Improved SNAP with Mask-based Venous Flow Suppression

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Purpose:

Simultaneous Noncontrast Angiography and intraPlaque hemorrhage (SNAP)[1] is a technique that has the capability to simultaneously detect lumen stenosis and hemorrhage of atherosclerotic plaque with good contrast and resolution. One limitation of this sequence is its inability to differentiate the venous flow from arterial ones [1]. Venous contamination like this will become a challenge to image reviews that focus only on the pathological characteristics of arteries [3]. To fill this gap, a mask-based improved SNAP is introduced in this study which can reliably suppress the venous luminal signal.

Methods

Sequence: In this scheme, two images with SNAP scheme are collected: One image is scanned with regular SNAP and the second is scanned with the SNAP that has an extra inversion pulse (IR_v) applied between image acquisition and reference image (FIG. 1b). IR_v is slice-selective and only applies on the venous flow inversion band (FIG. 2b). With this design, in steady state, the signal magnitude of venous lumen of these two images will be different while that of other components will be kept the same. Besides, since the venous flow is generally slow (<10cm/s for jugular vein) the long interval between IR_v and the center of gradient echo acquisition train guarantees that the venous blood is fully impacted within a large imaging band (FIG. 2c). A venous suppression mask based on the difference between these two images can then be generated to suppress the venous signal in the final image. Besides, these two sequences were interleaved to minimize the motion between two scans.

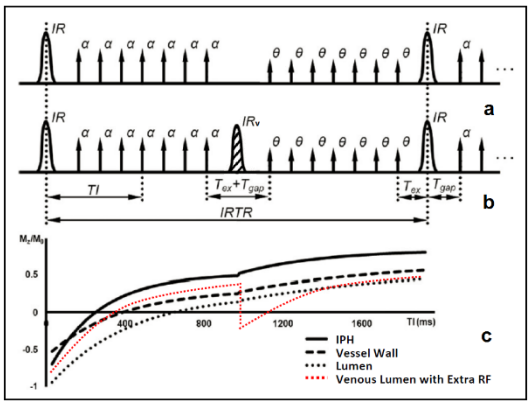

FIG. 1 a) the pulse sequence of regular SNAP sequence [1]. TI represents the imaging time and IRTR is the duration between two neighboring IR pulses. b) Represents the SNAP with IR_v. c) Is the signal recovery curve of major components (IPH, vessel wall, blood) and the red dot line represents the influence of IR_v on the recovery curve of venous lumen.

MRI Scan: Scans were conducted on healthy volunteers with a 3T whole body scanner (Philips Achieva, R3.21, the Netherlands). The coil used in this study is a 36-channel neurovascular coil. The scan parameters for SNAP with venous flow suppression were: IRTR: 1992ms, TR/TE: 9.9/4.8ms, FA: 11º, FOV: 160×160×32mm³, acquired matrix size: 1×1×1mm³, interpolated to 0.5×0.5×0.5mm³.

Reconstruction: Two scans required in this scheme will double the scan time. In this study, the SAKE [3] algorithm is used to accelerate the acquisition efficiency. Since theoretically SAKE requires no auto-calibration signals (ACS), we simulate the situation that each scan acquires only half of the data and reconstructed with SAKE before the venous suppression SNAP process. In this way, the scan time can be halved and is equal to the regular SNAP.

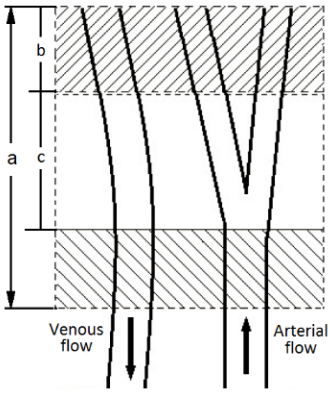

FIG. 2 Locations of different RF pulses. a) marks the flow inversion band; b) represents the inversion band specific for venous flow and c) represents the imaging band.

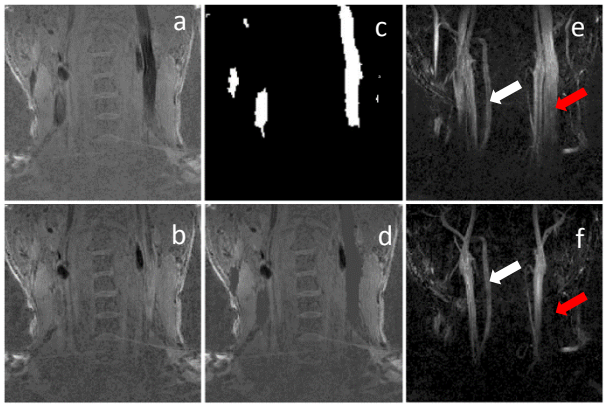

FIG. 3 a) is the image acquired with regular SNAP. b) is the image acquired from SNAP with IR_v. c) is the mask generated and d) shows the image after the venous lumen being suppressed by mask. e) is the MIPS image with commom SNAP and f) is the MIPS image from venous suppression SNAP. The white arrow points at the artery lumen and the red arrow points to the venous lumen.

Results and Discussion

FIG. 3a-d show the image processing of raw data. FIG. 3e and 3f compare MIPS images of the carotid artery from SNAP with (FIG. 3f) and without IR_v (FIG. 3e). In FIG. 3e, both arterial (white arrow) and venous lumen (red arrow) are bright while in FIG. 3f, the arterial lumen is bright which is the same as that in FIG. 3e while venous lumen signal is supressed.

Conclusion

In this study, a mask based SNAP is purposed to suppress the venous contamination in regular SNAP. As shown in the in vivo comparison, the venous flow was successfully suppressed while the contrast of arterial lumen was maintained. This study has the potential to be applied both to the atherosclerosis treatment and clinical research.

References: [1] Wang, Jinnan, et al. MRM 69.2 (2013): 337-345. [2] Wang, Jinnan, et al. MRM 64.5 (2010): 1332-1340. [3] Shin, P., et al. *submitted to MRM* (2012).