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Automated echocardiographic quantification of left ventricular ejection fraction without volume measurements using a machine learning algorithm mimicking a human expert

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Background. Echocardiographic quantification of left ventricular (LV) ejection fraction (EF) relies on either manual or automated identification of endocardial boundaries followed by standard calculation of model-based end-systolic and end-diastolic LV volumes. Recent developments in artificial intelligence resulted in computer algorithms that allow near automated detection of endocardial boundaries and measurement of LV volumes and function. However, boundary identification is still prone to errors limiting accuracy in certain patients. We hypothesized that a fully automated machine learning algorithm could be developed, which circumvents border detection and instead estimates the degree of ventricular contraction, similar to a human expert trained on tens of thousands of images.

Purpose. This study was designed to test the feasibility and accuracy of this approach.

Methods. Machine learning algorithm was developed and trained on a database of >50,000 echocardiographic studies, including multiple apical 2- and 4-chamber views, to automatically estimate LVEF (AutoEF, BayLabs). Testing was performed on an independent group of 99 unselected patients, whose automated EF values were compared to reference values obtained by averaging measurements by 3 experts using conventional volume-based technique. Inter-technique agreement was assessed using linear regression and Bland-Altman analysis of bias and limits of agreement (LOA). Consistency was assessed by mean absolute deviation (MAD) among automated estimates based on different combinations of apical views. Finally, sensitivity and specificity of detecting of EF=35% was calculated. These metrics were compared side-by-side against the same reference standard to those obtained from conventional EF measurements by clinical readers.

Results. Automated estimation of LVEF was feasible in all 99 patients. AutoEF values showed high consistency (MAD=2.9%) and excellent agreement with the reference values: r=0.95, bias=1.0%, LOA=±11.8%, with sensitivity 0.90 and specificity 0.92 for detection of EF=35%. This was similar to clinicians’ measurements: r=0.94, bias=1.4%, LOA=±13.4%, sensitivity 0.93, specificity 0.87.

Conclusions. Machine learning algorithm for volume-independent LVEF estimation is highly feasible and similar in accuracy to conventional volume-based measurements, when compared to reference values provided by an expert panel.