Externally-induced shear waves in the right ventricular free wall during the cardiac cycle

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Increased right ventricular (RV) diastolic stiffness is linked to adverse prognosis in pulmonary arterial hypertension. Currently, a non-invasive method for measuring RV stiffness is lacking. In the left ventricle, shear wave (SW) speed is related to diastolic stiffness. We show for the first time that SWs in the RV free wall (RVFW) can be induced and imaged transthoracically with ultrasound.

SW imaging was performed using an L7-4 array (ATL, USA) with a Vantage 256 system (Verasonics, USA) in a 5-weeks-old Yorkshire-Landrace pig (±120 beats/min). SWs were induced by a push beam (f_0=4.5MHz, push duration=800µs) on the RVFW and its propagation was imaged (f_0=5.2MHz) using plane wave compounding (-12°, 0°, +12°) at 3kHz framerate. Three acquisitions of 1 second were performed, where fourteen SWs were sequentially induced during each acquisition. SW propagation speeds were calculated using a semi-automatic pipeline that includes tissue velocity estimation along a manually traced spline on the RVFW, and Radon transform to estimate SW speed. At least 85% of the waves were tracked successfully for all acquisitions. The SW velocities varied during the heart cycle as expected, ranging from 0.58±0.09m/s at end-diastole to 1.8±0.2m/s during systole. Pathological increase in stiffness may be demonstrated in longitudinal case/control studies.