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ORIGINAL ARTICLE

Diagnostic Capability of Comprehensive Handheld vs Transthoracic Echocardiography

Michael W. Cullen, MD; Lori A. Blauwet, MD; Ori M. Vatury, MD; Sharon L. Mulvagh, MD; Thomas R. Behrenbeck, MD, PhD; Christopher G. Scott, MS; and Patricia A. Pellikka, MD

Abstract

Objective: To assess the diagnostic capability of handheld echocardiography (HHE) compared with transthoracic echocardiography (TTE) performed and evaluated by experienced sonographers and expert echocardiographers.

Patients and Methods: We conducted a prospective study of adult outpatients undergoing comprehensive TTE between July 9, 2012, and April 3, 2013. Experienced sonographers performed a detailed, standardized examination using a handheld ultrasound device that included 2-dimensional and color Doppler images from standard imaging windows. Images from TTE and HHE were independently interpreted by expert echocardiographers to whom the other study was masked. Agreement between the standard TTE and the HHE reports was analyzed.

Results: The study group contained 190 patients (mean ± SD age, 62±17 years; 49% male [n=93]). The κ values were 0.52 for left ventricular (LV) enlargement, 0.52 for right ventricular enlargement, 0.62 for regional wall motion abnormalities, 0.73 for aortic stenosis, and 0.61 for mitral regurgitation. Lin concordance correlation coefficients ranged from 0.89 for LV end-systolic diameter to 0.78 for LV end-diastolic diameter. In 51 patients (27%), echocardiographic findings were discordant between HHE and standard TTE. The most common discordant finding was the presence vs absence of any regional wall motion abnormalities. In discordant cases, HHE tended to underestimate, rather than overestimate, the severity of abnormal findings.

Conclusion: In experienced hands, HHE shows moderate correlation with standard TTE, but discordant findings were present in 27% of patients. Even when performed and interpreted by experienced operators, HHE should not be used as a surrogate for standard TTE.

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Transthoracic echocardiography (TTE) represents an essential diagnostic tool in cardiovascular disease.[1] In the United States, echocardiography is commonly performed by qualified sonographers using large ultrasound systems and is interpreted by cardiologists with specialized training.[2] Recently, the development of handheld ultrasound devices small enough to fit in the pocket of a physician's laboratory coat have raised new possibilities regarding the point-of-care applicability of echocardiography.[3,4]

Studies of handheld and portable echocardiograms have found that they can be used to accurately assess gross cardiac structure and function and to augment information available from the physical examination.[5-14] Inexperienced users can glean clinically useful information from portable echocardiography,[15-18] but they can also misinterpret the findings.[7,19] Studies assessing handheld devices have typically been small, have enrolled unselected patients, and have limited the scope of the handheld examination or diagnostic comparison.[9-13,19] Despite these limitations, reports have suggested that handheld echocardiography (HHE) may substitute for TTE in particular clinical settings.[20,21]

Critical assessment of HHE is crucial to its appropriate application and interpretation. Although previous studies have generally evaluated HHE favorably, they have not studied these devices as a surrogate for TTE under controlled clinical conditions. Therefore, we sought to assess the diagnostic capability of HHE in the hands of experienced sonographers and expert echocardiographers as a potential

From the Division of Cardiovascular Diseases (M.W.C., L.A.B., O.M.V., S.L.M., T.R.B., P.A.P) and Division of Biomedical Statistics and Informatics (C.G.S.), Mayo Clinic, Rochester, MN.

substitute for standard TTE. We hypothesized that HHE would show concordance with standard TTE for detection of clinically significant abnormal findings.

METHODS

Patient Selection

We conducted a prospective study of adult outpatients referred to the Mayo Clinic Echocardiography Laboratory (Rochester, Minnesota) for a resting TTE. Patients were enrolled in the study between July 9, 2012, and April 3, 2013. Patients with established congenital heart disease, with left ventricular (LV) assist devices, or who received intravenous echocardiographic contrast agent with their standard TTE were excluded. The Mayo Clinic Institutional Review Board approved this study.

Sonographic Equipment

This study used the Vscan handheld ultrasound device (GE Healthcare) for the HHE examination and the iE33 (Phillips) or Vivid E9 (GE Healthcare) device for the TTE examination. The Vscan weighs 13.8 oz and obtains 2-dimensional (2-D) grayscale and color Doppler ultrasound images. It does not contain zoom functions, spectral Doppler, the capability for velocity or time measurements, or an electrocardiography interface. The Vscan analyzes the cycle length of ultrasound images to detect and store clips that are 1 cardiac cycle in length. If the device cannot detect the cardiac cycle length, it stores 2-second clips. The US Food and Drug Administration has approved the Vscan for abdominal, cardiac, and obstetric imaging.[22]

HHE Examination

Eligible patients were approached for enrollment while they waited in the examination room during review of their clinical TTE. If patients provided informed consent, 1 of 6 experienced research sonographers performed the HHE examination without knowledge of the clinically indicated TTE results. The HHE examination included acquisition of 27 protocoled 2-D and color Doppler images from the parasternal, apical, and subcostal windows. Sonographers imaged all the cardiac chambers and valves plus extracardiac structures, such as the aorta and inferior vena cava. Table 1 outlines the specific imaging windows and views that the sonographers obtained. Sonographers adjusted the gain and depth of the Vscan to optimize image quality. They obtained additional images to clarify unclear or unexpected findings. No time limits existed on the sonographer examination.

Images from the HHE examination were uploaded to a secure server for offline viewing through Vscan gateway software (GE Healthcare). The sonographers recorded the HHE study findings in an electronic report formatted identically to the report of the clinical TTE. All HHE reports included measurements of LV systolic and diastolic diameters from the parasternal long-axis position at the level of the mitral valve leaflet tips.[1] When findings appeared qualitatively abnormal, sonographers were instructed to measure ventricular wall thickness or aortic dimensions. Volumetric measurements of atrial and ventricular size were not part of the HHE examination.

HHE Interpretation

One of 5 expert echocardiographers reviewed the HHE images and completed the report as he or she would a clinical TTE report. The clinicians reviewing the HHE image had access to the patient's medical record and the indication for the study, but the clinical TTE was blinded to them.

The clinicians interpreting the HHE study evaluated LV size qualitatively and quantitatively using 2-D measurements in end-diastole and end-systole at the level of the mitral valve leaflet tips, in accordance with published recommendations.[1] The LV wall thickness was evaluated qualitatively for all the studies and quantitatively at the discretion of the interpreting physician. The LV ejection fraction was calculated from LV systolic and diastolic diameters using the Quinones method.[23] When ventricular dimensions were technically not feasible, the LV ejection fraction was estimated visually. Resting LV regional wall motion and wall motion score index were assessed on the basis of the 16-segment model.[24] Right ventricular size, right ventricular function, left atrial size, and right atrial size were assessed qualitatively on the basis of recommended criteria.[1] Measurement functions on the Vscan gateway software program were available to the reviewing clinicians if the measurements would augment their interpretation of the HHE images. Valvular heart disease,