Imaging of myocardial infarction using carbon nanotube micro-computed tomography and delayed contrast enhancement

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Abstract

We demonstrate the application of our cardiac and respiratory-gated carbon nanotube (CNT) micro-CT system by evaluating murine myocardial infarction models with a delayed contrast enhancement technique. Myocardial infarction was induced in 8 wild-type male mice. The ischemia reperfusion model was achieved by surgical occlusion of the LAD artery for 30 minutes followed by 24 hours of reperfusion. Free-breathing subjects were anesthetized with isoflurane during imaging. Myocardial infarction was induced in 8 wild-type male mice. The ischemia reperfusion model was achieved by surgical occlusion of the LAD artery for 30 minutes followed by 24 hours of reperfusion. Free-breathing subjects were anesthetized with isoflurane during imaging.

Background

Cardiovascular disease; leading cause of deaths worldwide, 17.1 million deaths each year, 7.2 million from myocardial infarction. Myocardial infarction murine model used for myocardial infarction research required for advancements in diagnosis and treatment.

Motivation

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Methods

Eight wild-type male mice, 10-12 week old, 25-35 g, first acquisition time. X-ray source consists of a carbon nanotube cathode, gaseous two static focusing structures, and a tungsten anode target. Scanner resolution after reconstruction 77 μm. Step-and-shoot protocol, 288 projections over 288 degrees. X-ray pulses 15 milliseconds in duration, 50 keV.

Results

Images acquired an average of 0, 12 and 25 min after administration of Omnipaque show distinct hyperenhancement in myocardial wall corresponding to the region at risk of infarction due to LAD obstruction. Delayed enhancement visible in images from both time-points. The first acquisition time (approximately, 0-10 minutes post administration) appears optimal, and only one image is required to visualize the infarct.

Conclusion

Carbon nanotube micro-CT allows superior in vivo murine cardiac imaging. Both structural and functional information about the heart following ischemia can be obtained with a single imaging modality and straightforward contrast administration protocol. CT images obtained and diastole and systole allow measurement of ejection fractions, which quantify a decrease in heart function following ischemia and reperfusion. Further work is ongoing to streamline the imaging protocol and perform more quantitative analysis of the images.

References


Image 451x2009 to 607x2421

*-built in-house


Image 1111x1656 to 1270x2069

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Micro CT images demonstrate areas of delayed contrast enhancement in infarcted myocardium due to contrast agent retention in fibrotic tissue (top). Histological gross cross with TPE imaging reveal infarct within myocardium due to a lack of perfusate (bottom). Indications for the delayed contrast technique are comparable in location, shape, and volume between CT and histological images and histological results.