# Aortic stenosis peak velocity assessment by breath-hold Fourier velocity imaging

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**Background:** Phase-contrast peak blood velocity measurement through cardiac valves has important clinical applications, but is widely known to underestimate peak velocity in severe stenoses because of intravoxel averaging of phase, and difficulty positioning the image at the jet. For the first reason, Fourier velocity imaging (FVI) is an attractive method because it avoids intravoxel averaging of velocity (1), but practicable FVI requires accelerated acquisition (2,3). Other work (4,5) combined FVI with a localized excitation (non-slice-selective) technique to overcome the positioning difficulty, and this is also a fast method because it acquires only one direction of positional encoding i.e. along the ascending aorta.

**Aim:** To evaluate whether FVI in aortic stenoses avoids the underestimation by standard phase-contrast cine imaging (PC), and compare with Doppler echocardiography (US).

**Methods:** Six patients with severe aortic stenoses referred for PC assessment of aortic peak velocity consented to FVI in the same appointment. Cine FVI at 50ms/frame was performed in a 16-cardiac cycle breath-hold, along a 4cm diameter cylinder positioned along the systolic ascending aorta through the stenosis (Figure 1a) to assess the stenotic peak velocity (Figure 1b). The velocity FOV was adjusted by reacquisition to marginally exceed the peak for optimal velocity resolution, and the TE was minimized in every case. Ten healthy volunteers without previous valvular history were also studied. Peak aortic valve velocity by US was obtained in all sixteen subjects. The peak FVI velocity was assessed by the displacement of the velocity signal from the 0cm/s axis in the position-velocity image output by FVI (Figure 1b, velocity FOV offset by postprocessing to aid understanding).

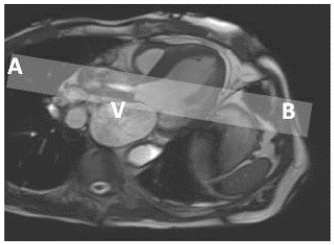


Figure 1a

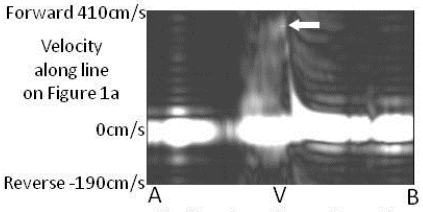


Figure 1b

Figure 1 (a): Location of cylindrical excitation along systolic ascending aorta, positioned including the entire aortic valve region V. (b): Fourier velocity image at peak systole. Arrow marks the peak velocity (370cm/s) measured as if from a graph of velocity at each position along the line. Cine view makes the peak easier to identify.

**Results:** Patient and normal data plotted together (Figure 2) for all 16 subjects show a wide scatter between FVI, PC and US. The underestimation by FVI compared to US (Figure2a) appears marginally improved against the underestimation by PC compared to US (Figure 2b) but this was insignificant. The velocity FOVs and TEs used were (for patients:) 350-600cm/s, 2.9-2.4ms and (for normals:) 150cm/s, 4ms.

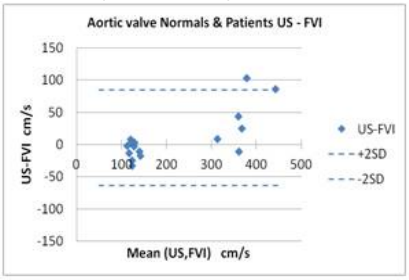


Figure 2a

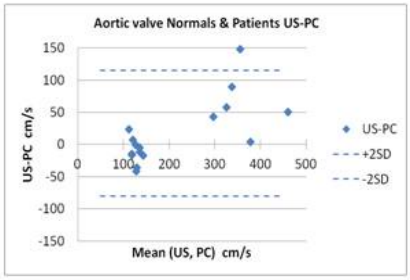


Figure 2b

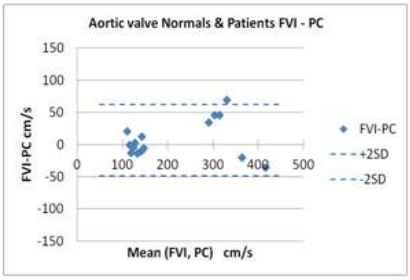


Figure 2c

Figure 2: Bland-Altman plots: (a) US-FVI, (b) US-PC, (c) FVI-PC. The six points to the right on each plot are the stenosis patients.

**Discussion/Conclusion:** The localized-excitation FVI appears less successful than previous FVI methods (2,3) for stenotic peak velocity assessment. Those previous FVI methods have not yet been established as clinically useful, and extreme jet signal may simply be too small for reliable FVI, perhaps further weakened or misregistered by the extension of TE required by the high kv-encode steps. While the cylindrical localization is advantageous for clinical users to easily include the entire stenotic valve region, the localized-excitation has the drawback of partially saturating the blood before its arrival in the stenosis requiring a low flip angle ($20^{o}$). The 30ms temporal resolution of FVI was sufficient to identify the systolic peak velocity, but nerve stimulation limits prevented desirable faster repetition at <20ms. To conclude, no significant improvement from this FVI method was found in this small initial study. (1) Moran 1982 (2) Baltes 2008 (3) Steeden 2012 (4) Mohiaddin 1997 (5) Hu 1993