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Diagnostic Accuracy of Emergency Physician - Focused Cardiac Ultrasound (EP-FOCUS) in Emergency Department

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A B S T R A C T

Background: Emergency physician (EP)-performed Focused Cardiac Ultrasound (EP FOCUS) is an important skill for the care of patients with potentially life-threatening presentation as chest pain, shortness of breath, shock or post-trauma. However, this relatively new skill in hands of emergency physicians may be less accurate compared to conventional Echocardiography. This study aimed to measure the diagnostic accuracy of bedside focused ultrasound cardiac examination in hands of emergency physicians (EP-FOCUS) in assessment forementioned presentation compared to findings verified by conventional Echocardiographers. Methods: This cross-sectional study was carried out on 100 patients aged from 18to 88 years old, both sexes, presented with acute onset of being unwell, dizziness, shortness of breath (SOB), transient loss of consciousness (TLOC) and blunt or penetrating chest trauma with provisional diagnosis of pericardial effusion, pulmonary embolism, ascending aortic dissection or congestive heart failure. EP-FOCUS was conducted and results compared with that of conventional Echocardiographer. Finally, diagnostic accuracy was calculated. Results: As a diagnostic for congestive heart failure, EP-FOCUS showed sensitivity, specificity, positive pressure ventilation (PPV), negative pressure ventilation (NPV) and accuracy 73, 88, 78, 84 and 83 respectively with measure of agreement kappa about 0.715. Regarding Pericardial Effusion EP-FOCUS showed sensitivity, specificity, PPV, NPV and accuracy of 86, 96, 93, 92 and 93 respectively with measure of agreement kappa about 0.826. As a diagnostic for pulmonary embolism EP-FOCUS showed sensitivity, specificity, PPV, NPV and Accuracy of 50, 92, 75, 81, and 80 respectively with measure of agreement kappa about 0.567. Conclusions: EP-FOCUS in trained hands can assist in accurate, timely diagnosis of such critical conditions and in its management consequently with acceptable accuracy.

Introduction

Echocardiogram (Echo) is a valuable tool in assessment of critically ill patients presenting to emergency department (ED) with a variety of symptoms such as undifferentiated shock, shortness of breath (SOB), syncope, chest pain and blunt or penetrating chest trauma **(**Sorensen and Hunskaar, 2019**)**. However, conventional Echocardiography examination may be time-consuming, requiring high level of training and experience making it less practical option in time-sensitive acute setting. Recently, Emergency physician (EP)-performed Focused Cardiac Ultrasound (EP FOCUS) is getting popular as an alternative, qualitative, bedside, point-of-caretest complementary to clinical assessment of such patients (Kirkpatrick *et al.,* 2020; Andersen *et al.,* 2022).

The "5Es" reflects a focused 5-steps ultrasound cardiac examination; where each E represents a specific assessment for immediately relevant clinical information. It includes assessment for presence of pericardial effusion, qualitative left ventricular ejection estimate, ventricular size equality, exit (aortic root diameter), and entrance (inferior vena cava diameter and respirophasic variation). This approach provides a reliable and easily recalled framework for assessing, teaching, and communicating EP FOCUS findings that are essential in caring for the patient in the emergency setting (Kirkpatrick *et al.,* 2020).

Findings obtained from such examination is highly crucial for patient management. Timely and accurate detection of a pericardial effusion is essential for expediting diagnosis and management given the wide range of symptoms and the potential for hemodynamic collapse **(**Guevarra and Greenstein, 2020; Hashim *et al.,* 2021**)**. Qualitative assessment of ejection fraction can help differentiate causes of hypotension, chest pain and dyspnea and may aid in expediting condition-specific therapies **(**Alerhand and Carter, 2019; Prada *et al.,* 2019**)**. Despite multiple quantitative modalities for LVEF calculation; qualitative estimates of ejection fraction by EP-FOCUS correlate well with both quantitative measurements and subjective estimates by cardiologists (Hussein *et al.,* 2019; Marik *et al.,* 2011). Estimating right ventricular (RV) size compared to left ventricle (LV) is paramount in diagnosis of possible pulmonary embolism as potential cause for SOB, chest pain and/or hemodynamic compromise.

The normal RV:LV diameter ratio is less than 0.6:1. When pressure in the pulmonary artery rises, the RV will dilate **(**Malbrain *et al.,* 2020**)**. Thoracic aortic dissection (TAD) is another time-dependent, potentially deadly disease process that can present silently or masquerade as a variety of clinical presentations (Fan *et al.,* 2022). Bedside accurate detection of aortic root dilation by emergency physicians is critical in patients presenting with acute chest pain and/or hemodynamic instability **(**Malbrain *et al.,* 2020**)**. Finally, qualitative assessment of inferior vena cava (IVC) size and respiratory changes is helpful in guessing cause of shock and gauging response to fluid therapy later on.

This study aimed to measure the diagnostic accuracy of bedside focused ultrasound cardiac examination in hands of emergency physicians (EP-FOCUS) in assessment of forementioned presentation compared to findings verified by conventional Echocardiographers.

Patients and Methods

This cross-sectional study was carried out on 100 patients aged from 18 to 88 years old, of both sexes, presented to ED with acute onset chest pain, dizziness, shortness of breath (SOB), transient loss of consciousness (TLOC), being unwell and blunt or penetrating chest trauma with provisional diagnosis of pericardial effusion, pulmonary embolism, congestive heart failure or ascending aortic dissection.

This study extended from September 2021 to January 2023, after approval from the Ethical Committee Tanta University Hospitals, Tanta,

Egypt. An informed written consent was obtained from the patients or their relatives. Pediatric age group < 18ys old, patients with burn, patients with myocardial infarction and patients with septic shock or in extreme hemodynamic instability were excluded.

All patients were subjected to: history taking, thorough clinical examination, laboratory and radiological investigations (as appropriate). Accordingly, included patients were categorized according to most possible initial diagnosis into 4 groups; pericardial effusion, pulmonary embolism, congestive heart failure or ascending aortic dissection. EP-FOCUS was performed by trained attending emergency physician to confirm or exclude clinical diagnosis and findings were recorded. Furthermore, patients were examined by an Echocardiographer blinded to EP-FOCUS findings. Again, patients diagnosis is documented and compared to emergency physician findings.

Machine setup and Examination Technique

The ultrasound machine (Digital ultrasound imaging system model Phillips affinity 50G) was used. The ultrasound machine was positioned so the screen was easily visible. Ambient lighting was reduced to maximize screen contrast. The depth setting was adjusted such that the organs were imaged.

Gain was adjusted to maximum contrast between different tissues. Transducer was held to the skin surface with the transducer marker (groove) pointing according to view and exam set; parasternal long (PLX) towards Rt shoulder, parasternal short (PSX) towards Lt shoulder, subxiphoid towards Lt shoulder and Apical four chamber (A4C) towards Lt elbow.

The 1st "E" is for Effusion

The subcostal window is the most reliable view for detecting pericardial effusions. In this window, the liver can also help provide an acoustic window to the inferior pericardium (Figure 1).

The 2nd "E" is for Ejection

For a visual determination of LVEF, the PLX view is an excellent initial window. The PLX includes the septum, apex, and posterior LV wall.

Movement of the anterior leaflet of the mitral valve so that it nearly touches the septum in diastole correlates with good LV filling and thus a good ejection fraction. (Figure 2)

The 3rd "E" for Equality

It was for equality, referring to the relative size of the RV to the LV. When the A4C view was properly obtained, all four chambers were visible and divided by a vertically oriented interventricular septum.

In healthy patients, the RV is a low-pressure, thin-walled, high-compliance chamber that is wrapped anteriorly around the muscular, cone-shaped LV. The normal RV: LV diameter ratio of less than 0.6:1. When pressure in the pulmonary artery rises, the RV dilates approaching diameter of LV.

The 4th "E" for EXIT

The proximal aortic root was best assessed using a PLX window. Diameter greater than 4 cm is used as threshold to diagnose ascending aortic aneurysm.

The 5th "E" is for Entrance

Assessment of the IVC requires a subcostal or subxiphoid approach. The IVC is assessed in terms of overall size and collapsibility. The qualitative assessment of the IVC entitles describing it as flat or plethoric, collapsible or not.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD). Qualitative variables were presented as frequency and percentage (%).

Results and Discussion

Mean age of study population was 48 ± 18, with slight male predominance; 58(58%) were male and 42 (42%) were female. Among this study patients, 40 % presented by chest trauma {27(27%) with blunt chest trauma, 13 (13%) with penetrating chest trauma} and the other 60(60%) patients were non traumatic. Regarding presenting complaints, 79(79%) patients presented by SOB, 72(72%) patients complained of Chest pain, 14(14%) patients presented by Orthopnea and 12(12%) patients presented by transient loss of consciousness (TLOC) (Table 1).

After clinical, laboratory and radiological assessment of this study patients. They were subdivided into 3 groups depending on most probable provisional diagnosis; Pericardial effusion (40 patients), pulmonary embolism (20 patients) and Congestive heart failure (40 patients).

Unfortunately, no patients with potential ascending aortic dissection was encountered. Findings of EP-FOCUS and conventional Echocardiography were then compared to calculate sensitivity, specificity, predictive values and overall diagnostic accuracy of EP-FOCUS.

As a diagnostic for congestive heart failure, EP FOCUS showed Sensitivity Specificity, PPV, NPV and Accuracy 73, 88, 78, 84 and 83 respectively with measure of agreement kappa about 0.715. Regarding Pericardial Effusion EP FOCUS showed Sensitivity, Specificity, PPV, NPV and Accuracy of 86, 96, 93, 92 and 93 respectively with measure of agreement kappa about 0.826. While for Pulmonary Embolism EP FOCUS showed Sensitivity, Specificity, PPV, NPV and Accuracy of 50, 92, 75, 81, and 80 respectively with measure of agreement kappa about 0.567 (Table.2).

Bedside emergency department echocardiography is a brief and rapid usage of cardiovascular ultrasound focusing on specific goal-directed indications, such as assessing cardiac function and contractility, to help differentiate the causes of shock, chest pain, SOB and TLOC in patients or to look for reversible causes during cardiac arrest; ruling out pericardial effusion causing hemodynamic compromise; and measuring the inferior vena cava (IVC) diameter to help guide fluid management, to help EP make the correct diagnosis, treatment, and enhanced disposition decision, and significantly improve patient care (Fan *et al.,* 2022). Moreover, identification of RV enlargement is identified as important to "prioritize further testing, alter differential diagnosis assessments, and assist with treatment decisions" for patients with possible PE (Vaid *et al.,* 2022).

The present study included 100 patients with the age of the study population ranged from 18 to 88 years with mean was 48 ± 18 with slight male predominance. Most patients were non-traumatic with chest pain and shortness of breath being the most important presenting complaints. Randazzo *et al.,* (2003) found that indications for echocardiography included chest pain (45.1%), congestive heart failure (38.1%), dyspnea (5.7%), and endocarditis (10.6%). Hall *et al.,* (2015) reported that the 5Es encompass the cardiac US findings most applicable in patients who present emergently with hypotension, dyspnea, syncope, penetrating thoracic trauma, chest pain, or other acute complaints where diagnosis may be aided by visualization of the heart.

The provisional working diagnosis by emergency physician in the present study was pericardial effusion (40%), CHF (40%) and pulmonary embolism (20%). Aortic dissection wasn't assigned as a provisional diagnosis of any of this study patient.

In the present study result, regarding pericardial effusion EP ECHO showed sensitivity, specificity, PPV, NPV and accuracy of 86, 96, 93, 92 and 93 respectively. The present study result was in agreement with Bustam *et al.,* (2014) who reported that the trainees detected pericardial effusion with a sensitivity of 60%, specificity of 100%, positive predictive value of 100% and negative predictive value of 97.9%.

Table.1 Descriptive analysis of Socio-demographic data and patient categories of studied cohort

		N (100)
Age		48 ± 18
Sex	**Male**	58(58.0%)
	Female	42(42.0%)
Patients categories		
Penetrating chest Trauma		13(13.0%)
Blunt chest trauma		27(27.0%)
Non traumatic		60(60%)
Patientscomplaints		
SOB		79(79.0%)
Chest Pain		72(72.0%)
Orthopnea		14(14.0%)
TLOC		12(12%)

Data are presented as mean ± SD or frequency (%), SOB: Shortness of breath, TLOC: Transient loss of consciousness.

Table.2 Estimates of diagnostic accuracy of EP-FOCUS in different clinical conditions.

Congestive heart failure								
		Conventional Echo		**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Measure of Agreement Kappa**
		+ve	**-ve**					
EP focus	**+ve**	11	3	73%	88%	78%	84%	0.715
	-ve	4	22					
Pericardial Effusion								
EP focus	**+ve**	13	1	86%	96%	93%	92%	0.826
	-ve	2	24					
Pulmonary Embolism								
EP focus	**+ve**	3	1	50%	92%	75%	81%	0.567
	-ve	3	13					

Data are presented as frequency (%), PPV: Positive pressure ventilation, NPV: Negative pressure ventilation, EP: Emergency Physician.

Fig.1 Parasternal view with large effusion

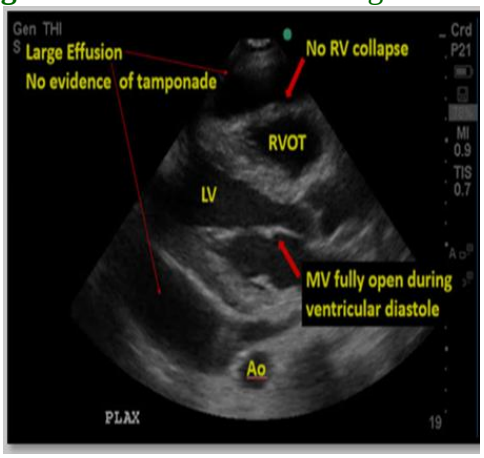
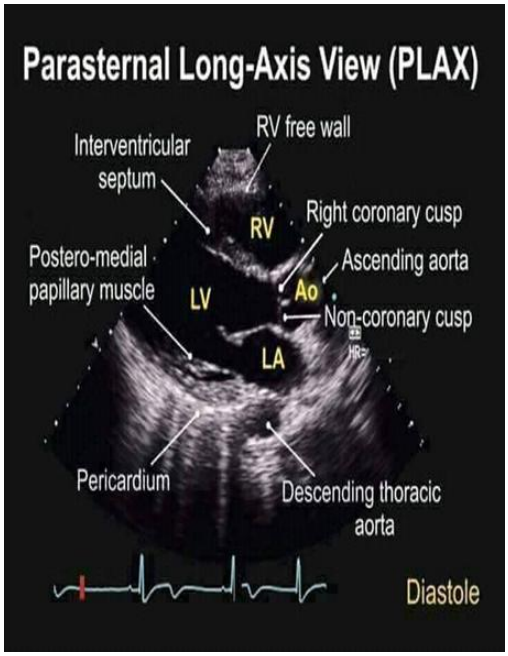


Fig.2 Parasternal view PSLA



Similarly, Mandavia *et al.,* (2001) designed a prospective study on emergency patients presenting with high-risk criteria for the diagnosis of pericardial effusion underwent emergency bedside 2-dimensional echocardiography by emergency physicians who were trained in ultrasonography to assess the accuracy of echocardiography performed by emergency physicians to detect pericardial effusions. Emergency physicians detected pericardial effusion with a sensitivity of 96%, specificity of 98%, and overall accuracy of 97.5%.

In the present study result, as a diagnostic for congestive heart failure, EP ECHO showed sensitivity, specificity, PPV, NPV and accuracy 73, 88, 78, 84 and 83 respectively. In agreement with the present study results, Moore *et al.,* (2002) found that emergency physicians with focused training in echocardiography can accurately determine LVF in hypotensive patients. Bustam *et al.,* (2014) showed substantial agreement with that made by the cardiologist (93%, K=0.79, n=100). Even with limited training, emergency medicine trainees were able to use visual estimation for global LV function with reliable accuracy. Using the more time-consuming method of M-mode measurements for LVEF did not add to significant increase in the trainees' accuracy. Therefore, in the busy emergency department, the use of one method rather than both methods for LV function estimation is reliable enough and can save time and costs. The visual technique to estimate LV function by emergency medicine trainees is not only accurate but also quicker to perform.

In the present study result, for pulmonary embolism EP ECHO showed sensitivity, specificity, PPV, NPV and accuracy of 50, 92, 75, 81 and 80 respectively. These results were also observed by Dresden *et al.,* (2014) who performed a prospective observational study to determine the diagnostic performance of right ventricular dilatation identified by emergency physicians on bedside echocardiography in patients with a suspected or confirmed pulmonary embolism. Pulmonary embolism on echocardiography had a sensitivity of 50%, a specificity of 98%, a positive predictive value of 88%, and a negative predictive value of 88% respectively. Moreover, Taylor and Moore (2014) conducted a retrospective cohort study of consecutive emergency department (ED) patients undergoing limited echo examinations for chest

pain, SOB, or hypotension and a subsequent consultative echo within 72 hours. The specificity of right ventricular dilation (RVD) on limited echo for right ventricular strain (RVS) was 95% with 6 false-positive categorizations, whereas the sensitivity was 95%.

So, Echocardiography performed by emergency physician has the most specificity and sensitivity in pericardial effusion then in congestive heart failure but the least in pulmonary embolism. There are several possible explanations for reduced levels of sensitivity in case of pulmonary embolism. First EPs in general may not be skilled at identifying more subtle signs of RVS on limited Echo and more experience is needed for the operators to overcome limitations and difficulties that may face them.

Limitations of this study were being a single center study with small sample size and absence of any patients with suspected aortic dissection. This study did not provide enough data to make associations between the findings of severe LV dysfunction with cardiogenic cause or between the IVC data with hypotensive patients. Furthermore, this study did not investigate the effect of such technique on overall patient outcome.

EP-FOCUS can rapidly be performed to determine the urgency of a cardiology consultation or echocardiography and to confirm whether the patient is stable enough to be transported to the echocardiography suite. Diagnostic accuracy and agreement was achieved highly in diagnosis of pericardial effusion, followed by congestive heart failure being least for pulmonary embolism. Taking these limitations in consideration, further training programs for emergency physicians should be designed.

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Conflict of Interest

Nil

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