Reduction of Flow Artifacts in 2D TOF Angiography by Preconditioning the Inflow Signal with a V-Equalizer

K. J. Jung and S. H. Park

MRI Research Center, Medison Co., 997-4 Daechi-dong, Kangnam-ku,Seoul, Korea

Introduction: In 2D TOF angiography the vessel contrast is achieved by the inflow enhancement that is proportional to the inflow velocity of the blood. Therefore, the velocity variation in the vessel due to the cardiac cycle induces a variation on the signal amplitude and results in flow artifacts on the reconstructed image (1). A technique is developed to remove the flow artifacts of the artery without the information of the cardiac cycle.

Methods: The variation of the inflow enhancement by the cardiac cycle can be reduced by employing an equalizer with a transfer function that compensates for the velocity. Let us call this equalizer as a V-equalizer. Since the inflow enhancement is proportional to the inflow velocity, the V-equalizer may have the weighting function that is inversely proportional to the velocity. The V-equalizer can be implemented by saturating the inflow in proportion to the velocity. Since the blood with higher velocity can travel longer within the repetition time, the distance from the imaging slice is considered to be proportional to the inflow velocity with respect to the inflow enhancement at the imaging slice. Therefore, the V-equalizing RF pulse with a ramp profile of the flip angle as seen in Fig. 1 could satisfy the condition for the V-equalizer. The V-equalizer will partially saturate the inflow with a high velocity, but the inflow with a slow velocity will recover to its maximum at the imaging slice. Therefore, the V-equalizer will not sacrifice the vessel contrast of small vessels. For the large vessel with high velocity, the blood signal may not be reduced much because the extra inflow enhancement due to the high velocity may be lost as flow artifacts in the reconstructed image anyway.

Results: The ramp RF pulse for the V-equalization was designed based on the SLR algorithm and is shown in Fig. 2 with its profile (2). This ramp RF pulse was incorporated into the typical 2D TOF angiography sequence of the Medisons Magnum1.0T superconducting MRI system. The 2D TOF angiography was compared for different conditions of the presaturation. The resultant images are shown in Fig. 3. For both cases, the veins were suppressed by the conventional way of presaturation. The width of the V-equalizing band was 40 mm, the gap between the imaging slice the V-equalizing band = 16 mm, and the flip angle at the ramp peak was 30. Other imaging parameters were TR = 30 ms , TE = 9 ms, number of averages = 1, and flip angle = 60.

Conclusions: The proposed V-equalizer is very successful in eliminating the flow artifacts due to the velocity variation. Especially, this technique is intrinsically robust irregardless of the cardiac cycle. However, the extra time needed to incorporate the V-equalizing RF pulse may increase the minimum repetition time.

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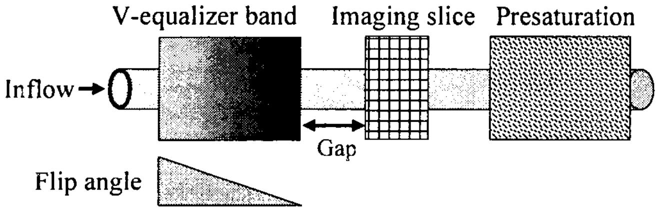

Fig. 1. A diagram to show the V-equalizer applied to the inflow. The flip angle of the V-equalizer band increases from zero to some angle as the position is farther away from the imaging slice plus some gap.

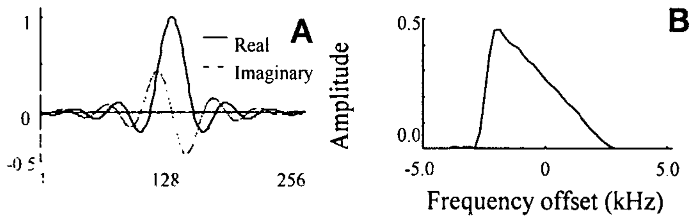

Fig. 2. The RF pulse (A) for the V-equalizer with a ramp profile (B).

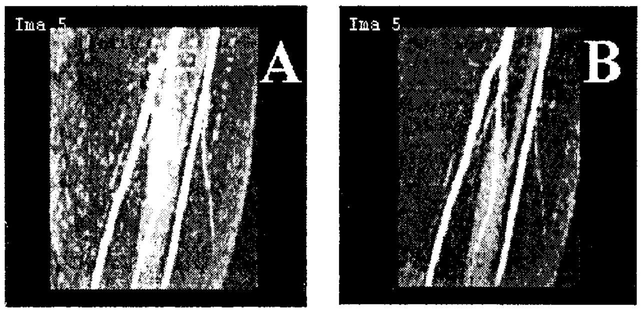

Fig. 3. Angiograms acquired without (A) and with the V-equalizer (B).
The gap between the imaging slice and V-equalizer band was 10 mm for (B).
The ghosts located near the true anterior tibial artery in (A) were clearly removed in (B).

References

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