

## Intracranial vessel wall imaging with simultaneous blood and CSF suppression

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**Introduction:** Recent studies suggested that the intracranial artery disease may have contributed to stroke and other clinical events more often than previous believes<sup>1,2</sup>. Although non-invasive MR techniques have long been used to evaluate the extracranial arteries' plaque burden and components<sup>3</sup>, only a few techniques are at the clinicians' deploy when studying the intracranial artery. One of the key reasons is that the successful delineation of intracranial artery outer wall boundary requires the simultaneous suppression of blood and cerebrospinal fluid (CSF). The two requirements are usually competing and it's challenging to achieve both in a time-efficient fashion. Previous techniques are limited either by low-efficiency<sup>4</sup> or the lack of a dedicated CSF suppression<sup>5</sup>. In this study, a fast intracranial wall imaging technique with simultaneous blood and CSF suppression was developed and tested in vivo.



Fig.1 Pulse sequence used for intracranial vessel wall imaging

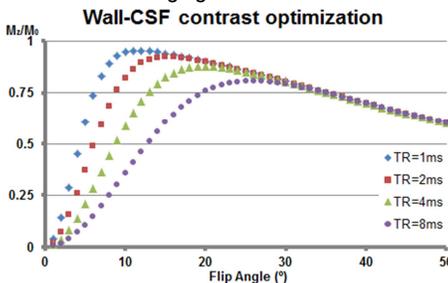


Fig. 2 The optimization of vessel wall & CSF contrast. Overall, shorter TR provides better contrasts and the contrast peaks when TR is 1ms and FA is 12°.

**Methods:** The pulse sequence diagram is shown in Fig.1. It contains a DANTE pre-pulse<sup>6</sup> and a long echo train extended TSE (VISTA) acquisition: the DANTE pulse is used to saturate CSF and blood while the VISTA acquisition will also contribute to effective blood nulling. To achieve the most effective wall-CSF contrast, TR and flip angle (FA) were optimized using a signal model proposed before<sup>6</sup>. In this simulation, flip angle ranges 1°-50° and TR ranges 1-8ms were tendered to identify the optimized parameter. The number of TRs was adjusted to keep the total time of preparation ( $n \times TR$ ) constant.

To evaluate the CSF nulling efficiency, 3 healthy volunteers were scanned after obtaining their informed consent. All scans were performed on a 3T whole body scanner (Philips Achieva, R3.21, the Netherlands). The proton density weighted VISTA acquisition was similarly configured as reported before<sup>5</sup>: TR/TE 2000/19ms, FOV 210×180×48mm<sup>3</sup>, voxel size 0.6×0.6×0.6mm<sup>3</sup>, ETL 38, half scan, SENSE 2.8. Total scan time: 4min30sec. The DANTE prepared sequence used optimized parameters as identified in the simulation and matched acquisition parameters to VISTA. To evaluate the performance of DANTE's performance on a multi-contrast imaging protocol, it was also added and compared to a regular 2D T<sub>2</sub> TSE sequence (where CSF is expected to be bright). The imaging parameters were: TR/TE 4000/80ms, FOV 220×220mm<sup>2</sup>, voxel size 0.6×0.6mm<sup>2</sup>, slice thickness 4mm, ETL 12, scan time: 3min40sec for 16 slices.

**Results:** As shown in Fig.2, the simulation indicates that shorter TR provides better contrast between vessel wall and CSF, and maximized contrast will be achieved when TR is 1ms and FA is 12°. In vivo tests found that DANTE VISTA demonstrated effective CSF suppression and helped greatly in visualizing the outer boundary of the intracranial artery (Fig.3), without compromising the scanning efficiency. In regular VISTA, the outer wall

boundary of basilar artery couldn't be visualized due to the similar contrast from CSF; while in DANTE, the outer wall can be better delineated as the CSF is much better suppressed. No apparent flow artifacts were identified on either set of the images. Similarly, in the traditional T<sub>2</sub> TSE (Fig.4), although the overall image contrast was kept the same, DANTE was able to effectively eliminate the bright signal from CSF, making the vessel wall much better visualized.

**Conclusion:** In this study, simultaneous blood and CSF suppression was achieved by taking the advantage of long T<sub>1</sub> saturation of DANTE and the high acquisition efficiency of VISTA. The technique was optimized for CSF suppression and tested in vivo. It has been shown to suppress the CSF signal effectively on both proton density and T<sub>2</sub> weighted images. This technique essentially provides an effective way to achieve multi-contrast intracranial atherosclerosis imaging, creating a unique solution to study the clinical impact of intracranial artery disease.

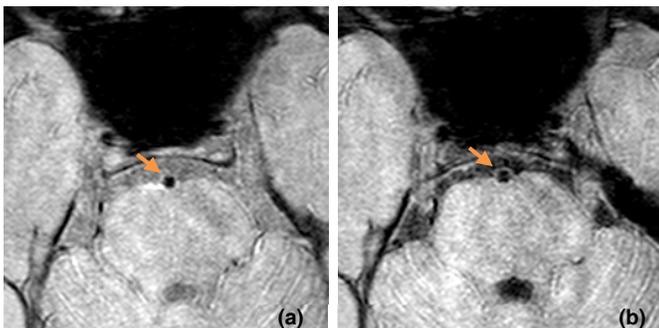


Fig. 3 The improved CSF suppression in DANTE VISTA (b) as compared with traditional VISTA (a). The basilar wall boundary was much better delineated on DANTE VISTA (arrows).

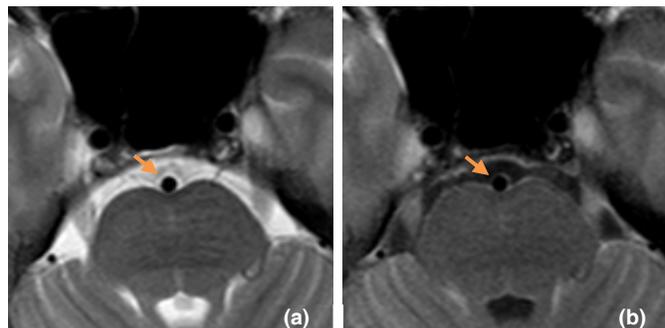


Fig. 4 The improved CSF suppression on T<sub>2</sub> weighted TSE on DANTE (b) as compared to regular TSE (a). The intracranial wall is invisible on regular T<sub>2</sub> due to the long T<sub>2</sub> of CSF, but becomes well visualized on DANTE (arrows).

**References:** 1. Wong LK. Intl. J Stroke 2006; 1:158-9. 2. Gorelick PB et al. Stroke 2008; 39:2396-9. 3. Yuan C et al. Circ 1998; 98:2666-71. 4. van der Kolk AG et al. Stroke 2011; 49:2478-84. 5. Qiao Y et al. JMRI 2011; 34:22-30. 6. Li L et al. Magn Reson Med 2012; 68:1423-38.