Supplementary Material

Non-invasive assessment of systolic and diastolic left ventricular function during rest and stress conditions using an integrated image-modelling approach

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1 Methods

1.1 Model parameters

Table S1: Parameters in the lumped-parameter model, including parameter values defined in literature.

Parameter	Description (units)	Literature values
Pulmonary venous system		
P_{pu}	Pulmonary capillary pressure (mmHg)	7.4 (Sun et al.)
R_{pv} [a]	Resistance of pulmonary veins (mmHg·s/mL)	$2\cdot10^{-3}$ (Sun et al.)
L_{pv} [a]	Inertance of pulmonary veins (mmHg· s^2/mL)	$5\cdot10^{-4}$ (Sun et al.[14])
R_{pvc} [a]	Viscoelastic resistance of pulmonary capillaries and veins (mmHg·s/mL)	0.01 (Sun et al.[14])
C_{pvc} [a]	Capacitance of pulmonary capillaries and veins (mL/mmHg)	4 (Sun et al.[14])

R_{pu} [a]	Resistance of pulmonary capillaries (mmHg·s / mL)	0.01 (Sun et al.[14])
Heart parameters		
Left atrium (LA)		
$K_{s,LA}$	Source resistance coefficient of the LA (s/mL)	$10\cdot10^{-9}$ (Mynard et al.[15])
$E_{min,LA}$	Minimal elastance of the LA (mmHg/mL)	0.08 (Mynard et al.[15])
$E_{max,LA}$	Maximal elastance of the LA (mmHg/mL)	0.17 (Mynard et al.[15])
$V_{0,LA}$ [a]	Unstressed volume of the LA (mL)	3 (Mynard et al.[15])
$R_{C,LA}$	Contraction rate constant of the LA (-)	1.32 (Mynard et al.[15])
$R_{R,LA}$	Relaxation rate constant of the LA (-)	13.1 (Mynard et al.[15])
$\alpha_{1,LA}$	Systolic time constant shape factor of the LA (-)	0.11 (Mynard et al.[15])
$\alpha_{2,LA}$	Diastolic time constant shape factor of the LA (-)	0.18 (Mynard et al.[15])
$R_{visc,LA}$ [a]	Viscous loss resistance for the LA (mmHg·s / mL)	$1\cdot10^{-4}$ (Mynard et al.[15])
$Onset_{LA}$	Onset of contraction of the LA (s)	0.85 (Mynard et al.[15])
Left ventricle (LV)		
$K_{s,LV}$ [a]	Source resistance coefficient of the LV (s/mL)	$4\cdot10^{-9}$ (Mynard et al.[15])
$E_{min,LV}$	Minimal elastance of the LV (mmHg/mL)	0.08 (Mynard et al.[15])
$E_{max,LV}$	Maximal elastance of the LV (mmHg/mL)	3 (Mynard et al.[15])
$V_{0,LV}$ [a]	Unstressed volume of the LV (mL)	10 (Mynard et al.[15])
$R_{C,LV}$	Contraction rate constant of the LV (-)	1.32 (Mynard et al.[15])
$R_{R,LV}$	Relaxation rate constant of the LV (-)	27.4 (Mynard et al.[15])
$\alpha_{1,LV}$	Systolic time constant shape factor of the LV (-)	0.269 (Mynard et al.[15])

$\alpha_{2,LV}$	Diastolic time constant shape factor of the LV (-)	0.452 (Mynard et al.[15])
$R_{visc,LV}$ [b]	Viscous loss resistance for the LV (mmHg·s/mL)	$1 \cdot 10^{-4}$ (Mynard et al.[15])
$Onset_{LV}$	Onset of contraction of the LV (s)	0 (Mynard et al.[15])
Mitral valve		
R_{mv}	Resistance of the mitral valve (mmHg·s/mL)	$3.75 \cdot 10^{-3}$ (Sun et al.[14])
L_{mv}	Inertance of the mitral valve (mmHg·s^2/mL)	$2 \cdot 10^{-4}$ (Sun et al.[14])
Aortic valve		
EOA_{av}	Effective orifice area of the aortic valve (cm^2)	1.69 (Garcia et al.[16])
A_{ao}	Cross sectional area of the aorta (cm^2)	5 (Olufsen et al.[64])
L_{av}	Inertance of the aortic valve (mmHg·s^2/mL)	$4 \cdot 10^{-4}$ (Sun et al.[14])
Systemic arterial system		
R_{aa}	Resistance of the ascending aorta (mmHg·s/mL)	0.04 (Sun et al.[14]),
L_{aa}	Inertance of the ascending aorta (mmHg· s^2/mL)	$5 \cdot 10^{-4}$ (Sun et al.[14]),
R_{aav}	Viscoelastic resistance for C_{aa} (mmHg·s/mL)	0.01 (Sun et al.[14])
C_{aa}	Capacitance of the ascending aorta (mL/mmHg)	0.1 (Sun et al.[14])
R_{pc}	Viscoelastic resistance for C_{pc} (mmHg·s/mL)	-
R_{pr}	Peripheral resistance (mmHg·s/mL)	1.2 (Sun et al.[14]),
C_{pc}	Peripheral compliance (mL/mmHg)	2 (Sun et al.[14])
Other parameters		
T [b]	Duration of the cardiac cycle (s)	-
ρ	Density of blood (g/mL)	1.06

2 Results

Table S2: Subject-specific fitting results for the nine subjects included in the study. The agreement between the measured and the model-generated waveforms is assessed using the root mean square error (RMSE). MV: mitral valve; AV: aortic valve; AA: ascending aorta.

	RMSE (ml/s)					
	Rest			Dobutamine		
Subject	**MV**	**AV**	**AA**	**MV**	**AV**	**AA**
1	29.7	25.8	21.5	58.3	66.8	31.1
2	32.4	26.1	23.0	58.0	29.5	36.2
3	22.7	16.1	23.3	49.4	51.9	35.6
4	27.7	17.2	20.6	77.6	29.0	21.5
5	15.4	19.6	18.7	32.3	35.6	25.1
6	34.8	30.4	33.1	76.6	82.4	47.9
7	24.3	19.7	24.9	44.1	82.7	46.1
8	18.4	16.0	16.0	60.5	46.1	62.2
9	20.0	18.6	19.0	22.1	24.8	27.5

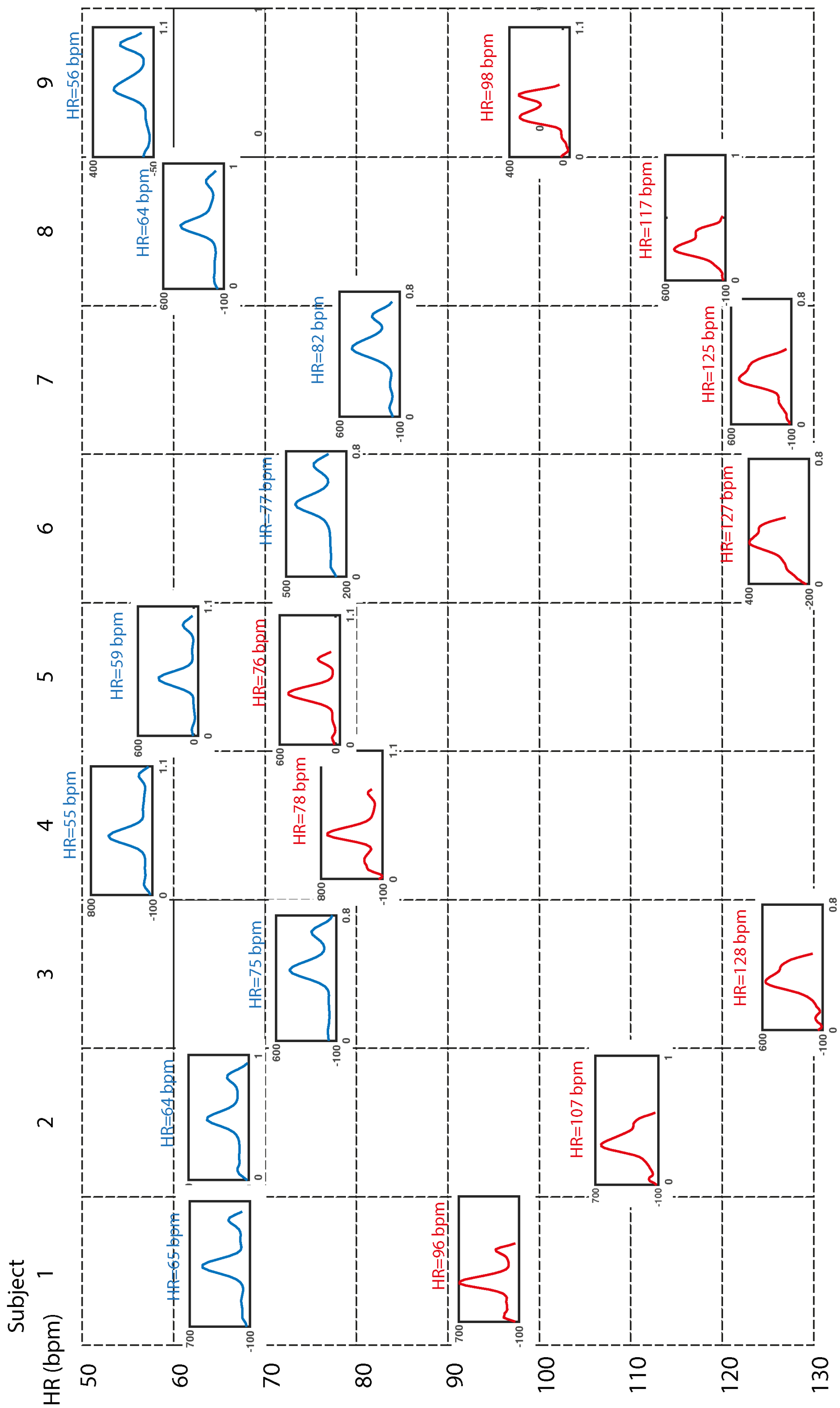

Figure S1: Changes in 4D Flow MRI-derived mitral flow waveforms with increasing heart rates for all study subjects. For each subject, the mitral flow patterns at rest (blue) and after dobutamine infusion (red) are included. The x and y-axis of the volumetric flow waveforms indicate time (s) and flow (ml/s), respectively.