Peripheral MRA with Flexible Parameters and a Novel, SENSE-Optimized 18-channel Coil

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Introduction

Peripheral contrast-enhanced MRA is rapidly gaining acceptance for the clinical evaluation of peripheral vascular disease. At present, there are two main competing strategies – single injection 3-station moving table, and a "hybrid" multiple injection approach where the contrast bolus is split; first imaging the lower station, then administering a second bolus for the 2-station upper and middle portion. Each technique has advantages. The single injection technique is simpler to perform and makes more efficient use of the contrast, effectively sharing the contrast among the 3 stations. This has been shown to increase SNR of the middle and lower stations [1]. The hybrid technique, while less efficient in terms of contrast utilization, is more robust in terms of preventing lower station venous enhancement, something that can significantly compromise the exam. Venous enhancement occurs more frequently with the single injection technique due to the finite time for upper and middle station acquisition delaying the lower station such that veins have begun to enhance. We describe here preliminary results using a custom-built 18 channel peripheral vascular coil that allows high SENSE factors (3-4) at all three stations. This dramatically accelerates individual station acquisition times, thereby allowing lower station acquisition to begin as early as 19 sec after the upper station acquisition with the single injection technique. This significantly reduces the possibility of venous enhancement with no loss in spatial resolution.

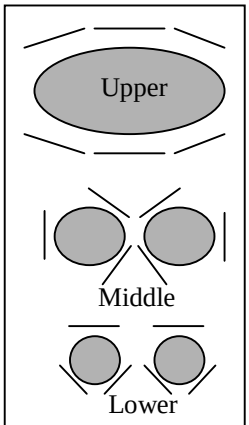

Figure 1. Coil Schematic.

Methods

A six channel per station, 3-station phased array prototype peripheral vascular coil was constructed to optimally incorporate parallel imaging technology (SENSE) at all stations (Fig. 1). The upper station consists of three long rectangular coil elements above and below the torso. The middle station is made up of two "V" shaped blocks each containing two rectangular coil elements – one between and underneath the thighs, the other above and between the thighs. Two additional coil elements are positioned laterally on the thighs. The lower station utilizes two rectangular coil elements beneath each calf, with an additional flexible single element coil along the dorsal aspect of each calf/foot. Foot-head field of view is > 44 cm for all stations. A logic box was built to interface the coil to the Synergy Multiconnect adapter for the Philips 1.5T Intera magnet (Philips Medical Systems, Best, the Netherlands). This box allows for user selection of coil station, disabling the coils in the two non-used stations. Standard single injection peripheral MRA protocols [2] were then adapted to this coil by a) adding SENSE to all stations (previously no middle station SENSE), and b) increasing SENSE factors to 3.5 in all stations. Typical true acquired resolution/scan time was 1.2 x 2.1 x 2.8 mm^3/6.4 sec, 1.2 x 2.1 x 2.6 mm^3/6.5 sec, and 1.0 x 1.0 x 1.0 mm^3/54 sec in the upper, middle, and lower stations respectively. Informed consent was obtained in all subjects.

Findings

The coil interface logic assembly successfully allowed the user to select any station while disabling the other two. Non-contrast acquisitions using SENSE factors as high as 4 at all three stations demonstrate minimal artifacts. Single injection contrast-enhanced moving table peripheral MRA studies on volunteers and patients using a SENSE factor of 3.5 at all stations have been successful, allowing for increased upper and middle station resolution while at the same time allowing us to begin lower station acquisition as soon as 19 sec after beginning the upper station (Figure 2). Previously our lower station began at 30 sec.

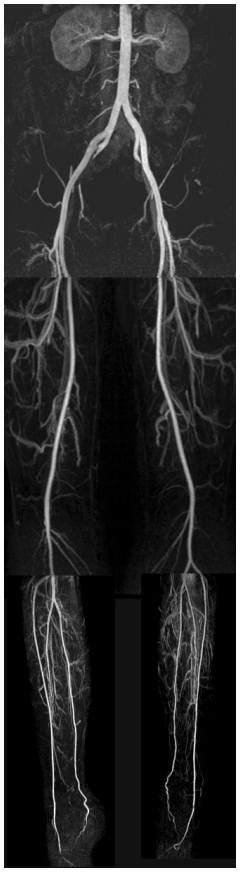
Figure 2. Volunteer MRA using prototype PV coil. SENSE factor 3.5 at all stations.

Discussion

Accelerating upper and middle station acquisition while maintaining or increasing spatial resolution will reduce the incidence of lower station venous enhancement in single injection peripheral MRA. Two station timing data [1] in 100 recent extremities (56 consecutive vasculopathic VA patients referred for peripheral MRA) shows a large variation in contrast travel time from the aorta to the ankle veins (venous onset time – Figure 3). As can be seen, 52% of the extremities show no venous enhancement on this 2-station timing study, while the remaining 48% demonstrate venous onset ranging from 7 to 65 sec. Examining this representative distribution and assuming venous enhancement is minimal provided lower station acquisition begins prior to venous enhancement [2], beginning lower station acquisition at 30 sec (Fig 3 – dashed arrow) would result in a venous incidence of 28%. Decreasing this to ~20 sec, as possible with this coil (Fig 3 – solid arrow), reduces this almost 3-fold to 10%. Thus there will likely always be a small minority of patients in whom venous enhancement is so rapid that the single injection technique is not possible. However, by using SENSE optimized peripheral vascular coils to accelerate upper and middle station acquisition without sacrificing spatial resolution, high quality single injection peripheral MRA should be successful in the vast majority of patients. Of note, this patient sub-population had a high incidence of distal inflammatory disease – for more typical sub-populations of run-off referrals, the incidence of venous enhancement will likely be even further reduced. The few in whom it will not work can be determined *a priori* from a timing study [1].

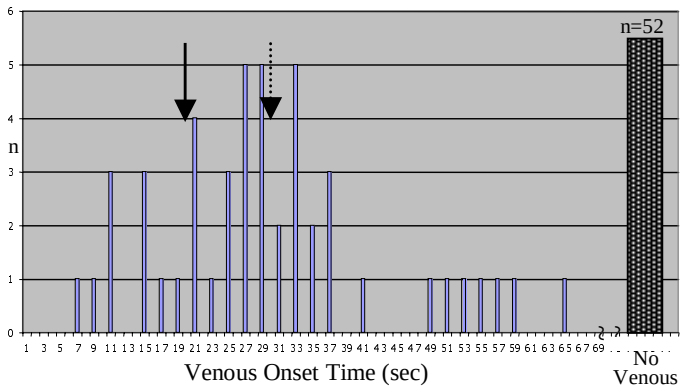

Figure 3. Histogram of aortic contrast arrival to ankle venous enhancement time in 100 extremities. Data from two station timing bolus [1].

Bibliography

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