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Meeting abstract

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1135 Exploring pressure gradients measured in the left heart during diastole

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Introduction

Blood flow in the filling heart during diastole is driven by pressure gradients (ΔP). Measurements of these gradients can provide insight into diastolic function, although the physical significance of the spatial variation of the pressure gradients is still not well understood. In the current literature ΔP is typically measured within the left ventricle [1-3]. This approach neglects the role of the atrium in filling, which can become increasingly important for patients with diastolic dysfunction. The effect of measurement location within the heart and the significance of different contributing terms (inertial and convective) have not been systematically addressed.

Purpose

Our goal is to characterize the spatial variations in ΔP throughout the left atrium and ventricle, including the relative magnitudes of the inertial (dv/dt) and convective (dv/dx) components ($\Delta P_{total} = \Delta P_{intertial} + \Delta P_{convective}$).

Methods

We used the Navier-Stokes equations to calculate ΔP, the pressure difference between 2 points, using measured blood velocity fields. We have previously validated MRI estimation of ΔP using invasive measures [4]. In 10 normal volunteers, phase contrast MRI was used to acquire blood velocity images in a standard 4 chamber view (figure 1a). The calculation of ΔP is compared for paths covering the entire left heart (path 1) or within the left

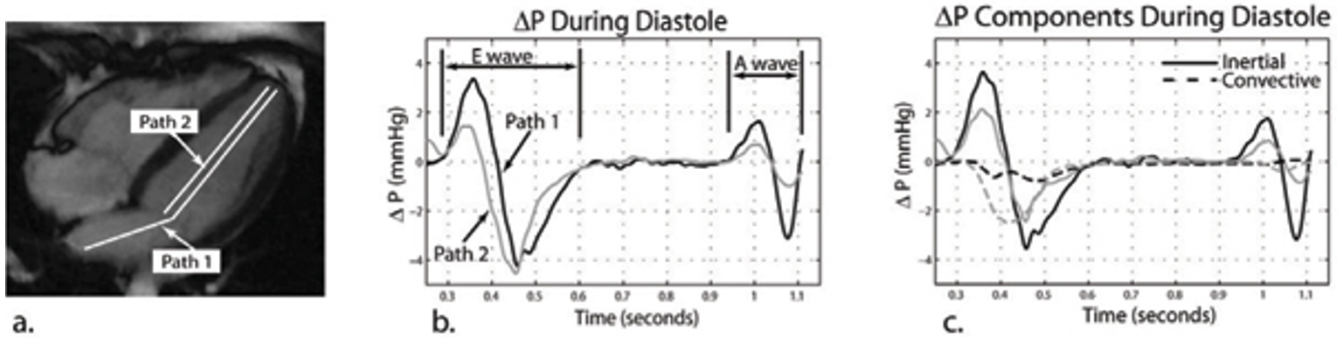

Figure 1
(a) ΔP is calculated along two paths in the left atrium and ventricle, shown on a four chamber view. (b) The resulting total ΔP curves and (c) the inertial and convective components are plotted.

Table 1: Peak values for pressure gradients (total, inertial, convective) for 10 normal volunteers

	Peak Positive (mmHg)			Peak Negative (mmHg)		
	Path 1	Path 2	Δ (1–2)	Path 1	Path 2	Δ (1–2)
Δ*P* (Total)	3.4 ± 1.3	1.6 ± 0.6	1.8 ± 0.8	-3.1 ± 1.0	-2.8 ± 1.3	-0.3 ± 0.4
Δ*P* (Inertial)	3.6 ± 1.3	2.3 ± 1.0	1.3 ± 0.4	-2.9 ± 0.9	-2.0 ± 0.8	-0.9 ± 0.2
Δ*P* (Convective)	NA	NA	NA	-0.5 ± 0.2	-1.6 ± 0.6	1.1 ± 0.6

ventricle (path 2). Measurements were made on a Siemens Sonata 1.5 T MRI scanner with imaging parameters: phase contrast pulse sequence (retrospectively gated), 360 × 250 mm FOV, 128 × 96 matrix, 6 mm slice, 12° flip angle, 100 cm/s V_{enc} (both in-plane velocities). Parallel imaging (GRAPPA, R = 2) is used to reduce the acquisition (breath-hold) to ~15 seconds.

Results

Figure 1b shows typical Δ*P* curves as a function of time from the QRS peak. The positive and negative lobes (for both the E-wave and A-wave) correspond to the acceleration and deceleration of the blood, respectively. Our analysis here is limited to the E wave. Table 1 shows average values for the positive and negative peak gradients for the two representative paths (including or excluding the atrium). The positive peak gradient is greater for path 1 than for path 2, while the negative peaks are similar. This finding supports the notion that during early filling the atrium applies significant filling forces, but acts more like a passive vessel during the deceleration time [5]. The inertial contributions have the same shape for both paths, with only a difference in magnitude. The convective terms are significant within the ventricle or atrium alone, but the combined atrio-ventricular system has a negligible convective term in all subjects. The peak value of the convective term occurs near the zero crossing of inertial term.

Conclusion

We have shown that the magnitudes of all diastolic pressure gradient components are sensitive to measurement locations within the heart, which reflects the joint role of the atrium and ventricle in diastolic function. The interpretation of pressure gradients should thus take into consideration where in space the measurements are made. Previous clinical studies (using Doppler ultrasound blood velocity imaging) have limited their consideration to within the left ventricle.

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