

Pursuing the non-invasive assessment of cardiac contractility: the added value of pressure-area-strain loop analysis in volume overload-induced heart failure

Tokodi M.; Lakatos BK.; Ruppert M.; Olah A.; Sayour AA.; Barta BA.; Ladanyi ZS.; Soos A.; Merkely B.; Radovits T.; Kovacs A.

Semmelweis University Heart and Vascular Center, Budapest, Hungary

Funding Acknowledgements: Type of funding sources: Public grant(s) – National budget only. Main funding source(s): This work was supported by the New National Excellence Programme (ÚNKP-19-3-I) of the Ministry for Innovation and Technology in Hungary, and the Artificial Intelligence Research Field Excellence Programme of the National Research, Development and Innovation Office of the Ministry of Innovation and Technology in Hungary.

Background: Global longitudinal strain (GLS) by speckle-tracking echocardiography (STE) is a sensitive parameter of left ventricular (LV) systolic function. Nevertheless, GLS is dependent on loading conditions. Through the analysis of pressure-strain loops, myocardial work was recently introduced and tested in different clinical scenarios. Myocardial work incorporates afterload, but still, it neglects changes in preload and LV geometry.

Purpose: Accordingly, our aim was to test our hypothesis that adding instantaneous LV size to myocardial work calculation can further mitigate the load-dependency of GLS, and therefore, a better correlation with intrinsic myocardial contractility can be achieved.

Methods: Volume overload-induced heart failure was established by an aortocaval fistula (ACF) in male Wistar rats ($n = 12$). Age-matched sham-operated animals served as controls ($n = 12$). STE was performed to assess GLS, which was immediately followed by invasive pressure-volume (P-V) analysis to assess LV pressure and to compute a gold-standard index of cardiac contractility (preload recruitable stroke work [PRSW]). Global myocardial work index (GMWI) was calculated from GLS and the invasively measured LV pressure. To compute GMWI indexed to LV area (GMWIA), the instantaneous power (calculated by multiplying the strain rate and the instantaneous LV pressure) was divided by the instantaneous LV area, and then it was integrated from mitral valve closure until mitral valve opening.

Results: LV ejection fraction did not differ significantly (ACF vs. controls: 59 ± 4 vs. $65 \pm 9\%$, $p = \text{NS}$), whereas GLS (Figure 1A - representative animals) was slightly decreased in the ACF group (-13.2 ± 2.3 vs. $-15.4 \pm 1.9\%$, $p < 0.05$). In contrast, PRSW, GMWI (Figure 1B - representative animals) and GMWIA (Figure 1C - representative animals) were considerably reduced in ACF compared to controls (57 ± 13 vs. $111 \pm 38 \text{ mmHg}$, 1383 ± 382 vs. $1928 \pm 281 \text{ mmHg\%}$, 11.6 ± 3.7 vs. $47.9 \pm 22.8 \text{ mmHg\%/mm}^2$, all $p < 0.01$). GLS showed moderate correlation with PRSW ($r = -0.550$, $p < 0.01$), whereas GMWI correlated more significantly, but still moderately with the invasively measured LV contractility ($r = 0.681$, $p < 0.001$). Correlation between the pressure-area-strain loop-derived GMWIA and P-V analysis-derived PRSW (Figure 1D) was found to be very strong ($r = 0.924$, $p < 0.001$).

Conclusions: In the case of LV volume overload-induced heart failure, our pressure-area-strain loop-derived metric reflected LV contractility better than GLS and even GMWI. Therefore, the incorporation of instantaneous LV size into myocardial work calculation represents a promising clinical tool to assess and monitor intrinsic myocardial function independently of loading conditions.

Abstract Figure 1

