Global longitudinal strain detects reduced exercise capacity and reduced systolic function in patients with heart failure with preserved ejection fraction

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Purpose

- Global longitudinal strain (GLS) of the left ventricle (LV) is more accurate and sensitive than ejection fraction (EF) for quantification of myocardial systolic function.
- Exercise capacity is a strong predictor of mortality in heart failure patients and in the healthy population.
- The mechanism of reduced exercise capacity in Heart Failure with preserved Ejection Fraction (HFpEF) is not well defined.
- The relationship between exercise capacity and myocardial strain is not fully explored.
- We investigated if exercise capacity is related to systolic function as measured by GLS.

Methods

- We included 100 patients with verified or suspected heart failure admitted to the dept of cardiology. (Table 1)
- Medical history, clinical examination and ECG were recorded.
- HFpEF was defined as EF ≥ 50% and echocardiographic signs of diastolic dysfunction.
- Exercise capacity was defined as peak VO_2.
  - Cardiopulmonary exercise testing by bicycle ergometry
  - Respiratory exchange ratio > 1.1
- Echocardiography
  - EF by Simpson biplane method and right ventricular (RV) fractional area change (*FAC*).
  - Strain by 2D speckle tracking technique: Peak longitudinal strains from each ventricular segment were averaged to LV GLS from a 16-segment LV model and RV strain from a 3-segment RV model.
  - Diastolic parameters:
    - E, E/A-ratio, deceleration time from mitral inflow pattern by pulsed wave Doppler.
    - e´ : mitral annulus velocity by tissue Doppler imaging.
    - Left atrial volume index (LAV) (area length method).

		All patients, n=100	Patients with HFpEF, n=37
Age at exam (years)		56 12	58 11
Gender (m/f) (n)		73 / 27	25/12
NYHA class (n)	I	23	16 (43 %)
	II	26	16 (43 %)
	III	38	5 (14 %)
	IV	13	0
EF (%)		42 19	62 7
GLS (%)		-12.0 7	-17.5 3
RV Fractional area change (%)		37 14	48 11
RV strain (%)		-15.4 6.3	-20.4 5.2
Peak VO2 (ml/kg/min)		15.4 6.3	20.1 6.9
E (m/s)		0.77 0.28	0.72 0.22
E/A		1.97 1.3	1.5 1.1
Deceleration time (ms)		206 76	245 75
E/e		17.0 12	11.0 5.3
Left atrial volume index (ml/m²)		56 26	45 22

Table 1: Patient characteristics

Correlation to peak VO_2	All patients, n=100		Patients with HFpEF, n=37	
	R*	p -value	R*	p-value
Age	0.13	0.20	-0.002	0.99
EF	0.62	<0.001	0.04	0.84
ESV	-0.42	<0.001	0.32	0.06
RV fractional area change	0.54	<0.001	0.35	0.03
GLS	-0.63	<0.001	-0.50	0.002
RV strain	-0.50	<0.001	-0.34	0.05
E/A	-0.43	<0.001	-0.26	0.13
E/e	-0.41	<0.001	-0.43	0.008
Left atrial volume index	-0.41	<0.001	-0.28	0.09

*Pearson

Table 2: Exercise capacity and echocardiographic variables

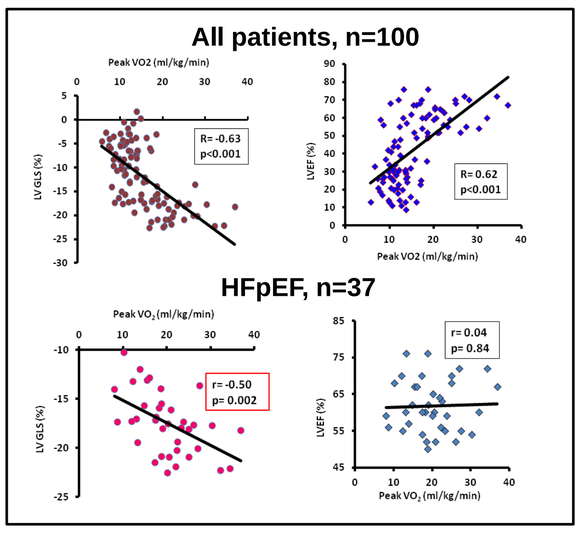

Figure 1: Exercise capacity and LV function. Upper panel: All patient, n=100. GLS and EF correlated to exercise capacity. Lower panel: HFpEF, n=37. Only GLS correlated to exercise capacity.

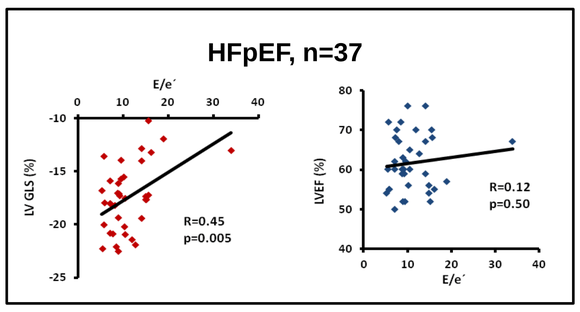

Figure 2: In HFpEF systolic function by GLS (left) correlated to diastolic function while systolic function by EF (right) did not.

Figure 4: HFpEF patient with normal EF 62%, reduced systolic function by GLS –13.2% and reduced diastolic function by E/e´14. Exercise capacity was reduced in line with GLS with a peak VO_2 14.9 ml/kg/min.

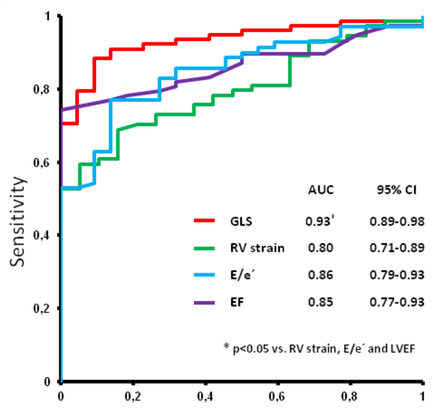

Figure 3:
Ability to detect peak VO_2 < 20 ml/kg/min*, n=100.

GLS showed the best ability to identify patients with peak VO2 < 20ml/kg/min.
-Sensitivity 0.89 (95% CI 0.79– 0.95)
-Specificity 0.91 (95% CI 0.71 – 0.99)

***Peak VO2 > 20ml/kg/min is classified as normal or only mildly reduced physical capacity (Weber et al. 1985).**

Abbreviations:
A= late diastolic transmitral filling velocity;
AUC= area under the curve;
E= peak early diastolic transmitral filling velocity;
e´ = early diastolic mitral annulus velocity;
EF= ejection fraction;
ESV= end systolic volume;
f= female;
GLS= global longitudinal strain;
HFpEF= heart failure with preserved ejection fraction;
HR= heart rate;
LV= left ventricular;
m= male;
NYHA= New York Heart Association;
RV= right ventricular.

Results

Total population, n=100:

- Exercise capacity correlated to LV and RV parameters. (Table 2 and Figure 1, upper panel)
- GLS was superior to EF, E/e´ and RV strain in identifying patients with peak VO_2 < 20 ml/kg/min as shown by ROC analyses. (Figure 3)
  -Sensitivity 0.89
  (95% CI 0.79– 0.95)
  -Specificity 0.91
  (95% CI 0.71 – 0.99)
  -Discriminating strain value
  -17.3%

HFpEF, n=37:

- GLS and E/e´ correlated to peak VO_2 (r=-0.50, p=0.002 and r=-0.43, p=0.008), while EF did not (r=0.04, p=0.84) (Table 2 and Figure 1, lower panel).
- GLS correlated to E/e´ and to left atrial volume index (r=0.45, p=0.005 and r=0.48, p=0.003), while EF did not (r=0.12, p=0.50 and r=0.02, p=0.91). (Figure 2)

Conclusions

- GLS detected reduced LV function in HFpEF with reduced exercise capacity.
- The observed relationship between GLS and diastolic function with exercise capacity confirms a tight coupling between systolic and diastolic function in HFpEF.
- These findings support that GLS is superior to EF in assessment of LV function.

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N.E.Hasselberg and K.H.Haugaa have received Norwegian governmental (non-profit) research grants.

None of the authors have any dislosures to declare