Focused Cardiac Ultrasound in Place of Repeat Echocardiography: Reliability and Cost Implications

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Background: Health care systems are increasingly moving toward models that emphasize the delivery of high-quality health care at lower costs. Rates of repeat echocardiography (two or more transthoracic echocardiographic studies performed within a short interval) are high and can contribute substantially to the cost of providing cardiovascular care. Certain findings from handheld ultrasound scans performed by echocardiographers have been shown to correlate well with findings on transthoracic echocardiography (TTE). It therefore may be feasible and cost effective to use expert focused cardiac ultrasound (eFCU) in place of repeat TTE for highly selected indications in certain settings. The aim of this study was to determine the reliability and cost implications of using eFCU in place of repeat TTE in selected inpatients.

Methods: Inpatients who underwent repeat TTE (prior TTE within 30 days) ordered for the assessment of ventricular function, pericardial effusion, or inferior vena cava collapse were prospectively enrolled. Subjects underwent eFCU in addition to TTE, and results were compared for correlation using the weighted κ statistic. The potential cost savings of using eFCU in place of TTE were modeled from the provider perspective (i.e., physicians and hospitals).

Results: Over 45 days, 105 patients were enrolled. The majority of scans were performed for assessment of left ventricular function and pericardial effusions. eFCU showed excellent correlation with TTE for most parameters, including left ventricular systolic function (κ = 0.80) and the presence and size of pericardial effusions (κ = 0.81) (P < .001 for both). Adoption of this eFCU protocol could save between $41 and $64 per study, or between $34,512 and $53,871 annually at the authors' institution.

Conclusions: Findings from eFCU correlate well with those from TTE when used in the setting of repeat testing for assessment of ventricular function, pericardial effusion, and inferior vena cava collapse. The judicious use of eFCU in place of repeat inpatient TTE has the potential to deliver quality cardiac imaging at reduced cost. (J Am Soc Echocardiogr 2015;28:1053-9.)

Keywords: Focused cardiac ultrasound, Echocardiography, Cost-effectiveness

Echocardiography is a mainstay of diagnostic cardiac imaging. It permits rapid and accurate assessment of cardiac morphology, function, and hemodynamics. However, the high growth rate in the use of echocardiography, despite cuts in reimbursement, has led to increased scrutiny regarding its appropriate use.[1] The recent development of pocket-sized handheld ultrasound devices has the potential to change how echocardiography is used in clinical practice. Studies have demonstrated efficacy of these devices in identifying cardiac pathology in diverse settings, such as critical care units, outpatient clinics, and underserved and remote populations.[2-5] Most studies have shown good correlation between imaging findings obtained with handheld devices by level II or III echocardiographers or sonographers (i.e., expert focused cardiac ultrasound [eFCU]) versus traditional transthoracic echocardiography (TTE).[6-8]

However, no study has assessed the feasibility of using eFCU for repeat or follow-up imaging, particularly in patients admitted to the hospital who have undergone recent diagnostic TTE. Changes in signs or symptoms, or the need to detect and correct adverse changes in cardiovascular status before they become clinically apparent, may prompt clinicians to order repeat echocardiography to assess for certain changes in cardiac function. It is possible that accurate answers to some of the discrete clinical questions prompting the ordering of repeat echocardiography could be cost-effectively provided by eFCU. Repeat testing is common; more than half of Medicare beneficiaries undergo repeat echocardiography within 3 years.[9] Furthermore, the health care cost of repeat imaging is substantial, because Medicare spending among cardiovascular

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Abbreviations

eFCU = Expert focused cardiac ultrasound

IVC = Inferior vena cava

LV = Left ventricular

LVEF = Left ventricular ejection fraction

RV = Right ventricular

RVU = Relative value unit

TTE = Transthoracic echocardiography

procedures has been driven largely by an increase in diagnostic imaging.[10] eFCU might be cost effective when used for repeat imaging, particularly in reimbursement schemes based on episodes of care ("bundling") or in accountable care organizations, by decreasing the need for the more resource intensive use of full-feature TTE.[11,12]

In this study, we sought to determine whether a protocol to use eFCU in place of repeat or follow-up TTE among highly selected inpatients for a limited set of indications would be feasible and to examine the differential health care costs associated with performing eFCU instead of TTE in this setting.

METHODS

Study Population

This was a prospective, single-center, nonrandomized intervention study. All inpatients for whom TTE was ordered by their primary treatment teams were screened for eligibility. Patients who had undergone previous TTE within the past 30 days, as either inpatients or outpatients at our institution, were then identified as potential candidates for enrollment. Patients for whom repeat TTE was ordered for the assessment of left ventricular (LV) size or systolic function, right ventricular (RV) size or systolic function, screening or follow-up for pericardial effusion, or assessment of inferior vena cava (IVC) collapse were included in the study. Patients in whom cardiac tamponade was a clinical concern were excluded. Because of a lack of spectral Doppler on the handheld ultrasound device (and therefore limited ability to provide accurate diagnosis of other disorders, such as valvular pathology), all other indications were also excluded. Indication for repeat TTE was determined by clinical information on the electronic order provided by the primary treatment team; if the indication was vague, personnel from the echocardiography laboratory contacted the ordering provider to determine the study indication. On the basis of the 2011 appropriate use criteria for echocardiography,[13] the appropriateness of each repeat study was determined from review of the medical record. Patients who were in a surgical or respiratory critical care unit and/or had undergone cardiac surgery during the admission were excluded because many patients in these settings have difficult imaging windows. The study was approved by the local institutional review board.

eFCU and Transthoracic Echocardiographic Protocol

All patients underwent eFCU in addition to repeat TTE ordered by the primary treatment team. TTE was performed with either a Philips iE33 (Philips Medical Systems, Andover, MA) or a GE Vivid7 or Vivid 9 (GE Healthcare, Fairfield, CT) machine by an experienced sonographer and interpreted offline by a level III echocardiographer on ProSolv Cardiovascular Client (Fujifilm, Tokyo, Japan) software with all routinely available parameters. eFCU was performed on the same day as repeat TTE (within 12 hours) with a VScan pocket ultrasound device (GE Healthcare). eFCU was performed and interpreted by level II echocardiographers who were blinded to the repeat transthoracic echocardiographic images and reports. eFCU examinations were tailored specifically to address the ordering indication, but the determinations of LV size and systolic function, RV size and systolic function, presence or absence of pericardial effusion, and assessment of IVC collapse were made for every scan. Typically, two or three views in each of the parasternal, apical, and subcostal views were obtained. Images were interpreted in real time and documented immediately after scanning, similar to the methods used in other focused cardiac ultrasound studies.[4]

Data Collection and Definitions

Demographic data collected included patient age and body mass index. VScan parameters included image quality, LV size, RV size, LV and RV systolic function, LV ejection fraction (LVEF), pericardial effusion or thrombus and chamber compression, and IVC collapse with inspiration (Table 1). All eFCU parameters were assessed qualitatively. Quantification of transthoracic echocardiographic parameters was not mandatory and was left to the discretion of the reader.

Statistical Analysis

Continuous variables are presented as mean ± SD. Agreement between categorical variables on TTE and eFCU (LV size, RV size, LV and RV systolic function, presence and size of pericardial effusion, presence of chamber compression, and IVC collapse with inspiration) was calculated by the weighted κ statistic. On the basis of the classification of Fleiss,[14] κ values > 0.75 were interpreted as representing excellent agreement, 0.61 to 0.74 as good agreement, 0.41 to 0.6 as fair agreement, and <0.4 as poor agreement. Correlation of LVEF between eFCU and TTE was calculated using the Spearman rank-order correlation coefficient. Bland-Altman analysis was used to evaluate bias.[15] P values $< .05$ were considered statistically significant.

Cost Analysis

We modeled the differential costs of performing eFCU versus TTE using a provider-perspective (defined as the local hospital and physician operating jointly, not just the physician) microeconomic analysis, similar to methods used in other economic analyses of cardiovascular procedure use.[16,17] First, the cost of the ancillary services required to perform limited or follow-up inpatient TTE was estimated. Specifically, this included the average labor costs of sonographers and patient transporters (derived from 2013 wage data from the Bureau of Labor Statistics),[18] and echocardiography laboratory overhead (derived from our institutional data and from the American Society of Echocardiography's recommendations for quality echocardiography laboratory operations).[19] Fixed costs of TTE (i.e., machine, depreciation, software platform, archiving) were not included, because these costs would have already been incurred at the time of implementation of a protocol using eFCU. Next, a per-scan estimate of the cost of eFCU equipment was calculated on the basis of purchase price ($7,900) and estimated depreciation (3 years) of the Vscan device. The cost of eFCU failure (i.e., poor imaging windows requiring use of full-feature TTE) was calculated on the basis of the ancillary costs of TTE and the failure rate of eFCU.

The physician cost of performing eFCU versus TTE was then estimated in two different ways. The first model used the physician component of the relative value unit (RVU) for limited or follow-up TTE (Current Procedural Technology code 93308, 0.53 RVUs, national average physician fee schedule payment of $26).[20-22] We did not include the technical component of the RVU, because