

The Use of Hand-carried Ultrasound in the Hospital Setting—A Cost-effective Analysis

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Objectives: We sought to assess the accuracy of hand-carried ultrasound (HCU) in the prediction of a normal study, and its cost-effectiveness in reducing the number of standard departmental echocardiograms (SDE) performed on hospital inpatients.

Methods: The setting was a district general hospital. Participants were 157 consecutive inpatients, mean age 68 (range: 18-97) years, 95 men (61%), referred for SDE. HCU was performed at the bedside as part of the clinical assessment. SDE was performed routinely. Main outcome measures were: (1) assessment of the accuracy of HCU in detection of a normal or abnormal study as determined by SDE; and (2) a cost-effectiveness analysis.

Results: Indications for echocardiography were: left ventricular (LV) function assessment, $n = 101$ (64.3%); valvular abnormalities, $n = 11$ (7%); arrhythmia, $n = 4$ (2.6%); miscellaneous, $n = 10$

(6.4%); and no reason stated, 31 (19.7%). The sensitivity, specificity, and positive and negative predictive values of HCU predicting a completely normal scan were 74%, 96%, 94%, and 81%, respectively, and of predicting normal LV function in requests specific for LV function assessment were 81%, 100%, 100%, and 77%, respectively. If either all inpatients or those with requests for LV function assessment underwent HCU initially, and only those with abnormal scans underwent further SDE, there would be a 29% and 22% reduction in departmental workload and a cost saving of £23,000 and £30,000, respectively.

Conclusion: HCU is an accurate method of identifying patients with normal hearts as determined by SDE. Its routine use is cost-effective and can significantly reduce the number of SDE that need be performed. (J Am Soc Echocardiogr 2005;18:620-5.)

Hand-carried ultrasound (HCU) used in specific clinical care settings has been shown to be of significant benefit.¹ Studies have demonstrated that point-of-care (POC) HCU performed by the consulting physician significantly improves the diagnostic accuracy of the bedside examination and assists in clinical decision making.² In addition, the resultant reduction in departmental workload and shortened time to diagnosis has been shown to produce cost savings of more than 30%.³ However, when HCU is used in a nontargeted setting there is a significant miss rate and, therefore, cannot replace a full departmental scan.⁴

HCU has been shown to be effective in screening large numbers of the community for low prevalence cardiac disorders such as left ventricular (LV) dys-

function and LV hypertrophy (LVH), but its value as a device for the detection of normal hearts in a population with a high prevalence of cardiac disorders has not been considered.^{5,6} The importance of normalcy is that many patients submitted for echocardiography within a hospital setting have no cardiac pathology. Therefore, the identification that a patient's echocardiogram is normal early during admission may reduce the number of referrals for departmental studies, resulting in both a shorter waiting list and earlier discharge for inpatients.

This study tested the diagnostic potential of HCU in the detection of a normal echocardiogram in a cohort of patients referred with suggested cardiac disorders. In addition, we investigated the impact, in terms of cost and workload, such a strategy would have on an echocardiography department.

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METHODS

Patients

In all, 157 inpatients consecutively referred to undergo routine standard departmental echocardiography (SDE) in

a district general hospital were recruited. The patients consisted of those from intensive care, coronary care, cardiac, and general medical wards. Requests for echocardiograms were made by the physician (consultant or specialist registrar) caring for the patient, which included cardiologists, general physicians, anesthetists, and intensivists. Of the patients, 95 (61%) were men, with a mean age of 68 (range: 18-97) years. The study was approved by the local ethical research committee.

Echocardiography

As soon as request forms for SDE were received, the patient underwent echocardiography using a hand-held portable ultrasound device (OptiGo, Philips, Eindhoven, the Netherlands) (Figure 1), performed by a trainee cardiologist (equivalent level of a grade 2 sonographer or above) as part of the clinical assessment. The hand-held device consisted of a base unit ($27 \times 21 \times 7$ cm), 2.5-MHz phased-array transducer, and battery, giving digital 2-dimensional fundamental imaging on a 5.5-in liquid crystal display. Total weight was 3 kg. The device provided basic B-mode imaging, color Doppler, freeze-frame, and linear distance measurement.

All patients subsequently underwent SDE, independent of the HCU examination, with experience equivalent to a grade 2 sonographer or above, using equipment (Sonos 5500, Philips, Eindhoven, the Netherlands) and standard views were taken using second harmonic imaging. The SDE was reported by a grade 3 sonographer or above who was accredited by the British Society of Echocardiography.

Echocardiographic Analysis

Standard views were obtained according to the recommendations made by the American Society of Echocardiography (ASE).⁷ LV end-diastolic chamber dimension and end-diastolic wall thickness of the interventricular septum and posterior walls were obtained in the parasternal long-axis views at the papillary muscle level for both studies according to the recommendations of the ASE.⁷

SDE were analyzed according to departmental protocol and a clinically significant abnormal echocardiogram was defined as the following: LV end-diastolic dimension greater than 5.5 cm; LV end-systolic dimension greater than 4.5 cm; left atrial size greater than 4.0 cm; LV wall thickness greater than 1.3 cm; LV ejection fraction 50% or less (visual); or regional wall-motion abnormality, right atrial dilatation, right ventricular (RV) dilatation (RV $\geq$ one-third size of LV in apical 4-chamber view), and a pericardial effusion 0.5 cm or greater. Significant LV diastolic dysfunction was excluded provided left atrial size was less than 4.0 cm, there was no regional wall-motion abnormality, and there was no significant LV hypertrophy. A pulmonary artery systolic pressure, where recordable, and measured to be greater than 50 mm Hg, was considered abnormal. Significant right heart dysfunction was excluded if the right atrium and RV were of normal size, with normal RV contractility and inferior vena cava diam-

Hand-Held Ultrasound Device



Size: 33.02cm x 22.86cm x 8.9cm
Weight 3.5 kg

Figure 1 Hand-held portable ultrasound device.

eter (< 2.5 cm and collapsing $> 50\%$ with inspiration). Clinically significant valvular disease was defined as mitral valve prolapse (≥ 3 -mm excursion of mitral valve leaflets beyond the mitral annular ring in the apical 4-chamber view), aortic stenosis (peak velocity ≥ 2.4 m/s), moderate or more mitral regurgitation, and mitral stenosis (mean mitral valve gradient ≥ 5 mm Hg). An abnormal echocardiogram was defined using the same definitions on HCU. The protocol for HCU involved using the same views as for SDE, except measurements were only taken if visually thought to be abnormal. Because of the absence of spectral Doppler facility on HCU no flow measurements were taken, but if HCU color Doppler suggested abnormal flow, or B-mode imaging demonstrated abnormal valve leaflet movement/calcification, this was taken to indicate possible valvular pathology and was recorded as abnormal. Furthermore, other pathologic structures such as a prosthetic heart valve, pacing wire, or thrombus were also considered abnormal. In both sets of studies, once completed, the sonographer was asked to report whether the following were normal or abnormal: (1) the overall study; (2) LV function; and (3) valvular function.

Cost-effectiveness Analysis

The cost-effectiveness analysis was based on our department performing 2000 inpatient echocardiograms per annum (pa). The unit cost of a SDE scan was based on a combination of the sonographer's fee, transportation by hospital porter, and depreciation of the device, and was calculated to be £66.15. The purchase cost of the device is £6000 and the hourly rate of a specialist cardiology registrar or above is approximately £18.00. On average, all HCU scans took approximately 10 minutes, including writing the report, and, therefore, the total cost, including yearly depreciation of the HCU device, was calculated to be £4.00 per scan.

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