Implementing SENSE in isotropic Mobitrak CE MRA

Roland BEZOOIJEN[1], Guillaume THELISSEN[2], Lucien E.M. Duijm[1], Harrie C.M. vd Bosch[1], John WONDERGEM[3], Xander V. Tielbeek[1]

[1]Catharina Hospital, Eindhoven, Netherlands; [2]Philips Medical Systems, MR Clinical Science, Best, Netherlands; [3]Eindhoven, Netherlands;

Introduction

Moving bed infusion tracking contrast enhanced MR angiography has proven to be a fast, robust and easy reproducible imaging technique for the detection of significant (> 50%) stenoses in patients with peripheral vascular disease. However venous enhancement can hamper lower leg artery evaluation and spatial resolution in MobiTrak CE MRA is limited. In order to combine the advantage of MobiTrak CE MRA (imaging the entire vascular tree from abdominal aorta down to the dorsal pedal artery with a single contrast bolus injection) with high resolution MR angiography of the lower legs we developed a protocol to implement sensitivity encoding (SENSE) and 3D "centric" k-space filling (CENTRA= Contrast ENhanced Timing Robust Angiography; Philips Medical systems, Best, The Netherlands) in an isotropic moving bed infusion tracking contrast enhanced MR angiography technique.

Methods

All patients with peripheral vascular disease referred to the department of radiology for conventional intra-arterial DSA of the lower extremities were asked to participate in our study. After obtaining informed consent they were scheduled for "Standard MobiTrak" CE MRA, "SENSE isotropic MobiTrak" CE MRA and conventional intra-arterial DSA within a 7 day time-interval.

Imaging protocol:

"Standard MobiTrak" CE MRA protocol:

Three-dimensional fast field echo sequence (shortest TR: 6.3 ms, shortest TE: 1.6 ms, flip angle 35°, total volume thickness 105 mm: 35 coronal slices, thickness 3 mm) using a Q-body coil. The images were acquired overcontiguously (interpolation of the 35 3 mm-thick slices to 70 overlapping 1.5 mm-thick slices), scan duration was 32 seconds, and a field of view of 430 mm (rectangular field of view = 80%) with a matrix size of 512 x 143 was used, resulting in a voxel volume of 6.1 mm3. In a dynamic study three volumes (with a 30 mm overlap) of lower leg arteries, upper leg arteries and the pelvic arteries respectively, were acquired. Table positioning was automatic. After acquisition of these first three volumes, 39 ml of Gadoteridol ("Prohance",Bracco-Byk Gulden, Konstanz, Germany) was injected by MR-compatible injector in two subsequent volumes: volume 1= 20ml at a flow rate of 0.6 ml/s, volume 2 = 19ml at a flow rate of 0.3 ml/s, total injection duration was 96.6 seconds. A Bolus timing sequence was used for determination of contrast arrival time. (MobiTrak, Philips Medical systems, Best, The Netherlands)

"SENSE isotropic MobiTrak" CE MRA:

Compared to "Standard MobiTrak" CE MRA parameters were changed in order to obtain isotropic voxel volume in each volume: a 2.2 mm, 2.0mm and 1.0 mm slice thickness was achieved in the pelvic, upper leg and lower leg region respectively. A 4-element synergy coil was used in both pelvic and lower leg regions, for upper leg acquisition a Q-body coil was used.. In order to save time (however maintaining good spatial resolution) and thus prevent venous enhancement in the lower regions SENSE was applied in the pelvic region (SENSE factor 2): scan duration 16 seconds. CENTRA is a new 3D centric k-space filling order in which the central line is filled 4 seconds after starting the volume acquisition (i.e. central 3D k-space filling during arterial contrast-bolus passage). If venous enhancement may occur this will be during peripheral k-space filling (providing image detail) thus veins will show low intensity compared to arteries. Scan duration for upper leg volume was 17 seconds, manual table positioning duration (2x5=) 10 seconds. Compared to "Standard MobiTrak" a 30 seconds time gain was achieved.after acquisition of both pelvic and upper leg volumes. This enabled contrast injection with single flowrate: 40ml gadoteridol 0.6ml/s, total injection duration was 67 seconds. Bolustracking was used for initialising contrast volume acquisition. The 30 seconds time gain was used to obtain high resolution mra images of the lower leg region, scan duration 1minute 7 seconds.

Conventional angiography:

All intra-arterial contrast angiograms were performed with a digital subtraction angiography system (Multistar T.O.P., Siemens AG Medical Engineering, Forchheim, Germany) using non-ionic contrast (Iomeprol: Iomeron 350", Bracco-Byk Gulden, Konstanz, Germany). After of the common femoral a 4 french pigtailcatheter was placed in the distal abdominal aorta. Contrast was injected by power injector. The standard imaging protocol included overlapping series from the distal abdominal aorta down to the dorsal pedal artery. Magnification images and angled views of suspected stenoses were obtained. In case the standard series failed to achieve good quality images, either selective contrast injection by hand in one limb and/or intra-arterial vasodilator (slow manual injection of 25 mg Papaverin) was administered to optimise contrast delivery. An experienced vascular radiologist supervised all procedures.

For image evaluation purposes, the arterial tree was divided into 17 segments: distal aorta, common iliac artery, external iliac artery, common femoral artery, deep femoral artery, superficial femoral artery above Hunter, superficial femoral artery below Hunter, supra-genual popliteal artery, infra-genual popliteal artery, tibiofibular trunk, anterior tibial artery, posterior tibial artery, peroneal artery (the latter three each divided in a proximal and distal half) and dorsal pedal artery.

The measured diameter of the residual lumen at the point of maximal narrowing in a segment (D) was compared with the measured diameter at a normal point in that arterial segment (N) using the following formula: Stenosis percentage = (1-[D/N]) x 100%. Grading of stenoses was performed at a workstation with enlarged MIP or DSA images using an electronic calliper.

A five-point scale (1:patency or 1-24% stenoses; 2: 25-49% stenoses; 3: 50-74% stenoses; 4: 75-99% stenoses: 5: occlusion) was used for statistical analysis.

Blinded reading of both "Standard MobiTrak" CE MRA and "SENSE isotropic MobiTrak" CE MRA was done by two MR radiologists with a three week interval between each MRA technique. Blinded reading of DSA was done by two interventional radiologists. Final MRA and DSA classification was reached by consensus. DSA served as the standard of reference.

The infra-popliteal arterial segments in "Standard MobiTrak" CE MRA and "SENSE isotropic MobiTrak" CE MRA were compared directly for venous enhancement hampering image evaluation and image detail by all four radiologists.

Results/Discussion

Using DSA as standard of reference in 15 patients with peripheral vascular disease "Standard MobiTrak" CE MRA and "SENSE isotropic MobiTrak" CE MRA showed a comparable sensitivity and specificity for the detection of significant (>50%) stenosis in the pelvic and upper leg region. "SENSE isotropic MobiTrak" CE MRA showed much better detail of the lower leg arteries than "Standard MobiTrak" CE MRA and less venous enhancement hampering infra-popliteal artery evaluation. This resulted in a higher sensitivity and specificity for significant stenosis detection for "SENSE isotropic MobiTrak" CE MRA in the lower leg arteries.

References

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