Estimation of Left Ventricular Ejection Fraction Using a Novel Acoustic-Based Device: Algorithm Development and Initial Clinical Validation

Naira Radzievsky [1], Surik Papyan [1], Igal Kushnir [1], Michael Nagler [1], Alex Sagie [2], Yoram Agmon [3]

[1] Deep Breeze Ltd, Or-Akiva, [2] Cardiology, Echocardiography, Rabin Medical Center, Petach Tikva, [3] Cardiology, Echocardiography, Rambam Health Care Campus, Haifa, Israel

Background: Heart sounds are related to heart function. We developed an algorithm and examined the feasibility of estimating left ventricular ejection fraction (LVEF) by a novel acoustic-based device (Vibration Response Imaging [VRI], Deep Breeze, Or-Akiva, Israel).
Methods: 141 subjects (117 patients and 24 healthy volunteers; age 55±15 yrs, 82% men) with sinus rhythm were examined by both the VRI device and echocardiography. Left ventricular ejection fraction (LVEF) was determined by echocardiography (echo-LVEF) using the biplane Simpson's method. Low-frequency acoustic signals (10-70 Hz) were recorded by VRI from the left posterior thorax by a matrix of 36 microphones during 8 seconds of breath-holding and an electrocardiogram was recorded simultaneously. The acoustic signals were processed digitally and an algorithm was developed to estimate LVEF (VRI-LVEF). The algorithm was based on a combination of multiple acoustic parameters (systolic and diastolic acoustic signals, beat-to-beat variability of acoustic signals, and propagation of the acoustic signals throughout the matrix), electrocardiographic, and clinical parameters. The algorithm was developed based on data from a stratified random sample of 70 subjects (training group) and tested on 71 subjects (validation group; the 2 groups were matched by LVEF).
Results: Mean LVEF was 51±15% (range 11-76%). LVEF was reduced (< 50%) in 55 subjects (39%) and severely reduced (< 35%) in 28 subjects (20%). Examples of peak early systolic acoustic signals in patients with normal and severely reduced LVEF are shown in the figure (graphic representation of spatial distribution of peak systolic acoustic signals in the matrix of microphones [top] and quantitative assessment of acoustic signals in the acoustic center during the cardiac cycle [bottom]). VRI-LVEF calculated by a multivariate algorithm correlated significantly with echo-LVEF (R^2 = 0.60; P <0.001). In all subjects (training and validation groups combined) – VRI-LVEF accurately predicted the presence of abnormal (<50%) or very abnormal (<35%) echo-LVEF, with sensitivities of 84% and 82% (respective sensitivities for detecting echo-LVEF <50% and <35%), specificities of 86% and 91%, positive predictive values of 79% and 70%, negative predictive values of 89% and 95%, and accuracies of 85% and 89% (similar results for training and validation groups).
Conclusions: LVEF can be estimated using a novel acoustic based device, with a high negative predictive value for detecting abnormal LVEF. This device may assist in triage of patients according to LVEF prior to definitive assessment of LVEF by echocardiography.