Non-Contrast-Enhanced Pulmonary MR Angiography based on ECG-gated 3D time-spatial labeling inversion pulse (Time-SLIP) Technique: Influence of Tag Pulse Position for Separation of Pulmonary Arteriogram and Pulmonary Venogram

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Introduction: A few novel procedures such as 2D or 3D fresh blood imaging sequence and time spatial labeling inversion pulse (Time-SLIP) techniques are recently proposed for non-CE-pulmonary MR angiography (non-CE-MRA) (1-3). However, one of the major concerns of Time-SLIP technique is limited capability for separation between pulmonary arteriography and venography. However, to the best of our knowledge, no one has assessed the influence of slice-selective Tag pulse position for separation of pulmonary venography from arteriography using Time-SLIP technique. We hypothesized that non-CE-MRA using Time-SLIP technique at 3T had significant influence of slice-selective Tag position to separately visualize pulmonary vein from artery. The purpose of this study was thus to prospectively and directly compare the influence of slice-selective Tag position for separation of pulmonary vein from artery on non-CE-MRA with Time-SLIP technique at *in vivo* study.
Materials and Methods: Eleven normal healthy male volunteers (age ranged from 23 to 45 year old) underwent non-CE-MR at 3T system with Time-SLIP technique applied three different slice-selective Tag pulse position as follows: 1) original Tag pulse position, 2) posterior position as compared with original position (posterior Tag pulse position), and 3) sagittal Tag pulse position. The sequence consisted of ECG-gated 3D time-spatial labeling inversion pulse (Time-SLIP) technique combined with half-Fourier FSE, obtained in the coronal plane for assessment of pulmonary arteries and veins. To determine the separation capability of venography from arteriography, visualizations of pulmonary artery and vein on all methods were assessed at main, lobar and segmental levels with five-point visual scoring system. To compare the separation capability of venography from arteriography among three slice-selective Tag pulse position, all scores were compared by Fisher's protected least significant difference (PLSD) test.
Results: Representative case is shown in Figure 1. Results of compared pulmonary artery visualization among three methods are shown in Table 1. Visualizations of pulmonary artery on non-CE-MRA using posterior and sagittal Tag positions were significantly lower than that using original Tag position ($p<0.05$). In addition, non-CE-MRA with sagittal Tag position significantly decreased pulmonary artery visualization at bilateral main and left lobar levels as compared with posterior Tag pulse position ($p<0.05$). Results of compared pulmonary vein visualization at each level are shown in Table 2. At bilateral main pulmonary vein, visualizations of non-CE-MRAs with posterior and sagittal Tag pulse positions were significantly higher than that with original Tag position ($p<0.05$). At lobar and segmental pulmonary vein levels, non-CE-MRA using sagittal Tag pulse position could significantly improve visualization capability than that using original and posterior Tag pulse positions ($p<0.05$). In addition, non-CE-MRA using posterior Tag pulse position had significantly better score than that using original Tag position at left segmental pulmonary vein ($p<0.05$).
Conclusion: On non-CE-MRA with time-SLIP technique, slice-selective Tag pulse position has great influence to separation of pulmonary veins from arteries. In addition, slice-selective Tag pulse would be better to plan on sagittal position in this setting.

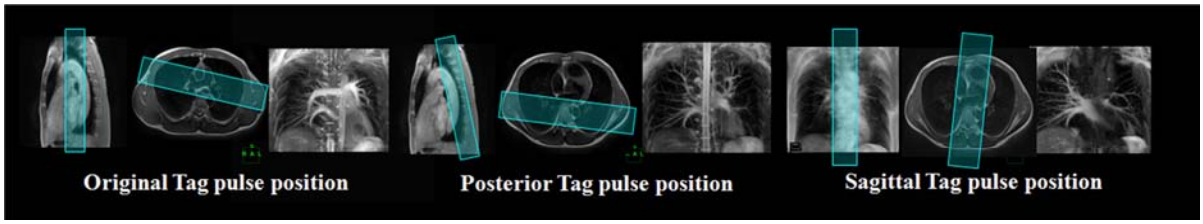

Figure 1. 32-year-old male normal volunteer (L to R:Non-CE-MRAs with original, posterior and sagital Tag positions.
On Non-CE-MRA with original Tag pulse position, pulmonary artery is well demonstrated with pulmonary vein. As pulmonary MR venography, separation of pulmonary vein from artery is failed. When slice-selective Tag pulse position is changed to posterior Tag pulse position, separation of pulmonary vein from artery is markedly improved. In addition, when slice-selective Tag pulse position is changed to sagital Tag pulse position, visualization of pulmonary vein, especially left inferior pulmonary vein, is markedly improved. However, visualizations of left upper segmental pulmonary vein are slightly decreased.

Table 1. Comparisons of capability for pulmonary artery visualization among three methods.

Tag pulse position	Main PA		Lobar PA		Segmental PA	
	Right lung Mean ± SD	Left lung Mean ± SD	Right lung Mean ± SD	Left lung Mean ± SD	Right lung Mean ± SD	Left lung Mean ± SD
Original	4.8 ± 0.6	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.2	4.5 ± 0.9	4.3 ± 1.0
Posterior	3.3 ± 0.8*	3.5 ± 0.9*	2.2 ± 1.0*	2.2 ± 1.7*	1.0 ± 0.2*	1.1 ± 0.2*
Sagittal	2.8 ± 0.4*, **	2.5 ± 0.5*, **	2.0 ± 0.8*	1.7 ± 0.9*, **	1.0 ± 0.1*	1.0 ± 0.2*

*: Significant difference with original Tag pulse position ($p<0.05$). **: Significant difference with posterior Tag pulse position ($p<0.05$).

Table 2. Comparisons of capability for pulmonary vein visualization among three methods.

Tag pulse position	Main PV		Lobar PV		Segmental PV	
	Right lung Mean ± SD	Left lung Mean ± SD	Right lung Mean ± SD	Left lung Mean ± SD	Right lung Mean ± SD	Left lung Mean ± SD
Original	4.8 ± 0.6	4.5 ± 0.9	4.0 ± 1.3	3.9 ± 1.5	3.4 ± 1.4	3.2 ± 1.5
Posterior	5.0 ± 0.0*	4.9 ± 0.3*	4.1 ± 1.4	3.9 ± 1.4	3.7 ± 1.6	3.6 ± 1.6*
Sagittal	5.0 ± 0.0*	4.9 ± 0.4*	5.0 ± 0.0*, **	4.8 ± 0.6*, **	4.7 ± 0.8*, **	4.6 ± 1.0*, **

*: Significant difference with original Tag pulse position ($p<0.05$). **: Significant difference with posterior Tag pulse position ($p<0.05$).

References:
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