CLINICAL RESEARCH STUDY

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Can Hospital Rounds With Pocket Ultrasound By Cardiologists Reduce Standard Echocardiography?

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ABSTRACT

BACKGROUND: Frequently, hospitalized patients are referred for transthoracic echocardiograms. The availability of a pocket mobile echocardiography device that can be incorporated on bedside rounds by cardiologists may be a useful and frugal alternative.

METHODS: This was a cross-sectional study designed to compare the accuracy of pocket mobile echocardiography images with those acquired by transthoracic echocardiography in a sample of hospitalized patients. Each patient referred for echocardiography underwent pocket mobile echocardiography acquisition and interpretation by a senior cardiology fellow with level II training in echocardiography. Subsequently, transthoracic echocardiography was performed by skilled ultrasonographers and interpreted by experienced echocardiographers. Both groups were blinded to the results of the alternative imaging modality. Visualizability and accuracy for all key echocardiographic parameters (ejection fraction, wall motion abnormalities, left ventricular end-diastolic dimension, inferior vena cava size, aortic and mitral valve pathology, and pericardial effusion) were determined and compared between imaging modalities.

RESULTS: A total of 240 hospitalized patients underwent echocardiography with pocket mobile echocardiography and transthoracic echocardiography. The mean age was 71 $\pm$ 17 years. Pocket mobile echocardiography imaging time was 6.3 $\pm$ 1.5 minutes. Sensitivity of pocket mobile echocardiography varied by parameter and was highest for aortic stenosis (97%) and lowest for aortic insufficiency (76%). Specificity also varied by parameter and was highest for mitral regurgitation (100%) and lowest for left ventricular ejection fraction (92%). Equivalence testing revealed the pocket mobile echocardiography outcomes to be significantly equivalent to the transthoracic echocardiography outcomes with no discernible differences in image quality between pocket mobile echocardiography and transthoracic echocardiography ($P = 7.22 \times 10^{-7}$). All outcomes remain significant after correcting for multiple testing using the false discovery rate.

CONCLUSIONS: The results from rapid bedside pocket mobile echocardiography examinations performed by experienced cardiology fellows compared favorably with those from formal transthoracic echocardiography studies. For hospitalized patients, this finding could shift the burden of performing and interpreting the echocardiogram to the examining physician and reduce the number and cost associated with formal echocardiography studies.

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KEYWORDS: Bedside echocardiography; Echocardiography; Handheld echocardiography; Pocket mobile echocardiography

Transthoracic echocardiography is a remarkably popular imaging technique with more than 20 million procedures performed each year in the United States.[1] However, a recent analysis of appropriateness indicated that 22% of transthoracic echocardiography scans performed were deemed unnecessary.[2] Hospitalized patients are often

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referred for echocardiography because they have signs or symptoms of cardiovascular disease or risk factors for cardiovascular disease. The recent availability of a high-resolution pocket mobile echocardiography device provides a potential alternative to use in hospitalized patients on rounds instead of referral for a formal transthoracic echocardiography. We and others have performed studies to validate that the image quality of pocket mobile echocardiography is comparable to transthoracic echocardiography.[3-9]

We compared a rapid pocket mobile echocardiography examination on bedside hospital rounds, performed and interpreted by senior cardiology trainees, with standard transthoracic echocardiography performed by skilled ultrasonographers and interpreted by senior cardiology imaging specialists. We assessed key echocardiographic parameters and major diagnostic findings.

CLINICAL SIGNIFICANCE

- Overuse of cardiac imaging contributes to the exponential increase in healthcare-associated costs.
- A new high-resolution pocket mobile echocardiography device has excellent diagnostic accuracy and compares favorably with transthoracic echocardiography.
- Widespread and routine use of pocket mobile echocardiography by experienced cardiologists has the potential to decrease referrals for transthoracic echocardiography and minimize costs associated with cardiac imaging.

METHODS

Sample Population

The institutional review board at Scripps Clinic approved the study. A cohort of 240 inpatients referred for transthoracic echocardiography were enrolled consecutively from September 25, 2012, to March 12, 2013. The patients were selected according to a "next available" model based on the consent of the patient, availability of the patient for imaging, and availability of 1 of 3 senior cardiology fellows to perform the image acquisition. The exclusion criteria were only patients in the intensive care unit or patients who were on positive pressure ventilation because of the inherent limitations of acquiring images in this patient population.

Study Acquisition

Third-year cardiology fellows at Scripps Clinic with more than 6 months of training in echocardiography (level II competence) attempted to acquire standard echocardiography projections of parasternal (long axis and short axis); apical 2-, 3-, and 4- chamber; and subcostal views, along with color Doppler analysis of valvular blood flow with a pocket mobile echocardiography (Vscan; GE Healthcare, Milwaukee, Wis). On the same day, as close in time as possible, a comprehensive transthoracic echocardiography was performed by an ultrasonographer with the Philips iE33 Echocardiograph System (Philips Medical Systems, Andover, Mass).

Blinding

Every pocket mobile echocardiography study was assigned a number, and patients were identified by their medical record number only. The cardiology fellows and ultrasonographers acquiring the respective images were not blinded to the clinical indication for the study. The pocket mobile echocardiography images were analyzed at the bedside by the cardiology fellow performing the study, and findings were not modified once they had been interpreted. The cardiology fellow acquiring pocket mobile echocardiography images was not aware of the findings on the transthoracic echocardiography. The standard transthoracic echocardiography images were interpreted by cardiologists with level III competence in echocardiography in accordance with standard clinical care and were blinded to the results of the corresponding pocket mobile echocardiography examination. The cardiology readers also were unaware that patients had undergone image acquisition with the pocket mobile echocardiography device. An independent statistician who had no role in image acquisition or processing performed the comparison of pocket mobile echocardiography findings and transthoracic echocardiography findings.

Study Interpretation

The following elements were interpreted on images acquired by both the pocket mobile echocardiography and transthoracic echocardiography devices: ejection fraction (normal or moderately reduced or severely reduced); segmental wall motion abnormality (present or absent); left ventricular end-diastolic dimension (normal or enlarged); mitral valve appearance (normal or abnormal); mitral stenosis (present or absent); mitral regurgitation (present or absent); aortic valve appearance (normal or sclerotic or stenotic); aortic regurgitation (present or absent); aortic stenosis (present or absent); pericardial effusion (present or absent; small or large); and inferior vena cava (normal or dilated) size. Miscellaneous findings, such as tricuspid valve appearance, right ventricular function, and presence of pleural effusions, also were recorded and compared between the 2 devices.

Ejection fraction was graded as normal ($\geq$55%), moderately reduced (>35% but <55%), or severely reduced ($\leq$35%) by visual estimation. Segmental wall motion was considered abnormal if there was at least 1 segment with lack of translational motion toward the centerline or lack of normal systolic thickening in accordance with standard

echocardiography guidelines. Left ventricular end-diastolic dimension was measured in the parasternal long-axis view with electronic calipers built into the software of the pocket mobile echocardiography device and was considered enlarged if greater than 5.3 cm for women or 5.9 cm for men. Pericardial effusion was considered significant if it was at least moderate or associated with evidence of hemodynamic changes and collapse of the right atrium or right ventricle during diastole as per accepted definitions. The mitral valve was considered structurally abnormal if it seemed to have moderate or severe mitral annular calcification, prolapse, flail, or at least moderately thickened leaflets or subvalvular apparatus according to accepted criteria.[10] The aortic valve was considered stenotic if the valve was thickened or abnormally echodense with restricted leaflet opening in the representative views. The aortic valve was considered sclerotic if the valve was thickened or abnormally echodense but noted to have no restriction in leaflet opening. The inferior vena cava was considered dilated if its diameter was greater than 2.1 cm or there was less than 50% collapse during inspiration (corresponding to a right atrial pressure $\geq$10 mm Hg).

Color Doppler flow mapping of mitral and aortic valves was performed in a systematic manner in their representative views. Physiologic and trace amount of regurgitation in the mitral and aortic positions were interpreted as the absence of any significant valvular regurgitation. Each clinical element also could be classified as "not well visualized" if the images were inadequate for interpretation. If a clinical element was not well visualized with the standard transthoracic echocardiography machine, the interpretation of that element on the corresponding pocket mobile echocardiography was excluded from further analysis. Finally, each pocket mobile echocardiography and transthoracic echocardiography study was classified as "technically adequate" or "technically difficult" on the basis of the ease of image acquisition, the echogenicity of the patient, the visualizability of key clinical elements, and the overall quality of acquired images. Studies were deemed "technically adequate" especially if the image quality was satisfactory for making measurements and analyzing the key echocardiographic variables mentioned previously.

Statistical Analysis

Measurement outcomes were categorized on the basis of clinical significance. Agreement between transthoracic echocardiography and pocket mobile echocardiography was calculated as the proportion of observations in which both devices provided identical results. Logistic regression was performed to assess the relationship between device agreement and age, sex, and body mass index. Overall image quality, defined as technically adequate or difficult, was similarly evaluated.

Equivalence testing between echocardiogram and pocket mobile echocardiography was performed by assessing the hypotheses

$$\begin{aligned} H_{0,j} &: D_j \geq \delta_j \\ H_{A,j} &: D_j < \delta_j, \end{aligned} \tag{1}$$

where D_j is the difference between the echocardiogram and the pocket mobile echocardiography of the j^{th} outcome, and $\delta_j > 0$ is the margin of clinically acceptable difference, determined a priori as one fourth of the standard deviation of the echocardiogram outcomes. The paired, 2-sided test statistic for (1) is

$$z_j = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(PME_{i,j} - TTE_{i,j}\right) \pm \delta_j}{\left(\frac{\mathrm{Var}\left(PME_{i,j} - TTE_{i,j}\right)}{n}\right)^{\frac{1}{2}}}, \tag{2}$$

where $TTE_{i,j}$ and $PME_{i,j}$ are the outcomes from the transthoracic echocardiography and pocket mobile echocardiography for the i^{th} study participant, respectively. Under $H_{0,j}$, z_j has a standard normal distribution. Thus, P values were calculated as the area of the density function beyond the lower and upper bounds of z_j.

Role of the Funding Source

This study was funded by a Clinical and Translational Science Award from the National Institutes of Health to the Scripps Translational Science Institute (NIH/NCATS 8UL1 TR000109-05). The pocket mobile echocardiography devices (Vscan) were available on loan from GE Healthcare for the purposes of this study. The funding source and GE Healthcare had no role in the study design, data collection or interpretation, writing of the report, or input to the manuscript for publication.

RESULTS

Baseline Characteristics

Table 1 shows the characteristics of the 240 patients we evaluated. All patients were admitted to the general medical, cardiac, or surgical floors of Scripps Green Hospital. The indications for echocardiography are outlined in Table 1. The most common indications were chest pain, coronary artery disease, arrhythmia, congestive heart failure, and shortness of breath. A total of 105 studies (44%) were ordered by cardiologists, and 135 studies (56%) were ordered by other specialists at our medical center.

RESULTS

The mean duration of image acquisition using the pocket mobile echocardiography device was 6.3 $\pm$ 1.5 minutes compared with 46 minutes for the transthoracic echocardiography studies. This included 2-dimensional image

Table 1 Patient and Echocardiography Characteristics

Characteristic	Value
Patients (n = 240)	
Mean age (SD), y	71 (17)
Male (%)	128 (53)
Female (%)	112 (47)
BMI	
Mean (SD), kg/m^2	26 (5.0)
<18.5 kg/m^2, %	3
18.5-30 kg/m^2, %	75
>30 kg/m^2, %	22
Echocardiography	
Indication %	
Coronary artery disease, chest pain	27
Arrhythmia	18
Congestive heart failure	12
Shortness of breath	11
Valve evaluation	8
Syncope	6
Pericardial effusion	5
Hypotension	4
Endocarditis	4
CVA or TIA	4
Preoperative evaluation	2.5
Left ventricular function evaluation	2
Pulmonary embolism	2
Other	1
Ordered by cardiologist, %	44
Mean time to complete PME examination (SD), min	6.3 (1.5)
Patients with echocardiogram within 1 y, %	33
Ejection fraction* >0.55, %	70
Ejection fraction <0.35, %	11
Segmental WMA, %	39
Enlarged LVEDD, %	14
Abnormal aortic valve, %	23
Abnormal mitral valve, %	27
Dilated IVC, %	30
Pericardial effusion, %	10
Technically adequate images, %	56
Echocardiographic contrast use, %	10

BMI = body mass index; CVA = cerebrovascular accident; IVC = inferior vena cava; LVEDD = left ventricular end diastolic dimension; PME = pocket mobile echocardiography; SD = standard deviation; TIA = transient ischemic attack; WMA = wall motion abnormality.

*Data were not available for 1 patient.

Table 2 Number of Observations Obtained from Transthoracic Echocardiography and Pocket Mobile Echocardiography

TTE Variable	TTE	PME
Ejection fraction		
<35	27	32
35-55	43	46
>55	169	161
Not visualized	1	1
LVEDD		
Small	5	5
Normal	197	189
Enlarged	33	31
Not visualized	5	15
WMA		
No	140	147
Yes	94	85
Not visualized	6	8
Aortic valve		
Normal	169	161
Abnormal	56	61
Not visualized	15	18
Aortic insufficiency		
No	146	163
Yes	90	71
Not visualized	4	6
Aortic stenosis		
No	193	191
Yes	43	43
Not visualized	4	6
Mitral valve		
Normal	167	168
Abnormal	65	65
Not visualized	8	7
Mitral regurgitation		
No	94	111
Yes	142	125
Not visualized	4	4
Mitral stenosis		
No	223	221
Yes	13	15
Not visualized	4	4
IVC size		
Normal	121	111
Dilated	67	62
Not visualized	52	67
Pericardial effusion		
No	216	219
Yes	24	21
Not visualized	0	0

IVC = inferior vena cava; LVEDD = left ventricular end diastolic dimension; PME = pocket mobile echocardiography; TTE = transthoracic echocardiography; WMA = wall motion abnormality.

acquisition and color flow Doppler imaging of the aortic, mitral, and tricuspid valves. The findings for what was well visualized for pocket mobile echocardiography and transthoracic echocardiography are summarized in Table 2. There were no discernible differences in image quality between transthoracic echocardiography and pocket mobile echocardiography ($P = 7.22 \times 10^{-7}$). For what was deemed high image quality, there was agreement of 85.0% between devices. Because of suboptimal visualization of endocardial borders, 8 (3.3%) pocket mobile echocardiography images and 6 (2.5%) standard transthoracic echocardiography images were not adequate for interpretation of wall motion abnormalities. Left ventricular end-diastolic dimension could not be measured in 15 (6.3%) pocket mobile echocardiography images because of poor visualization of endocardial borders. The inferior vena cava was not well visualized in 67 (28%) of the pocket mobile

echocardiography images and 52 (22 %) of the transthoracic echocardiography images. The aortic valve was not well visualized in 18 (7.5%) pocket mobile echocardiography images and 15 (6.3%) transthoracic echocardiography images. The mitral valve was not well visualized in 7 (2.9%) pocket mobile echocardiography images and 8 (3.3%) transthoracic echocardiography images. Echocardiography contrast (Definity, Lantheus Medical Imaging, North Billerica, Mass) was required to assist interpretation of 24 (10%) of the transthoracic echocardiography images.

Point-of-Care Diagnostic Accuracy of Pocket Mobile Echocardiography

Accuracy of interpretation, including sensitivity, specificity, positive predictive value, negative predictive value, and overall agreement of pocket mobile echocardiography images compared with standard transthoracic echocardiography images, is summarized in Table 3, using transthoracic echocardiography as the reference standard. The sensitivity of pocket mobile echocardiography ranged from 76% for detection of aortic insufficiency to 97% for aortic stenosis. The specificity of pocket mobile echocardiography ranged from 92% for ejection fraction to 100% for mitral regurgitation. In general, there was a high proportion of agreement between outcomes across the devices. Equivalence testing revealed the pocket mobile echocardiography outcomes to be significantly equivalent to the transthoracic echocardiography outcomes. The smallest P value was obtained for aortic stenosis ($P = 2.16 \times 10^{-57}$), and the largest P value was obtained for aortic insufficiency ($P = .014$). All outcomes remain significant after correcting for multiple testing using the false discovery rate. For the most part, differences between the devices could not be attributed to age, sex, or body mass index (Table 4).

The incidence of missed diagnoses by pocket mobile echocardiography varied by echocardiographic parameter, and the majority of false-negative findings on pocket mobile echocardiography were clinically insignificant. The missed diagnoses with potential clinical relevance are detailed in Table 5. There were 13 cases (5.4%) in which a segmental wall motion abnormality was missed by pocket mobile echocardiography. Left ventricular ejection fraction was falsely read as normal in 5 patients (2.1%) with a moderately reduced ejection fraction (>35% but <55%) on transthoracic echocardiography. There were 2 (0.8%) pocket mobile echocardiography studies in which a diagnosis of moderate aortic stenosis was missed. No moderate, large, or hemodynamically significant pericardial effusions were missed by pocket mobile echocardiography.

DISCUSSION

In comparing pocket mobile echocardiography and transthoracic echocardiography imaging, we found remarkable concordance for all key parameters, including the ejection fraction, cavity dimensions, valve structure and function, presence or absence of a pericardial effusion, and size of the inferior vena cava. Transthoracic echocardiography proved to be more sensitive in the diagnosis of a wall motion abnormality or aortic insufficiency, and the presence of small, trivial pericardial effusions. The proportion of technically adequate studies that were satisfactory for image interpretation was similar between pocket mobile echocardiography and transthoracic echocardiography. However, the evaluation of both the inferior vena cava and the left ventricular end-diastolic dimension was diminished with pocket mobile echocardiography because of suboptimal visualization. The diagnostic accuracy of pocket mobile echocardiography with regard to left ventricular function, wall motion analysis, and valvular lesions has been demonstrated to be equally concordant in a previous report.[7] The key difference in our study is that all pocket mobile echocardiography examinations were performed and interpreted by cardiology

Table 3 Visualizability and Accuracy of Images Obtained by Using Pocket Mobile Echocardiography Compared with Transthoracic Echocardiography

TTE Variable	Visualized by PME, %	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Overall Agreement	P Value
Ejection fraction	99	0.93	0.92	0.84	0.97	0.90	1.81×10^{-9}
LVEDD	94	0.87	0.98	0.91	0.98	0.97	3.36×10^{-15}
WMA	97	0.86	0.97	0.95	0.91	0.93	1.08×10^{-6}
Aortic valve	96	0.96	0.96	0.88	0.98	0.96	9.11×10^{-11}
Aortic insufficiency	97	0.76	0.98	0.96	0.87	0.90	1.40×10^{-2}
Aortic stenosis	97	0.97	0.99	0.97	0.99	0.99	2.16×10^{-57}
Mitral valve	98	0.95	0.98	0.97	0.98	0.98	1.88×10^{-29}
Mitral regurgitation	98	0.88	1.00	1.00	0.84	0.93	1.35×10^{-3}
Mitral stenosis	98	0.92	0.98	0.81	0.99	0.98	4.61×10^{-9}
IVC size	72	0.93	0.98	0.98	0.95	0.97	2.16×10^{-57}
Pericardial effusion	100	0.79	0.99	0.92	0.977	0.97	1.81×10^{-9}

Overall agreement between TTE and pocket mobile echocardiography was calculated as the proportion of observation in which both devices provided identical results. P values represent statistical equivalence testing results.

IVC = inferior vena cava; LVEDD = left ventricular end diastolic dimension; TTE = transthoracic echocardiography; WMA = wall motion abnormality.

Table 4 Logistic Regression Results Among Age, Sex, and Body Mass Index and Differences in Outcomes from Transthoracic Echocardiography and Pocket Mobile Echocardiography

TTE Variable	Age	Sex	BMI
Ejection fraction	(1.04) 0.031	0.44	0.67
LVEDD	0.16	0.86	0.43
WMA	0.41	0.99	0.43
Aortic valve	(1.08) 0.034	0.25	0.87
Aortic insufficiency	0.15	0.55	0.75
Aortic stenosis	0.16	0.94	0.51
Mitral valve	0.60	0.74	0.99
Mitral regurgitation	0.76	0.99	0.72
Mitral stenosis	0.25	0.39	0.40
IVC size	0.22	0.16	0.69
Pericardial effusion	0.52	0.58	0.83

Results are presented as *P* values with odds ratios, in parentheses, when $P < .05$.

BMI = body mass index; IVC = inferior vena cava; LVEDD = left ventricular end diastolic dimension; TTE = transthoracic echocardiography; WMA = wall motion abnormality.

fellows at the bedside, making this a true "point of care" evaluation, although all examinations in the aforementioned report were performed by experienced cardiologists under optimal conditions and patient positioning in a dedicated echocardiography laboratory. Furthermore, in our study all images were analyzed on the smaller display of the pocket mobile echocardiography device while they were uploaded to a computer work station and reviewed on a larger display in the prior report.

The logistics of the study strongly favored the superiority of transthoracic echocardiography. Such studies were not only on average 46 minutes in duration but also performed by skilled ultrasonographers and interpreted by senior cardiologists (compared with trainees who performed and analyzed the pocket mobile echocardiography studies) who are dedicated imaging specialists. Furthermore, the transthoracic echocardiography study incorporates M-mode, spectral Doppler, tissue harmonic imaging, and tissue Doppler imaging. Such enhanced imaging allows for more extensive hemodynamic assessment, such as pulmonary artery pressure along with the detection and quantification of intracardiac shunts. The spectral Doppler capabilities of transthoracic echocardiography also make it a superior tool over pocket mobile echocardiography to discern the causes of heart failure with preserved ejection fraction (diastolic heart failure, restrictive cardiomyopathy, and constrictive pericarditis) and quantify the severity of valvular abnormalities. Transthoracic echocardiography studies also used intravenous contrast enhancement in 10% of the patients to improve endocardial border evaluation. Accordingly, the traditional echocardiographic laboratory examination is far more comprehensive and labor intensive, but it also is far more expensive, with an average combined technical and professional fee of $800, which may not be appropriately justifiable in all hospitalized patients. In contrast, the routine use of pocket mobile echocardiography is free except for the initial cost of a device, which is currently $7900 and the additional 5 to 10 minutes spent per patient by a cardiologist in obtaining and interpreting the images. This is not an insignificant amount of time for a busy clinician and may dissuade many from performing pocket mobile echocardiography examinations routinely on all patients, especially given the lack of established reimbursement for the study.

Table 5 Missed Diagnoses with Clinical Significance on Pocket Mobile Echocardiography Examination

TTE Variable	PME Results	TTE Results	No. of Instances, %
Ejection fraction	>55%	>35% but <55%	5, 2.1
WMA	Absent	Present	13, 5.4
Aortic valve	Normal	Moderate stenosis	2, 0.8

PME = pocket mobile echocardiography; TTE = transthoracic echocardiography; WMA = wall motion abnormality.

The upfront cost of the device and the time spent in imaging may be offset by practical advantages of pocket mobile echocardiography on hospital rounds, such as the avoidance of transporting the patient to an echocardiography laboratory, which leads to additional personnel costs and potential compromise of safety during the time a patient is left without nursing surveillance or monitoring. Pocket mobile echocardiography also allows for a rapid, point-of-care assessment that helps in the early diagnosis and treatment of patients compared with a median wait time of up to 24 hours for image acquisition and interpretation among inpatients referred for transthoracic echocardiography.[11] This has the potential to improve hospital workflow and aid in the earlier discharge of patients, which could help reduce the costs associated with inpatient care. In addition, there is the opportunity to directly share and discuss the results of the pocket mobile echocardiography with the patient in real-time, an interaction that certainly does not occur during a transthoracic echocardiography examination. On the other hand, our study begins to define the boundaries for pocket mobile echocardiography as a screening tool. For clinical concerns about a regional left ventricular wall abnormality, detailed color flow mapping of a valvular lesion, quantification of left ventricular diastolic function, or determination of right-sided pressures, current pocket mobile echocardiography is limited without spectral Doppler capability or fully comparable endocardial visualization.

Study Limitations

Although attempts were made to simulate real practice for inpatients, the knowledge that the pocket mobile echocardiography studies would be directly compared with transthoracic echocardiography examinations made for a longer acquisition and more quantitative analysis than might be necessary. This prolonged imaging time also is the likely explanation for the comparable image quality between pocket mobile echocardiography and transthoracic

echocardiography. We believe that our patient cohort is fully representative of hospitalized patients who are not critically ill in the intensive care unit, and that the inclusion of a sample of 240 patients can be considered definitive to recommend the widespread use of pocket mobile echocardiography in this patient population. However, our design can be criticized by not eliminating any potential for sample bias. It would have been preferred to have every patient referred for transthoracic echocardiography to be enrolled in the current study, but because of patient availability or cardiology fellow availability, we were unable to perform a pocket mobile echocardiography examination on every patient referred for transthoracic echocardiography.

Another potential limitation of our study is that we did not use an independent core laboratory to assess all of the images, but instead performed the analysis in a blinded fashion with the data assessed by a biostatistician without any knowledge of what type of imaging was being compared. It also is possible that the use of a core laboratory would have detected a greater discrepancy in key echocardiographic parameters, especially the presence of wall motion abnormalities, which can be subtle and easily missed on the small display of the pocket mobile echocardiography device. It is vitally important to underscore that all examinations were performed by senior cardiology fellows with significant ultrasound experience, and thus we cannot comment on the use of this device by medical professionals lacking echocardiography training. Furthermore, cardiology fellows performing imaging were aware of the clinical indication for the study, which may have biased them to pay particular attention to certain cardiac structures and improve the overall accuracy of the pocket mobile echocardiography examination.

CONCLUSIONS

Notwithstanding these limitations, we interpret our findings as providing the evidence for the potential use of pocket mobile echocardiography instead of transthoracic echocardiography for many hospitalized patients who are referred for echocardiography. There is a possibility that widespread use of pocket mobile echocardiography by unskilled clinicians may lead to false-positive findings and actually increase diagnostic testing for patients, and we only support the increased use of pocket mobile echocardiography by trained cardiologists for improving the diagnostic yield of the bedside clinical examination and reducing the growing number of unnecessary transthoracic echocardiography studies. In the event of poor visualization with pocket mobile echocardiography and for quantifying the severity of a valvular lesion or for particular questions that require Doppler assessment with hemodynamics, a transthoracic echocardiography can be performed. There is the unaddressed, lingering question as to whether any echocardiographic examination is needed for many of these patients, but if a pocket mobile echocardiography ultimately supplanted the stethoscope for bedside cardiac examination, that question would be preempted.

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