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Original Research Article

Comparison of postprocessing techniques for the detection of perfusion defects by cardiac computed tomography in patients presenting with acute ST-segment elevation myocardial infarction

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BACKGROUND: Despite rapid advances in cardiac computed tomography (CT), a strategy for optimal visualization of perfusion abnormalities on CT has yet to be validated.

OBJECTIVE: We evaluated the performance of several postprocessing techniques of source data sets to detect and characterize perfusion defects in acute myocardial infarctions with cardiac CT.

METHODS: Twenty-one subjects (18 men; 60 ± 13 years) that were successfully treated with percutaneous coronary intervention for ST-segment myocardial infarction underwent 64-slice cardiac CT and 1.5 Tesla cardiac magnetic resonance imaging (MRI) scans after revascularization. Delayed enhancement MR images were analyzed to identify the location of infarcted myocardium. Contiguous short-axis images of the left ventricular myocardium were created from the CT source images with 0.75-mm multiplanar reconstruction (MPR), 5-mm MPR, 5-mm maximal intensity projection (MIP), and 5-mm minimum intensity projection (MinIP) techniques. Segments already confirmed to contain infarction by MRI were then evaluated qualitatively and quantitatively with CT.

RESULTS: Overall, 143 myocardial segments were analyzed. On qualitative analysis, the MinIP and thick MPR techniques had greater visibility and definition than the thin MPR and MIP techniques ($P < 0.001$). On quantitative analysis, the absolute difference in Hounsfield unit attenuation between normal and infarcted segments was significantly greater for the MinIP (65.4 Hounsfield unit [HU]) and thin MPR (61.2 HU) techniques. However, the relative difference in Hounsfield unit attenuation was significantly greatest for the MinIP technique alone (95%; $P < 0.001$). Contrast to noise was greatest for the MinIP (4.2) and thick MPR (4.1) techniques ($P < 0.001$).

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CONCLUSION: The results of our current investigation found that MinIP and thick MPR detected infarcted myocardium with greater visibility and definition than MIP and thin MPR.

Introduction

Recent studies suggest that cardiac computed tomography (CT), a study commonly performed for the detection of coronary artery stenosis,[1] may afford the ability to assess myocardial perfusion. In preliminary work among patients with ST-elevation myocardial infarction (MI), Mahnken et al[2] demonstrated excellent agreement of contrast-enhanced cardiac CT with cardiac magnetic resonance imaging (MRI). With the use of delayed enhancement (DE) MRI as a "gold standard: agreement was seen in 92.6% of segments on DE-CT, 83.7% of segments with early-phase CT, and 82.4% of segments with late enhancement CT. Moreover, an excellent correlation was observed between early and delayed CT and MRI for infarct size ($r = 0.93$, $r = 0.89$, respectively) in both acute and chronic MI.[3]

Given the potential for CT evaluation of myocardial perfusion, an optimal strategy for optimal visualization of perfusion abnormalities on CT must be validated. Most analyses performed to date have empirically evaluated CT-based myocardial perfusion with thick (ie, 5–10 mm) sliced multiplanar reconstructions (MPRs).[4,5] Because cardiac perfusion abnormalities manifest as areas of hypoattenuation relative to the surrounding myocardium, thick MPR images or minimum intensity projection (MinIP) reconstructions might theoretically allow for better identification of perfusion abnormalities. In this study, we sought to compare different image postprocessing techniques of source data sets to identify the best method to detect and characterize perfusion defects in acute MI.

Methods

Patient population

For our initial analysis, subjects that presented with ST-segment MI and were successfully treated with percutaneous coronary intervention were prospectively enrolled from the cardiac intensive care unit of our institution as previously described.[6] The study protocol was approved by our institutional review board and was in compliance with the Health Insurance Portability and Accountability Act. All subjects provided written informed consent.

All subjects subsequently underwent 64-slice cardiac CT and 1.5 Tesla cardiac MRI scans on average 2.8 days (range, 1–5 days) from reperfusion for research purposes.

Subjects were excluded if they had a known history of MI, required the support of intraaortic balloon counterpulsation or intravenous inotropic therapy, had evidence of ongoing myocardial ischemia, had arrhythmia that caused hemodynamic compromise or irregular heart rhythm, were pregnant, had impaired renal function, were claustrophobic, or had metal implants that contraindicated MR imaging.

CT image acquisition

Cardiac CT images were obtained on a 64-slice multidetector scanner (Sensation 64; Siemens, Forchheim, Germany) with a rotation time of 330 milliseconds, temporal resolution of 165 milliseconds, 32 $\times$ 0.6-mm-wide detector collimation, and double z-axis acquisition technology (Z-Sharp; Siemens).[7] The CT was obtained after a 20-mL test bolus with 75–90 mL of iodixanol (Visipaque; GE Healthcare, Princeton, NJ), a tube voltage of 120 kV, mean tube current of 871 $\pm$ 29 mAs, and was timed to 4 seconds after peak aortic root enhancement to provide for myocardial enhancement. Tube current modulation was used in 17 subjects, and the average ($\pm$ SD) heart rate during acquisition was 65 $\pm$ 8 beats/min.

MR image acquisition

Cardiac MR images were obtained on a 1.5 Tesla scanner (Twin-Speed Excite; GE Healthcare, Milwaukee, WI.) with an 8-element phased-array cardiac coil and high-speed gradients (maximum amplitude, 40 mT/m; slew rate, 150 T/m/s). Delayed enhancement images were obtained 10–15 minutes after the intravenous injection of 0.2 mmol/kg gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) to diagnose myocardial infarction. Images were acquired as 8-mm thick consecutive short-axis images with the use of an inversion-recovery prepared fast gradient-echo pulse sequence (20-degree flip angle; 180-degree inversion pulse; 150- to 300-millisecond inversion time).

MR infarct interpretation

MR images were interpreted on a dedicated cardiac MR (Advantage WS; GE Medical Systems) image processing workstation. The location of infarcted myocardium was recorded by an experienced reader (R.C.C., 5 years of cardiac MRI experience) as areas of hyperenhancement on delayed enhancement images in segments 1–16 of the myocardium with the use of the American Heart Association/American College of Cardiology (AHA/ACC) 17-segment model. DE-MRI scans were used as the reference, given that this current analysis was conducted to