Comparison of non contrast-enhanced balanced TFE and CE-MRA for Evaluation of Upper Extremity Vasculature Prior to Vascular Access Creation

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Introduction

Pre-operative mapping of upper extremity vascular geometry is highly desirable in patients with end-stage renal disease (ESRD) scheduled to undergo dialysis access creation. Precise knowledge of arterial and venous anatomy helps to prevent short- and long-term post-operative complications by enabling selection of the most suitable site for vascular access creation[1]. Unfortunately the current standard of reference for non-invasive vascular imaging – contrast-enhanced (CE) MRA – has been linked to nephrogenic systemic fibrosis (NSF) in patients with ESRD[2,3]. Recently developed non contrast-enhanced (NCE) MRA techniques might offer an attractive alternative in these patients. However, little is known at present about the feasibility and image quality of NCE MRA for evaluation of the upper extremity vasculature.

Purpose

The purpose of this work was to evaluate a NCE balanced turbo field echo (bTFE) MRA protocol for the assessment of upper extremity vasculature prior to dialysis access creation and to validate this protocol in comparison to the current standard of reference for vascular imaging, CE-MRA using a macrocyclic gadolinium chelate.

Materials and Methods

All MR acquisitions were performed with a commercially available 1.5T MR scanner (Gyroscan Intera, R11.0, Philips Medical Systems, Best, The Netherlands) using multi-element phased-array surface receive coils to cover the entire upper extremity and central part of the chest. The bTFE imaging protocol was a modified version of the sequence as described Gjesdal et al[4]. First, the imaging protocol was optimized mainly by varying the size of the FOV to minimize black banding artifacts at the edges of the FOV associated with the bTFE sequence. Other imaging parameters were: TR (ms) / TE (ms) / FA (º) / Acquisition duration: 11 / 5.6 / 80 / 4m19s. To cover the entire upper extremity from the palmar arch to the heart three scans were acquired, making the total acquisition duration of approximately 12m30s. Acquired voxel size was 1.56 x 0.78 x 0.78 mm^3. The CE-MRA acquisition comprised two separate injections of 10 mL 1:1 diluted macrocyclic contrast medium (Gadovist, Bayer Schering Pharma, Berlin, Germany). Each acquisition consisted of 4 dynamic scans. Imaging parameters were: TR (ms) / TE (ms) / FA (º) / Acquisition duration: 5.4 / 1.6 / 40 / 45s. Acquired voxel size was 0.75 x 1.38 x 1.68 mm^3. We acquired bTFE and CE-MRA datasets in ten healthy volunteers. Subsequently, five patients with CKD 4-5 were enrolled to prove the feasibility in the diseased population. All datasets were reviewed in a blinded fashion by a radiologist with >5 years experience in vascular MR imaging. For analysis purposes the upper extremity vascular tree was divided in 11 arterial and 16 venous segments. The institutional ethics committee approved the study protocol and written informed consent was obtained from all participants.

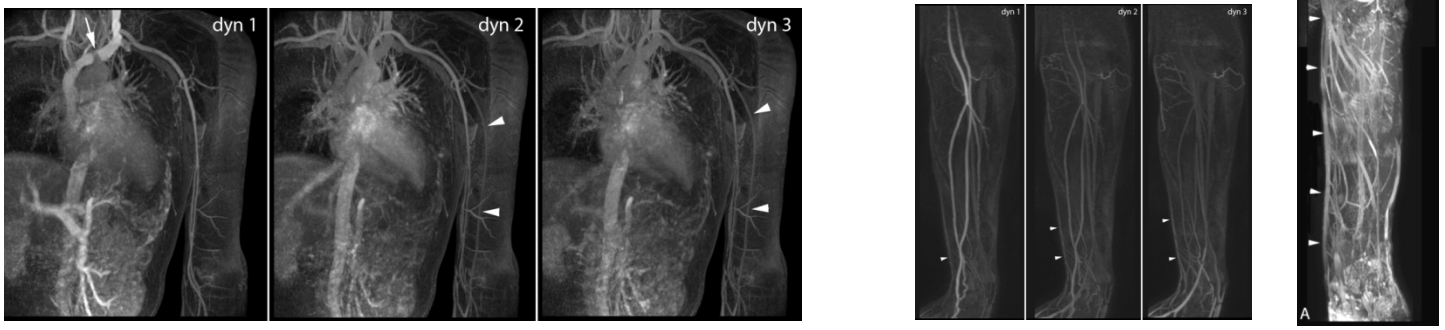

Figure: CE-MRA (left and middle panels) and corresponding NCE bTFE (right panel) acquisitions of the upper arm and forearm vasculature in a 49-year old male patient due to undergo dialysis access construction in the forearm. Because of the high spatial resolution arteries and veins can easily be differentiated in the source images. Note better visibility of veins (arrowheads) in the NCE bTFE acquisition compared the CE-MRA technique (dyn denotes dynamic phase).

Results

Comparison of number of visible vascular segments, subjective image quality, artifacts and vessel-to-background ratio for NCE-bTFE and CE-MRA

	Arterial vascular tree			Venous vascular tree		
	NCE-bTFE	CE-MRA	P-value	NCE-bTFE	CE-MRA	P-value
Visible segments with IQ>0 (%)	160/165(97)	165/165(100)	0.025	212/229(93)	183/229(80)	< 0.001
Image Quality (0-4)	2.95	3.87	< 0.001	2.59	2.39	0.070
Flow artifacts (0-2)	0.48	0.07	< 0.001	0.33	0.13	0.020
Magnetic field inhomogeneities artifacts (0-2)	0.20	0.00	< 0.001	0.26	0.03	< 0.001
Compression artifacts (0-2)	0.01	0.00	0.158	0.28	0.31	0.502
Vessel-to-background ratio	4.22	6.00	< 0.001	5.52	4.27	0.003

Image Quality: 0=not visible; 1=suboptimal depiction; 2=visible and interpretable; 3=visible and interpretable with good image quality, and 4=visible and interpretable with excellent image quality. Artifacts: 0=no artifacts; 1=minor artifacts not hampering image interpretation, and 2=major artifacts hampering image interpretation.

Discussion and Conclusions

Depiction of arterial and venous structures in the upper extremity is feasible using a NCE-bTFE technique. Arterial image quality and image contrast of CE-MRA remain superior to NCE-bTFE. However, NCE-bTFE yields images that are of diagnostic quality in the vast majority of subjects. With NCE-bTFE on the other hand it was possible to visualize significantly more venous segments with comparable or superior image quality compared to CE-MRA. In conclusion, NCE-bTFE is an attractive alternative for CE-MRA in patients with ESRD who need to undergo imaging to determine the optimal site for access creation.

Acknowledgement

This work was carried out in the context of the ARCH project (ICT-22439) funded by the European Union 7th Framework Programme.

References

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