Comparison of CAPR MRA with CT Angiography for Evaluation of Below the Knee Runoff: Preliminary Results of Radiologist Confidence

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Introduction: Computed tomographic angiography (CTA) is widely used for vascular imaging of the lower extremities. However, it has several disadvantages compared with magnetic resonance angiography (MRA), including limitation by calcification and uncertainties in contrast bolus timing which may result in images obtained too early (with poor arterial opacification) or too late (poor opacification and venous contamination). For this reason, time-resolved MRA may be a better examination for evaluating below-the-knee runoff. Our laboratory has developed an MRA technique called CAPR (Cartesian acquisition with projection-like reconstruction) which obtains time-resolved, 1 mm isotropic resolution images with 5 second temporal update time. (1) This could be an optimal technique for imaging lower extremity vessels. The purpose of this work was to compare radiologist confidence in CTA and CAPR MRA in a cohort of clinical patients.

Methods and Materials: Our study was HIPAA and IRB-compliant, and all subjects signed informed consent prior to enrollment. 19 consecutive subjects were imaged with CTA and CAPR MRA for known or suspected peripheral vascular disease. The CTA technique was 64-detector row scanner with injection of 145 mL Omnipaque 350, 25 mL at 5 ml/sec and 120 ml at 4 ml /sec and 30 ml of saline at 4 ml/sec. The CT examination covered from 4 cm above the iliac crest to the bottom of the feet. Parameters included 0.5 sec rotation time, pitch 0.8, 15 mm/rotation, 120 kVp, 250 mAs. Automated triggering and exposure control were employed. CT spatial resolution was 0.6 x 0.6 x 2.0 mm^3. CAPR MRA followed a previously described technique (2): 0.15 mmol/kg gadobenate dimeglumine injected at 3 ml/sec followed by 20 ml saline at 3 ml/sec. Imaging was on a 3T scanner, 8 channel receive array coil, 3D GRE Sequence, TR/TE = 5.85/2.7 msec, FA 30°, BW = ±62.5 kHz, FOV 40 (S/I) x 32 (L/R) x 13.2 (A/P) cm^3, 8x SENSE acceleration, spatial resolution 1 mm^3, frame time 4.9 sec, temporal footprint 17 sec. Some patients were referred for CAPR MRA because of nondiagnostic CTA. Four board-certified radiologists assessed 11 vessel segments in each calf on both CT and MR in blinded and randomized fashion according to the following criteria: (1) full diagnostic confidence, (2) moderate uncertainty, and (3) cannot be ascertained. Pooled histograms were created and analyzed for any difference with the Wilcoxon signed rank test.

Results: Figure 1 shows a representative case of failed CTA due to calcification (a) with good vessel depiction on CAPR MRA (b). Analysis of pooled histograms revealed that assessment of popliteal arteries was superior on CTA compared to CAPR MRA ($p<0.05$). Assessment of tibioperoneal trunks and the left proximal anterior tibial artery was not significantly different between CTA and CAPR MRA. Assessment of all other 17 segments was superior with CAPR MRA than CTA ($p<0.02$). Figure 2 summarizes the comparison of confidence scores (CTA-CAPR) by upper, middle, and lower aspects of the three major vessels of the calves. 135/1672 segments were not confidently assessed on CTA. When assessed with CAPR, 128/135 were assessed with full diagnostic confidence,2/135 with moderate uncertainty, and 5/135 were not confidently assessed. 28/1672 segments were not confidently assessed on CAPR. When assessed with CTA, 24/28 were assessed with full diagnostic confidence, 1/28 with moderate uncertainty, and 3/28 not confidently assessed.

Figure 1: a. CTA MIP with bones removed demonstrates heavily calcified posterior tibial artery (arrow) which could not be assessed for patency. b. Best arterial phase MIP image from CAPR MRA demonstrates occlusion of the posterior tibial artery and small collaterals which have developed from the peroneal artery.

Discussion: Limitations to CTA assessment included calcification, poor opacification, and venous contamination. These issues are essentially overcome with the currently described CAPR technique. There is some referral bias because some of our subjects were recruited for CAPR MRA after poor evaluation on CTA. However, our results indicate that CAPR MRA can overcome some limitations of CTA and result in improved diagnostic confidence for evaluating lower extremity arteries. In no case did SENSE artifact on CAPR MRA limit clinical interpretation, despite quite high (R = 8) acceleration factors. The major limitation to vessel evaluation in CAPR MRA in these subjects was loss of signal toward the upper edge of the coil, leading to poor assessment of the popliteal arteries in some cases. Currently, anatomic coverage is the greatest limitation of CAPR MRA compared to CTA for imaging the lower extremities; ongoing work in coil design and multi-station runoff imaging may help make CAPR MRA a first-line diagnostic test for evaluation of lower extremity runoff vessels, particularly in patients with known or suspected calcification or abnormal or asymmetric inflow patterns. A comparison with dual-energy subtraction CTA technique may be interesting, as this technique helps reduce the limitations to CTA imposed by calcification.

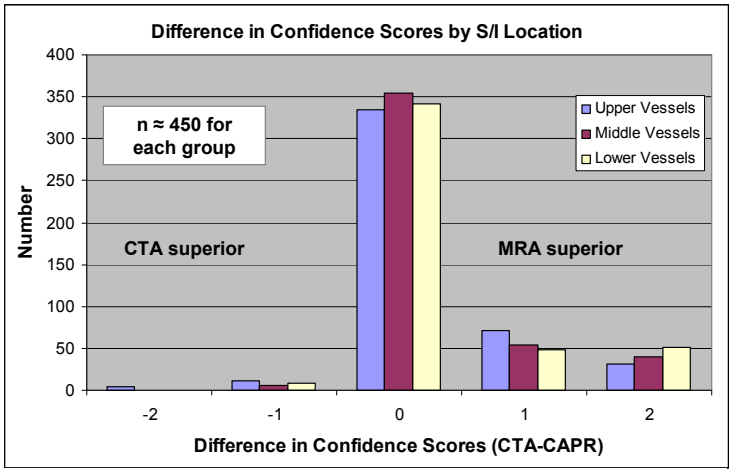

Figure 2: Histogram of the difference in confidence scores (CTA-CAPR) for the upper, middle and lower vessels. The right skew indicates the overall higher confidence in assessing vessel segments with CAPR MRA vs. CTA. At all three levels (upper, middle, lower) MRA was significantly superior to CTA in the confidence of diagnosis ($p < 0.01$).

References: 1. Haider CR et al. Magn Reson Med 2008;60(3):749–760. 2. Haider et al. Radiology. 2009;253(3):831-843.