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Valvular heart disease screening using a point-of-care ultrasound device according to physician experience: Non-expert versus expert



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ABSTRACT

Background: A point-of-care ultrasound (POCUS) device (Vscan™) is reliable in valvular heart disease (VHD) screening when used by expert physicians.

Aims: To compare the feasibility and accuracy of a POCUS device in VHD screening according to physician experience (non-expert versus expert).

Methods: In a prospective study including 240 outpatients referred to the echocardiography laboratory, POCUS was performed by one expert cardiologist and one non-expert cardiologist blinded to each other. These were then compared to standard transthoracic echocardiography performed by an expert cardiologist (gold standard). Left-sided VHD and significant tricuspid regurgitation were systematically recorded.

Results: Standard transthoracic echocardiography identified 250 cases of VHD in 240 patients. VHD was correctly identified in 247 of 250 cases (98.8%) by expert POCUS and in 219 of 250 cases (87.6%) by non-expert POCUS. Expert POCUS was highly sensitive (99%) and specific (93%) for VHD screening. Non-expert POCUS was also sensitive (88%) and specific (88%). The efficiency of POCUS was high for significant mitral, aortic and tricuspid regurgitation: sensitivity and specificity were 100% for expert POCUS and 94% and 99%, respectively, for non-expert POCUS.

Conclusion: POCUS performed by a non-expert physician is reliable for VHD screening and should be used as a triage tool to exclude the diagnosis of VHD or to refer patients to an echocardiography laboratory.

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1. Abbreviations

2D	two-dimensional
AR	aortic regurgitation
AS	aortic stenosis
EACVI	European Association of Cardiovascular Imaging
MR	mitral regurgitation
MS	mitral stenosis
NPV	negative predictive value
POCUS	point-of-care ultrasound

PPV	positive predictive value
STTE	standard transthoracic echocardiography
TTE	transthoracic echocardiography
VHD	valvular heart disease

2. Background

Valvular heart disease (VHD) is an important cause of mortality and morbidity in France and worldwide [1,2]. Despite the recent updating of European and American guidelines [3,4], many patients do not receive an early diagnosis and optimal care [1]. VHD screening is currently performed in the echocardiography laboratory by expert cardiologists or sonographers. However, work overload in the echocardiography laboratory or missed opportunities to refer patients to the laboratory may, in part, be responsible for failures in VHD screening. Thus, point-of-care ultrasound (POCUS) devices, which are user-friendly and portable, could usefully extend

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VHD screening. Furthermore, these devices have been validated for non-cardiologists (intensivists, emergency care physicians and anaesthesiologists) for the assessment of cardiac chamber morphology and function, inferior vena cava dilatation and pericardial effusion [5–8].

There is a good correlation between standard transthoracic echocardiography (sTTE) and POCUS in screening for left-sided VHD by expert cardiologists [9]. Screening for VHD by non-expert physicians would provide patients with the best possible chance of an early diagnosis of VHD. The aim of the present study was to compare the feasibility and accuracy of a POCUS device in VHD screening according to the experience of the physicians.

3. Methods

3.1. Study population

We conducted a prospective, single-centre study of consecutive patients referred for transthoracic echocardiography (TTE) to the outpatient cardiology department of the Ambroise-Paré University Hospital, Boulogne-Billancourt, France. Exclusion criteria were critically ill patients, mechanically ventilated patients and those with prosthetic heart valves. Assessment of left-sided VHD and tricuspid regurgitation (TR) was systematically performed by: (1) sTTE (Vivid 95 System, GE Medical Systems, Horten, Norway), considered as the gold standard, by an expert cardiologist; (2) POCUS (Vscan™, GE Healthcare) by another expert cardiologist; and (3) POCUS (Vscan™, GE Healthcare) by a non-expert cardiologist. Two cardiologists with level III competency in echocardiography were considered ‘expert’ [10]. One of these performed the sTTEs, the other performed the POCUS examinations. The non-expert cardiologist was a first-year cardiology resident (with 6 weeks of echocardiography training [theory and practical cases], see [Text A.1](#)) without experience prior to training. The examinations were performed consecutively and the three physicians were blinded to the results of the other examinations. This study was approved by the Institutional Data Protection Authority of Paris Saclay University Hospitals. Written informed consent from all patients was obtained.

3.2. sTTE examination

The following two-dimensional (2D) measurements were routinely assessed by sTTE to assess the potential impact of VHD [11]: (1) end-diastolic measurements of the interventricular septum, posterior wall and left ventricle; (2) left ventricular mass; (3) left atrial diameter; (4) aorta diameter; (5) right ventricular diameter; and (6) left ventricular ejection fraction using Simpson’s method. The following Doppler parameters were routinely determined by sTTE: (1) E and A waves of the mitral inflow; (2) assessment of filling left ventricular pressure; (3) aortic velocity; and (4) systolic TR velocity. The presence or absence of pericardial effusion was also noted. Screening and quantification of left-sided VHD and TR by sTTE were assessed according to current guidelines [4,11]. Each VHD was assessed using specific parameters. Regurgitant VHD were first detected by colour Doppler. The assessment of pressure half-time on the aortic regurgitation (AR) velocity curve and the degree of diastolic flow reversal in the aortic arch were used for the quantification of AR. We used several parameters for the assessment of mitral regurgitation (MR): effective regurgitant orifice, regurgitant volume, vena contracta and mechanism of MR. Aortic stenosis (AS) was assessed using aortic Vmax by continuous wave Doppler and calculation of aortic valvular area by the continuity equation. Mitral stenosis (MS) was assessed using transmitral flow velocities and calculation of mitral valve area by planimetric mitral

valve and/or diastolic pressure half-time. After the visualization of colour Doppler jet of TR (calculation of the ratio of TR area to right atrial area), we used several parameters for the assessment of TR: vena contracta width, effective regurgitant orifice and hepatic vein systolic flow reversal.

3.3. Pocket-sized device for TTE

Vscan is a POCUS device with record-keeping capabilities, measuring $135 \times 73 \times 28$ mm for the display unit and $129 \times 39 \times 28$ mm for the probe, weighing 436 g. This device includes 2D imaging and colour Doppler, but has no M-mode, continuous or pulsed wave Doppler. POCUS was performed twice: by an expert (expert POCUS) and by a non-expert cardiologist (non-expert POCUS), blinded to each other. The operators were aware of the reason for the echocardiography request but had no access to the patient’s medical record nor prior echocardiographic findings. No discussion between operators was permitted. POCUS examination included parasternal long-axis and short-axis views, and apical two, three, four and five-chamber views. VHD was detected and quantified by 2D and colour Doppler analysis. Left-sided valvular regurgitation (MR and AR) and its severity (trivial or significant) were assessed according to cardiac morphology (left ventricular dimension and systolic function, left atrial size) and the visual interpretation of the colour Doppler jet. Trivial left-sided valvular regurgitation was defined as normal cardiac morphology, visual small colour Doppler jet area and no criteria of significant valvular regurgitation (no proximal isovelocity surface area radius). The assessment of stenotic left-sided VHD (AS and MS) was based on the interpretation of the greyscale (chamber hypertrophy, valvular calcification and mobility) and colour Doppler information (aliasing). However, we did not attempt to assess the stenotic VHD severity since the Vscan device features no spectral Doppler. Concerning right-sided VHD, we only reported significant TR, defined as a ratio of the tricuspid regurgitated jet area to the right atrial area >0.4 in an apical four-chamber view [12].

3.4. Statistical analysis

Continuous variables are presented as means $\pm$ standard deviation (SDs) based on their distributions, which were assessed graphically using histograms. Categorical data are presented as numbers and percentages. sTTE was considered as the gold standard for screening and quantification of the severity of VHD. Sensitivity, specificity, positive predictive values (PPVs) and negative predictive values (NPVs) were calculated to evaluate the accuracy of POCUS in the detection of VHD when used by an expert cardiologist and a non-expert cardiologist. Cohen’s kappa coefficient was also used to determine the agreement between POCUS by an expert, POCUS by a non-expert and sTTE [13]. Kappa values ≥ 0.81 are associated with excellent agreement, 0.61 to 0.80 good agreement, 0.41 to 0.60 moderate agreement, 0.21 to 0.40 fair agreement, 0.01 to 0.20 slight agreement and ≤ 0.01 poor agreement. *P* values <0.05 were considered statistically significant. Statistical analyses were performed with R Development Core Team (2019) (R: a language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria).

4. Results

4.1. Study population

Overall, 240 patients (mean $\pm$ SD age 67.0 ± 17.5 years; 57.1% men; [Table 1](#)) underwent echocardiography for the following main indications: asymptomatic cardiovascular check-up ($n=44$, 18.3%), acute heart failure ($n=40$, 16.7%), ischaemic heart disease

Table 1
Characteristics of the study population.

	All patients (n = 240)
Age (years)	67.0 ± 17.5
Men	137 (57.1)
Weight (kg)	76.0 ± 21.2
Height (cm)	169.1 ± 10.0
Body surface area (m ²)	1.8 ± 0.3
Results of standard TTE	
Aorta diameter (mm)	33.9 ± 5.0
Indexed left atrial volume (mL/m ²)	38.4 ± 16.0
End-diastolic left ventricular diameter (mm)	49.5 ± 8.3
Interventricular septum (mm)	9.6 ± 2.6
Posterior wall (mm)	9.4 ± 2.3
Interventricular septum to posterior wall ratio	1.0 ± 0.2
Left ventricular mass (g)	165.5 ± 76.5
Indexed left ventricular mass (g/m ²)	88.8 ± 39.4
End-diastolic left ventricular volume (mL)	121.2 ± 50.6
End-systolic left ventricular volume (mL)	56.0 ± 46.0
Left ventricular ejection fraction (%)	54.0 ± 12.2
Aortic velocity (m/s)	1.8 ± 1.2
Mitral E wave (m/s)	0.8 ± 0.8
Mitral A wave (m/s)	0.9 ± 0.2
E/A ratio	1.1 ± 0.8
Elevated filling left ventricular pressure	27 (11.3)
Systolic TR velocity (m/s)	2.5 ± 0.4
Systolic pulmonary artery pressure (mmHg)	33.3 ± 14.2
Dilated right ventricle	11 (4.6)
Pericardial effusion	12 (5.0)
AR	56 (23.3)
Significant AR	3 (1.3)
MR	153 (63.8)
Significant MR	20 (8.3)
Significant TR	12 (5.0)
AS	23 (9.6)
MS	6 (2.5)

Data are expressed as number (%) or mean ± standard deviation. AR: aortic regurgitation; AS: aortic stenosis; MR: mitral regurgitation; MS: mitral stenosis; TR: tricuspid regurgitation.

(n = 32, 13.3%), preoperative assessment (n = 23, 9.6%), chemotherapy follow-up (n = 18, 7.5%), dilated cardiomyopathy (n = 10, 4.2%) and dyspnea (n = 10, 4.2%). Among the 240 patients included, 250 cases of VHD were diagnosed by sTTE (some patients had more than one VHD): 221 (88.4%) cases of valvular regurgitation and 29 (11.6%) cases of valvular stenosis. No patients were excluded because of poor echogenicity, but 19 (7.9%) had low echogenicity. Characteristics of the study population and echocardiographic features are described in Table 1.

4.2. VHD assessed by expert and non-expert POCUS

In total, 247 of 250 cases (98.8%) of VHD were correctly identified by expert POCUS and 219 of 250 (87.6%) by non-expert POCUS. Expert POCUS was highly sensitive (99%) and specific (93%) in VHD screening (Table 2). Non-expert POCUS was also sensitive (88%) and specific (88%). Concerning significant AR, MR and TR, sensitivity and specificity were 100% for expert POCUS, and 94% and 99%, respectively, for non-expert POCUS.

4.3. Valvular regurgitation

Among the 221 cases of valvular regurgitation, 56 AR (25.3%), 153 MR (69.2%) and 12 significant TR (5.4%) were detected by sTTE (Fig. 1A). All 20 cases of significant MR were detected by expert POCUS, whereas two cases of significant MR were misclassified as trivial by non-expert POCUS (Fig. 1B). Sensitivity and specificity for the screening of MR were 99% and 94%, respectively, by expert POCUS, and 85% and 94%, respectively, by non-expert POCUS (Table 2). The kappa correlation coefficient between sTTE and expert POCUS for the detection of MR was 0.94, indicating an

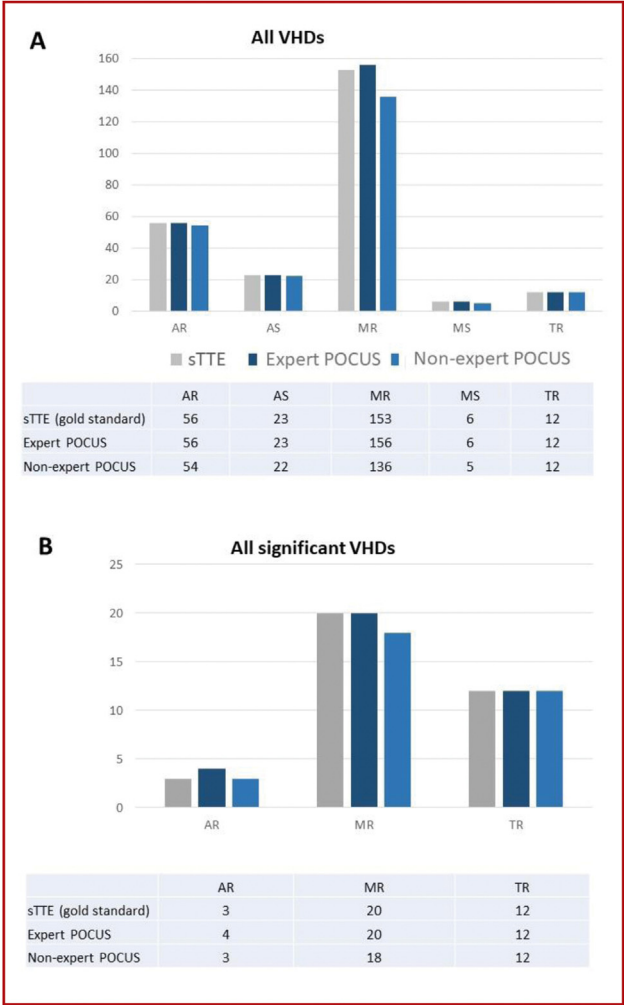


Fig. 1. A. All VHD diagnosed by sTTE (considered to be the gold standard), by expert POCUS and by non-expert POCUS. B. Significant AR, MR and TR diagnosed by sTTE (considered as the gold standard), by expert POCUS and by non-expert POCUS. AR: aortic regurgitation; AS: aortic stenosis; MR: mitral regurgitation; MS: mitral stenosis; expert POCUS: point-of-care ultrasound performed by an expert; non-expert POCUS: point-of-care ultrasound performed by a non-expert; sTTE: standard transthoracic echocardiography; TR: tricuspid regurgitation; VHD: valvular heart disease.

excellent correlation. The kappa coefficient between sTTE and non-expert POCUS for the screening of MR was 0.75, indicating a good correlation. All cases of MR and AR not identified by expert and non-expert POCUS were trivial.

Among the 56 cases of AR detected by sTTE, 56 (100%) and 54 (96.4%) were correctly identified by expert POCUS and non-expert POCUS, respectively (Fig. 1A). All three cases of significant AR were identified by expert and non-expert POCUS, with one extra AR misclassified by expert POCUS. Sensitivity and specificity for the screening of AR were 98% and 99%, respectively, by expert POCUS and 89% and 98%, respectively, by non-expert POCUS (Table 2). The kappa correlation coefficients between sTTE and expert and non-expert POCUS for the screening of AR were 0.98 and 0.88, respectively, indicating excellent correlations. Among the 153 cases of MR detected by sTTE, 153 (100%) and 136 (87.1%) were correctly detected by expert POCUS and non-expert POCUS, respectively, with three extra MR misclassified by expert POCUS.

All 12 cases of significant TR were identified by expert and non-expert POCUS (Fig. 1). Sensitivity and specificity for the screening of significant TR were 100% for both expert and non-expert POCUS (Table 2). The kappa coefficients for the screening of TR

Table 2

Reliability of point-of-care ultrasound performed by one expert and one non-expert in detection of VHD, as compared to sTTE.

		All VHD (n = 250)	AR (n = 56)	MR (n = 153)	TR (n = 12)	AS (n = 23)	MS (n = 6)	All significant valvular regurgitation (n = 35)
Sensitivity (%)	Expert POCUS	99 (97–100)	98	99	100	100	100	100 (99–100)
	Non-expert POCUS	88 (86–93)	89	85	100	96	83	94 (92–95)
Specificity (%)	Expert POCUS	93 (91–95)	99	94	100	100	100	100 (98–100)
	Non-expert POCUS	88 (86–91)	98	94	100	100	100	99 (98–100)
PPV (%)	Expert POCUS	96 (94–98)	98	97	100	100	100	100 (98–100)
	Non-expert POCUS	90 (87–92)	93	95	100	100	100	99 (97–100)
NPV (%)	Expert POCUS	98 (96–100)	99	98	100	100	100	100 (99–100)
	Non-expert POCUS	89 (86–92)	97	93	100	99	99	97 (95–99)

Data are expressed as % or % (95% confidence interval). AR: aortic regurgitation; AS: aortic stenosis; MR: mitral regurgitation; MS: mitral stenosis; PPV: positive predictive value; expert POCUS: point-of-care ultrasound performed by an expert; non-expert POCUS: point-of-care ultrasound performed by a non-expert; NPV: negative predictive value; sTTE: standard transthoracic echocardiography; TR: tricuspid regurgitation; VHD: valvular heart disease.

between sTTE and expert and non-expert POCUS were 1.00, indicating excellent correlations. Sensitivities, specificities, PPVs and NPVs of POCUS are presented in Table 2. Among the 35 significant regurgitant VHD detected by sTTE, 35 were classified as significant by expert POCUS (100%) versus 33 by non-expert POCUS (94.3%). No difference of misdiagnosis or misclassification by non-expert cardiologists using POCUS was observed between the beginning and the end of the study (data not shown).

4.4. Valvular stenosis

Among the 29 cases of valvular stenosis, 23 cases of AS (79.3%) and six cases of MS (20.7%) were identified by sTTE. All cases of AS were correctly identified by expert POCUS, with 22 (95.7%) identified by non-expert POCUS (Fig. 1A). All six cases of MS were correctly identified by expert POCUS and five (83.3%) by non-expert POCUS. Sensitivity and specificity for the screening of AS by expert POCUS were 100%, while those for non-expert POCUS were 96% and 100%, respectively (Table 2). The kappa correlation coefficients between sTTE and expert and non-expert POCUS for the screening of AS were 1.00 and 0.98, respectively, indicating excellent correlations. Sensitivity and specificity for the screening of MS by expert POCUS were 100%, while those for non-expert POCUS were 83% and 100%, respectively. The kappa correlation coefficients between sTTE and expert and non-expert POCUS for the screening of MS were 1.00 and 0.91, indicating excellent correlations.

5. Discussion

Our study demonstrates that non-expert cardiologists can reliably screen for VHD using a POCUS device, as compared to the gold standard of sTTE. Nearly 20% of the studied outpatients were referred to our echocardiography laboratory for cardiovascular check-ups, and these patients represent an unselected population. The population characteristics are also in line with patient characteristics from previous studies in similar settings [9,14,15].

Pocket-sized echocardiography has shown high feasibility and accuracy for the detection of VHD when performed by experts [9,16,17]. On the other hand, several studies have shown great accuracy in the assessment of cardiac chamber morphology and function, inferior vena cava dilatation and pericardial effusion when performed by non-experts [5–7]. VHD assessment requires high technical skills in image acquisition and interpretation and thus raises the question of its feasibility in the hands of non-experts. The present study is the first to demonstrate that non-experts can assess VHD using a pocket-sized ultrasound device. This result contrasts with a previous study that showed that the detection of VHD by a non-expert hospitalist using a hand-carried ultrasound device was very poor, and no better than cardiac auscultation in a pop-

ulation of general medical inpatients [18]. In a Norwegian study that compared the performance of pocket-sized echocardiography performed by medical residents with limited experience in ultrasound with the results of standard echocardiography performed by an expert, the assessment of AS and AR was correct, but assessment of atrioventricular VHD was only moderately satisfactory [19]. On the other hand, pocket-sized devices have improved in quality, as compared to the first devices, and may now be used to assess VHD.

In our study, the non-expert was a first-year cardiology resident. The feasibility was excellent, with no patients excluded because of poor echogenicity. Among the 250 cases of VHD diagnosed, 87.6% were identified by the non-expert (versus 98.8% by the expert), and results were even better with significant regurgitant VHD (94.3% were identified by the non-expert, 100% by the expert). VHD is common in low-income countries, where full-sized high-end echocardiography is costly and not always available. The introduction of pocket-sized echocardiography, used by non-experts after initial training, could be a way of making a quick, reliable, cost-effective, triage diagnosis [20]. The user-friendliness and ultraportability of pocket-sized echocardiographs are great advantages, which should result in wider usage by physicians beyond echocardiography laboratories, both in developed and developing countries [21]. It could be of interest to assess the accuracy of POCUS for VHD detection in emergency departments in unselected patients. Furthermore, it could be of interest to test POCUS for VHD screening in patients who face difficulties getting to the laboratory (e.g., geriatric patients).

Despite recent technological advances, the performance of pocket-sized ultrasound devices for the assessment of VHD should not be overestimated. According to the European Association of Cardiovascular Imaging (EACVI), handheld ultrasound devices can be used as an extension to physical examination, to triage candidates for sTTE and as a reliable screening tool for cardiac diseases [22]. An expert in echocardiography is required to confirm the VHD diagnosis and its severity, and in the case of doubt.

Furthermore, EACVI guidelines advise against the use of pocket-sized devices for quantitative assessment of VHD. The lack of spectral Doppler prevents comprehensive quantitative assessment of valve disease severity. However, in our study, both the expert and non-expert were able to detect significant regurgitant VHD, based on indirect assessment as described in the Methods section. Interestingly, the lack of VHD detection by POCUS allows significant VHD to be excluded. As mentioned, we were not able to assess the severity of stenotic VHD.

5.1. Strengths and limitations

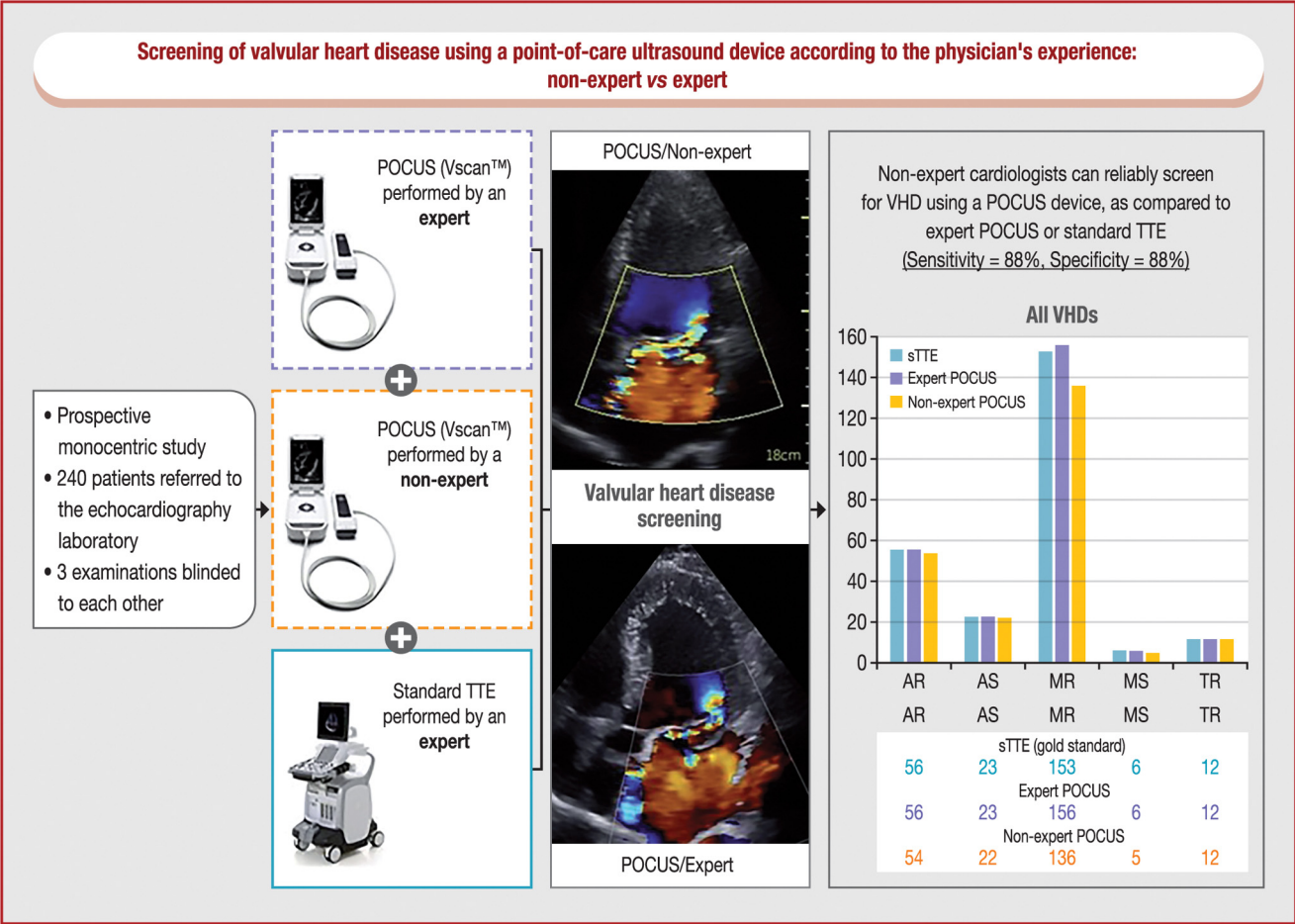
The patients included in our study were unselected, but were all referred to the echocardiography laboratory, leading to a

potential selection bias, with a large prevalence of VHD among this population. This could affect both the sensitivity and specificity of POCUS. However, operators were blinded to the reason for the examination and the other results, except for the operator who performed the sTTE. Furthermore, a strength of our study is that we assessed VHD using three different methods (sTTE, POCUS by an experienced cardiologist and POCUS by a non-expert cardiologist) in 240 patients. A limitation has been previously reported, namely that the lack of continuous wave and pulsed wave Doppler in POCUS means that not all echocardiographic parameters can be used in the quantification of VHD. Consequently, for VHD, POCUS should be used as a triage tool, to exclude the diagnosis or to refer patients to an echocardiography laboratory. Only one non-expert participated in the study and other non-experts might not have

performed so well. Larger studies including more non-experts and/or different patient populations would be useful to confirm these results. Finally, although feasibility was excellent in this study, as no patients were excluded because of poor echogenicity, examination duration and operator confidence were not reported.

6. Conclusions

This prospective study shows that POCUS (Vscan) allows reliable screening of VHD whether carried out by an experienced or a non-experienced operator. Pocket-sized echocardiography is a reliable screening tool to triage patients before sending them to an echocardiography laboratory to confirm VHD, when performed by minimally-trained operators (Central Illustration).



Central Illustration. VHD screening using a POCUS device by physician experience. AR: aortic regurgitation; AS: aortic stenosis; MR: mitral regurgitation; MS: mitral stenosis; expert POCUS: point-of-care ultrasound performed by an expert; non-expert POCUS: point-of-care ultrasound performed by a non-expert; POCUS: point-of-care ultrasound; sTTE: standard transthoracic echocardiography; TTE: transthoracic echocardiography; TR: tricuspid regurgitation; VHD: valvular heart disease.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.acvd.2025.05.001.

Disclosure of interest

The authors declare that they have no competing interest.

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