Flow-Saturation-Preparation pulse for lower extremity Non-Contrast-Agent MR Angiography

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Abstract

Cardiac Gated 3D FSE has been applied to Non-Contrast-Agent lower extremity MR Angiography imaging [1][2]. Flow void of arterial signals of FSE depends on cardiac delay time and flow velocity. Subtraction images between diastolic and systolic images depict arteries. Flow Preparation pulse (Flow-Prep) is another flow enhancement technique [3][4], in which bipolar Velocity ENCoding (VENC) gradients are utilized. As the Flow-Prep enhances the contrast of longitudinal magnetization of specific velocity flow, image subtraction is not required [4].

In this paper, we present new Flow-Saturation-Prep (Flow-Sat-Prep) method, in which the bipolar VENC and crusher gradients are used to saturate flow signals. Arterial signals of the lower extremity are depicted in volunteer studies.

Introduction

Typical data acquisition for Non-Contrast-Agent lower extremity MRA is 3D FSE-IR that enhances long T2 signals like arteries, veins and stationary fluids. STIR saturates fat signals. When 3D FSE-IR data acquisition is performed in systolic phase, arterial signals are saturated because of the flow void effect. On the other hand, arterial signals are high in diastolic phase because velocities of arteries are low. Subtraction images between diastolic and systolic phase images depict arterial signals [1]. However, arterial signals in subtraction image are less than diastolic phase image (Signal loss due to subtraction).

Flow-Prep is a VENC based flow selective preparation pulse. As the preparation pulse increases the contrast of arterial signals, image subtraction is not required and flow void effect of FSE is not utilized. However, only single directional flow is depicted because of single VENC direction.

New Flow-Sat-Prep, which saturates two directional flow signals with VENC and crusher gradients, is reported in this paper. Subtraction between control and Flow-Sat-Prep images provide arterial images. Signal loss due to subtraction is reduced and two directional flows are depicted.

Methods

Pulse sequence chart of the Flow-Sat-Prep is shown in Fig.1. Non-selective RF pulses sandwich the VENC and crusher gradients. As this pulse sequence is based on MLEV-4, it's insensitive to magnetic field and RF inhomogeneity. VENC gradients, 90x and –90x pulses invert the flow signals along G-venc axis. On the other hand, G-crush gradients work as flow crusher. Because of 1st order moment, flow signals are not refocused correctly and signal intensity is reduces (flow void effect). If the flow direction is not along G-venc nor G-crush axis, both VENC and flow void influence the flow signal intensity. As a result, transverse magnetization after the Flow-Sat-Prep depends on its flow velocity along both two axes.

In the volunteer test, Flow-Sat-Prep was applied in systolic phase. Data acquisition was done in diastolic phase with 3D FSE-IR (Fig.2). In the case of control images without Flow-Sat-Prep, simple MLEV-4 RF pulses without VENC or crusher gradients were applied to make background contrast equivalent to Flow-Sat-Prep images. Image subtraction was done in raw data before image reconstruction. The scanning plane was oblique coronal. G-venc and G-crush axes were set in SI and RL direction respectively. Flow velocity along G-venc axis was previously measured with Gated Phase Contrast. Flow velocity along G-crush axis was assumed to be 20 cm/s. SI flow compensation was used to reduce flow void in FSE data acquisition. Peripheral cardiac gate was used. TE/TR/TI were 85/3RR/150. Echo space was 7.0ms. Thickness was 2.0mm. Total scanning time was 3:18.

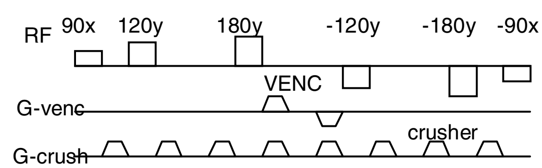

Fig.1 pulse sequence chart of Flow Sat Prep

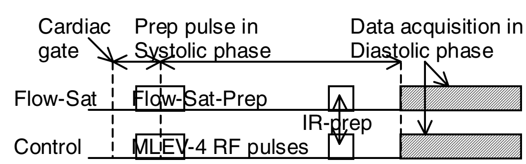

Fig.2 Flow-Sat-Prep and data acquisition timing

Results

Fig.3-1 and 3-2 show MIP of control and subtraction images, respectively. Signal intensities at the blue arrow of control and subtraction images were 1468 and 1987, respectively. The arterial signal phase at the blue arrow in Flow-Sat-Prep images could be opposite to control images and subtraction images had higher signals than control images. Signal loss due to subtraction was decreased effectively. RL directional flow was depicted in Fig.3-2 because of flow void effect by G-crush. Image subtraction well suppressed the background signals like veins and stationary fluids.

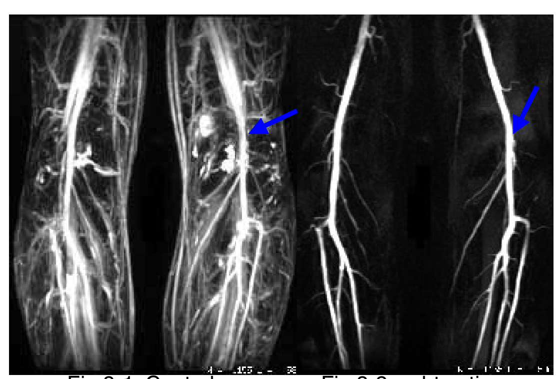

Fig.3-1: Control Fig.3-2: subtraction

Discussion and Conclusion

Two directional flows were depicted even in the lower extremity, where arterial flow velocity was slow. Signal loss due to subtraction was reduced. The Flow-Sat-Prep could depict the arterial signals and was an effective method for Non-Contrast-Agent lower extremity MRA.

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