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Original Research Article

A direct comparison of the sensitivity of CT and MR cardiac perfusion using a myocardial perfusion phantom

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ABSTRACT

Background: Direct comparison of CT and magnetic resonance (MR) perfusion techniques has been limited and in vivo assessment is affected by physiological variability, timing of image acquisition, and parameter selection.

Objective: We precisely compared high-resolution k-t SENSE MR cardiac perfusion at 3 T with single-phase CT perfusion (CTP) under identical imaging conditions.

Methods: We used a customized MR imaging and CT compatible dynamic myocardial perfusion phantom to represent the human circulation. CT perfusion studies were performed with a Philips iCT (256 slice) CT, with isotropic resolution of 0.6 mm^3. MR perfusion was performed with k-t SENSE acceleration at 3 T and spatial resolution of $1.2 \times 1.2 \times 10$ mm. The image contrast between normal and underperfused myocardial compartments was quantified at various perfusion and photon energy settings. Noise estimates were based on published clinical data.

Results: Contrast by CTP highly depends on photon energy and also timing of imaging within the myocardial perfusion upslope. For an identical myocardial perfusion deficit, the native image contrast-to-noise ratio (CNR) generated by CT and MR are similar. If slice averaging is used, the CNR of a perfusion deficit is expected to be greater for CTP than MR perfusion (MRP). Perfect timing during single time point CTP imaging is difficult to achieve, and CNR by CT decreases by 24%–31% two seconds from the optimal imaging time point. Although single-phase CT perfusion offers higher spatial resolution, MRP allows multiple time point sampling and quantitative analysis.

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Conclusion: The ability of CTP and current optimal MRP techniques to detect simulated myocardial perfusion deficits is similar.

1. Introduction

Myocardial perfusion is a major determinant of cardiovascular risk and is an essential tool for the guidance of interventional strategies.[1] Magnetic resonance perfusion (MRP) represents a highly accurate clinical perfusion imaging technology,[2,3] with higher spatial resolution than single-photon emission CT[4] and excellent correlation with invasive fractional flow reserve (FFR) data.[5]

The potential use of CT for the assessment of myocardial perfusion has long been recognized[6]; however, only recently has the advent of fast multislice CT technology resulted in potential widespread clinical application. The most prevalent method of CT perfusion (CTP) is a single time point comparison of myocardial contrast densities at rest and pharmacologic stress. A major multicenter trial of this CTP methodology[7] has recently concluded.

Although CTP findings correlate well with MRP,[8–10] direct and precise comparison of the sensitivity of the 2 techniques is hampered by several factors, including the lack of an adequate noninvasive "gold standard," the wide variety of acquisition modes of both MRP and CTP, and physiological and disease variability. Although data from animal models have been useful for the validation of both MRP[11–13] and CTP[14,15] individually, prolonged anesthesia and contrast accumulation make this technique problematic for systematic side-by-side comparison of multiple perfusion modes.

We therefore used a validated myocardial perfusion phantom[16] to precisely compare high-resolution k-t SENSE MRP at 3 T, an optimal available clinical standard, with single-phase CTP under identical perfusion conditions. The comparative sensitivity of each method was evaluated with a variety of simulated perfusion deficits and CT energy levels.

2. Methods

2.1. *Perfusion phantom*

A more detailed description and evaluation of the myocardial perfusion phantom for MRP have previously been published.[16] A simplified model of the human cardiovascular circulation was constructed, consisting of tubing and mixing chambers to represent the human circulation and to allow physiological contrast dispersion within the model. The phantom includes a venous input, atrial and ventricular cardiac chambers, pulmonary and aortic outputs, coronary arteries, and 2 diffusion chambers to represent myocardial tissue (Figs. 1 and 2).

Input ports on the venous side of the model allow for contrast injection, and coronary arteries that lead from the

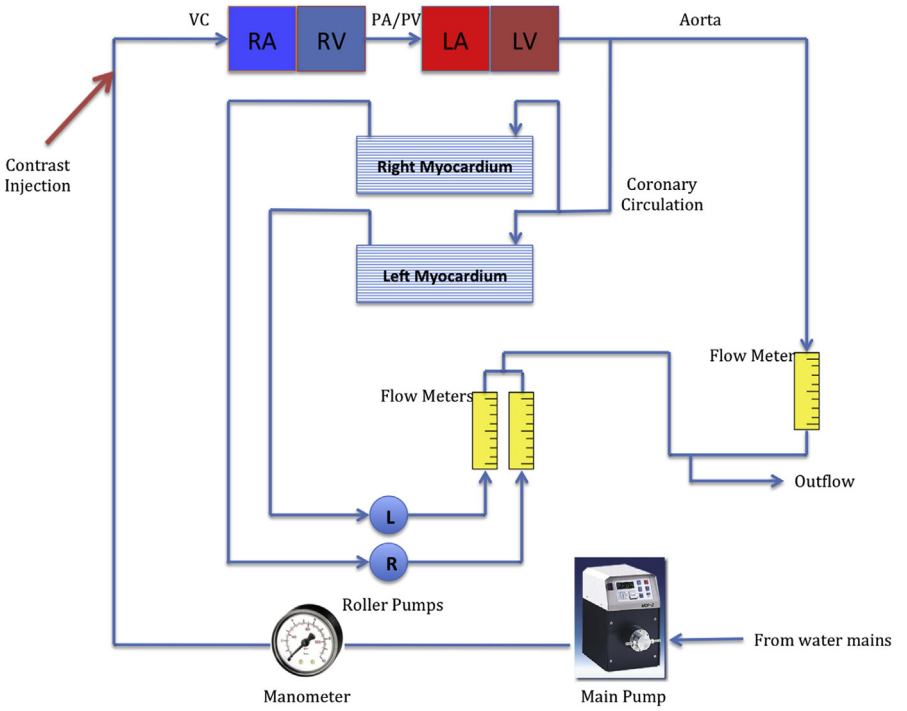

Figure 1 – Myocardial perfusion phantom schematic. L, left; LA, left atrium; LV, left ventricle; PA, pulmonary artery; PV, pulmonary vein; R, right; RA, right atrium; RV, right ventricle; VC, vena cava. Adapted from Chiribiri et al[16] with permission of Wiley Publishers.