Supplementary appendix: The half-ellipsoid model of the left ventricle

Basic linear measured and derived measurements

Basic measurements are described in the main paper. Mean chamber diameters (LVIDd and LVIDs) wall thicknesses (midwall) in systole and diastole (WTd and WTs) were taken from M-mode measures. External diameters (LVEDd and LVEDs) were calculated from LVID and WT. This is described in the methods section. All primary linear measurements used for calculations are given in supplementary Table S1 and have been published previously [28]. As wall thickness decreases from base to apex, apical wall thicknesses were assumed to be ½ of midwall WT.

Diastolic total, or external left ventricular length (LVLd) was calculated from WLd and radius by the Pythagorean theorem using LVIDd + ½ WTd as shown in Figure S1, while LV systolic length (LVLs) was calculated as LVLd – annular plane motion (MAPSE). Internal diastolic length is then LVILd = LVLd - ½ WT. MAPSE is the same for the internal and total volume, so left ventricular internal systolic length (LVILs) would be LVILd – MAPSE. Wall lengths are likewise given in Table S1. LVIDd, and the derived linear measures of LVLd and WTd were all near normally distributed, with skewnesses of 0.35, -0.32 and 0.31, respectively. All of these measures are illustrated in Figure S1.

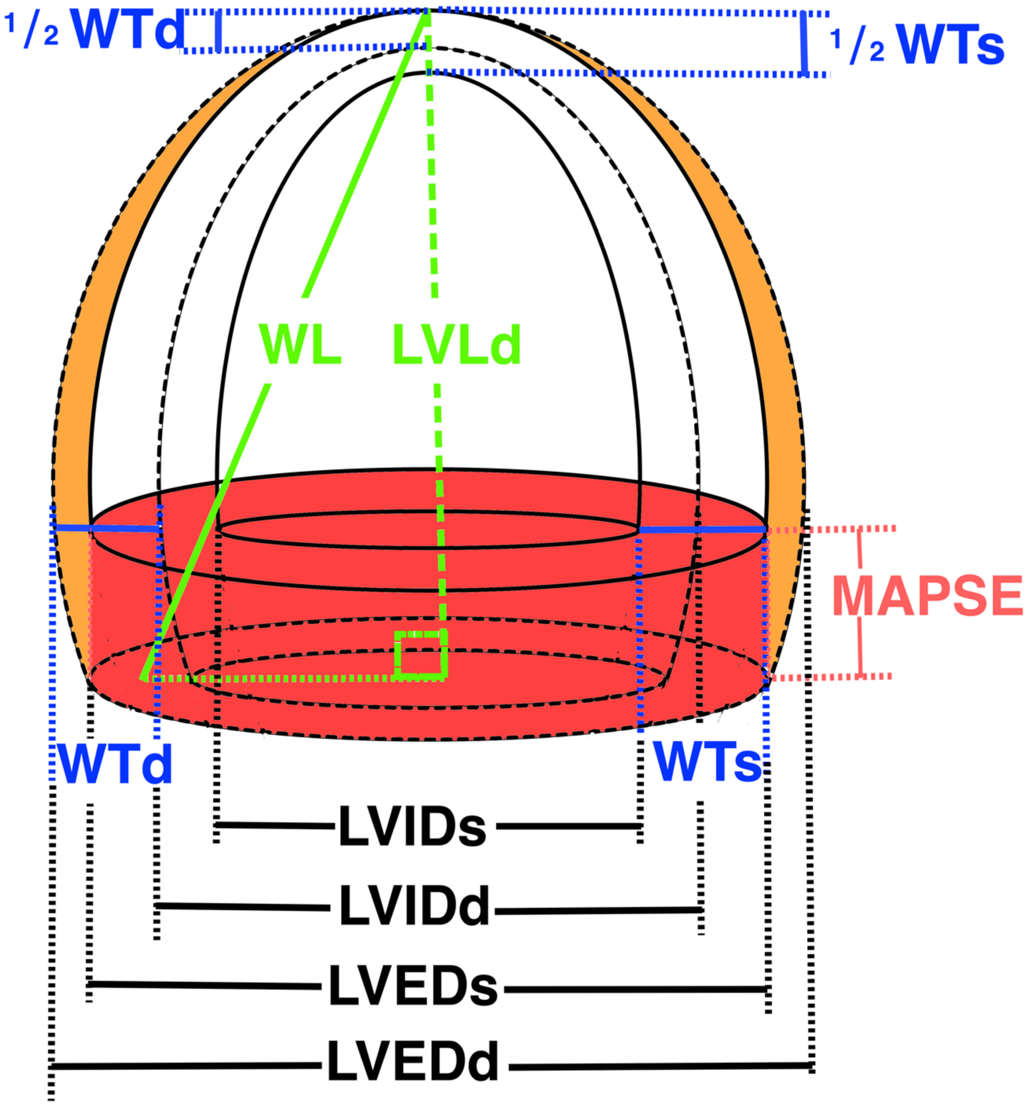

Figure S1. Basic and derived linear measures related to the half-ellipsoid left ventricular (LV) model.

Abbreviations: WL; wall length, WT; Wall Thickness, LVL; Left ventricular length, LVID; Left Ventricular Internal Diameter, LVED; Left ventricular external diameter, subscript d; diastole, subscript s; systole.

Table S1: Basic and derived linear measurements for volume calculations.

Age (years)	LVIDd (mm)	LVIDs (mm)	WTd (mm)	WTs (mm)	LVEDd (mm)	LVEDs (mm)	WLd (mm)	LVLd (mm)	LVILd (mm)
Women									
<40	49.3 (4.2)	31.2 (3.8)	7.6 (1.2)	12.0 (1.6)	64.5 (4.8)	55.3 (4.5)	93.0 (15.9)	91.0 (6.2)	87.2 (6.1)
40 – 60	48.8 (4.4)	31.0 (4.2)	8.2 (1.1)	12.8 (1.7)	65.3 (5.2)	56.6 (4.8)	90.5 (16.2)	88.5 (6.0)	84.3 (5.9)
> 60	47.8 (4.8)	30.5 (4.7)	8.9 (1.2)	13.6 (2.0)	65.6 (5.3)	57.6 (4.73)	88.2 (13.0)	85.0 (5.9)	80.1 (5.9)
Total	48.8 (4.5)	31.0 (4.2)	8.1 (1.2)	(12.7)	65.1 (5.1)	56.4 (4.7)	90.9 (15.7)	88.7 (6.4)	84.6 (6.4)
Men									
<40	53.5 (4.9)	34.5 (4.7)	9.0 (1.1)	14.0 (1.9)	71.6 (5.3)	55.3 (4.5)	101.9 (17.2)	99.6 (6.4)	95.0 (6.4)
40 – 60	53.0 (5.5)	34.0 (5.1)	9.6 (1.3)	14.6 (1.9)	72.2 (5.8)	56.6 (4.8)	99.8 (17.4)	97.3 (7.4)	92.5 (7.4)
> 60	52.1 (6.4)	33.4 (5.5)	10.0 (1.3)	15.1 (2.4)	72.2 (6.87)	57.6 (4.73)	94.2 (19.0)	92.1 (7.8)	87.1 (7.8)
Total	52.9 (6.0)	34.0 (5.1)	9.6 (1.3)	14.6 (2.0)	72.1 (6.0)	56.4 (4.7)	98.8 (18.0)	96.5 (7.8)	91.7 (7.8)
All	50.8 (5.4)	32.4 (4.9)	8.8 (1.5)	13.6 (2,1)	68.4 (6.5)	55.3 (4.5)	94.7 (17.3)	92.4 (8.1)	88.0 (7.9)

Abbreviations: LVIDd; Left ventricular internal (cavity) diameter in end-diastole; LVIDs; Left ventricular internal diameter in end-systole, WTd; end-diastolic mean wall thickness, WTs; end-systolic mean wall thickness, LVEDd; Left ventricular external end-diastolic diameter, LVEDs; Left ventricular external end-systolic diameter, WLd; Mean end-diastolic wall length, LVLd; left ventricular total (external) length in end-diastole, LVILd; Left ventricular internal (cavity) length in end-diastole.

Calculations of volumes

The volume of a symmetrical half ellipsoid with a circular cross section is $2/3 \times \pi \times a \times b^2$ where a is length (long radius) and b is cross sectional radius. The total (external) diastolic volume of the LV as seen in Figure S1, is then given by the LVLd as the long radius, and the square of the cross-sectional radius being 1/2 × LVEDd, so Total end-diastolic volume = $2/3 \times \pi \times \text{LVLd} \ (1/2 \times \text{LVEDd})^2$, and the total systolic volume = $2/3 \times \pi \times \text{LVLs} \ (1/2 \times \text{LVEDs})^2$. As seen from the figure, this is a slight approximation, as the diastolic configuration of the LV may be a little more than a half ellipsoid.

Diastolic and systolic cavity volumes (LVEDV and LVESV) can be calculated in the same way, using internal measures. Diastolic and systolic cavity radii is ½ internal diameters; (LVIDd and LVIDs). LV cavity volumes was then LVEDV = $2/3 \times \pi \times \text{LVILd} \ (1/2 \times \text{LVIDd})^2$ and LVESV = $2/3 \times \pi \times \text{LVILs} \ (1/2 \times \text{LVIDs})^2$. Stroke volume (SV) is then SV = LVEDV – LVESV and EF = SV / LVEDV.

Finally, myocardial end-diastolic and end-systolic volume (MVd and MVs) myocardial volume is the difference between total volume and cavity volume in end of systole and diastole, respectively. Myocardial systolic compression (MC) is the difference between end-diastolic and end-systolic myocardial volume. Mitral annular plane area was calculated as $A = \pi \times (½ \ \text{LVEDs})^2$. As the mitral annulus is less compressible than the mid-ventricular diameter, it is presumed that LVEDs would be closer to the annular plane diameter as indicated in Supplementary Figure 1. The stroke volume due to left ventricular shortening (MAPSE_SV) would then be MAPSE × A. The part being due to short axis shortening was then presumed to be the rest of SV.

Volumes and Functional measures are given in the main paper.