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Stress-strain loop area better represents regional myocardial work than pressure-strain loop area in the dyssynchronous and remodelled left ventricle

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Background: Pressure-strain-loops (PSL) have been suggested as surrogate parameter of regional myocardial work. However, in left ventricles (LV) with inhomogeneous remodelling, e.g. due to left bundle branch block (LBBB), wall stress may be unevenly distributed. Stress-strain loops (SSL) include information on both regional wall thickness and curvature, and may therefore provide a better surrogate.

Study plan: We therefore compared the correlation of segmental myocardial work estimated through both PSL and SSL to segmental myocardial glucose metabolism as a gold standard, in an animal model of pacing-induced LV remodelling.

Methods: Twelve sheep developed LV dilatation, thinned septum and thickened lateral wall, due to eight weeks of rapid right-atrial and right-ventricular free wall (DDD) pacing (at 180 bpm), causing a LBBB-like dyssynchrony. Invasive LV pressure and echocardiographic speckle tracking based circumferential strain were used to construct PSL. SSL were calculated by considering in addition dynamic changes in segmental myocardial wall thickness and curvature using the formula of Laplace. 18F-fluorodeoxyglucose (FDG)-uptake was measured by positron emission tomography (PET) in absolute values as standardised uptake ratio (SUR). Spatial resolution of PET was improved by ECG- and breathing-gating and using anatomical priors. All imaging was performed during dyssynchronous DDD-pacing and synchronous AAI-pacing (right-atrial pacing only), at baseline (n=3 animals), and after eight weeks of pacing induced remodelling (n=12 animals).

Results: Both at baseline (Fig. A+B) and after 8 weeks (Fig. D+E), switching between AAI and DDD-pacing caused an acute re-distribution of regional myocardial work as measured by both PSL and SSL. In contrast to PSL, however, SSL identified more regional differences among walls in remodelled hearts and showed clearer regional changes when switching between AAI and DDD-pacing. The correlation between regional work, assessed by PSL and SSL, and metabolism by PET, was comparable at baseline (r=0.65 and r=0.64, respectively) (Fig. C). In remodelled hearts after 8 weeks, however, the correlation of regional work assessed by SSL and glucose uptake by PET was significantly higher compared to PSL (r=0.73 vs. r=0.59, respectively; $p<0.05$) (Fig. F).

Conclusions: Regional myocardial work assessed by stress-strain loops correlates significantly better to regional metabolism as measured by PET glucose uptake, particularly after remodelling. Our findings therefore suggest that integrating information on wall thickness and curvature is essential for the reliable assessment of regional myocardial work, especially in dyssynchronous and remodelled left ventricles.