Efficient Substitute for Inversion Preparation in TSE Angiography

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INTRODUCTION

Turbo spin echo (TSE or FSE) is an important technique in the discrimination of atherosclerotic plaque components such as hemorrhage, disrupted fibrous cap, lipid/necrotic core, calcification and ulceration (1). To distinguish between stationary tissue and flowing blood, several techniques such as Double Inversion Recovery (DIR), Quadruple Inversion Recovery (QIR) or Motion-Sensitized Driven-Equilibrium (MDSE) have been proposed (2-4). These suppression techniques involve various combinations of inversion pulses over a large volume outside the slice(s) of interest. This prevents efficient interleaving of multiple slices and results in a dramatic increase in total scan time. This work utilizes a novel dynamic TSE sequence (cineTSE) to provide analogous information to blood suppression techniques with no increase in scan time over a typical (non-inversion prepared) TSE protocol.

THEORY

In many applications, blood suppression may not be necessary if we can identify blood signal using dynamic information throughout the cardiac cycle. The cineTSE sequence generates a full sequence of cardiac cycle correlated images at each slice location throughout the cardiac cycle in the same scan time that is conventionally used by standard TSE sequences to produce a single image at each slice location. With the cineTSE sequence, magnitude and phase variations of flowing blood during the cardiac cycle are easily distinguishable from surrounding tissue.

METHOD

With informed consent, data for six slices of T1w QIR TSE and T1w cineTSE was acquired before and after Gd contrast injection on one subject using a Siemens Trio 3T MRI scanner with custom designed 16 element phased array surface coils. For cineTSE, the conventional TSE sequence was modified to store information about the subject's cardiac cycle during the MR scan utilizing a pulse oximeter. The acquired k-space data lines are sorted into temporal bins according to the time elapsed since the last systolic trigger. The resulting randomly undersampled k-space bins are reconstructed into a sequence of images by simultaneously considering information encoded by the coil sensitivities as well as applying a temporal constraint. Data sets are all 256x264, 12 echoes per train, 0.5x0.5x2mm resolution, TR/TE=800/9.2ms and 2 averages worth of data. For QIR, both inversion delays were 300ms.

RESULTS

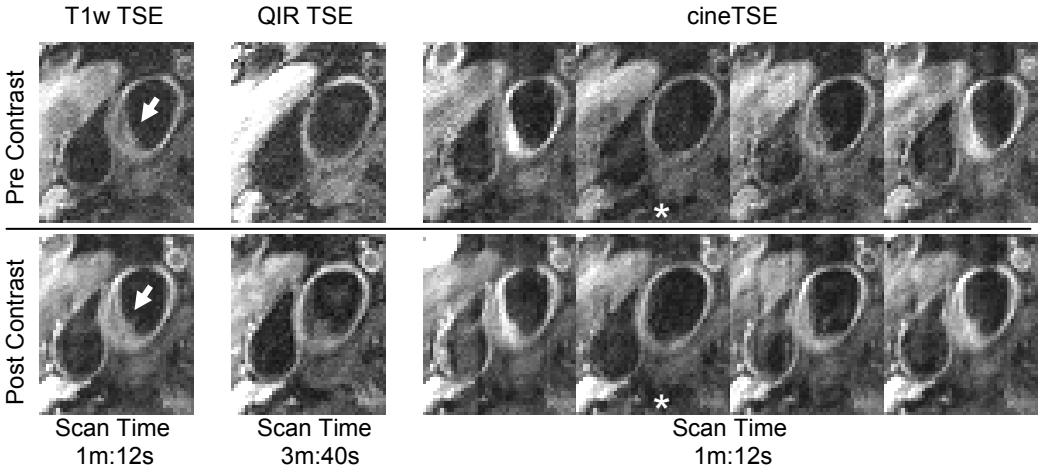

Figure 1: 2D TSE images of the common carotid artery before and after contrast. Multihance contrast agent was admnistered as a rapid bolus at a concentration of 0.1 mmol/kg. Immediately after injection, the cineTSE data was acquired followed by the QIR data. Only 4 (of 12) equally spaced cardiac phases are shown for the cineTSE.

DISCUSSION AND CONCLUSION

The standard T1w TSE images suffer from flow artifacts in both pre and post contrast data sets (arrow in Fig. 1). While the QIR eliminated most of the flow effects in the pre contrast data, the post contrast still had some residual flow which could be the result of not optimizing inversion times. The QIR will also suffer from some motion artifacts since it is not gated. If the cineTSE images are observed, it is evident that the suspected flow artifact in the T1w images (arrow in Fig. 1) is indeed blood signal. The signal is seen to come and go throughout the cardiac cycle. In this case, just a single frame of the cineTSE images (star in Fig 1) could be used to distinguish the flow artifact, however, in general the entire dynamic sequence will be necessary. CineTSE has the added benefit of providing tissue information that is not blurred by the cardiac motion. The major benefit in this application is that the acquisition time was about a third of that required for the QIR sequence. The cineTSE sequence can provide analogous information to blood suppression techniques without substantial increases in scan time.

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