Impact of hand-carried cardiac ultrasound on diagnosis and management during cardiac consultation rounds

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KEYWORDS

Hand-carried ultrasound device; Consultation rounds; Management

Abstract  Aim  To evaluate the impact of hand-carried cardiac ultrasound (HCU) on the diagnosis and management of patients during cardiac consultation rounds.  

Methods and results  One hundred and fifty patients hospitalized in non-cardiac units were included after the consulting cardiologist felt that an echocardiographic examination was indicated as part of his work-up. They were randomly allocated to echocardiography with an HCU device (SonoHeart™, SonoSite, Inc.) (75 patients) or with a full-featured standard echo (FE) system (75 patients). The consulting cardiologist noted whether a definitive diagnosis was made or further study was necessary. Diagnosis and change in management were noted. In the HCU patient group there were 103 clinical questions. Seventy-two percent of the referral questions required no comprehensive echocardiographic evaluation. For questions of left ventricular function, valve abnormalities and pericardial effusion this was 98%. In 48% there was an immediate change in clinical management. In the FE patient group there were 94 clinical questions. In 32% the FE examination led to change in clinical management.

Conclusion  HCU echocardiography provides clinically worthwhile assessment of left ventricular function, valve abnormalities and pericardial effusion in 98% of the cases. A direct assessment of cardiac function and anatomy at the bedside by an experienced cardiologist results in a significant immediate change in clinical management during consultation.

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Introduction

Echocardiography is the most widely used imaging modality with excellent diagnostic accuracy in the hands of trained operators. However, the non-availability of an echosystem and/or operator at the point-of-care may lead to a delay in diagnosis and patient management. The recent introduction of relatively inexpensive hand-carried ultrasound (HCU) devices broadened its application at the bedside during consultation rounds, in acute care setting and outpatients clinic and complements the physical examination by rapid assessment of the cardiovascular structure, function and patho-physiology. This will undoubtedly result in improved patient care.

We evaluated the use of an HCU device during cardiac consultations at non-cardiac units to assess its impact on patient management of patients with suspected cardiac disease.

Methods

Study patients and methods

Between 1 April 2002 and 1 April 2003 there were 450 requests from non-cardiac units for a cardiac assessment. These patients with a suspected cardiac abnormality were seen by a cardiologist who decided after his physical examination whether an echocardiographic study was felt necessary or not. One hundred and fifty patients were included in this study. Critically ill patients were excluded.

These 150 patients were randomly allocated to an echo study with an HCU device (75 patients, mean age 60.9 ± 15.5 years, 38 men) at the bedside or were referred to an FE system (75 patients, mean age 60.4 ± 17.9 years, 40 men) (Fig. 1). In case the HCU study did not allow to make or exclude a diagnosis an FE was requested. The consultation and the examination with the HCU device were performed by an experienced consultant cardiologist (expertise level II according to the American Society of Echocardiography) at the patient’s bedside and data were recorded with a portable VCR. The consultant cardiologist noted whether a definitive diagnosis was made or a further study with an FE was necessary and he advised the referring physician accordingly. The patients to whom an FE examination was randomly assigned were scheduled according to routine procedures of the echolaboratory. After getting the echocardiogram report, the consultant cardiologist contacts the referring physician to advise him and finish the consultation. Diagnosis and change in management, i.e. change in therapy or additional examination request, were confirmed by reviewing the patients’ file and discharge reports. Date of consultation and date of echocardiographic examination were noted. After a six-month period it was noted whether an FE request was felt necessary after the HCU examination.

Referral questions were divided into the assessment of severity of left ventricular function, valve abnormalities, pericardial effusion, source of embolism/endocarditis and miscellaneous questions.

The SonoHeart Plus™ and the SonoHeart Elite™ (SonoSite Inc., Bothell, Washington, USA) handheld devices were used. These are equipped with a 2—4 MHz phased-array broadband transducer with second harmonics and operate on a rechargeable lithium ion battery or alternating current. They can be connected to a video-recorder, a printer or an external monitor. We used a portable VCR to record data. The two-dimensional control settings are comparable to a standard echocardiographic device and a color power Doppler flow mapping, pulsed wave Doppler (plus continuous wave Doppler for the SonoHeart Elite™) are integrated to the unit. Quantitative assessment of the heart is possible with inclusive linear measurement callipers.

The HCU examination method was flexible according to the specific clinical scenario and the
specific clinical question. The consultant cardiologist used a standard form to note the results of the echocardiographic examination. This included quality of images divided into good, moderate or poor quality. For severity of left ventricular systolic function a grading scale of good, reasonable, moderate and bad function was used. In case of suspected left ventricular hypertrophy the interventricular septum and left ventricular posterior wall measurements were noted. There was also possibility to note other measurements of left ventricle or aorta. The color power Doppler was used to detect valve abnormalities. When the SonoHeart Elite™ became available the continuous wave Doppler was used in case of suspected aortic stenosis. Collapse of the vena cava inferior and presence of pericardial effusion were noted. The Philips (Sonos 5500; Andover, MA) or Vingmed (System V; Horten, Norway) was used for an FE examination. This detailed examination was performed by a sonographer using the routine protocol and standard report.

Statistical analysis

Categorical data are presented as counts and percentages, whereas continuous data are summarized as mean ± standard deviation or median value. The baseline variables of the patients with HCU and with FE echocardiogram were compared with the Student’s t-test (for continuous variables) and chi-square test (for categoric variables). A p value of <0.05 was considered to be statistically significant for both the tests.

Results

HCU patient group

Table 1 presents the characteristics of HCU and FE groups. After clinical examination there were 103 questions in the 75 patients of the HCU group. Left ventricular function assessment was requested in 56 (75%) patients, valve abnormalities in 18 (24%), pericardial effusion in 8 patients (11%), source of embolism or endocarditis in 16 (21%) and miscellaneous in 5 (7%) (some patients had more than one echo referral question). Fig. 2 presents the referral diagnosis/question for an HCU echocardiogram and the reason for further FE request. It was felt that 72% of the referral questions required no FE evaluation. Answering the questions of assessment of left ventricular function, valve abnormalities and presence of pericardial effusion with the HCU device was possible in 98%. Reasons for referral for an FE evaluation after the HCU examination were mainly poor image quality and lack of continuous wave Doppler (SonoHeart Plus™) to estimate severity of aortic stenosis. Some miscellaneous questions such as metastasis of carcinoit or cardiac involvement of amyloidosis also required comprehensive examination.

In this HCU group 37 patients underwent an echocardiographic examination with the SonoHeart Plus™ device and 38 patients with the SonoHeart Elite™ device. For these devices 24/37 patients (65%) and 29/38 patients (76%) required no further examination with FE \( (p = 0.3) \).

For the patients with a left ventricular function assessment request, the HCU led in 92% to diagnosis and therapy. In particular, 27/56 (48%) patients had a change in management, 17/56 (30%) had no echocardiographic abnormalities and 8/56 (14%) patients received after the HCU echo permission for undergoing an operation or chemotherapy without further examination or change in therapy. For the assessment of valve abnormalities, 10/18 (56%) patients had a change in management and 6/18 (33%) had a normal ultrasound examination including 2 patients with permission for undergoing operation or chemotherapy. For the evaluation of pericardial effusion and cardiac source of embolism/endocarditis, there was a change in management in 4/8 (50%) and in 8/16 (50%) patients, respectively. In 2/8 (25%) patients echocardiography showed mild pericardial effusion and in the other 2 (25%) patients pericardial effusion was excluded. The diagnosis of cardiac source of embolism/endocarditis was rejected in 7/16 (44%) patients. Miscellaneous questions were metastasis of carcinoit, ventricular septal defect, abnormalities for CREST (calcinosisis, Raynaud’s

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>HCU (n = 75)</th>
<th>FE (n = 75)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>60.9 ± 15.5</td>
<td>60.4 ± 17.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Male gender</td>
<td>38 (51%)</td>
<td>40 (53%)</td>
<td>0.7</td>
</tr>
<tr>
<td>First cardiac evaluation</td>
<td>45 (60%)</td>
<td>24 (32%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>COPD</td>
<td>14 (19%)</td>
<td>8 (11%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Risk factors for CAD</td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>None</td>
<td>15 (20%)</td>
<td>30 (40%)</td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>34 (45%)</td>
<td>17 (23%)</td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td>16 (21%)</td>
<td>15 (20%)</td>
<td></td>
</tr>
<tr>
<td>More than two</td>
<td>10 (13%)</td>
<td>13 (17%)</td>
<td></td>
</tr>
</tbody>
</table>

Data presented are mean (± standard deviation) or totals with percentages. CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease.
phenomenon, esophageal dysfunction, sclerodactyly, telangiectasia), acromegaly and amyloidosis. Four (80%) of these 5 patients had a normal ultrasound examination and for 1 patient a ventricular septal defect was suspected with HCU and excluded with an FE. A six months follow-up of the patients’ files showed no additional FE request in patients who underwent an echocardiographic examination with only the HCU device.

Incidental findings detected with the HCU device were: right atrium collapse, thrombus in left ventricle, severe aortic valve regurgitation, dilation of the ascending aorta and pericardial effusion/tamponade.

**FE patient group**

There were 94 questions/indications for echocardiography in the 75 patients of the FE group. In 49 (65%) patients an FE examination was requested for left ventricular function assessment. Sixteen out of 49 (33%) patients had change in management, 13/49 (27%) had no abnormalities on echocardiography and 7/49 (14%) received permission for chemotherapy or operation after the FE. For the assessment of valve abnormalities, FE was requested in 12 (16%) patients. None of these 12 patients had change in management, 4/12 (33%) patients had a normal echo and 4/12 (33%) got permission for undergoing an operation.

Referral questions of pericardial effusion and cardiac source of embolism/endoendocarditis were requested in 6 (8%) and in 22 (29%) patients, respectively. Two out of the 6 (33%) patients with questions of pericardial effusion had change in management and in the other 4 (67%) patients pericardial effusion was excluded. Cardiac source of embolism/endoendocarditis was rejected in 11/22 (50%) patients and 11/22 (50%) patients had change in management. Miscellaneous indications were metastasis carcinoid, amyloidosis and aortic dissection. One (20%) of these 5 patients had change in management and 4/5 (80%) patients had a normal echocardiographic examination.

13/75 patients transesophageal echocardiography or other tests were requested to give a diagnosis. Incidental findings with FE were: severe mitral regurgitation, aneurysm/prolapse of mitral valve, pericardial effusion, structure in the apex of the left ventricle suspected for a thrombus, clear echocardiographic abnormalities in left ventricle suspected for infiltrative abnormalities, severe aortic stenosis, dilatation of the proximal ascending aorta.

In the HCU group and the FE group requests for cardiac evaluation of a patient came from the internal medicine department in 55% and 64%, respectively. There was a trend towards shorter hospitalization stay for patients in the HCU group (19 [IQR: 92] days) than in the FE group (22 [3–146]) (median, [range]) ($p = NS$).

**Discussion**

For almost two centuries the stethoscope has been the only technological aid for bedside cardiac...
diagnosis. Echocardiography is a non-invasive diagnostic imaging tool that provides important information in a variety of cardiovascular diseases but equipment size and time limits its use at the bedside. The recent introduction of small HCU devices broadened its application at the bedside.

The first suggestion for such a device in clinical practice was by Roelandt et al. in 1978 but the utility of small HCU devices has recently been evaluated in different clinical settings. 

It has been shown that the HCU machines are effective in the detection of most common cardiac abnormalities such as left ventricular size and function, presence of pericardial effusion and valve abnormalities. Limitations of many previous studies were the lack of spectral Doppler and limited storage capacity of images. The HCU devices used in the current study are equipped with pulsed wave/continuous wave Doppler and directional color power Doppler so that basic haemodynamic data can be assessed by mitral valve inflow, velocity aortic valve and vena cava inferior collapse.

We have demonstrated that these HCU devices can answer the questions for left ventricular function, pericardial effusion and valve abnormalities in 98% of the cases. The main reason for a further FE request after HCU exam was to exclude/diagnose or detect a cardiac source of embolism or endocarditis. The small screen size of the HCU device may limit the diagnostic sensitivity and for these conditions an FE examination should always follow. Importantly, in the FE group 9/22 (41%) patients with this clinical question were further referred for transesophageal echocardiography after the FE examination.

An early etiologic diagnosis or exclusion often determines the most appropriate management plan. Unsuspected not clinically apparent abnormalities are regularly detected by a simple (echo/Doppler) examination and may be important for therapeutic decisions and outcome.

In the current study HCU and FE examinations led to a management change in 48% and 32% for clinical questions (p = 0.03) and 49% versus 37% for patients (p = 0.1), respectively. This can be explained by the different way the definitive diagnosis is made. In the HCU group the consultant cardiologist can advise the referring physician immediately about therapeutic changes or additional examination. However, in the FE group the results of the FE examination were mostly known after two days which requires another deliberation between the consultant cardiologist and the referring physician about the management. In some cases this delay leads to less direct management changes. In the study of Rugolotto et al. the HCU altered therapy in 24% (13/55) of patients admitted to the in-service of their hospital. In another study Kim et al. found a change in management in only 17% (23/133) of patients in a coronary care unit setting using a standard echocardiographic machine. The discrepancy with our results is partly due to the different definition of “change in management”. Kim et al. defined the management change including the therapeutic change and the exclusion of expected abnormalities. We defined change in management as the therapeutic change and the request for an additional examination, like transesophageal echocardiography and other imaging tests. In both groups (HCU and FE) 16% of the patients were referred for further examination. Using the definition of Kim et al. we found a change in management in 32% (33/103) using the HCU device and 19% using the FE system (p = 0.03).

Although many studies found the HCU devices are often perceived as helpful to address focused clinical questions at the bedside when used by cardiologist with and without significant echocardiographic training and experience, a level II trained echocardiographer should use the HCU device during consultation rounds as immediate management decision is made. An inexperienced in echocardiography could potentially not be able to provide a sufficient diagnosis or treatment advice to the referring physician and augment the number of referrals to the echolaboratory.

Prior studies showed good results using an HCU device in the acute care setting, the outpatient clinic, during patient transport and during consultation rounds. In a previous study of our group, Vourvouri et al. demonstrated that the implementation of an HCU device during consultation rounds in non-cardiac wards leads to immediate diagnosis and cost savings. In the current study we further showed the impact of bedside HCU examination on patients management. The requests for cardiac evaluation in the current study were mainly from the internal medicine department in contrast to our previous study where 85% were preoperative patients. This shift is largely due to the new preoperative consultation service at the outpatient clinic of our hospital, which led to less “acute” requests for preoperative risk assessment the day before operation as shown previously. The hypothesis that for these patients a direct assessment of cardiac function at the bedside can lead to shortening of length of stay in the hospital and also to potential financial savings could therefore not be demonstrated in the current study. However, there was a trend towards shorter hospitalization stay in the HCU group.
Limitation

Goodkin et al.\textsuperscript{7} compared the use of an HCU device and an FE system in critically ill patients and reported that in the evaluation of these patients the HCU device provided important anatomic information but missed clinical finding in half of the patients. For this reason we excluded critically ill patients from the current study.

We used the SonoHeart Plus\textsuperscript{TM} and the SonoHeart Elite\textsuperscript{TM}. Both devices are equipped with color power Doppler and pulsed wave Doppler. The Elite has on top the continuous wave Doppler. Although statistically not significant, 76% of the clinical questions were answered with the Elite against 65% with the Plus device. One paper published positive results about the good quality of HCU Doppler capabilities, but like other new modalities the additional Doppler capabilities of HCUs have to be further tested and may form a base for a future study.\textsuperscript{14}

Conclusion

Direct assessment of cardiac pathomorphology and function at the bedside by an experienced cardiologist results in a significant immediate change in management during consultation in approximately 48% of the referral questions based on physical examination. HCU echocardiography provides clinically worthwhile assessment of left ventricular function, valve abnormalities and presence of pericardial effusion in 98% of the cases.

These findings underscore the importance of echocardiography at the bedside and use of an HCU device during consultation rounds.

References