

Selective MRA for portal venography using Beam Saturation pulse

Takashi Nishihara¹, Hiroyuki Itagaki¹, Kuniaki Harada¹, Masatomo Yokose¹, Oka Kuniharu¹, and Tetsuhiko Takahashi¹

¹MRI System Division, Hitachi Medical Corporation, Kashiwa, Chiba, Japan

Introduction

The non-contrast enhanced MRA is used widely for the portal venography, but it is difficult to image the hemodynamics. We confirmed that 2D beam excitation pre-pulse (hereafter Beam Sat pulse) is able to saturate the carotid artery selectively with healthy volunteers. And collaterals via the circle of Willis in patients with the internal carotid artery stenosis were visualized, and these corresponded well with the digital subtraction angiography (DSA) imaging [1, 2]. Beam Sat pulse is applied to VASC-ASL sequence that is used for non-contrast enhanced MR portal venography. In order to visualize the blood flow in portal vein, we investigate use of a Beam Sat pulse with the flow phantom and healthy volunteer.

Materials and Methods

Imaging sequence

VASC-ASL is respiratory triggered steady-state free precession (SSFP) sequence with slice selective IR to suppress background signals. Beam Sat pulse was applied between IR pulse and data acquisition continuously. Hence, a total Beam Sat duration is T_{beam} (Fig.1). A 1.5T MRI unit (Hitachi Medical Corporation, Tokyo, Japan) and 16ch Body coil were used for all imaging.

The flow phantom evaluation

Two separate silicon tubes (diameters = 15 mm) with flowing water ($v = 14.9$ cm/s, $T_1 = 2500$ ms) was placed between two phantoms containing static water. The beam was set in upstream of flow phantom (Fig.2 hatching), and T_{beam} was changed from 0 ms to 617 ms. We evaluate the relation of saturation ratio to T_{beam} . Typical scan parameters: TR/TE = 3.9 ms / 1.95 ms, FA = 120 deg., TI=1600 ms, imaging matrix = 192 / 64, Scan time 2:07, beam diameter = 30 mm, $FA_{beam} = 90$ deg.

Volunteer Study

The effective saturation of signal intensity in the portal vein (PV) was evaluated by studying the saturated range and saturation rate of the blood. The number of volunteers was 6. We explained the purpose and significance of this study to healthy volunteers and obtained written consent. Beam Sat pulse is set in PV (Fig.5 (a) arrow head) to suppress inflow blood signal from the splenic vein (SpV) and the superior mesenteric vein (SMV). Typical scan parameters: TR/TE = 3.9 ms / 1.8 ms, TI = 1600 ms, imaging matrix 192 / 160, Thickness = 4.0 mm, Slice# = 30, respiratory gating (RG), fat suppression = CHESS, scan time = 5:32, beam diameter = 30 mm, $T_{beam} = 0\text{--}938$ ms. The vein from main PV to left PV was evaluated by measuring blood signal and calculating the signal ratio of one with and without saturation on original images. We evaluated the visibility of each blood vessel by making MIP images.

Results and Discussion

The flow phantom evaluation

The saturated distance W_{sat} that is from the saturated position (Fig.3 arrow) become longer with increasing T_{beam} (Fig.2, Fig.3). The measured W_{sat} in Fig.3 (Fig.4 solid line) was shorter than calculated length from the flow velocity and T_{beam} (Fig.4 dashed line). We assume that the decrease of W_{sat} is related to T1 relaxation time and to traveling time from the saturated position. When the T1 value is low or flow velocity is slow, measured W_{sat} becomes shorter because of farther T1 relaxation or longer traveling time.

Volunteer Study

The saturated range of PV became larger with increasing T_{beam} (Fig.5) same as phantom study. PV was saturated in all images selectively without the inferior vena cava (IVC) saturation. In volunteer study, CHESS pulse (duration = 110 ms) is applied between Beam Sat pulse and data acquisition. So, the calculated W_{sat} was $v_{PV} * (T_{beam} + 110$ ms). The v_{PV} was 15.1 cm/s at main PV. The difference between a calculated W_{sat} and a measured W_{sat} was bigger than phantom's one (Fig.7). We assume that the difference is effect of T1 value shortening ($T1_{water} = 2500$ ms, $T1_{blood} = 1200$ ms). The optimization of T_{beam} for slower v_{PV} is needed such as collateral blood flow in patients with portal hypertension.

Signal intensity ratio is decreasing in distal position from saturated position (Fig.6 arrowhead). We assume that the decreasing of signal intensity ratio is affected by magnetization transfer (MT) effect of Beam Sat pulse. In our initial results, the blood signal in whole PV can be saturated by Beam Sat pulse when it is set in the main PV.

Conclusion

The Beam Sat pulse is able to saturate the portal vein selectively. When combined with non-contrast enhanced portal venography, the Beam Sat pulse seems to visualize additional information about the blood flow in PV.

References

[1] T. Nishihara, Proc. In 20th ISMRM, 2497 (2012),
 [2] Ito K, Sasaki M et al.; J Stroke Cerebrovasc Dis. S1052-3057(13)00347-9 (2013)

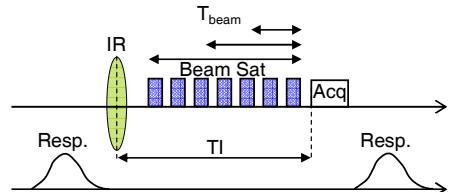


Figure 1 VASC-ASL with Beam Sat pulse sequence.

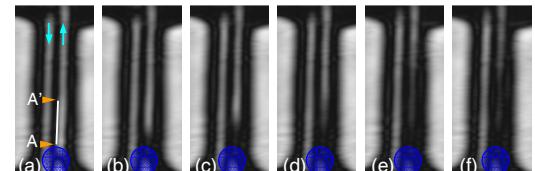


Figure 2 The flow phantom images ($T_{beam} = 0\text{--}617$ ms)
 (a) 0 ms, (b) 16 ms, (c) 83 ms,
 (d) 216 ms, (e) 484 ms, (f) 617 ms

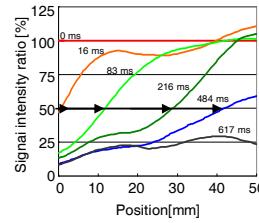


Figure 3 The signal intensity ratio from A to A'. The range of T_{beam} is from 0 to 617 ms.

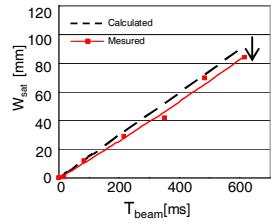


Figure 4 The saturated distance. The range of T_{beam} is from 0 to 617 ms.

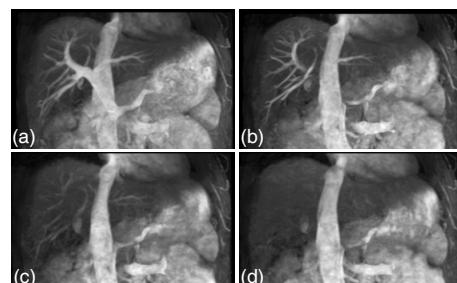


Figure 5 MIP images ($T_{beam} = 0\text{--}938$ ms)
 (a) 0 ms, (b) 335 ms, (c) 670 ms, (d) 938 ms

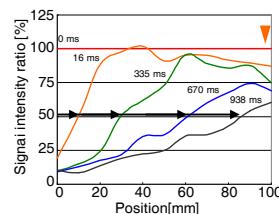


Figure 6 The signal intensity ratio from main PV to left PV. The range of T_{beam} is from 0 to 938 ms.

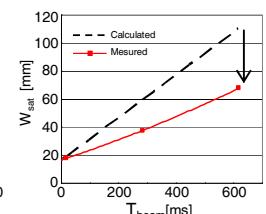


Figure 7 The saturated distance. The range of T_{beam} is from 0 to 938 ms.