2.5D flow MRI of tricuspid valvular flow: An accurate automated valve-following phase-contrast approach

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Purpose

An unmet need in cardiac MRI is evaluation of diastolic dysfunction, which by echo requires measurement of LA volumes, E/e' and tricuspid regurgitant flow velocity[1]. Of these parameters, tricuspid regurgitant flow (indicating right heart pressure) is not yet feasible. 4D flow[2,3] has been investigated, but scan times are long, and trade-offs are needed. 2D flow cannot map TV regurgitant velocities due to the valvular motion. Recently, we adapted 2D valve-following PC[4] that follows the displacement of the mitral valve throughout the heartbeat, to use modern feature tracking[5,6]. Here we present a pilot study in tricuspid 2D flow using a valve-following slice[7], which we call **2.5D flow**, due to its partial third dimension. The valve-following is now automated using deep-learning networks for tracking the valves[8,9].

Methods

Ten healthy subjects were imaged on a 3T MRI (Siemens), acquiring 4ch cine and RV 2ch cine and using TVnet to track the TV valve automatically. The displacements and rotations were provided to the scanner for prospectively tracking the valve with a dynamic slice prescription (Figure 1). PC data sets of the tricuspid valve were acquired during a single breath-hold with retrospective-gating using the following scan parameters: VENC=150cm/s, TR/TE/Θ=5.3ms/3.2ms/15, matrix size 256x156, FOV 380mm, voxel size 1.48x1.48x6mm, 4 bipolar pairs per repetition and 42ms temporal resolution. This acquisition was repeated for a static TV plane coinciding with the systolic valve plane. Standard PC of the main pulmonary artery (PA), aorta and cine were performed to compare resultant stroke volumes (SV) values. PC analysis was done using Segment software. Velocity correction was performed for eddy currents and for valve plane motion.

Results

A plot of the resulting flow patterns is shown in Figure 2A. A comparison of diastolic forward flow of the tricuspid valve vs. PA stroke volume is shown in Figure 2B. The 2.5D method outperformed static PC of the tricuspid valve in their agreement with PA flow; agreement was strong.

Discussion

Tricuspid valve forward flow was accurately measured using 2.5D PC, but less so with conventional 2D PC. Future studies in patients with regurgitant jets will demonstrate its accuracy in regurgitant velocity measurement.

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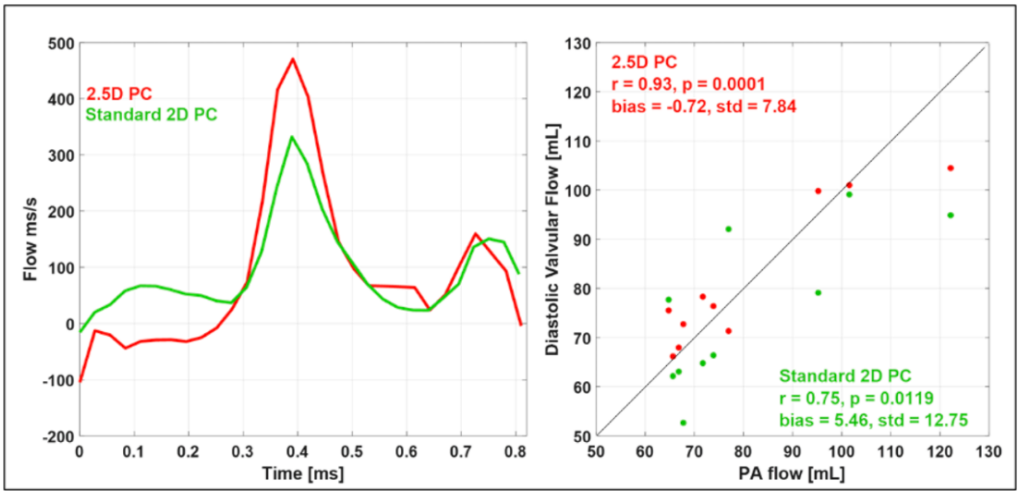

Figure 1. A) Flow wave-forms across the tricuspid valve, show physiologically reasonable flow pattern for 2.5D flow (i.e., no flow in systole, E and A waves in diastole). B) Comparison of tricuspid forward flow with PA flow showed stronger agreement using 2.5D flow, vs. standard 2D PC.

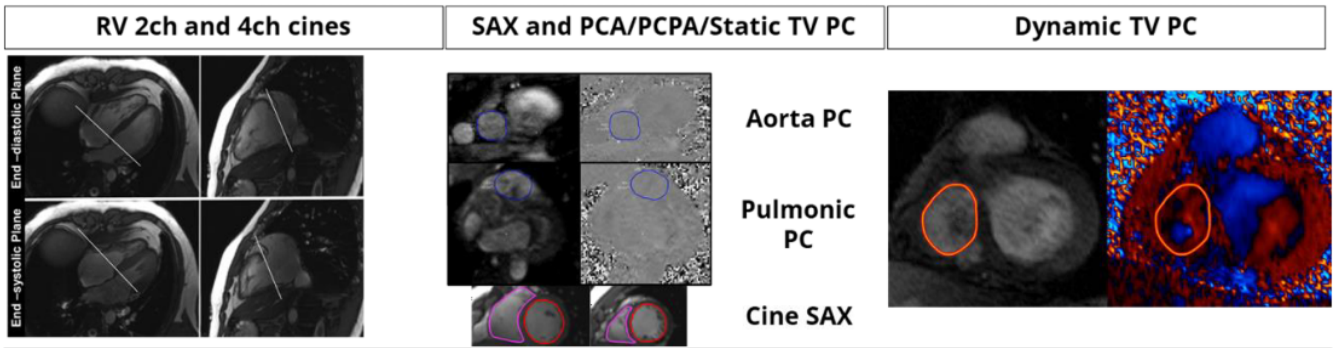

Figure 2. RV 2ch and 4Ch were automatically tracked through the cardiac cycle, and 2.5D PC with dynamic slice-prescription was obtained of the tricuspid valve (TV), for comparison with stroke volume by pulmonic (PA) flow.