Table S1 Collinearity among the variables

Variable	GLSendo	GLSmyo	GLSepi	ΔGLS	GWI	GCW	GWW	GWE
GLSendo	1.0000000	0.9753538	0.9738902	0.9778983	−0.8255900	−0.7919999	0.3872230	−0 5237344
GLSmyo	0.9753538	1.0000000	0.9593204	0.9464148	−0.8061497	−0.7852991	0.3513478	−0.4835264
GLSepi	0.9738902	0.9593204	1.0000000	0.9058257	−0.7837603	−0.7568263	0.3163845	−0.4371486
ΔGLS	0.9778983	0.9464148	0.9058257	1.0000000	−0.8270022	−0.7913221	0.4351369	−0.5790045
GWI	−0.8255900	−0.8061497	−0.7837603	−0.8270022	1.0000000	0.9698087	−0.3707544	0.4870180
GCW	−0.7919999	−0.7852991	−0.7568263	−0.7913221	0.9698087	1.0000000	−0.3490359	0.5090048
GWW	0.3872230	0.3513478	0.3163845	0.4351369	−0.3707544	−03490359	1.0000000	−0.3611222
GWE	−0.5237344	−0.4835264	−0.4371486	−0.5790045	0.4870180	0.5090048	−0.3611222	1.0000000

GLSendo, global longitudinal strain of subendocardium; GLSmyo, global longitudinal strain of myocardium; GLSepi, global longitudinal strain of subepicardium; ΔGLS, transmural gradient of global longitudinal strain; GWI, global myocardial work index; GCW, global myocardial constructive work; GWW, global myocardial wasted work; GWE, global myocardial work efficiency.

Table S2 Principal component analysis

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
GLSendo	0.4010051	0.12797544	0.081591467	0.2604638	0.08511564	0.24807306	0.157922956	0.8090392752
GLSmyo	0.3933049	0.17580012	0.102206080	0.2563187	0.05857815	0.74430516	0.425247526	0.0017769114
GLSepi	0.3840215	0.22820903	0.138521383	0.2890481	0.62914839	0.36035437	0.111308427	0.3995480759
ΔGLS	0.3986318	0.03030077	0.026560740	0.2179079	0.73281159	0.09741572	0.245766843	0.4301920588
GWI	0.3752587	0.08010353	0.007442325	0.5655097	0.10929670	0.36754169	0.620902236	0.0188536251
GCW	0.3675868	0.07151657	0.074401478	0.6233219	0.15260327	0.33108418	0.576546431	0.0197290712
GWW	0.1942046	0.82261478	0.527502969	0.0172615	0.08210996	0.01662637	0.003665575	0.0004795524
GWE	0.2539130	0.45988350	0.824067765	0.1636988	0.12044635	0.01201761	0.059119914	0.0018697451

PC, principal component; GLSendo, global longitudinal strain of subendocardium; GLSmyo, global longitudinal strain of myocardium; GLSepi, global longitudinal strain of subepicardium; ΔGLS, transmural gradient of global longitudinal strain; GWI, global myocardial work index; GCW, global myocardial constructive work; GWW, global myocardial wasted work; GWE, global myocardial work efficiency.

Table S3 Results of the ULRM prediction models for impaired LV systolic function in HFpEF

Variable	AUC	Cutoff value	Sensitivity (%)	Specificity (%)
GLSendo (%)	0.841	0.581	68.0	100
GLSmyo (%)	0.805	0.575	64.0	95.8
GLSepi (%)	0.790	0.583	64.0	91.7
ΔGLS (%)	0.891	0.579	72.0	100
GWI (mmHg%)	0.792	0.489	80.0	79.2
GCW (mmHg%)	0.795	0.331	95.7	61.9
GWW (mmHg%)	0.752	0.433	68.0	87.5
GWE (%)	0.882	0.322	92.0	66.7

ULRM, univariate logistic regression model; LV, left ventricular; HFpEF, heart failure with preserved ejection fraction; AUC, area under the curve; GLSendo, global longitudinal strain of subendocardium; GLSmyo, global longitudinal strain of myocardium; GLSepi, global longitudinal strain of subepicardium; ΔGLS, transmural gradient of global longitudinal strain; GWI, global myocardial work index; GCW, global myocardial constructive work; GWW, global myocardial wasted work; GWE, global myocardial work efficiency. GMW, global myocardial work.

Table S4 Comparison of derivation cohort with validation cohort for HFpEF and Control groups

Variable	HFpEF group			Control group		
	Derivation cohort (n=49)	Validation cohort (n=15)	P value	Derivation cohort (n=49)	Validation cohort (n=15)	P value
Clinical characteristics						
Age (years)	67.39±7.69	69.53±6.25	0.33	64.89±9.17	62.20±6.30	0.30
Female gender	28 [57]	10 [67]	0.51	20 [43]	8 [53]	0.51
Height (cm)	165.82±6.97	164.80±3.59	0.59	166.89±5.35	164.67±5.01	0.16
Weight (kg)	66.08±10.23	67.87±4.98	0.52	61.33±10.79	61.40±4.14	0.98
BMI (kg/m^2)	24.03±3.53	25.12±1.76	0.26	21.88±2.52	22.71±1.71	0.24
HR (beats/min)	75.57±7.20	76.13±9.40	0.81	72.61±9.99	69.87±3.85	0.31
SBP (mmHg)	142 [125 to 146.50]	139 [135 to 144]	0.68	125.37±10.05	122.47±10.13	0.34
DBP (mmHg)	86.18±12.65	84.60±4.58	0.64	77 [73.25 to 84]	72 [70 to 80]	0.09
NT-proBNP (pg/mL)	674 [418.50 to 1115]	678 [230 to 1145]	0.51	62.33±22.67	54.73±8.19	0.21
NYHA						
II	21 [43]	6 [40]	0.85			
III	23 [47]	5 [33]	0.35			
IV	5 [10]	4 [27]	0.11			
Comorbidity						
Hypertension	33 [67]	8 [53]	0.32			
Coronary artery disease	27[55]	6 [40]	0.31			
Diabetes mellitus	14 [29]	6 [40]	0.40			
Paroxysmal atrial fibrillation	9 [18]	2 [13]	0.65			
Conventional echocardiography parameters						
LAd (mm)	40 [36 to 42.5]	37 [30 to 45]	0.61	36.34±3.48	34.67±2.58	0.10
E/A	0.77 [0.62 to 0.87]	0.85 [0.70 to 1.26]	0.46	1.31 [1.24 to 1.40]	1.20 [1.14 to 1.35]	0.11
The average E/e'	15.26 [13.25 to 16.94]	15.80 [12.60 to 18.40]	0.57	6.49±1.75	7.34±0.67	0.07
IVSd (mm)	11.02±1.18	11.25±1.45	0.52	8.96±1.08	8.55±0.80	0.18
LVPWd (mm)	10.72±1.35	11.02±1.29	0.45	8.96 [7.74 to 9.56]	9.00 [8.30 to 9.50]	0.59
RWT (mm)	0.46±0.06	0.48±0.06	0.29	0.39±0.07	0.38±0.03	0.67
LVMI (g/m^2)	109.90±17.52	108.00±14.21	0.70	84.64±17.77	79.72±9.59	0.31
LVEDd (mm)	47 [45 to 49]	46 [45 to 47]	0.18	45.87±3.01	45.53±1.60	0.68
EDV (mL)	104.63±13.84	98.20±12.91	0.11	99.89±14.39	97.33±10.58	0.53
ESV (mL)	40.61±7.92	39.67±4.35	0.66	38.33±7.23	35.47±5.42	0.17
LVEF (%)	60.18±4.04	59.93±2.76	0.82	60.50 [60 to 64]	61 [60 to 64]	0.39
Stratified longitudinal strain and MW parameters						
GLSendo (%)	−20.90 [−22.60 to −19.10]	−21.14 [−21.71 to −18]	0.40	−24.18±1.90	−24.28±2.86	0.87
GLSmyo (%)	−18.20 [−19.95 to −16.90]	−19.10 [−20 to −17]	0.56	−20.46±1.67	−21.14±3.11	0.28
GLSepi (%)	−16.37±1.38	−15.81±2.05	0.23	−17.59±0.96	−18.20±3.50	0.29
ΔGLS (%)	−4.50 [−5.55 to −3.95]	−3.71 [−5.14 to −2.60]	0.09	−6.58±0.97	−6.08±1.97	0.19
GWI (mmHg%)	1,818 [1,662 to 1,959]	1,996 [1,625 to 2,171]	0.11	2,123.50 [1,874.25 to 2,336]	2,014 [1,689 to 2,101]	0.15
GCW (mmHg%)	2,092.18±255.52	2,221.00±284.90	0.10	2,419 [2,069 to 2,611.25]	2,303 [2,013 to 2,429]	0.09
GWW (mmHg%)	87.48 [66.23 to 121.50]	62 [40 to 135]	0.13	60.50 [48.75 to 73.75]	54 [48 to 84]	0.80
GWE (%)	94.29±2.56	95.67±1.84	0.06	98 [96.75 to 99]	97 [95 to 98]	0.10

Data are expressed as the n [%], mean ± SD, or M [P25 to P75]. HFpEF, heart failure with preserved ejection fraction; BMI, body mass index; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; NT-proBNP, N-terminal-pro-brain natriuretic peptide; NYHA, New York Heart Association; BP, blood pressure. 1 mmHg=0.133 kPa. LAd, left atrial diameter; E/A, the ratio of mitral valve peak early to late diastolic filling velocity; E/e', the ratio of early mitral inflow velocity to mitral annular early diastolic velocity; IVSd, interventricular septal thickness in diastole; LVPWd, left ventricular posterior wall thickness in diastole; RWT, relative wall thickness; LVMI, left ventricular mass index; LVEDd, left ventricular end-diastolic diameter; EDV, end-diastolic volume; ESV, end-systolic volume; LVEF, left ventricular ejection fraction. MW, myocardial work; GLSendo, global longitudinal strain of subendocardium; GLSmyo, global longitudinal strain of myocardium; GLSepi, global longitudinal strain of subepicardium; ΔGLS, transmural gradient of global longitudinal strain; GWI, global myocardial work index; GCW, global myocardial constructive work; GWW, global myocardial wasted work; GWE, global myocardial work efficiency.