Feasibility of High Frame Rate EchoPIV in Patients with Heart Failure

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Background, Motivation and Objective

Flow patterns in the left ventricle (LV) may reveal early signs of cardiac dysfunction. Echo-particle image velocimetry (echoPIV) can measure 2D flow patterns, by tracking the displacement of ultrasound contrast agent (UCA) microbubbles. However, conventional echoPIV severely underestimates diastolic velocities during filling, due to the low frame rates provided by clinical scanners (< 100 Hz). We demonstrate that high frame rate (HFR) echoPIV is capable of measuring the high velocities present during diastole and also affords greater temporal resolution for studying flow patterns in the LV.

Statement of Contribution/Methods

Twenty patients with symptoms of heart failure were scanned using HFR contrast enhanced echocardiography after approval by Erasmus Medical Center's medical ethics committee (NL63755.078.18). Apical 3-chamber views were obtained using both a clinical system (EPIQ 7 with X5-1 probe, Philips), and a research system (Vantage 256, Verasonics) with a P4-1 probe (ATL). Pulsed-wave (PW) Doppler measurements were obtained, using the clinical system, in the region of the mitral valve tips. HFR acquisitions were acquired using a 2-angle (-7°, 7°) pulse-inversion diverging-wave sequence (transmit voltages tested: 5V, 10V, 15V, 20V and 30V) at a pulse repetition frequency of 4900 Hz (framerate of 1225 Hz), while SonoVue® (Bracco) was continuously infused at three different rates (0.3, 0.6 and 1.2 ml/min).

EchoPIV analysis was performed using custom PIV software that used correlation compounding on ensembles of 5 frames for each angle. The final vector-grid resolution was 1.25° by 1.25 mm. HFR echoPIV magnitudes were validated by comparing the mean temporal velocity profile to the PW Doppler spectrum captured in the same location.

Results/Discussion

Preliminary analysis shows that HFR echoPIV can measure the high velocity diastolic flow patterns. Figure 1.a shows the good correspondence between the echoPIV velocity magnitude and the PW Doppler spectrum. A snapshot during filling of the same acquisition shown in Figure 1.a is shown in Figure 1.b. High-velocity filling patterns of two patients with different pathologies are shown in Figure 1.c and d. We conclude that HFR echoPIV is able to measure the high velocity diastolic flow patterns and may provide useful clinical insights in future.

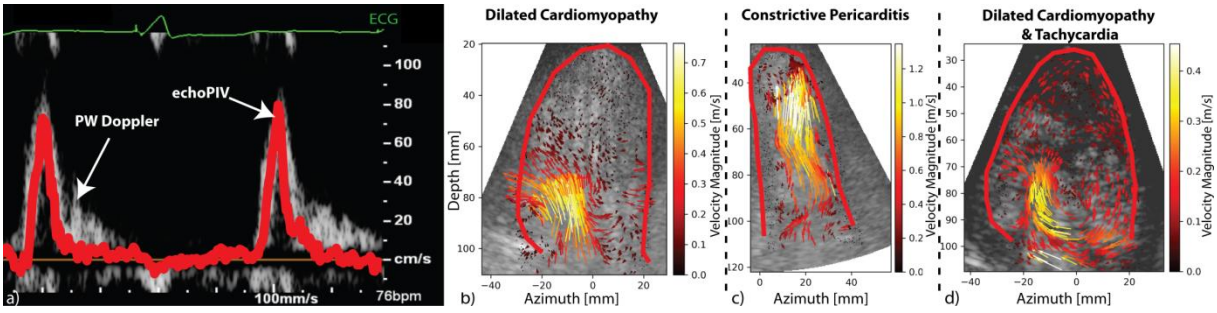

Figure 1