Influence of Slice-Selective Tag Thickness for Non-Contrast-Enhanced Pulmonary MR Venography based on ECG-gated 3D time-spatial labeling inversion pulse (Time-SLIP) technique

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Introduction: Evaluation of pulmonary vein is fundamental issue before thoracic surgery and after radiofrequency ablation (RFA) for arrhythmia in routine clinical practice. Currently, contrast-enhanced pulmonary CT and MR angiography are suggested as useful, and applied in routine clinical practice. However, one of the major drawbacks of these techniques are side effect due to contrast-media injection induced side effect and renal dysfunction in routine clinical practice. Since the early days of use of MR imaging in the clinical setting, non-CE-MRA using two-dimensional (2D) or 3D time of flight (TOF), 2D or 3D phase contrast (PC) MR imaging and 2D or 3D balanced steady-state free-precession (bSSFP) imaging have been introduced for pulmonary disease assessment. In addition, during the past decade or so, several novel procedures have been introduced as a new version of non-contrast-enhanced MR angiography using 2D or 3D fresh blood imaging (FBI) obtained with an ECG-gated 3D half-Fourier fast spin-echo (FSE) sequence, and 2D or 3D time spatial labeling inversion pulse (time-SLIP) techniques, which are performed as arterial spin labeling technique (1-3). In the above-mentioned non-CE-MRA technique, time-SLIP technique has been suggested as useful for separate visualization pulmonary artery and vein. However, a few manuscripts reported its' potential for separation of pulmonary arteries, and did not show its' capability for separation of pulmonary veins (1-3). In addition, the separation of pulmonary vein from pulmonary artery by using time-SLIP technique has been more difficult than that of pulmonary artery from pulmonary vein in routine clinical practice. However, to the best of our knowledge, no one has assessed the influence of slice-selective Tag pulse thickness for pulmonary venography using time-SLIP technique since it was introduced as one of the technique for non-CE-pulmonary MRA. We hypothesized that non-CE-MRA using time-SLIP technique at 3T had significant influence of Tag position and thickness to pulmonary MR venography. The purpose of this study was thus to prospectively and directly compare the influence of slice-selective Tag thickness for non-contrast-enhanced pulmonary MR venography using time-SLIP technique at *in vivo* study.

Materials and Methods: Eight normal healthy male volunteers (age ranged from23 to 47 year old) underwent pulmonary MR venography by using time-SLIP technique with a 3T MR system (Vantage Titan 3T; Toshiba Medical Systems, Ohtawara, Tochigi, Japan) using an eight-element phased-array body surface coil and receiver channels combined with parallel imaging capability (SPEEDER, Toshiba Medical Systems). The sequence consisted of ECG-gated 3D time-spatial labeling inversion pulse (time-SLIP) technique combined with half-Fourier FSE (TR3-4<R-R>/ TE 80 ms/ flip angle 90°/ ETL 64, 256×208 matrix, 512×416 reconstruction matrix, FOV 500 mm, NEX: 2, SPEEDER factor: 3, voxel size=2.0× 1.4× 6mm, reconstructed voxel size=1.0× 0.7× 6mm), obtained in the coronal plane for assessment of pulmonary arteries and veins. TI of 900msec, which was empirically determined to best visualize pulmonary vessels, was used throughout the examination. Spectral attenuated inversion recovery (SPAIR) pulse was used to suppress signal from background tissue. Slice-selective Tag thickness were applied 30-40 mm (type A) and 60 mm (type B) . Then, visualizations of main trunk of pulmonary vein and lobar pulmonary vein were assessed by two chest radiologists by 5-point visual scoring systems in each subject. Interobserver agreements of all vasculature were assessed by kappa statistics. To compare image quality between two methods, signal-to-noise ratios (SNRs) were statistically compared by means of t-test. To compare visualization of pulmonary MR venography between both methods, visualization scores at main trunk and lobar pulmonary veins were statistically compared by means of t-test. A p value less than 0.05 was considered statistically significant for all statistical analyses.

Results: Representative case is shown in Figure 1. Interobserver agreement of each trunk and lobar pulmonary vein was substantial or almost perfect (0.63<kappa<0.87). SNR of type B Tag pulse was significantly higher than that of type A Tag pulse ($p<0.05$). Results of compared main trunk and lobar pulmonary veins are shown in Table 1 and 2. On main trunk of pulmonary vein, visualization and image quality of each main trunk of pulmonary vein with type B Tag pulse was significantly higher than that with type A Tag pulse ($p<0.05$). On lobar pulmonary vein, visualization and image quality of each lobar pulmonary vein with type B Tag pulse was significantly higher than that with type A Tag pulse ($p<0.05$).

Conclusion: On non-CE-MRA with time-SLIP techniques, slice-selective Tag pulse thickness has great influence to visualization of pulmonary vein and image quality of pulmonary MR venography.

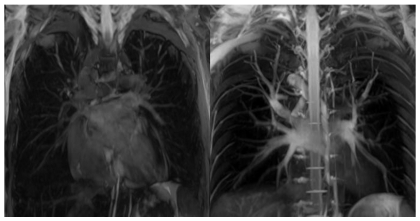

Figure 1. 47-year-old male normal volunteer (L to R:Non-CE-MRA with time-SLIP technique using type A Tag pulse to that using type B Tag pulse.

Visualization of main trunks and lobar pulmonary veins and separation of pulmonary veins from pulmonary arteries are markedly improved on Non-CE-MRA with time SLIP technique using type B Tag pulse, when compared with that using type A Tag pulse. Visualization socre of non-CE-MRA with time-SLIP technique using type A Tage pulse is 3, and that using type B Tag pulse is 5.

Table 1. Comparison of assessment of main trunk of pulmonary vein between two methods.

	Rt. Superior Trunk (Mean ±SD)	Rt. Inferior Trunk (Mean ±SD)	Lt. Superior Trunk (Mean ±SD)	Lt. Inferior Trunk (Mean ±SD)
Type A Tag pulse	4.2±0.7	3.8±0.7	4.4±1.0	3.3±0.9
Type B Tag pulse	4.8±0.4*	4.7±0.5*	4.6±0.7*	4.5±1.0*

*: Significant difference with type A Tag pulse ($p<0.05$)

Table 2. Comparison of assessment of lobar pulmonary vein between two methods.

	Rt. Upper Lobe (Mean ±SD)	Rt. Middle Lobe (Mean ±SD)	Rt. Lower Lobe (Mean ±SD)	Lt. Upper Lobe (Mean ±SD)	Lt. Lingula (Mean ±SD)	Lt. Lower Lobe (Mean ±SD)
Previous Tag pulse	2.9±1.2	2.8±1.6	1.4±0.7	3.1±1.5	2.5±0.7	1.8±0.8
New Tag pulse	4.8±0.4*	3.1±0.6	4.1±1.0*	4.7±0.5*	3.0±1.5	4.7±0.6*

*: Significant difference with type A Tag pulse ($p<0.05$)

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