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Impact of Pitch Selection on Coronary Artery Calcium Scores in Lung Cancer Screening CT

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BACKGROUND

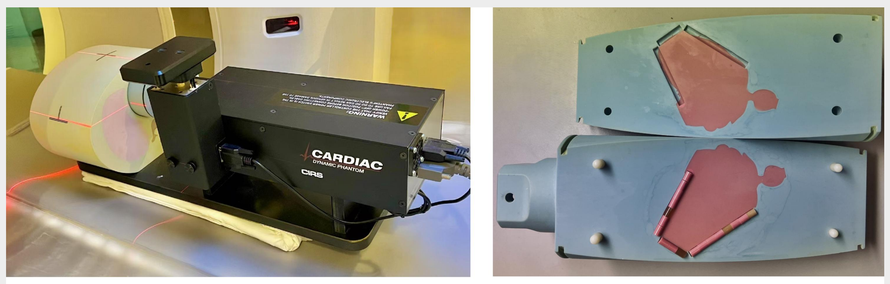
Lung cancer screening (LCS) CT enables opportunistic coronary artery calcium (CAC) scoring in a population at elevated risk for both lung cancer and cardiovascular disease. However, unlike electrocardiogram (ECG)-gated cardiac CT, which reconstructs images from projection data acquired during a selected low-motion cardiac phase, helical LCS CT traverses the heart continuously, with image reconstruction using projection data that span multiple cardiac motion phases and, potentially, adjacent cardiac cycles. The resulting cardiac motion blur and artifacts can reduce coronary calcium detectability and compromise CAC-score quantification.

PURPOSE

Opportunistic coronary artery calcium (CAC) assessment from lung cancer screening (LCS) CT can broaden cardiovascular risk stratification, but cardiac motion and acquisition settings may impact the calcium score. This study quantifies the impact of helical pitch on CAC score accuracy and reproducibility from non-gated LCS.

METHODS AND MATERIALS

A CIRS dynamic cardiac phantom with nine calcification inserts (diameter 1.2–5 mm; density 100–400 mg/cc) was scanned on a Siemens Force CT. Heart rates of 60 and 90 beats-per-minute (BPM) were used. Non-gated LCS CT ($CTDI_{vol}$ = 2.0 mGy) was acquired at 0.25-second rotation at pitches 0.9, 1.2, 1.5, and 3.0 (dual-source Turbo flash). All images were reconstructed at 3-mm slice thickness and 20 cm field-of-view. Additionally, ECG-gated CAC scans were performed ($CTDI_{vol}$ = 1.7 mGy) for ground-truth calcium scores. Siemens Syngo.Via was used to score discernible calcium inserts.



A B

Figure 1. Dynamic cardiac phantom. (A) Phantom placement inside CT gantry. The actuator was driven by a motion controller in the back. (B) Two phantom halves with a 13° split angle and a coronary artery track.

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RESULTS

Over the five repeated ECG-gated scans, four discernible inserts had a total score of 356 ± 9.7 (coefficient of variation [CV] = 0.03) at 60 BPM and 352 ± 27.8 (CV = 0.08) at 90 BPM. Non-gated LCS scans showed pitch-dependent underestimation and higher variability. At 60 bpm, a pitch of 0.9 scored 173.5 ± 55.7, with the highest CV (0.32); whereas a pitch of 1.5 improved agreement (300.2 ± 30.3) and reduced variability (CV = 0.10). At 90 bpm, a pitch of 1.2 scored 194.6 ± 48.8, with the highest CV (0.25); pitch 1.5 improved agreement (259.0 ± 29.1). The lowest CV at 90 bpm was 0.06 with Turbo-Flash mode.

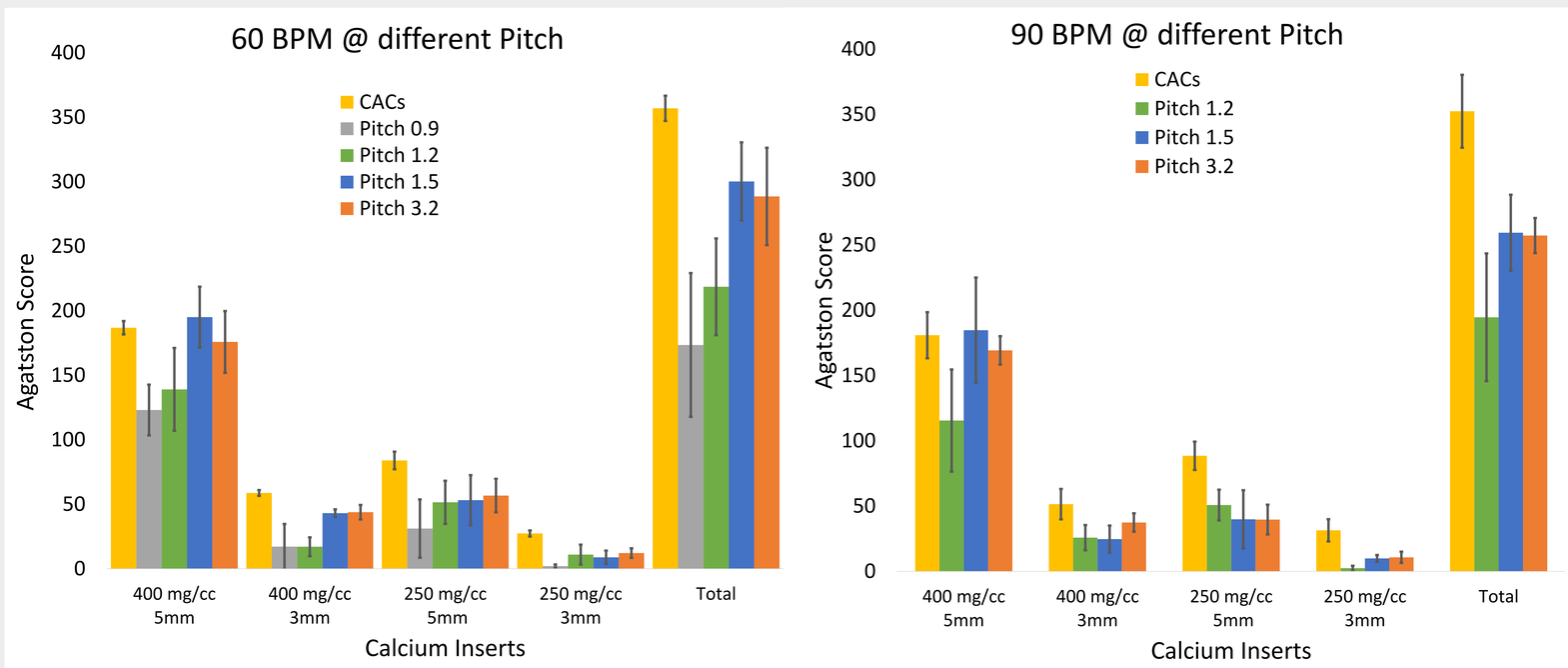

Figure 2: At 60 BPM (left), for non-ECG-gated scans, lower pitch resulted in underestimated calcium scores in all calcium inserts in comparison to the gated CAC scan, Turbo Flash mode is comparable to results from a pitch of 1.5. At 90 BPM (right), for non-ECG-gated scans, higher pitch resulted in improving results in small or lower-density calcium inserts.

DISCUSSION

Pitch changes the time required to traverse the heart and the phase encountered at each z-position. Prior patient work using wide-detector, high-pitch, fast-rotation non-gated chest CT showed strong agreement with dedicated calcium scoring CT, with best performance near 1.25-mm reconstruction[1,2]. However, pitch is not an isolated optimization variable. It also affects interpolation, longitudinal resolution, image noise, dose efficiency, and lung image quality. Any pitch change would require recalculation of the scan-start delay and validation of lung nodule performance.

The Turbo Flash acquisition provided further evidence that shorter cardiac traversal time can reduce motion-related error, and it should be considered exploratory[3]. But it differs from routine helical LCS CT and was used primarily to isolate the physical effect of shortened heart coverage time. A clinically used LCS protocol must balance CAC accuracy with lung nodule detectability, image noise, spatial resolution, dose, scanner availability, and workflow.

CONCLUSIONS

Compared with standard lung cancer screening CT (pitch 1.2), lower pitch (0.9) increases scan time relative to cardiac motion, causing calcium score underestimation and variability. Higher pitches (1.5) improve reproducibility and accuracy. Turbo flash mode further improves reproducibility, especially with a high heart rate. This study highlights the impact of helical pitch on CAC assessments.

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