ON-LINE APPENDIX: OPTIMIZATION STUDY

Optimization

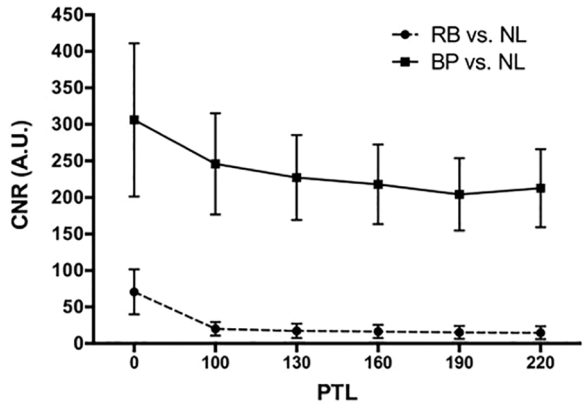
Sequence optimization was focused on the DANTE module with the goal of achieving satisfactory suppression of venous blood signals in BTI. Several DANTE parameters, including radiofrequency pulse train length (PTL), pulse flip angle, and the zeroth gradient moment between 2 successive radiofrequency pulses, are the determinants of the blood-suppressing performance.[1] Many optimal combinations of these parameters may exist for a particular application.[1–4] To account for real flow characteristics in cerebral venous sinuses, we conducted DANTE optimization through in vivo experiments. Briefly, the duration (0.8 ms) and strength (20 mT/m) of each gradient pulse, radiofrequency pulse gap (1 ms), and pulse flip angle (12°) were kept fixed, whereas PTL with different values (ie, 100, 130, 160, 190, 220) was respectively tested in BTI scans to determine an optimal one. Moreover, a BTI scan without DANTE preparation was also conducted to serve as a reference. The 6 BTI scans were collected in a random order from each healthy subject using the same imaging parameter setting as in the patient study.

Study Population

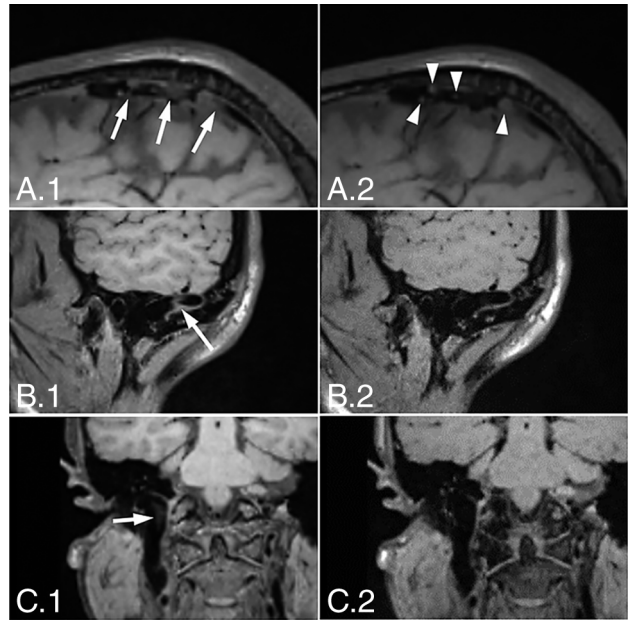
Ten healthy subjects (3 women; age range, 27–60 years; mean age, 45 years) without known cerebrovascular diseases were recruited to optimize the BTI technique.

Image Analysis

In the optimization study, the 6 BTI image sets of each subject were reviewed together by a radiologist (G.W., with 8 years of experience in MR image interpretation) to identify residual blood signals in individual segments on the image set without DANTE preparation. When residual blood was observed in a segment, the mean signal intensity was measured (N.Z., with 7 years of experience in image analysis) at the regions of residual blood, adjacent normal venous lumen, and adjacent brain parenchyma, respectively, with ROIs. The noise, σ, was also measured as the signal intensity (SI) SD from an ROI in the adjacent air space. The contrast-to-noise ratio (A-to-B CNR = $[SI_A - SI_B]/\sigma$) was calculated for residual blood versus normal lumen (indicating the blood-suppressing performance of DANTE) and for brain parenchyma versus normal lumen (indicating the overall sacrifice in black-blood contrast caused by DANTE), respectively. CNRs averaged over all residual blood–detected segments were derived for each subject. With these ROIs directly copied, CNR calculations were then repeated for all other DANTE-prepared BTI image sets. Optimal PTL was finally determined on the basis of a balance between a low residual blood-to-lumen CNR and adequate brain parenchyma-to-lumen CNR.



ON-LINE FIG 1. CNR measured on BTI with different DANTE pulse train lengths (PTLs). The CNR of residual blood (RB) versus normal lumen (NL) is reduced by 71%–79% when applying the DANTE preparation with a PTL of 100–200 to BTI. In contrast, the CNR of brain parenchyma (BP) versus NL is reduced only by 20%–33%. AU indicates arbitrary units.



ON-LINE FIG 2. Examples from 3 health volunteers illustrating the improved black-blood effect using BTI with an optimized DANTE preparation. The residual blood signals observed in the superior sagittal sinus (*arrow, A.1*), right sigmoid sinus (*arrow, B.1*), and right internal jugular vein (*arrow, C.1*), respectively, on BTI can be effectively suppressed using an optimized DANTE preparation (*A.2*, *B2*, *C2*). Arachnoid granulations (*arrowheads* in *A.2*) that often coexist with residual flow artifacts and thus could mimic an isointense thrombus on BTI are also distinctly identified when applying the optimized DANTE preparation.

AQ: P

RESULTS

On BTI without the DANTE preparation, residual blood signals were observed in 1–3 segments in each of the healthy subjects. When PTL was 10–220 in the DANTE module, residual blood signals were effectively suppressed as evidenced by a reduced residual blood-to-lumen CNR by 71%–79% (On-line Fig 1). However, DANTE also induced signal drop-out in static tissues, resulting in reduced overall black-blood contrast as evidenced by a reduced brain parenchyma-to-lumen CNR by 20%–33% (On-line Fig 1). DANTE with a PTL of 160 appeared to be a suitable preparation module to yield sufficient blood signal suppression while avoiding considerable signal loss in static tissues; thus, it was chosen as an optimal parameter for the BTI application. The improved black-blood effect when using the optimized DANTE setting is exemplified in On-line

Fig 2. Of note, arachnoid granulations (arrowheads in On-line Fig 1*A.2*), normal structures protruding into the sinuses, are distinctly identifiable when residual blood signals are suppressed.

REFERENCES

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