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A New Scheme for Coronary Calcium Scoring at Reduced Dose with Lower Tube Voltage – A Simulation Study Based on Reference Image Acquisitions

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INTRODUCTION

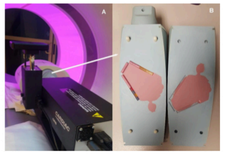
The screening nature of coronary calcium scoring calls for dose reduction. The standard score relies on 120 kVp acquisitions that limit dose reduction to mA adjustment. The score is categorized to five Hounsfield unit (HU) ranges with different weight factors: for HUs ranges of 0-129, 130 -199, 200-299, 300-399, and above 400, the calcium is scored zero, 1, 2, 3, and 4, respectively. The utilization of lower kVp makes further dose reduction possible. However, because the HU of calcification increases with decreasing kVp values, the thresholds must be adjusted accordingly. As such, it makes the current commercially available calcium scoring software unusable.

AIM

We propose a new scheme to achieve correct scores at lower kVps without changing the thresholds.

METHOD

Images were first acquired in axial mode at various kVps (120–70) on a Siemens Force CT from a stationary heart phantom (CIRS) with four 3-cm hydroxyapatite inserts (200 and 800 mg/cc). The ratios of HU at lower kVps to that at 120 kVp were obtained. The phantom was then embedded with 1.2- 5 mm HA inserts (50 –400 mg/cc) on the coronary track and the heart module was set in 3D motion with the ECG of 60 bpm. Axial image acquisitions were made at 120 kVp and various CTDIvol (3 –0.78 mGy). To simulate the calcium enhancement at lower kVps, all calcium pixels were selectively scaled up with the HU ratios obtained from the first step. To apply the CCS thresholds of 120 kVp, all pixel values in the image were scaled down to maintain the contrast-to-noise ratio. Calcifications were then scored using the SyngoVia CCS software.



RESULTS

1. The ground-truth calcium score was obtained at 120 kVp and 3 mGy, consistent with the typical clinical practice. Furthermore, the noise in the myocardium was measured as 16 HU, which is better than the noise threshold (20 HU) for calcium scoring recommended by Society of Cardiovascular CT (SCCT).
2. As compared to the ground-truth CCS results, the scores obtained for lower kVps from the simulated images based on the acquired images at 120 kVp using the new approach were consistent (error < 1%), except for the very low dose (0.78 mGy).
3. For images acquired at 120 kVp and 0.78 mGy where the noise generated significant false calcifications, the new approach resulted in better scores at lower kVps.

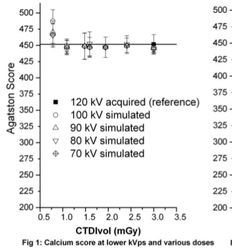


Fig 1: Calcium score at lower kVps and various doses

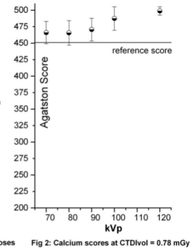


Fig 2: Calcium scores at CTDIvol = 0.78 mGy

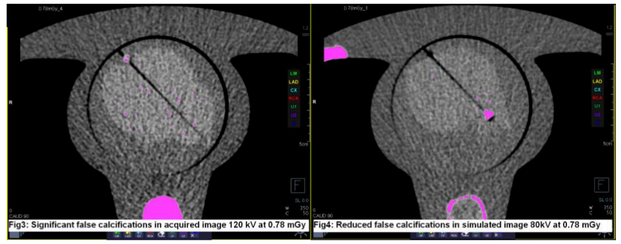


Fig3: Significant false calcifications in acquired image 120 kV at 0.78 mGy

Fig4: Reduced false calcifications in simulated image 80kV at 0.78 mGy

CONCLUSIONS

The coronary calcium scores at lower kVps using the new approach to the simulated images at lower kVps were verified to be consistent with the reference results at 120 kVp.

REFERENCES

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