Maximal left ventricular mass-to-power output: A novel index to assess left ventricular performance and to predict outcome in patients with advanced heart failure

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Similarly to any mechanical engine, whose performance is proportional to the power generated with respect to weight, the left ventricle can be viewed as a power generator whose performance can be related to left ventricular muscular mass. Therefore, indices that relate maximal left ventricular power output and left ventricular mass, such as maximal power output-to-LV mass (LVPOMmax) and maximal indexed left ventricular mass-to-power output (LVMPOMmax), may be proposed as novel measures for estimating left ventricular systolic function. These indices can be assessed by Doppler echocardiography and appear to be useful to risk stratify patients with left ventricular systolic dysfunction, especially those with advanced heart failure where the prognostic value of left ventricular ejection fraction has been challenged.
This Doppler-echocardiographic study was designed to evaluate LVPOMmax and LVMPOmax in patients with advanced HF compared to healthy subjects and to assess their prognostic value.
METHODS

Sixty-six consecutive patients with heart failure due to left ventricular systolic dysfunction (54 patients with advanced HF [LVEF <35%] and 12 controls) presenting at the Biomedical Application Laboratory of Cardiovascular Unit 2 “Tito Giulio Sicca” of the Santa Chiara Hospital, Pisa, were studied.

All patients and healthy subjects underwent an ultrasound examination at baseline and during bicycle semi-supine exercise (Figure 1).

LV power output (LVPO) was measured at rest and at peak exercise. Maximal LVPO (watt) was calculated as the maximal product of 133 $10^{-6}$ x stroke volume (ml) x mean arterial pressure (mmHg) x heart rate. LV mass was assessed according to the recent recommendations. Receiver operating characteristic (ROC) curves were generated to define cut-off values for outcome predictors.
Power output (watt) = \( \frac{0.133 \times \text{Stroke Volume (l)} \times \text{Mean BP (mmHg)} \times \text{HR}}{60} \)

Figure 1. All patients and healthy subjects underwent an ultrasound examination at baseline and during bicycle semi-supine exercise. Graded bicycle semi-supine exercise was performed at an initial workload of 20 watts lasting for one minute; thereafter the workload was increased stepwise by 10 watts every minute.
RESULTS

LVMPOMax in controls and in patients with HF are illustrated in Figure 2. Using univariate logistic regression analysis, LVMPOMax emerged as the best predictor of outcome (OR 1.059, p=0.0006) followed by maximal LVPO and LVEF. The only predictors of outcome at multivariate logistic regression analysis were LVMPOMax (OR 1.013, p=0.0038) and LV EF at peak exercise (0.878, p=0.014). LVMPOMax >87 g/m2/watt exhibited the greatest area under the curve for HF-related events (0.94, p<0.0001). Kaplan-Maier event-free survival curves in patients categorized according to LVMPOMax are shown in Figure 3. The comparison of ROC curves between LVMPOMax and LVEF at rest is displayed in Figure 4.
Figure 2. Indexed left ventricular mass-to-power output in patients with heart failure and in controls (A) and in patients with or without cardiac events at follow-up (B).
Figure 3. Event-free survival in patients with heart failure categorized according to peak mass-to-power (that reflects the extent of indexed LV mass that is necessary to develop one watt of power).
Figure 4. Receiver-operating characteristic curves comparing resting left ventricular ejection fraction and peak mass-to-power for the prediction of adverse events at follow-up.
CONCLUSION

Estimation of indices that relate maximum left ventricular power to myocardial mass may be useful to evaluate left ventricular performance. In this study, assessment of LVMP0max during exercise stress echocardiography appeared to effectively contribute to discriminate the outcome among patients with heart failure and severely reduced ejection fraction.