Axial 2D TOF-Venography with Continuously Moving Table Acquisitions

S. Huff[1], D. Paul[1], M. Markl[1], and U. Ludwig[1]

[1]Department of Diagnostic Radiology, Medical Physics, University Hospital Freiburg, Freiburg, Germany

Introduction

Time-of-Flight-MR-Angiography (TOF-MRA) [1] allows for vessel imaging without the application of contrast agents. The static tissue signal in the acquisition slice is suppressed by choosing high flip angles and short repetition times. The blood flow carries unsaturated spins from the outside into the acquisition slice which results in a blood tissue contrast caused by inflow enhancement. However, currently available methods suffer from small volumetric coverage or limited vessel tissue contrast. In this context, whole body MRI offers the possibility to cover an extended FOV. Moreover, recently reported 'move during scan' (MDS) techniques based on axial image orientation [2] may help to enhance the inflow effect in TOF imaging if the table motion is opposite to the blood flow direction. In the following a difference method for TOF-MRA of an extended FOV is presented in combination with a continuously moving patient table during an axial 2D gradient echo data acquisition. This technique is ideally suited for peripheral MRA. Initial results for TOF-Venography of the peripheral veins from the bifurcation to the feet are presented.

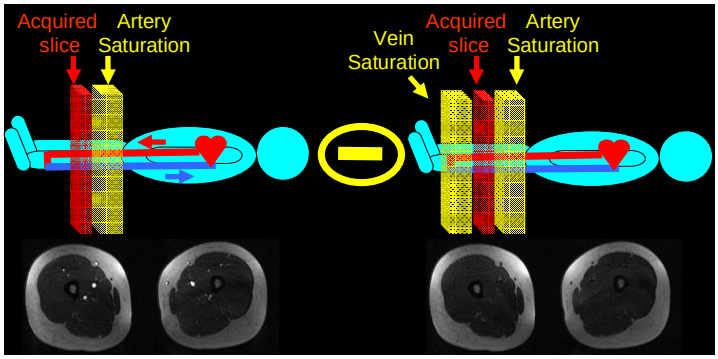

***Figure 1**: Difference method for TOF MRA.*

Methods

Data acquisition during continuous patient motion results in a permanent change of the acquired volume at the same physical scanner position. For this reason the usually used chemical shift selective fat saturation does not work with MDS. Therefore a difference method was used to achieve the cancellation of the fat signal (Fig. 1). The extended FOV was acquired twice, saturating either the signal of arteries only or of both, arteries and veins. Finally the signal magnitudes of corresponding slices were subtracted voxel by voxel.

The signal from blood in a TOF-MRA image S depends on TR, the flip angle α, the T_1 relaxation time for blood, the slice thickness TH and the blood flow speed v [1]. For a given TR and TH is S maximal for one α in a certain vessel. Since a difference method is applied the blood tissue contrast is maximal if S is maximal. For this reason a suitable flip angle α_{opt} for the in vivo measurement situation was determined by measuring S as a function of α.

For each α = 5°, 10°, …70° (5° increment) 10 axial slices of the upper leg were acquired on a 1.5 T system (Magnetom Espree, Siemens Medical Solutions, Erlangen, Germany) with continuous table motion. For one of the 10 images mean and standard deviation of S were evaluated within a ROI in a femoral vein. Further sequence parameters were: *Matrix* = 208 x 320, *voxelsize* = 1.5 x 1.3 x 3 mm^3, *GRAPPA acceleration factor* = 2, *TE* = 4.67 ms, *TR* = 18.74 ms.

Using α_{opt} axial images of the region from the bifurcation to the feet were acquired twice for multiple volunteers applying the presented difference method for TOF-MRA (TA = 2 x 10 min.). Application of a maximum intensity projection (MIP) on the subtracted volume data set results in a venogram.

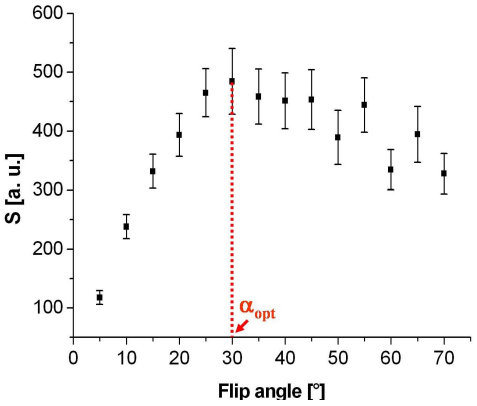

***Figure 2:** Blood signal S as a function of the flip angle.*

Results and Discussion

Figure 2 shows the blood signal S in a femoral vein as a function of the flip angle α. S is maximal for $\alpha = \alpha_{opt} = 30°$ and decreases slowly for higher flip angles. In Figure 3 the coronal view of a venogram resulting from all axial slices acquired with $\alpha = \alpha_{opt} = 30°$ is shown for one volunteer.

The presented difference method for TOF-MRA provides peripheral vein imaging of good quality without the application of a contrast agent. Subtracting two datasets of the extended FOV provides the cancellation of the fat signal and additionally increases the blood tissue contrast by reducing the background signal of the suppressed static tissue.

In clinical routine the application of a contrast agent is as well standard as a coronal orientation of the acquisition slice. The data acquisition is performed with a continuously moving patient table [3] or with a stationary patient table [4] in multiple steps. In this case the quality of the resulting angiogram strongly depends on the adaption of the data acquisition to the bolus application and to the movement of the patient table. In contrast to this the TOF-MRA is a non-invasive technique which is temporally not limited. Especially peripheral veins can be imaged well with the TOF technique, since the orientation of the vessel lumen is mostly normal to the axial imaging slice thereby providing optimal TOF vessel-lumen contrast.

The presented method is suitable for application subsequently to a contrast enhanced (CE-) MRA. The late enhancement of the contrast agent can then be used to increase the blood tissue contrast. Furthermore the presented technique provides an additional imaging plane with high axial in-plane resolution for diagnosis, if the CE-MRA is performed with a coronal slice orientation. In cases where a CE-MRA fails, the proposed method can be used to provide a backup strategy to acquire whole body MR data. Future work will focus on accelerating the image acquisition as well as imaging the peripheral arteries. The latter is more complicated than imaging the veins because of the more pulsatile blood flow in the arteries.

Acknowledgement: This work was supported by the German Research Foundation (HE 1875/15-1).

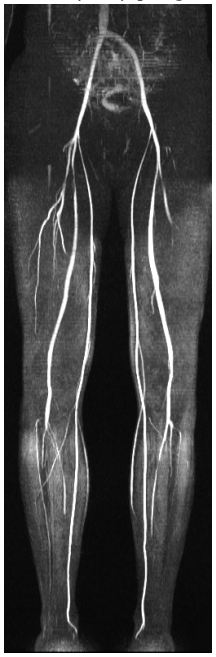

***Figure 3:** MIP of the TOF difference MRA.*

References

[1] Haacke EM et al. *Magnetic Resonance Imaging: Physical Principles and Sequence Design*. J. WileySons, 1999.
[2] Ludwig U et al. *Magn. Reson. Med.*, 55(2): 423-430, 2006.
[3] Kruger DG et al. *Magn. Reson. Med.*, 47(2): 224-231, 2002.
[4] Goyen et al. *Radiology*, 227(1): 277-282, 2003.