

Residual blood signal elimination on T1W non-gated radial scan for MR carotid plaque imaging

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Introduction

Non-gated radial T1W SE imaging has been proposed for evaluating plaque characteristics [1]. This approach uses a short constant TR [2], and avoids the relatively long and variable TR that is caused by ECG gating.

T1W plaque images obtained in this way may show residual blood signal. In order to eliminate the residual blood signal, we have introduced flow dephasing pulses in the 2D T1W radial scan sequence and evaluated the image quality improvements.

Subject and Method

For the non-gated radial SE sequence we inserted flow dephasing pulses into the echo time period, TE (Fig. 1a). We evaluated flow signal intensity for a series of low b values [s/mm²] of the dephasing pulse. Use of large b values can eliminate flow signal well, but may cause signal loss of the tissues. Therefore it is necessary to determine minimum b values that are just enough to minimize the residual flow signal. Further, using dephasing pulses with large b values may extend TE because the echo space between the refocusing (180 degree) pulse and echo acquisition is limited by time period of TE/2 (typically TE = 12ms). To achieve short TE for T1W image, asymmetric sampling is used for echo acquisition. In this study, we define the ratio of the asymmetric sampling as a parameter P [%];

$$P = \frac{(A - B)}{A} \times 100 \quad (1)$$

where A and B are durations of the echo sampling shown in Fig.1. For this definition, a larger value of P makes possible a shorter TE, but possibly at the cost of reducing spatial resolution of the final image for lack of some part of the k-space trajectory (Fig. 1b). In this study, we combined the dephasing pulses and asymmetric data sampling and looked for optimal values of the parameters b and P that could eliminate the residual flow signal without substantial loss in image quality. We followed the steps below.

- 1) Find the main direction of residual flow signal of the carotid artery by using ultrasound color doppler imaging.
- 2) Determine the minimum b values that achieved good elimination of flow signal without affecting signal intensity of tissues for a healthy volunteer. We explained the purpose and significance of this study to a healthy volunteer and obtained written consent.
- 3) Determine the largest value of P that can be used without affecting the image resolution by using a structural phantom.
- 4) Image a volunteer applying optimal values of P and b with TE = 12ms.

In step 2, two ROIs set on intra carotid arteries (ICA) and sternocleidomastoid muscle (SCM) were used to evaluate signal intensity. All studies were performed on a 1.5T MRI unit (Hitachi Medical Corp., Tokyo, Japan), using an 8ch Neuro-Vascular coil. Scan parameters were; non-gated radial sampling 2D SE, Axial, TR = 500ms, FA = 90deg, FOV = 180mm, sampling matrix = 256, projection number = 404, slice number = 7, slice thickness = 4mm, reconstruction matrix = 256, number of averages = 1, scan time = 3:24.

Results and Discussion

- 1) Residual flow signal came from blood whose flow direction was head to foot. Therefore the flow dephasing pulse was set to head-foot direction.
- 2) The residual flow signal decreased linearly as b increased up to 0.4, then remained constant for b > 0.4. Signal intensity of SCM remained constant over the range of b tested (Fig. 2). From these results, we chose the appropriate minimum b value of 0.4.
- 3) The image resolution was not affected for P < 30% (Fig.3).
- 4) We applied a P value of 8% which is compatible with b = 0.4 for volunteer imaging. The residual flow signal in ICA was eliminated and image resolution was not affected (Fig.4). The vessel walls of carotid arteries were imaged clearly.

We observed that the dephasing pulse b = 0.4 did not disturb the visibility of the plaque, because signal intensity of SCM which was used as reference [1] is constant. In this study, the b value needed to eliminate residual blood was very low. The original residual blood signal was low because of the flow void of the 2D sequence; only a small b value was needed to suppress the remaining signal. In this evaluation (Fig.3), we found an appropriate b-value which didn't affect the image resolution. Asymmetric sampling was useful in plaque imaging because it allowed us to keep short TE while using gradient dephasing.

Conclusion

The combination of dephasing pulses and asymmetric sampling minimized the residual flow signal without any loss in the image quality. As a result, we achieved a good contrast for plaque imaging by using a non-gated radial sampling SE sequence.

References

- [1] Narumi S, Sasaki M, et al., *Neuroradiology* 2010 Apr; 52(4):285-290
- [2] Glover GH, et al., *Magn. Reson. Med.* 1992; 28: 275-289,

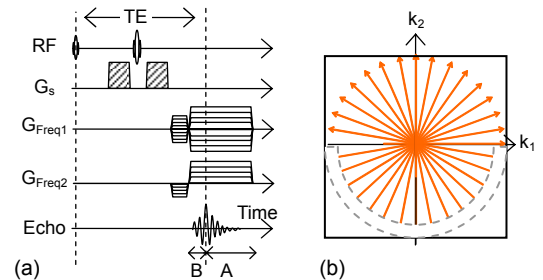


Figure 1 (a) Pulse sequence diagram of asymmetric radial sampling SE sequence with dephasing pulses. Asymmetric sampling is used for shorting TE. (b) k-space trajectory

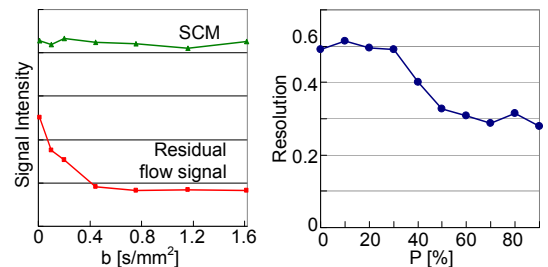


Figure 2 Signal intensity of the residual flow signal and image. The range of P is SCM. The range of b is from 0 to 90. from 0 to 1.6.

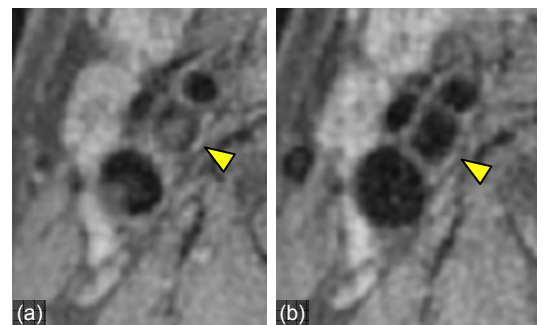


Figure 4 Volunteer images using determined b and P (a) b = 0, P = 0%, (b) b = 0.4, P = 8%