Clinical utility and cost effectiveness of a personal ultrasound imager for cardiac evaluation during consultation rounds in patients with suspected cardiac disease

E C Vourvouri, L Y Koroleva, F J Ten Cate, D Poldermans, A F L Schinkel, R T van Domburg, W B Vletter, J R T C Roelandt

Objective: To assess the clinical utility and cost effectiveness of a personal ultrasound imager (PUI) during consultation rounds for cardiac evaluation of patients with suspected cardiac disease.

Methods: 107 unselected patients from non-cardiac departments (55% men) were enrolled in the study. After the physical examination the consulting cardiologist performed an echocardiographic study with a PUI. The final report was given instantly to the referring physician. All patients subsequently underwent a study with a standard echocardiographic device (SED). For each patient the consulting cardiologist noted whether the findings of the PUI were adequate for final diagnosis. The total cost when full echocardiography was used was compared with the cost when the PUI was used. The time interval from request to diagnosis was also compared.

Results: In 84 (78.5%) patients no further examination with an SED was regarded as necessary. Twenty three patients (21.5%) required a further detailed examination with the SED because of the need for haemodynamic information. There was an excellent agreement for the detection of abnormalities between the two devices (96%). The total cost was €132 per patient with the SED and €75 per patient with the PUI. According to this study, the use of the PUI can lead to a 33.4% reduction of total cost. The mean time from request to diagnosis at the authors’ institution was four days for the SED and instantly for the PUI, for additional potential cost savings.

Conclusions: Immediate echocardiographic assessment during consultation rounds can lead to significant cost savings and can shorten the time to diagnosis.
The PUI

The SonoHeart system (fig 1) is a small hand held ultrasound device equipped with a 2–4 MHz phased array broadband transducer and operating on a rechargeable lithium ion battery or alternating current power. Two dimensional control settings similar to those on an SED and colour power Doppler flow mapping are integrated in the unit. Distance measurements are possible with inclusive callipers. SonoHeart has a storage memory of 50 images and can be connected to a videocorder, a printer, or an external monitor.

Statistical analysis

Descriptive statistics are reported as mean (SD) or frequency percentages. The agreement for detection of abnormalities was assessed from 2 × 2 tables using weighted $\kappa$ statistics. Values of $\kappa$ of 0.4, between 0.4–0.75, and > 0.75 were considered to indicate poor, fair to good, and excellent agreement, respectively, based on Fleiss's classification.

In addition, specificity, sensitivity, and positive and negative predictive values of the PUI in detecting abnormalities were calculated.

RESULTS

Cardiac visualisation by PUI

In all of the patients, visualisation adequate to answer the request was achieved.

Agreement

Table 1 lists the most common referral questions for which a cardiac evaluation was requested. The yardstick SED examination detected 71 clinically significant findings (table 2). The agreement in identifying abnormalities between the PUI and the SED was 96% ($\kappa = 0.93$; table 3).

Table 2 Abnormal findings detected with the standard echocardiographic device in 107 patients referred for cardiac evaluation during consultation rounds

<table>
<thead>
<tr>
<th>Abnormal finding</th>
<th>SED</th>
<th>PUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left ventricular dysfunction</td>
<td>33.8%</td>
<td>28.0%</td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>28.0%</td>
<td>11.2%</td>
</tr>
<tr>
<td>Mitral valve regurgitation</td>
<td>7.0%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Dilated ascending aorta</td>
<td>7.0%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>4.0%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Aortic valve regurgitation</td>
<td>1.4%</td>
<td>1.4%</td>
</tr>
</tbody>
</table>

Total number of findings was 71. Some patients had more than one finding. The regurgitation jets noted are of moderate or severe degree. Trivial or mild regurgitation jets were characterised as normal.

Table 3 Agreement in detection of patients with abnormalities between the SonoHeart and a standard echocardiographic device, showing the number of patients

<table>
<thead>
<tr>
<th>SonoHeart</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard echocardiographic device</td>
<td>Normal 51</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Abnormal 2</td>
<td>52</td>
</tr>
</tbody>
</table>

There were 107 patients. Agreement = 96%, $\kappa = 0.92$, sensitivity = 96% (95% confidence interval (CI) 0.89 to 0.99), specificity = 96% (95% CI 0.89 to 0.99), positive predictive value = 96% (95% CI 0.89 to 0.99), negative predictive value = 96% (95% CI 0.89 to 0.99).
Clinical utility and cost effectiveness of a personal ultrasound imager

A  Standard echocardiography

Day 1: Consultation visit by cardiologist

Day 1: Echo request

Mean waiting time: 2 days

Day 3: Echo performed (by sonographers)

Mean waiting time: 1–2 days

Day 4: Echo report [by cardiologist]

In 78%: definitive decision

B  Personal ultrasound imager

Day 1: Consultation visit by cardiologist

Day 1: Echo request

Day 1: Echo performed by cardiologist

Day 1: Echo report [by cardiologist]

In 22%: SED needed

Echocardiographic examination by the PUI is considered to be part of the physical examination and is therefore not charged. However, we incorporated in the final cost the capital investment of such a device, which is about €15 000. The five-year equipment depreciation of this amount is €3 000 per year, which results in €3 per patient on a basis of 1000 patients seen during consultation rounds per year. Thus, the cost of a consultation visit with the use of the PUI was calculated to be €75 per patient.

Applying these data to our study results, the total cost for the 107 echocardiographic examinations performed was €14 124 for the standard procedure using the SED. However, with the PUI the total cost was €9 405, since only 23 patients were considered to need further investigation with an SED. Thus, with the use of PUI a cost reduction of 33.4% was achieved.

In addition, the mean time interval between a request for an echocardiogram by the consultant cardiologist and the final echocardiography report was reduced substantially. At our institution the average time was four days when standard echocardiography was requested, whereas the PUI provided results instantly. Figure 2 shows the logistical flowcharts of an echocardiography examination. Thus, the standard approach for these patients is to request an echocardiographic examination further to the physical examination. The instant answer to a request can prevent potential delay in a patient who is planned for surgery as an inpatient referred for cardiac consultation are preoperative patients. In fact, in our hospital the majority of inpatients referred for cardiac consultation are preoperative patients. The usual request from anaesthesiologists and surgeons is to evaluate the systolic left ventricular function or a murmur, which can reliably be answered by an echocardiographic examination. Thus, the standard approach for these patients is to request an echocardiographic study further to the physical examination. The instant answer to a request can prevent potential delay in a patient who is planned for surgery and can therefore lead to cost savings. But this is only a hypothesis that has to be investigated.

Recently, Kimura and colleagues reported that the consequence of the presence of an abnormal initial limited echocardiographic examination in the emergency department was that patients had a significant length of hospital stay (that is more than two days). Furthermore, their study showed that, in the setting of the emergency department, a limited echocardiographic examination has better diagnostic accuracy than a physical examination in identifying cardiac abnormalities.

The present study was performed by cardiologists with experience in echocardiography. Immediate decision making diagnosis based on the echocardiographic examination with a PUI during consultation rounds requires level II or III training in echocardiography. Kimura and colleagues proved that it
is feasible to train health care providers to obtain a parasternal long axis view and to interpret significant abnormalities. However, training and licensing non-cardiologists to use these devices will become an important issue in the future.

**Study limitations**

In the present study we did not specifically address the impact of the use of the PUI on hospitalisation stay. This may form the basis for future studies.

The PUI that was used for this study had no Doppler modalities to obtain haemodynamic data. Spectral Doppler and colour Doppler are now integrated in the new generation of PUIs.

**Conclusion**

During consultation rounds, a PUI can help to make an instant diagnosis at the bedside, leading to a shortened time to diagnosis with efficacy equal to that of an SED and with lower cost.

**REFERENCES**

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**IMAGES IN CARDIOLOGY**

Infective endocarditis with progressive periaortal abscess formation in a previously healthy girl

A previously healthy 14 year old girl presented with a three week history of high grade fever and progressive dyspnoea. On admission to the hospital in Mozambique, she had signs of cardiac insufficiency with peripheral oedema, orthopnoea, and tachycardia. The chest x ray on admission demonstrated massive lung oedema and cardiomegaly, and the ECG revealed a right bundle branch block and a strain pattern. Because of limited resources no laboratory work up could be done, and no microorganism could be isolated. The transthoracic echocardiogram showed destruction of the aortic valve with massive aortic regurgitation and two periaortal abscess cavities (below left, parasternal long axis view, arrow indicates abscess cavities). The left ventricle was dilated with severely reduced systolic function. The patient was treated with ampicillin, gentamicin, oxacillin, digoxin, and diuretics. She initially responded well with symptom improvement, but after about 14 days her clinical status worsened. Echocardiography now showed an increase of the abscess formation that also appeared midseptal (below centre, parasternal long axis view, and below right, parasternal short axis view midseptal). Because of lack of treatment options (there is no cardiac surgery available in Mozambique) and the ongoing deterioration of the patient, the parents took the girl home where she presumably died.

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