Heart Online First, published on January 22, 2016 as 10.1136/heartjnl-2015-308421

ORIGINAL ARTICLE

Hand-held cardiac ultrasound screening performed by family doctors with remote expert support interpretation

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▸ Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/heartjnl-2015-308421).

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Received 29 July 2015
Revised 4 December 2015
Accepted 15 December 2015

To cite: Evangelista A, Galuppo V, Méndez J, *et al*. *Heart* Published Online First: [*please include* Day Month Year] doi:10.1136/heartjnl-2015-308421

ABSTRACT

Objective To assess the usefulness of hand-held cardiac ultrasound (HCU) performed by family doctors (FDs) in primary care, with web-based remote expert support interpretation, in a cohort of patient with symptoms or physical examination signs suggestive of cardiovascular disease.

Methods This prospective observational study included 1312 consecutive patients, in three remote primary care areas, with symptoms or physical examination signs suggestive of cardiovascular disease. In 859 patients (group A), FDs had indicated conventional echocardiography (CE), and in 453 (Group B) the study was performed to complement the physical examination. HCU was carried out by 14 FDs after a short training period. The scans and preliminary FD reports were uploaded on a web-based program for remote expert support interpretation in <24 h.

Results Experts considered HCU to be inconclusive in 116 (8.8%) patients. FD and expert agreement on diagnosis was moderate (K=0.40–0.70) except in mitral stenosis (K=0.29) and in left atrial dilation (K=0.38). Diagnostic agreement between expert interpretation and CE was good (K=0.66–0.85) except in mitral stenosis (K=0.43). After remote expert interpretation, conventional echocardiograms were finally requested by FDs in only 276 (32.1%) patients, and discharges increased by 10.2%. Furthermore, significant heart diseases were diagnosed in 32 (7%) patients of group B.

Conclusions HCU performed at the point of care by FDs with remote expert support interpretation using a web-based system is feasible, rapid and useful for detecting significant echocardiographic abnormalities and reducing the number of unnecessary echocardiographic studies.

INTRODUCTION

Hand-held, cardiac ultrasound (HCU) devices offering the possibility of performing cardiac ultrasound at the point of care have recently become available. Several studies have shown increased benefits when these tests are added to the general physical examination.[1–5] These devices provide excellent quality 2D and colour Doppler imaging and, in experienced hands, highly accurate diagnosis and acceptable semiquantitative severity definition of many abnormalities compared with traditional echocardiography.[6 7] However, a lack of trained personnel capable of accurate imaging interpretation may hinder their adoption in clinical practice. Although remote expert echocardiographic interpretation has been shown to be feasible,[8] there is a paucity of information regarding the large-scale integration of web-based modules of HCU in primary care. Considering the portability of these devices, similar to that of a stethoscope, their use as an initial screening tool has the potential to significantly modify current diagnostic strategy in clinical practice. Currently, family doctors (FDs) request conventional echocardiographic (CE) studies or refer patients to a consultant cardiologist who, in most cases, finally requests a CE to rule out most heart diseases. However, most echocardiography labs are overloaded, with long waiting lists and potentially significant time delays in obtaining the required diagnostic information. Accurate triage provided by HCU assessment could contribute to a reduction in the overly large number of unnecessary CE studies.

The aim of the present study was to test the feasibility and usefulness of HCU performed by FDs in primary care sent for web-based remote expert support interpretation and compare the impact on clinical management of this innovative diagnostic method versus conventional strategy with standard echocardiography.

METHODS

Study population

This prospective observational study included 1312 consecutive patients seen in primary care units by FDs. Inclusion criteria were symptoms (eg, shortness of breath, chest pain or palpitations), signs on physical examination (heart murmur, oedema in the feet) or abnormal ECG, suggestive of cardiovascular disease, with no previous diagnosis of heart disease and evaluation by CE. In 859 patients (group A), FDs indicated CE; however, in the remaining 453, FDs (Group B) had not indicated CE, but HCU was carried out to complement physical examination.

Design of the study

From January 2014 to July 2014, patients from three different health areas were included: the referral area of the coordinating centre (SAP Montanya, Vall d ´Hebron, Barcelona), a referral area of another city near Barcelona (Costa Ponent, Hospitalet de Llobregat) and a remote area in a small town in the mountains with CE facilities 100 km away (Vielha, Lerida). Fourteen FDs performed the cardiac echoscopy studies. Prior to the cardiac echoscopy study, FDs completed a questionnaire to specify inclusion criteria: symptoms, physical examination or ECG abnormalities, demographic data and brief relevant clinical history information and defined what the management of the patient would be to request a CE, refer the patient to a consultant cardiologist, follow-up at a primary care unit at 3–6 month intervals and discharge or transfer the patient to the emergency room. After the HCU study, FDs uploaded 8–12 loops to the web program system and together with their preliminary diagnoses for evaluation at the remote coordinating centre. Two expert echocardiographers (EXP) evaluated all loops, reported echocardiographic and colour Doppler findings and made a final diagnosis. This EXP report was uploaded in the web program application in <24–48 h, except when an urgent reply was requested. Finally, after receiving EXP information, FDs reported the final management strategy. Evaluation of changes in management strategy and validation of EXP diagnosis by CE were performed in group A patients. CEs were carried out by blinded independent expert echocardiographers, according to ASE and EACVI recommendations, within an interval of 3 months at the referral centres. The study protocol was approved by the institutional review boards of the participating centres and all patients provided their written informed consent.

Training of FDs

The FDs underwent a brief training programme covering both the acquisition of skills to obtain correct images by hand-held echography and recordings interpretation. The programme consisted of 7 h/day for 4 days and included lectures dealing with the theoretical basis and pitfalls of 2D echocardiography and colour Doppler. Training in imaging acquisition included using a simulator with normal examinations and several diseases (Heartwork Dual Simulator, Inventive Medical, London UK) and healthy human models over four session days. The programme was not ended until FDs were able to correctly acquire four projections: parasternal long-axis and short-axis views, apical four-chamber view and subcostal view.

Hand-held cardiac ultrasound

Ultrasound studies by hand-held echography were performed using Vscan (GE Medical Systems, Milwaukee, Wisconsin, USA). The Vscan is a small, pocket-sized device (135×73×28 mm), weighs <400 g and has an 8.9 cm display with a resolution of 240×230 pixels. It uses a phased-array transducer (1.7–3.8 MHz) and displays greyscale images with a sector width of 75° and colour Doppler images with a fixed sector width of 30°. However, this device lacks the capabilities of spectral Doppler and M-mode imaging. All studies were digitally recorded in MP3.

Parasternal long-axis and short-axis views and four-chamber view by 2D echocardiography and by colour Doppler were obtained. Subcostal views to visualise the inferior vena cava were obtained according to clinical indications. The following abnormalities were visually assessed: (1) Left ventricular (LV) systolic dysfunction, (2) LV hypertrophy (LVH), (3) left atrium enlargement, (4) morphological valvular abnormalities, (5) valvular regurgitation (mild, moderate–severe), (6) aortic root and ascending aorta size, (7) pericardial effusion, (8) inferior vena cava dilation and (9) proximal aortic root and ascending aorta enlargement.

Image transfer

Studies and reports were uploaded to a cloud-based web server (Studycast; Core Sound Imaging, Raleigh, North Carolina, USA), using commercially available software (Studycast CoreConnect; Core Sound Imaging). The studies were then securely transmitted using a broadband internet connection. CoreConnect ensured the validity of the transmitted data by applying multiple integrity checks during the transmission process. Confidentiality of the transmitted data was ensured using Standard Secure Sockets Layer (Transport Layer Security) encryption while the data were in transit between CoreConnect and CoreWeb and between CoreWeb and the user. Once the study images and data were transmitted to CoreWeb, they were available to the experts with valid login credentials. This system was protected by several authentication layers, including unique usernames and passwords.

Interpretation

FDs and experts were requested to give only visual, semiquantitative insight (normal–mild or moderate–severe) on specific pathological issues. LV systolic dysfunction was semiquantitatively graded according to ASE definitions. Mitral regurgitation (MR) and tricuspid regurgitation (TR) were semiquantitatively estimated by colour Doppler flow mapping of spatial distribution of the regurgitant jet in the left and right atria, respectively. Aortic regurgitation (AR) was assessed by the spread of the regurgitant jet within the LV outflow tract in the parasternal long-axis view. For mitral valvular stenosis (MS) or aortic valvular stenosis (AS), 2D aspects of the valve, such as leaflet movement, fibrosis, calcification and accelerated abnormal flow by colour Doppler, were estimated. Hypertensive heart disease was diagnosed in the presence of LVH (interventricular septum thickness >11 mm) in patients with hypertension with the absence of AS or hypertrophic cardiomyopathy (HCM). An abnormality was considered major if any of the following was found: valvular disease more than mild, LV systolic dysfunction, aortic root or ascending aorta dilation (>40 mm), LVH (>13 mm), pericardial effusion >10 mm and left atrial (LA) dilation (>45 mm). All other echocardiographic abnormalities were deemed to be minor. The quality of HCU images was graded as good, acceptable or poor by the EXPs.

Data analysis

Descriptive analysis was performed to summarise the abnormal echocardiographic findings. The on-site interpretations by FDs were compared with remote expert interpretations. Discordance between on-site and expert readings was considered when disagreements in diagnoses of significant abnormalities were found. Kappa coefficient (κ) was calculated as the degree of agreement between the two. p Values <0.05 were considered significant. Sensitivity, specificity and predictive values were determined from the percentage of patients with true-positive and true-negative results with 95% CIs. Continuous data are reported as mean±SD or as median and IQRs if not normally distributed, and categorical data are reported as numbers and percentages.

RESULTS

The clinical characteristics and reasons for HCU in both groups are summarised in table 1. Of the 1312 HCU, image quality was considered good in 35.4%, acceptable in 45.4% and poor in 19.2% with similar results in three tertile periods of the

Table 1 Characteristics of the sample population and cardiac echoscopy indications

Demographic characteristics	Group A, n (%)	Group B, n (%)	p Value
Total number	859 (65.5%)	453 (34.5%)	
Age (years), mean±SD (range)	67±15 (15–97)	62±17 (16–92)	<0.001
Male	43.4%	42.5%	0.75
Clinical history			
Hypertension	601 (70.0)	269 (59.4)	0.002
Dyslipidaemia	381 (44.4)	180 (39.7)	0.293
DM	214 (29.4)	80 (17.7)	0.042
Smokers	94 (10.9)	55 (12.1)	0.823
Asthma/COPD	86 (10)	41 (9.1)	0.872
Stroke	42 (4.9)	12 (2.6)	0.731
Peripheral vascular disease	27 (3.1)	7 (1.5)	0.818
HCU study indication			
Dyspnoea	273 (31.8)	129 (28.5)	0.503
Heart murmur	222 (25.8)	40 (8.8)	0.019
HBP	148 (17.2)	70 (15.4)	0.738
Palpitations	59 (6.9)	89 (19.6)	0.031
Chest pain	58 (6.8)	78 (17.2)	0.072
Oedema	48 (5.6)	18 (4)	0.793
Heart Failure	26 (3)	8 (1.8)	0.855
Syncope	24 (2.8)	20 (4.4)	0.774
Other	1 (0.1)	1 (0.2)	–

COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HBP, high blood pressure; HCU, hand-held cardiac ultrasound.

study with good-acceptable quality in 77.4%, 83.2% and 81.6%, respectively. Overall, only in 115 cases (8.7%) HCU study was considered inconclusive for the expert. The main reasons were inadequate LV wall definition to assess ventricular function in 46 cases, failure to correctly visualise the aortic valve in 38, inadequate visualisation of the right side cavities in 17 and failure to correctly define colour Doppler regurgitant jets in 14.

FD and expert diagnosis concordance

Overall diagnoses by FDs and EXPs coincided in 761 (58.0%) studies. Of the 274 studies considered normal by FDs, only 2 were significant diseases: one, moderate LV dysfunction and the other, moderate AR (table 2). Mild abnormalities were the most frequent diagnosis in 638 (49%), mainly valvular regurgitation (n=316) and LVH (n=208), EXPs diagnosed right ventricular enlargement in only 6 cases and mild aortic root or proximal ascending aorta dilation in 17, while FDs diagnosed 5 and 14 cases, respectively. In addition, inferior vena cava dilation was visualised only in 12 cases and mild pericardial effusion in 4 cases; in all these cases, agreement was present between FDs and EXPs. However, although FDs and EXPs agreed on the diagnosis of severe LV dysfunction in 15 cases, FDs more frequently diagnosed mild LV dysfunction in 93 cases and EXPs in only 15.

Agreement between FD and EXP diagnoses was moderate κ=0.52 (0.46–0.57) and did not change significantly in the three tertiles during the study: 0.47 (0.38–0.56), 0.53 (0.43–0.62) and 0.55 (0.46–0.64), respectively. Agreement was good on the diagnosis of LVH, moderate in valvular disease, except in mitral stenosis and LV dysfunction, and poor in LA enlargement (table 3) (figures 1 and 2).

Agreement and accuracy of HCU diagnosis by experts compared with conventional echocardiography

In 723 (84.2%) cases of group A, expert main diagnosis agreed with CE, including 34 cases of AS, 5 AR, 3 MS, 24 MR, 6 HCM and 15 LV dysfunction. In 33 cases (4.2%), CE ruled out doubtful diagnoses of echoscopy (ie, 15 AS, 1 AR, 4 MS, 3 LV dysfunction). Five missed echoscopy diagnoses were considered significant after CE: 1 AS, 2 MR, 1 AR and 1 LV dysfunction (see online supplementary table S1). Agreement between EXP interpretation of significant lesions by HCU and CE diagnoses was good κ=0.74 (0.71–0.78) (table 4).

Management strategy

Of the 859 cases in which FDs had requested a CE prior to HCU (group A) based on symptoms and/or physical examination, CE was finally requested in only 212 patients (25%) after

Table 2 Main HCU diagnoses by family doctors at point-of-care and remote expert interpretations

		Family doctor diagnosis												
		Not evaluable	Normal	Mild disease	AA dilation	Per effusion	LVH*	AS*	AR*	MR*	MS*	HCM	LVD dysf	Total
Remote expert diagnosis	Not evaluable	14	16	51	0	0	3	7	3	5	4	0	12	115
	Normal	2	141	93	0	0	9	2	0	3	2	0	12	264
	Mild disease	5	107	421	5	2	8	14	4	12	10	1	49	638
	AA dilation	0	0	3	14	0	0	0	0	0	0	0	0	17
	Per effusion	0	0	1	0	3	0	0	0	0	0	0	0	4
	LVH*	1	6	5	0	0	90	2	1	4	3	0	12	124
	AS*	0	0	15	0	0	4	**28**	0	3	1	0	5	56
	AR*	0	1	2	0	0	0	1	**5**	0	1	0	1	11
	MR*	0	0	6	0	1	2	2	0	**21**	1	1	2	36
	MS*	0	0	0	0	1	1	1	0	0	**5**	0	0	8
	HCM	0	0	2	0	0	3	0	0	0	0	**4**	0	9
	LVD dysf	0	1	8	0	0	1	0	0	2	3	0	**15**	30
Total		22	272	608	19	7	121	57	13	50	30	6	108	1312

Mild disease includes cases with mild abnormalities in diseases with severity quantification. Below dashed line, variables were considered to be significant findings by expert echocardiographer. Agreement on diagnosis of the main significant finding between family doctors and remote experts is shown in bold.
*Moderate–severe lesion.
AA, aortic root or proximal ascending aorta; AR, aortic regurgitation; AS, aortic stenosis; HCM, hypertrophic cardiomyopathy; HCU, hand-held cardiac ultrasound; LVD dysf, left ventricular dysfunction; LVH, left ventricle hypertrophy; MR, mitral regurgitation; MS, mitral stenosis; Per, pericardial.

Table 3 Agreement and accuracy of HCU findings between family doctors and expert diagnosis in the overall series (n=1312 patients)

HCU expert diagnosis	n (%)	κ (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
AS*	72 (5.5)	0.53 (0.39–0.63)	50.0 (36.1 to 64.0)	98.1 (97.0 to 99.1)	49.2 (35.3 to 63.0)	98.1 (97.2 to 99.0)
AR*	51 (3.9)	0.61 (0.50 to 0.74)	58.3 (43.3 to 73.3)	99.0 (98.3 to 99.6)	68.3 (52.8 to 83.8)	98.4 (97.7 to 99.1)
MR*	79 (5.6)	0.65 (0.56 to 0.74)	72.7 (61.2 to 84.2)	97.7 (96.8 to 98.6)	62.3 (50.9 to 73.8)	98.5 (97.8 to 99.3)
MS*	8 (0.6)	0.29 (0.9 to 0.47)	62.8 (22.7 to 100)	98.1 (97.3 to 98.9)	18.7 (1.9 to 31.7)	99.8 (99.5 to 100)
TR*	54 (4.1)	0.42 (0.25 to 0.59)	41.4 (21.7 to 61.0)	98.9 (98.3 to 99.5)	46.2 (25.1 to 67.2)	98.7 (98.0 to 99.3)
HCM	9 (0.6)	0.53 (0.23 to 0.83)	44.4 (6.4 to 82.5)	99.8 (99.6 to 100)	66.7 (20.6 to 100)	99.6 (99.2 to 99.9)
LV dysf	51 (3.9)	0.51 (0.37 to 0.62)	50.0 (30.4 to 69.6)	92.7 (91.3 to 94.2)	13.9 (6.9 to 20.8)	98.7 (98.1 to 99.4)
LVH*	164 (12.5)	0.70 (0.60 to 0.78)	71.4 (63.1 to 79.7)	97.4 (96.7 to 98.6)	74.4 (66.2 to 82.6)	97.0 (96.0 to 98.0)
LA dil*	41 (3.1)	0.38 (0.24 to 0.50)	41.5 (25.2 to 57.8)	97.7 (96.8 to 98.6)	37.0 (21.9 to 52.0)	98.1 (97.3 to 98.9)
AA dilat	122 (9.3)	0.54 (0.43 to 0.71)	54.1 (37.1 to 70.2)	99.1 (98.4 to 99.6)	64.5 (45.4 to 80.2)	98.7 (97.8 to 99.2)

*Moderate or severe lesion.
AA, aortic root or proximal ascending aorta; AR, aortic regurgitation; AS, aortic stenosis; HCM, hypertrophic cardiomyopathy; HCU, hand-held cardiac ultrasound; LA, left atrial; LV, left ventricle; LVH, left ventricular hypertrophy; MR, mitral regurgitation; MS, mitral stenosis; n, number of diseases diagnosed by experts; NPV, negative predictive value; PPV, positive predictive value; TR, tricuspid regurgitations.

remote EXP interpretation. Changes in FD strategy after remote expert interpretation are shown in figure 3. Of 453 HCU performed by FDs thanks to device availability (group B), 32 (7%) were diagnosed of significant diseases: 7 AS, 7 MR, 5 AR, 11 LV dysfunction and 2 HCM and indicated CE. Overall, using this strategy, CE indication by FDs decreased from 859 to 276 cases (32.1%).

DISCUSSION

This study demonstrated that HCU performed by FDs with remote expert support interpretation on a web-based system permits significant heart diseases to be rule out and improves the indication (triage) for CE. This new strategy with a limited scanning protocol can successfully permit accurate diagnosis in primary care areas, thereby facilitating rapid and appropriate care of patients while providing cost-saving potential.[9]

Several studies have already reported comparable results by HCU and CE with regard to the measurement of cardiac chamber sizes and function, semiquantitative assessment of valvular diseases and pericardial effusion, assuming that it is not appropriate for assessing pulmonary arterial hypertension, LV diastolic dysfunction or constrictive pericarditis.[9–13] Our results showed good agreement between EXPs and CE in the basic semiquantitative diagnosis. Although HCU is limited in valvular stenosis quantification since continuous-wave Doppler information is not available, the diagnosis can be suspected by morphological valvular analysis and motion restriction of the valve leaflets.[14]

Previous studies reported that the use of pocket-size ultrasound devices was associated with a 20–30% cost reduction in healthcare costs[9 15–20] Nevertheless, most reported studies were conducted by experts. It has been suggested that internist may

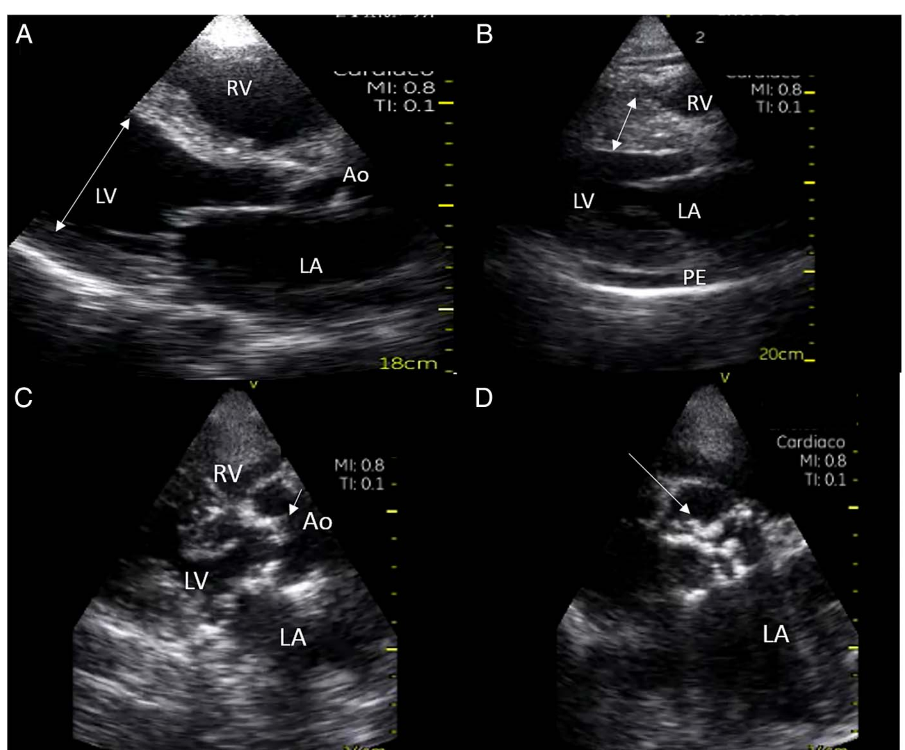

Figure 1 Hand-held cardiac ultrasound: (A) moderate LV dilation (arrow) in a patient with systolic LV dysfunction by parasternal long-axis view; (B) hypertrophic cardiomyopathy with severe septal hypertrophy (arrow) and mild pericardial effusion; (C) aortic stenosis defined by thickening of the aortic valve (arrow) by parasternal long-axis view; (D) significant aortic stenosis with a severe reduction in aortic valve opening (arrow) defined by short-axis view. LA: left atrium, LV: left ventricle, RV: right ventricle, Ao: ascending aorta, PE: pericardial effusion.

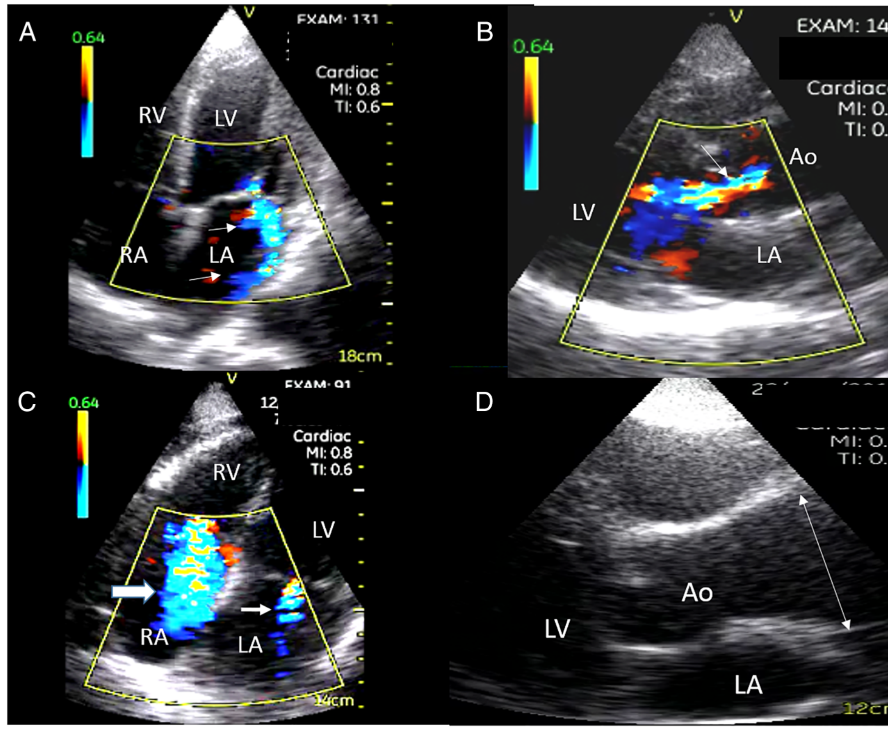

Figure 2 Hand-held cardiac ultrasound: (A) severe mitral valve regurgitation with Coanda effect (arrows) showed by colour Doppler in a four-chamber view; (B) severe aortic valve regurgitation visualised by parasternal long-axis view (arrow); (C) severe tricuspid valve regurgitation (large arrow) and mild mitral valve regurgitation (small arrow) in the apical four-chamber view; (D) ascending aorta enlargement in the upper part of the sinotubular junction (arrow) by parasternal long-axis view. LA: left atrium, LV: left ventricle, RV: right ventricle, Ao: ascending aorta, PE: pericardial effusion.

be able to use these hand-held devices after a limited training period.[21–24] However, this approach has recently been questioned,[25–29] since their major limitation is interpretation.[11 25 26] As proven in the present study, FDs obtained an excellent negative predictive value (NPV) when the study was normal; however, one of the main limitations is the assessment of abnormal findings. These doubtful cases can lead to an unnecessary increase in CE indications. For this reason, expert support interpretation seems crucial to improve the accuracy of intermediate lesions quantification, mainly in the early years of the implementation of this strategy.

The typical tertiary hospitals echo labs are usually busy, and the work flow is often associated with delayed examination and excessive waiting list.[15] The work-flow integration of hand-held devices, as a triage method to select CE, has already been suggested.[15] However, an inappropriate use or misdiagnosis by non-expert users can potentially result in worsened patient care.

With the aim of reducing this limitation, the present study design aimed to offer remote expert support on a web-based system for the evaluation of the studies performed by FDs in primary care. Using this proposal strategy, limitedly trained FDs reduced CE indications in 68% of cases. In addition, the best use of this technology may rely on a better triage strategy by selecting patients who need to be sent to CE for a comprehensive examination and aid the prioritisation of the study, with clinical and economic benefits.

Study limitations

HCU images reviewed by experts, but acquired by trained FDs, were considered sufficient when the studies fulfilled the required information. Therefore, we cannot rule out a potential risk of missing abnormalities due to limited imaging of HCU to allow rapid scanning in an not complete echo study. However, we defined this study as inconclusive in around 10% of cases,

Table 4 Agreement and accuracy of remote expert HCU diagnosis respect to conventional echocardiography in group A (n=774 patients)

Conventional echocardiographic diagnosis	n (%)	κ 95% CI	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
AS*	66 (7.7)	0.66 (0.57 to 0.74)	98.4 (90.7 to 99.9)	92.1 (88.8 to 93.9)	53.7 (44.5 to 62.7)	99.8 (99.0 to 99.9)
AR*	32 (3.7)	0.84 (0.75 to 0.93)	96.8 (82.0 to 99.8)	98.6 (97.4 to 99.3)	75.6 (53.3 to 87.1)	99.8 (99.1 to 100)
MR*	51 (5.9)	0.88 (0.81 to 0.94)	96.0 (85.4 to 99.3)	98.6 (97.3 to 99.3)	83.5 (70.5 to 91.1)	99.7 (98.8 to 99.9)
MS*	4 (0.5)	0.43 (0.13 to 0.82)	100 (31.9 to 100)	98.9 (94.6 to 99.6)	27.3 (17.3 to 60.1)	100 (99.6 to 100)
TR*	42 (4.9)	0.78 (0.68 to 0.88)	80.9 (66.3 to 90.8)	98.6 (97.4 to 99.3)	77.2 (61.7 to 88.0)	98.9 (97.7 to 99.)
HCM	8 (0.9)	0.73 (0.50 to 0.96)	87.5 (44.7 to 99.3)	99.5 (98.6 to 99.8)	63.6 (31.6 to 87.6)	99.9 (99.1 to 100)
LV dysfunction	40 (4.7)	0.72 (0.62 to 0.83)	90.0 (75.4 to 96.7)	97.1 (95.5 to 98.1)	63.1 (49.3 to 75.2)	99.4 (98.4 to 99.8)
LVH*	134 (17.3)	0.77 (0.67 to 0.88)	92.5 (86.3 to 96.1)	96.5 (94.7 to 97.8)	84.9 (77.8 to 90.1)	98.4 (96.9 to 99.1)
LA dilation*	86 (11.1)	0.63 (0.53 to 0.73)	62.5 (50.9 to 72.8)	93.9 (91.8 to 96.5)	54.4 (43.7 to 64.7)	95.6 (93.7 to 96.9)
AA dilation	50 (6.5)	0.71 (0.61 to 0.0.82)	76.0 (61.5 to 86.5)	97.9 (96.5 to 98.7)	71.7 (57.4 to 81.8)	98.5 (97.0 to 99.1)

*Moderate or severe lesion.
AA, aortic root or proximal ascending aorta; AR, aortic regurgitation; AS, aortic stenosis; HCU, hand-held cardiac ultrasound; HCM, hypertrophic cardiomyopathy; LVH, left ventricle hypertrophy; MR, mitral regurgitation; MS, mitral stenosis; NPV, negative predictive value; PPV, positive predictive value; TR, tricuspid regurgitations.

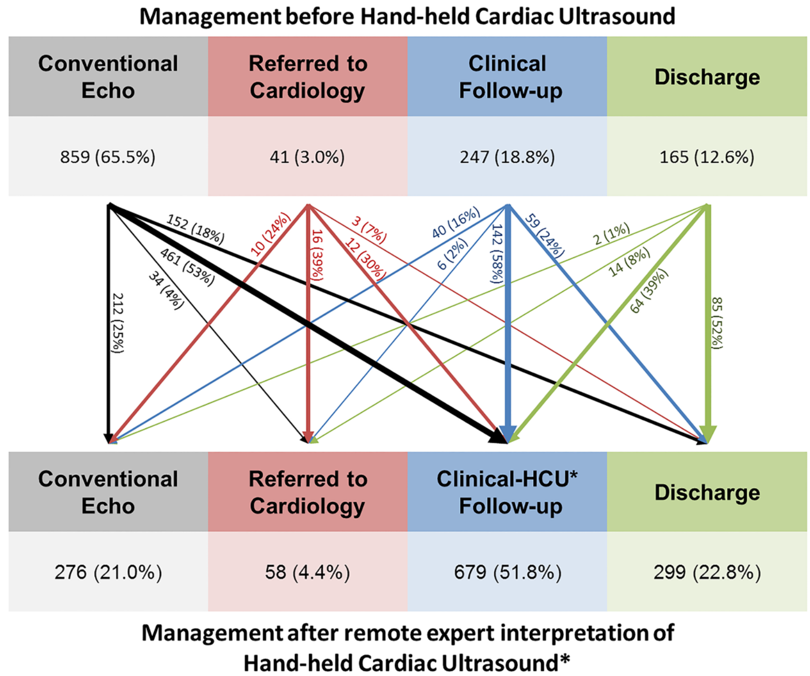

Figure 3 Management of patient by family doctors before hand-held cardiac ultrasound and after remote expert interpretation in 1312 consecutive patients.

particularly when left and right cardiac chambers or aortic, mitral and tricuspid valves were not well visualised. Another limitation of the current study is that we used a visual, qualitative or semiquantitative approach to the diagnosis and grading of abnormalities. One of the objectives of the study was to determine the usefulness of HCU in identifying significant heart diseases and not to test the accurate quantification of those abnormalities. FD training was more centred on obtaining a good acquisition level of echocardiographic images than on their interpretation. More experienced examiners might achieve better diagnostic accuracy than shown in this study. We analysed the agreement diagnosis between HCU and CE only in group A as these patients had the CE scheduled and constituted 65% of cases.

Key messages

What is already known on this subject?

The usefulness of hand-held cardiac ultrasound performed by experts has been confirmed in several studies. The extension of its use to non-cardiologists at the point of care has been proposed. However, these non-experts require an appropriate period of training, which is not always feasible, and help with image interpretation.

What might this study add?

This study showed that family doctors given short adequate training can competently acquire images although their interpretation may be limited and require support from remote experts by telemedicine. Expert diagnosis shows adequate agreement with conventional echocardiography. Indication for conventional echocardiography using this novel strategy was reduced to 30%.

How might this impact on clinical practice?

This novel strategy may reduce the number of unnecessary conventional echocardiographic studies, shorten waiting list time and prioritise the use of conventional echocardiography depending on the findings of hand-held cardiac ultrasound screenings.

CONCLUSIONS

This study demonstrates that HCU performed at the point of care by FDs with remote expert interpretation using a web-based system is feasible, rapid and useful for detecting significant echocardiographic abnormalities and reducing unnecessary echocardiographic studies. The application of this new strategy as a triage method to select and prioritise which patients need complete and detailed studies with high-end machines has the potential to significantly change the diagnostic management of cardiac disease in clinical practice in different heath systems.

Acknowledgements We are indebted to Christine O'Hara for help with the English version of the manuscript and to Augusto Sao-Aviles for the statistical analysis.

Contributors AE designed the protocol of the study. AE and VG were the experts who reviewed all cases. JM, LE, LA, CR, MV, ML, FL, CS, VM, AG, JP, MA, BS and CL are the family doctors who performed the study and pocked-sized echoscopy, and DG-D reviewed and helped in writing the manuscript.

Competing interests None declared.

Patient consent Obtained.

Ethics approval The study protocol was approved by the Institutional Review Board of the participating centres.

Provenance and peer review Not commissioned; externally peer reviewed.

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Heart published online January 22, 2016