

EIGHT-FOLD K-T BLAST ACCELERATED DCE-MRI FOR HIGH RESOLUTION ASSESSMENT OF MYOCARDIAL PERFUSION

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Introduction: Assessment of myocardial perfusion by dynamic contrast enhanced MRI (DCE-MRI) is still an evolving technique and is yet to become a part of standard diagnostic assessment of patients with coronary heart disease (CHD). Despite its advantages over other tomographic methods, the transition of DCE-MRI from a promising research technique into a robust clinical tool has been impeded by the severe spatial and temporal constraints imposed by the nature of this examination. k-t BLAST is an acceleration method which differs from other acceleration approaches in that it allows reconstruction from undersampled data based on low resolution training data taking into account similarities in space and among time frames [1]. By exploiting the spatio-temporal correlations in the image series, this technique aims at full recovery of the missing information. We hypothesised that significant improvement in spatial resolution can be achieved through k-t BLAST acceleration of DCE-MRI without loss of image quality or diagnostic information.

Methods: The boundary conditions used in the design of the high-resolution sequence were: a) spatial resolution ~2mm in plane for a FOV of 400mm, b) acquisition duration ~100ms, c) total shot duration <200ms. Temporal requirements b and c allow the imaging of three short axis slices through the left ventricle at every heart beat (for heart rates of up to 100bpm). Scanning was performed on a whole body 1.5 T MR scanner (Gyrosan Intera CV, Philips Medical Systems) with dedicated k-t BLAST/k-t SENSE acquisition and reconstruction software (GyroTools Ltd, Switzerland). DCE-MRI with k-t BLAST incorporated a single shot TFE readout (TR/TE/ ϕ = 3.6/1.7/15°), k-t acceleration factor = 8, image matrix = 192x187 (acquired voxel volume 0.045ml). Three short axis slices were individually prepared with a saturation recovery pre-pulse (150ms pre-pulse delay). Accelerated DCE-MRI first-pass studies were acquired within a single breathhold.

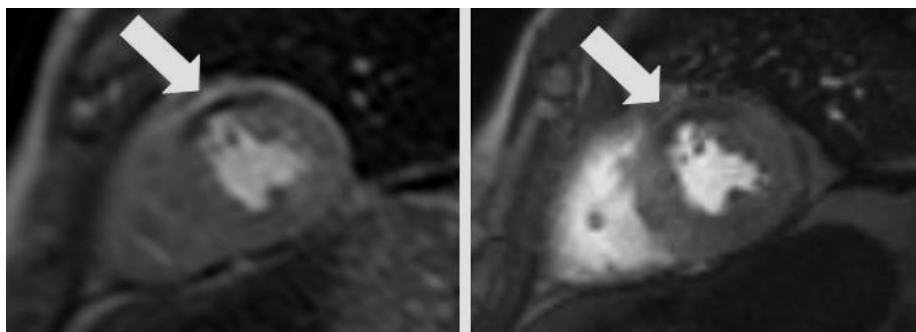


Figure 1. Conventional (left) and high resolution k-t BLAST accelerated (right) DCE-MRI, in a patient with a significant lesion in the LAD territory. The reduction of image voxel size from 0.077ml to 0.045ml was achieved through k-t BLAST acceleration.

Results: DCE-MRI studies acquired in healthy volunteers were of consistently high quality, for a range of cardiac, respiratory and haemodynamic conditions. In a patient with suspected CHD, a lesion in the LAD territory can be seen on both the conventional and k-t accelerated images acquired under adenosine stress (Figure 1). A significant lesion in the LAD was subsequently confirmed on X-ray angiography. Quantitative analysis of k-t accelerated DCE-MRI perfusion studies was performed by calculating high resolution parametric maps of enhancement ratios (E) expressed as % signal change over baseline (Figure 2).

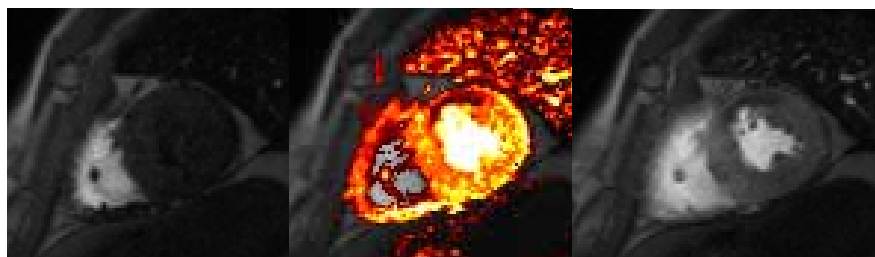


Figure 2. Pre-contrast (left) and first-pass (right) dynamic frames acquired using k-t BLAST DCE-MRI with an acceleration factor 8. Parametric map of enhancement ratios (center) Red colour indicates locations where $E < 100\%$, orange: $E < 200\%$, yellow: $E < 300\%$, bright yellow: $E < 400\%$.

The regional ethics review board's permission was obtained and six healthy volunteers were scanned at rest and under adenosine induced stress with peripheral venous administration of Gd-DTPA (Magnevist).

A 63-year-old male patient with suspected CHD was scanned using a conventional sequence employing a single-shot TFE readout with TR/TE/ ϕ =2.7/1.0/15°, SENSE factor = 2 and acquisition matrix of 144x144 (acquired voxel volume 0.077ml, with FOV=400mm and slice thickness = 10mm). Seven weeks later, a repeated examination was performed using the optimised high resolution k-t BLAST sequence and identical geometry settings.

Discussion: The requirement for rapid collection of signal during the first arterial pass of the contrast agent through the myocardial vasculature limits the maximal achievable spatial resolution in DCE-MRI studies of myocardial perfusion. With the spatial resolution currently achieved through conventional fast DCE-MRI, adequate assessment of the subendocardial layer is not possible. Myocardial perfusion imaging with the application of eight-fold k-t BLAST acceleration allows a significant improvement in spatial resolution over other fast MRI acquisition methods.

In this pilot study, the feasibility of eight-fold k-t BLAST DCE-MRI of myocardial perfusion was demonstrated. Further work is needed to formally investigate the diagnostic utility of this method.

Reference: [1]Tsaio, Boesinger and Preussman. MRM 50:1031-1042, 2003.