Blood Inertia is Essential for Realistic Simulation of Left Ventricular Relaxation

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Acceleration and subsequent deceleration of blood during left ventricular (LV) ejection require LV pressure (LVP) to rise above and then fall below aortic pressure (AoP). However, computer simulations of LV mechanics often neglect blood inertia during ejection. We therefore investigated the impact of this omission on simulated diastolic behaviour.

A computer heart model incorporated a blood inertia module extending from the LV apex to the aorta through the aortic valve. The module was derived from the Navier-Stokes equation under the assumption of one-dimensional incompressible flow with friction. Simulations were performed with and without the inertia module. LVP, AoP, active stress, and isovolumic relaxation time (IVRT) were evaluated. Aortic valve closure (AVC) was defined as the first time point at which aortic flow velocity became negative.

Without inertia, AoP and LVP were nearly identical at AVC (107 mmHg), and LVP at AVC was 95% of peak LVP (112 mmHg) (**Figure 1A**). At AVC, active stress had declined by only 9% from its peak, and IVRT was 171 ms. With inertia, AoP exceeded LVP by 40 mmHg at AVC. LVP at AVC was 72 mmHg, corresponding to 68% of peak LVP (106 mmHg) (**Figure 1B**), consistent with a recently reported value of 65±7% in 81 patients. Active stress had declined by 57% by AVC, and IVRT decreased to 73 ms.

Omission of blood inertia substantially underestimates active myocardial relaxation before AVC and prolongs isovolumic relaxation time. Incorporation of blood inertia yields more realistic LV-aortic pressure relations and more physiologic diastolic timing. Models intended to investigate diastolic function should therefore incorporate inertia.

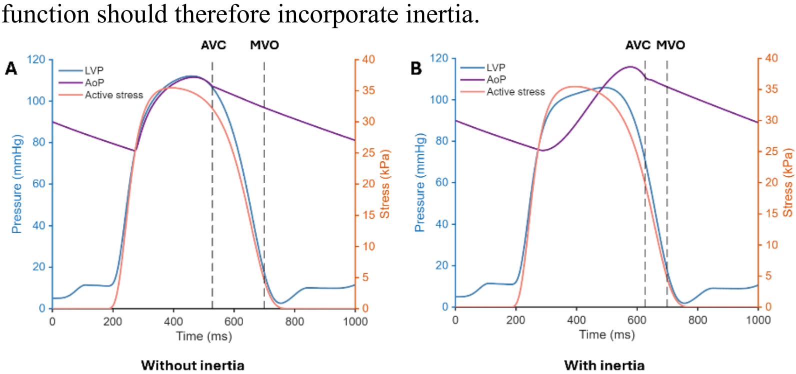

Figure 1. Effect of blood inertia on left ventricular relaxation.