



## Junior medical student performed focused cardiac ultrasound after brief training to detect significant valvular heart disease☆

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### ABSTRACT

**Background:** Focused cardiac ultrasound (FOCUS) examination using a portable device is increasingly used for bedside diagnosis of cardiovascular diseases. This is a 4-week pilot project aiming to teach medical students to perform FOCUS to detect valvular heart lesions.

**Methods:** Patients undergoing routine transthoracic echocardiography (TTE) were recruited by third year medical students who performed physical examination (PE) and FOCUS after 6-hour training to detect significant (moderate-to-severe) valvular lesions. Performance of FOCUS and PE was compared to TTE as reference using kappa statistics.

**Results:** 10 medical students performed 212 PE and FOCUS on 107 patients with mean age  $63.7 \pm 14.9$  years. TTE detected 126 significant valvular lesions of which FOCUS correctly identified 54 lesions ( $\kappa = 0.45$ ) compared to 32 lesions by PE ( $\kappa = 0.28$ ,  $p < 0.01$ ). FOCUS was better than PE in identifying mitral stenosis ( $\kappa = 0.51$  vs. 0.17), aortic stenosis ( $\kappa = 0.45$  vs. 0.16) and tricuspid regurgitation ( $\kappa = 0.39$  vs. 0.09, all  $p < 0.01$ ). Students became more proficient in performing FOCUS examination with time.

**Conclusions:** Teaching junior medical students to perform and interpret FOCUS was feasible after brief training and better than PE in detecting significant valvular lesions. Further studies are warranted to determine the utility of incorporating this new technology into mainstream medical training.

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## 1. Introduction

Physical examination (PE) is a time-honored clinical skill which takes years to become proficient. Errors in the detection and interpretation of clinical signs are common among medical students [1,2]. The diagnosis of valvular lesions based on auscultation of heart sounds is especially challenging for the inexperienced medical students [3,4]. Echocardiography is considered the gold-standard for the diagnosis and assessment of valvular heart disease. However, standard echocardiogram machines

are bulky, expensive and not readily available. In recent years, focused cardiac ultrasound (FOCUS) examination using portable pocket-sized ultrasound has been increasingly used for bedside diagnosis of cardiovascular diseases [5]. Combining traditional PE and FOCUS has the potential to improve bedside diagnostic accuracy as well as a tool to improve clinical skills [6–8]. A number of medical schools in the United States have integrated cardiac ultrasound skills as part of the curriculum with very positive student feedback and results [9]. This study aimed to teach medical students how to perform FOCUS to assess valvular heart disease in a 4-week student project and to evaluate the agreement between students performed FOCUS and PE to formal echocardiography.

## 2. Methods

### 2.1. Medicine year 3 selected study modules (SSM)

Ten medical students participated in this 4-week project as part of a Year 3 Selected Student Module (SSM) designed to stimulate in-depth study on topics of their own interest during the medical program and help equip students with a basic understanding of scientific research and related methods. Each SSM project is guided by an academic project supervisor.

**Abbreviations:** ECG, Electrocardiography; FOCUS, Focused cardiac ultrasound; K, Kappa; LEAP, Limited echo assessment project; PE, Physical examination; SSM, Selected student module; TTE, Transthoracic echocardiography.

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<sup>2</sup> This author is the medical student who participated in this project.

<sup>3</sup> This author is an academic physician with interest in medical education.

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## 2.2. Study population

We recruited 107 patients who underwent clinically indicated transthoracic echocardiography (TTE) at the Prince of Wales Hospital over two 4-week periods from April to May in 2014 and 2015. Standard TTE was performed by trained nurses or cardiologists using either Philips iE33 (Philips Medical, Best, Netherlands) or GE E9x machines (GE Healthcare, WI, U.S.A.). Valvular lesions of moderate to severe severity were considered significant in this study based on the assumption that moderate to severe lesions detected by TTE could be detected by PE, whereas mild lesions were assumed to be undetectable by auscultation. Each recruited patient was examined by more than one student to determine inter-observer variability. A brief medical history and PE of the cardiovascular system was performed by each student. History included the presenting symptoms and past medical history of the patient. PE was standardized to include inspection (jugular venous pressure, peripheral pitting edema, peripheral stigmata of endocarditis), palpation (arterial pulse, apex, right parasternal for ventricular lift, hepatomegaly), cardiac (quality of heart sounds, added heart sounds, murmurs), and lung (crepitations, wheeze, dullness) auscultation. PE was performed before FOCUS. The study was performed in accordance with the Declaration of Helsinki and approved by the Joint Chinese University of Hong Kong – New Territories East Cluster Clinical Research Ethics Committee (The Joint CUHK-NTEC CREC). All the participants had signed the consent form before taking part in this study. Only patients who were in stable condition and given informed consent were enrolled in the study.

## 2.3. Student performed pocket ultrasound

The V-scan (GE Healthcare, WI, U.S.A.) mobile pocket-sized ultrasound device was used in this study. The device can obtain two-dimensional imaging in B-mode and color flow Doppler. It also allows image storage and calipers for linear measurements. Ten Year 3 medical students with no prior knowledge and experience in echocardiography underwent 6 h of training by a cardiologist including 2-hour tutorial on echocardiographic anatomy, examination views and simple evaluation of valvular lesions; 1-hour case studies of valvular heart disease and 3-hour hands-on training on patients with different valvular heart diseases including aortic stenosis, aortic regurgitation, mitral stenosis, mitral regurgitation and tricuspid regurgitation. For this study, FOCUS examination was performed using 4 views: parasternal long- and short-axis, apical 4-chamber and subcostal views in B- and color Doppler-mode to detect significant (moderate or severe) aortic, mitral and tricuspid valve regurgitation or stenosis. Duration of the FOCUS examination was recorded.

## 2.4. Statistical analysis

Categorical and continuous data were presented as percentage and mean  $\pm$  SD, respectively. Chi-square test was used to compare sensitivity and specificity of the students' PE and FOCUS findings using TTE as the reference standard. Kappa ( $\kappa$ ) statistic was used for assessing agreement between the students' PE and FOCUS findings and TTE results. Kappa values  $< 0$  indicated no agreement and 0–0.20 as slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1 as almost perfect agreement. Inter-observer agreement was also assessed between students examining the same patient. SPSS version 22 (SPSS Inc., Chicago, IL, USA) was used for data analyses and 2-tailed *p*-value  $< 0.05$  was considered significant.

## 3. Results

### 3.1. Patient demographics

Patients' demographics were summarized in Table 1. The majority of patients were outpatients (61.7%). Indications for TTE included chest

**Table 1**  
Patient characteristics and transthoracic echocardiography results.

Baseline characteristics	Patients (n = 107)
Age, mean $\pm$ SD, years	63.7 $\pm$ 14.9
Inpatient	41 (38.3%)
Outpatient	66 (61.7%)
Men	69 (64.5%)
Presenting symptoms	
Chest discomfort/pain	21 (19.6%)
Palpitation	20 (18.7%)
Shortness of breath	27 (25.2%)
Past medical history	
Coronary artery disease	29 (27.1%)
Heart failure	21 (19.6%)
Congenital heart disease	3 (2.8%)
Valvular heart disease	25 (23.4%)
Hypertension	61 (57.0%)
Diabetes mellitus	28 (26.2%)
Hyperlipidaemia	31 (29.0%)
Smoking	25 (23.4%)
Transthoracic echocardiography results	Cases (n = 211)
Mitral regurgitation	
Normal or mild	161 (76.3%)
Moderate or severe	50 (23.7%)
Mitral stenosis	
Normal or mild	201 (95.3%)
Moderate or severe	10 (4.2%)
Aortic regurgitation	
Normal or mild	193 (91.5%)
Moderate or severe	18 (8.5%)
Aortic stenosis	
Normal or mild	200 (94.8%)
Moderate or severe	11 (5.2%)
Tricuspid regurgitation	
Normal or mild	174 (82.5%)
Moderate or severe	37 (17.5%)

pain (19.6%), palpitation (18.7%) and shortness of breath (25.2%). Many patients have known cardiovascular diseases including hypertension (57.0%), coronary artery disease (27.1%), valvular heart disease (23.4%), heart failure (19.6%) and congenital heart disease (2.8%). Among the 107 patients, 6 were examined by 1 student, 99 by 2 students and 2 by 4 students. Therefore, a total of 212 sets of student PE and FOCUS were collected for analysis. One TTE result could not be retrieved and therefore was excluded from analysis.

### 3.2. Transthoracic echocardiogram results

126 significant valvular lesions of moderate to severe severity were detected on TTE (Table 1): 23.7% (n = 50) mitral regurgitation, 4.2% (n = 10) mitral stenosis, 8.5% (n = 18) aortic regurgitation, 5.2% (n = 11) aortic stenosis, 17.5% (n = 37) had tricuspid regurgitation.

### 3.3. Physical examination agreement

Overall agreement between student PE and TTE was fair with  $\kappa$  value of 0.28 (Table 2 and Fig. 1). Agreement was highest for mitral regurgitation ( $\kappa = 0.39$ ) which was fair. Agreement for other lesions was worse with  $\kappa$  values ranging from 0.09 to 0.20.

### 3.4. Focused cardiac ultrasound agreement

Overall agreement between FOCUS and TTE ( $\kappa = 0.45$ ) was moderate and better than PE for all lesions (Table 2 and Fig. 1). Agreement for mitral stenosis ( $\kappa = 0.51$ ), mitral regurgitation ( $\kappa = 0.48$ ) and aortic stenosis ( $\kappa = 0.45$ ) were all moderate. Agreement for tricuspid ( $\kappa = 0.39$ ) and aortic regurgitation ( $\kappa = 0.23$ ) was fair.

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