High-Quality Venography from Multi-echo MR Dataset using T2* Relaxation Model

U. Jang[1], and D. Hwang[1]
[1]School of Electrical and Electronic Engineering, Yonsei University, Seoul, Korea, Republic of

Introduction

MR venography (MRv) has an important role in diagnosis of venous diseases. Unlike x-ray or CT venography, MRv produces venographic images without any ionizing radiation. Obtaining venographic image with low noise and high contrast is clinically important for diagnosis of vascular diseases based on MRv. It has been reported that the best venography can be acquired at TE=28ms for veins in parallel to the static field of 3T while much longer TE is needed for the veins not parallel to the static field [1]. However, such a long TE would result in lower signal-to-noise ratio (SNR) in MRv image since the signals from veins and other tissues drastically decay with time. Therefore, reducing noise at longer TE is important in order to acquire a clinically meaningful venography. Employing conventional spatial filters such as low-pass filter, median filter, and anisotropic diffusion filter are typical denosing methods. Although such spatial filters reduce noise, they also smooth out the details of images such as small structures and edges, or introduce an artificial appearance such as stair-casing artifact due to nonlinear process. These degradations of image quality resulted from interference of neighbor pixels [2, 3]. The aim of this study is to obtain high-quality venography at longer TE without introducing blurring effects or any artificial appearance, by reducing noise on temporal domain of 3D multi-echo datasets.

Methods

A 3D multi-echo GRE sequence was used in 3T Siemens MRI system with 4-channel head coils for data acquisition. Data acquisition was done with the parameters of field of view=21.5×21.5×5.12cm^3, acquisition matrix size=512×512×32, voxel size= 0.42×0.42×1.60mm^3, repetition time=95ms, and flip angle=15˚. Sixteen echoes, starting at 5.67ms and spaced by 5.51ms, were acquired. After reconstruction, resulting images were interpolated to matrix size of 1024×1024×32 (spatial resolution of 0.21×0.21×1.60mm^3).

Since the decay rate of the T_2* weighted MR signal on temporal domain at each location is governed by T_2* relaxation, a modeling for the decay signals can be used to reduce noise on the temporal domain. The decay signal, then, can be modeled with a multi-exponential function because a single voxel may contain several different tissues [4]. Non-negative least square algorithm (NNLS), which compares a specific multi-exponential signal with the original signal iteratively and then chooses solution with least square error, was used as modeling method. Vein has a negative phase and smaller magnitude than background tissue due to the susceptibility difference between venous blood and parenchyma, the signal from a venous vasculature cannot be modeled with multi-exponential decay curve [5]. Hence, the noise in vein signal was suppressed by piecewise polynomial function modeling. A venography, which was filtered with median filter, was used as prior information to discriminately model veins and other tissues. The effect of denoising was evaluated by qualitative comparison of a profile from each resulting image.

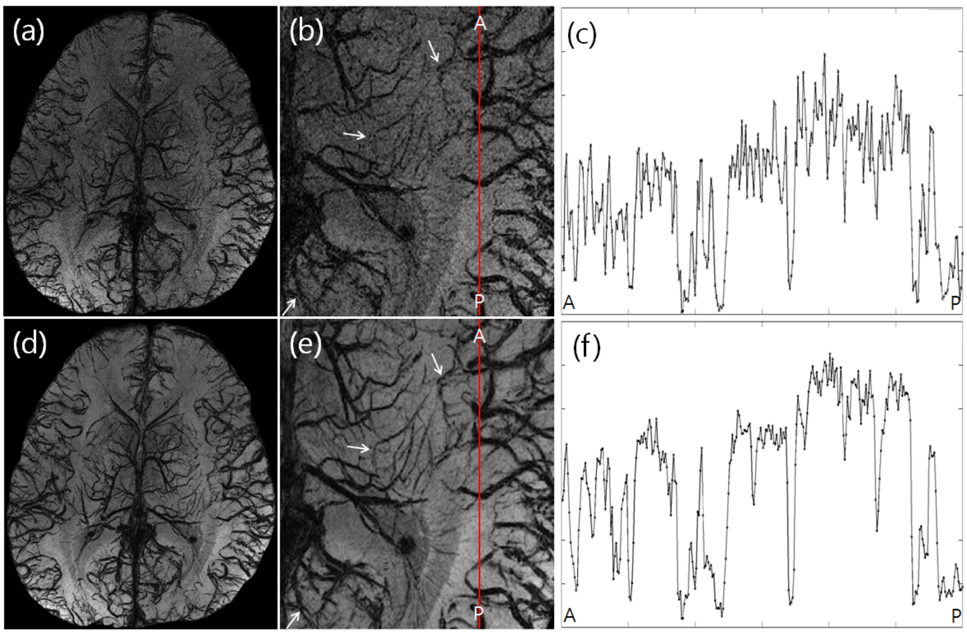

Fig1. The mIPs of the MR magnitude data at TE=38.73ms (a) without denoising process and (b) its enlarged image, (d) with proposed denoising method and (e) its enlarged image, profile (c) and (f) of a redline in (b) and (e), respectively.

Results

Fig1-(a) shows the venography without denoising at TE=38.73ms, which has poor contrast due to low SNR. Fig1-(d) is the denoised venography with the proposed method at the same TE. Fig1-(b) and (e) are the enlarged images of Fig1-(a) and (d) respectively. In Fig1-(e), significant removal of noise was observed at tissues and blood vein. Due to the noise reduction, the veins indicated by white arrows in Fig1-(e), which were barely seen in Fig1-(b), became distinct with clean contours. Fig1-(c) and (f) are the profiles of venography along the red solid line in Fig1-(b) and (e), respectively. Noisy signal fluctuation was substantially reduced at the region of tissues, and vein signals were enhanced by the proposed denoising method.

Conclusion

This study demonstrates that the denoising method on the temporal domain using T2* relaxation model can effectively reduce the noise on the images without blurring or any artifacts. By using the proposed denoising method, high-quality MRv at 3T can be obtained which has not only high resolution but also high contrast.

Reference

[1]Haacke EM et al., MRM 2004; 52:612-8. [2]AM Wink et al., IEEE Trans. Med imaging 2004; 23:374-87. [3]Alexei A Samsonov et al., MRM 2004; 52:798-806. [4]Dosik Hwang et al., JMRI 2009; 30:203-8. [5]Reichenbach JR et al., Radiology 1997; 204:272-7.

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