR through the left anterior descending coronary artery for a CTCA patient scanned at 100 kV, reconstructed with AIDR 3D Mild, Standard and Strong (Aquilion v4.74), AIDR (Aquilion v4.6) and the filtered back projection based QDS+ algorithm (Aquilion v4.6). Mean HU and standard deviation results for ROIs placed over the aorta illustrate the increase in HU for iodinated contrast with the new software as well as progressive reduction in noise standard deviation with increasing AIDR 3D iterative blend.

Dose reduction

The significant gains in CNR found with AIDR 3D for a given exposure imply potential to reduce patient dose while maintaining an adequate level of image quality. Our results illustrate scope for substantial patient dose reduction in CTCA using AIDR 3D. The amount of dose reduction achievable will be dependent on the AIDR 3D strength (Mild, Standard, and Strong) selected as well as specific scan conditions such as tube kilovoltage and body habitus. However, dose reductions of up to 75 % may be achievable [2]. The observed increase in contrast may provide an opportunity to reduce another risk factor associated with CTCA. The increased sensitivity of the new reconstruction software to high density iodinated contrast material may allow the contrast agent dose to be reduced while maintaining adequate opacification of the coronary arteries and, consequently, help to reduce the risk of contrast induced nephropathy [5].

References

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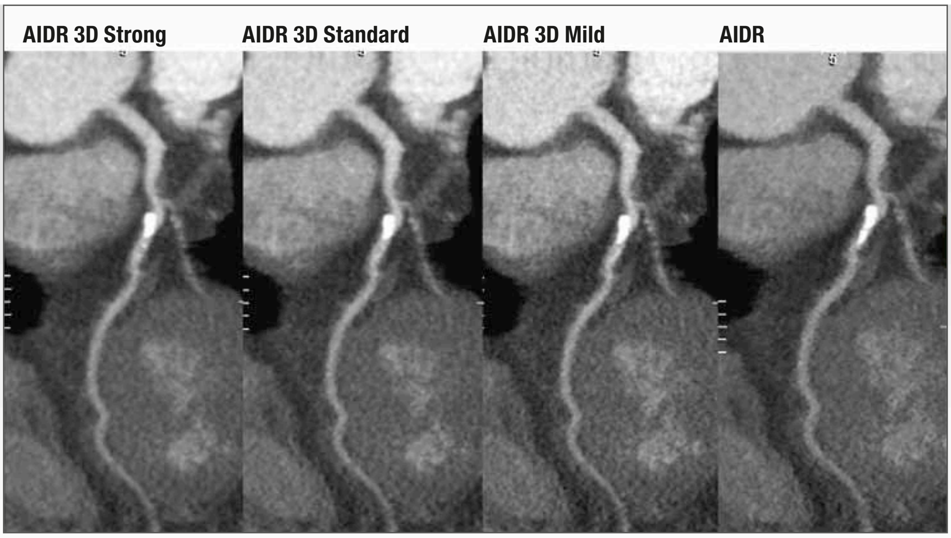

Fig. 3: MPR through LAD from a CTCA patient scanned at 100 kV reconstructed with AIDR 3D Mild, Standard and Strong, AIDR, and QDS+

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