LOWER EXTREMITY MRA WITH FULL PRIOR SPECIFICATION OF BOLUS TRANSIT TIMES

JP Finn[1], CJ Francois[1], JR Moore[2], R Niemczura[1].
Dept. of Radiology[1], Northwestern University Medical School, and Siemens Medical Solutions USA[2], Chicago, Illinois.

We measured contrast transit times independently to calf vessels and lower aorta in 10 patients with peripheral arterial disease, using a thin-slice, flow-insensitive pulse sequence and online mask image subtraction. Transit times to calf vessels were highly variable among subjects. Bolus dispersion curves were much broader in calves than in aorta, suggesting that more rapid contrast injection schemes are appropriate. Using this information, it was possible to fully prescribe optimum time delay, acquisition time windows and contrast infusion scheme for subsequent contrast-enhanced 3D MRA, in a 3-station, 2-injection protocol. High-quality MRA studies were obtained in all subjects, free of venous contamination.

Introduction: CEMRA is now widely used to evaluate the arteries of the lower extremities. Single-injection, multi-station, bolus-chase methods are popular, where image acquisition in the most proximal station is synchronized with contrast arrival in the lower aorta. Measurement of pelvic, thigh and calf stations then proceeds sequentially, without further a priori information about the distal circulation. Because the contrast transit time is not known for the calves, there is a risk of venous contamination or sub-optimal enhancement of calf vessels; a well-recognized drawback. By measuring transit times to the pelvis and calves independently, it is entirely feasible to prescribe the available time windows for optimal evaluation at all stations. Such a scheme should therefore result in virtually total reliability for lower extremity CEMRA. However, up to now it has not proved practical to measure transit times to the calf with test doses, due to the small size and low flow rates in the vessels of interest [1-5].

Purpose: To develop and evaluate techniques for measurement of bolus transit times to the lower aorta and calf vessels, and to use this information for full prior specification of acquisition time windows for MRA imaging sequences, eliminating venous contamination.

Materials and Methods: 10 patients undergoing LE-CEMRA with a dedicated, multi-channel peripheral array coil were studied in accordance with an IRB-approved protocol. Initially, bolus transit times were evaluated in the calves using a T1-weighted, flow-insensitive 2D gradient-echo sequence in the axial plane with the following parameters: TR/TE=16/2, FOV 300x180mm, slice thickness 5mm, matrix 130x256. Image acquisition was initiated simultaneously with injection of 3 ml Gd-DTPA (Magnevist, Berlex Laboratories) and was prescribed to continue for two minutes, updated every 2 seconds. On-line mask image subtraction, and real-time image display was implemented, and the images were time-stamped, referenced to the first image in the time-series. Immediately following the calf transit time measurement, a similar procedure was applied to the lower aorta, using a separate injection of 2mls Gd-DTPA. Next, a 3D single-station CEMRA study of the calves was performed following injection of 20 ml Gd-DTPA at 2ml/sec, using the timing data derived from the transit time study. Subsequently, the pelvis and thigh vessels were imaged using a separate, 2-station, single-injection of 35 mls Gd-DTPA and automatic table movement.

Enhancement curves for the calf vessels and aorta were generated using commercially-available software (Mean Curve, Siemens Medical Systems, Iselin, NJ), and values were recorded for time of first appearance, time to peak, and full-width at half-maximum value (FWHM); the latter serving as an index of bolus dispersion. Separate curves were generated for the anterior tibial, posterior tibial and peroneal arteries, if these were not occluded.

Results: Transit times in the calves and aorta were successfully measured in all cases, and clear enhancement curves were generated, based on the subtracted images (Fig 1). Wide variation was found in the arm-aorta transit times, arm-calf transit times, aorta-calf transit times, and calf dispersion curves (Fig 2 and Table 1), such that these would be difficult to predict in an individual case. However, the mean FWHM in the calf was 18.8 seconds, such that a 10 second infusion would produce a contrast dispersion > 20 seconds, well within the acquisition window for the calf station in the current study.

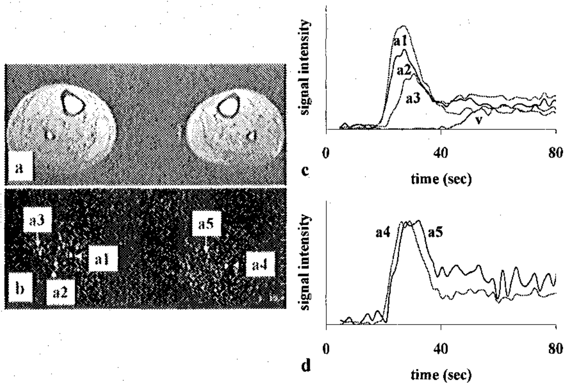

Figure 1. Transit-time curves for five patent calf vessels (right calf a1-a3; left calf a4-a5) in the patient shown in fig 2. Figure 1a shows the mask image used for subtraction. **a1, a2, a3, a4, a5** are the same as in the subtraction image b, and **v** is for the small saphenous vein (not seen in these images).

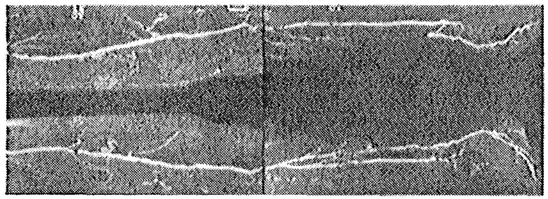

Figure 2. Maximum-intensity projection images of thigh and calf arteries in same patient as in figure 1, showing extensive disease, but visualizing all patent vessels as far distally as the plantar arch, with no venous contamination.

	1^{st}	Peak	FWHM
Aorta	15.3±4.9	21.2±8.3	10.2±6.0
Calf	26.6±8.6	37.9±12.0	18.8±9.0
Aorta to Calf	11.9±7.6	16.7±11.8	

Table 1. Summary of arm-aorta, arm-calf, and aorta-to-calf transit times measured by first and peak enhancement as well as FWHM of bolus dispersion.

Conclusion: Data acquisition timing for LE-CEMRA can be fully pre-specified by measuring arm-aorta and arm-calf transit times. This results in predictable and reliable visualization of the entire lower extremity arterial tree with a two-injection, mixed-station acquisition protocol. Furthermore, measurement of individual vessel transit times may prove useful in assessing the hemodynamic consequences of anatomic stenoses.

References:

1. Prince, M. *Radiology* 191, 155-164, 1994
2. Rofsky, N. and Adelman, M. *Radiology* 214, 325-338, 2000
3. Ruehm, S.G., et al. *Am J Roentgenol* 174, 1127-1135, 2000
4. Huber, A., et al. *Am J Roentgenol* 175, 1291-1298, 2000
5. Li, W., et al. *J Magn Reson Imaging* 12, 884-889, 2000

© Proc. Intl. Soc. Mag. Reson. Med. 10 (2002)