

## Focused Cardiac Ultrasound Using a Pocket-Size Device in the Emergency Room

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### Abstract

**Background:** Cardiovascular urgencies are frequent reasons for seeking medical care. Prompt and accurate medical diagnosis is critical to reduce the morbidity and mortality of these conditions.

**Objective:** To evaluate the use of a pocket-size echocardiography in addition to clinical history and physical exam in a tertiary medical emergency care.

**Methods:** One hundred adult patients without known cardiac or lung diseases who sought emergency care with cardiac complaints were included. Patients with ischemic changes in the electrocardiography or fever were excluded. A focused echocardiography with GE Vscan equipment was performed after the initial evaluation in the emergency room. Cardiac chambers dimensions, left and right ventricular systolic function, intracardiac flows with color, pericardium, and aorta were evaluated.

**Results:** The mean age was  $61 \pm 17$  years old. The patient complaint was chest pain in 51 patients, dyspnea in 32 patients, arrhythmia to evaluate the left ventricular function in ten patients, hypotension/dizziness in five patients and edema in one patient. In 28 patients, the focused echocardiography allowed to confirm the initial diagnosis: 19 patients with heart failure, five with acute coronary syndrome, two with pulmonary embolism and two patients with cardiac tamponade. In 17 patients, the echocardiography changed the diagnosis: ten with suspicious of heart failure, two with pulmonary embolism suspicious, two with hypotension without cause, one suspicious of acute coronary syndrome, one of cardiac tamponade and one of aortic dissection.

**Conclusion:** The focused echocardiography with pocket-size equipment in the emergency care may allow a prompt diagnosis and, consequently, an earlier initiation of the therapy. (Arq Bras Cardiol. 2014; 103(6):530-537)

**Keywords:** Echocardiography; Diagnostic Equipment, Emergency Medical Services; Diagnostic Imaging.

### Introduction

Emergency care services play an important role in the treatment of cardiac emergencies, such as acute coronary syndrome (ACS), aortic dissection, acute cardiac failure, arrhythmias, cardioembolic stroke, and cardiac tamponade; the rapid recognition and treatment of these conditions are fundamental to better outcomes<sup>1,2</sup>.

Data from the United States indicate that approximately 10% patients who seek these services present with chest pain or dyspnea<sup>3</sup> as their chief complaint, and ischemic and nonischemic heart diseases are the leading causes of hospitalization after emergency care<sup>3</sup>. Although many advances have been made in diagnosing such conditions, some patients

with ACS are discharged without receiving the correct diagnosis<sup>4</sup>, which consequently increases their mortality<sup>5,6</sup>.

Echocardiography is a noninvasive, low-cost and reproducible examination<sup>7</sup> that has great diagnostic and prognostic value in patients with suspected ACS<sup>8</sup> and acute cardiac failure<sup>2</sup>. It also assists in determining the appropriate therapy for patients with arrhythmias<sup>9,10</sup>.

Recent technological advances in the field of ultrasound have made it possible to build echocardiography equipment just slightly larger than a smart phone that fits in the pocket of a lab coat, permitting its quick use in an emergency at the patient's bedside.

The aim of this study was to describe our initial experience using an ultra-portable echocardiography device to perform focused cardiac ultrasound (FoCUS) in the emergency department; our objective was also to observe the number of cases in which the initial clinical diagnosis was confirmed or was altered after the cardiac ultrasound, and describe any technical difficulties related to the use of this device.

### Methods

The patients in the study were adults who sought treatment from the emergency department in a tertiary hospital for the

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chief complaint of chest pain, dyspnea, or palpitations, and whose diagnosis was questioned after the initial assessment. The initial assessment consisted of the assessment the medical history, physical examination, electrocardiography (ECG) reading. Patients with known cardiac or pulmonary disease were excluded, as were those with ischemic changes in ECG (ST-segment depression or elevation) or fever (axillary temperature  $\geq 37.8^{\circ}\text{C}$ ).

All participants signed an informed consent form and the study was approved by the institution's Ethics Committee (process registration number 16723413.7.0000.5505).

### Ultra-portable FoCUS

FoCUS scans were carried out using the ultra-portable Vscan device (GE Healthcare, Milwaukee, Wisconsin, USA) shown in Figure 1, and were performed by a single cardiologist. FoCUS scans were carried out in a targeted manner and at the patient's bedside shortly after the initial clinical evaluation and ECG reading, with the goal of resolving doubts about the diagnosis. Subjective analysis was performed on the two-dimensional images and color flow mapping, focusing on the following aspects: the dimensions of the cavities, global systolic function, evaluation of segmental and global contractility of the left ventricle (LV), right ventricular systolic function, anatomical appearance of the mitral and aortic valves, presence of significant mitral and aortic valve regurgitation, presence of indirect signs of pulmonary hypertension (dilatation of the right chambers, bulging of the interventricular septum to the left, dilatation of the pulmonary trunk), presence of pericardial effusion, assessment of the dimensions of the thoracic aorta (ascending aorta and aortic arch), and presence of a dissection line.

### Statistical analysis

The statistical calculations were performed using Microsoft Excel 2010. Continuous data were presented as mean  $\pm$  standard deviation and categorical data were presented as percentages.

### Results

One hundred patients were evaluated: 54 were male, with an average age of  $61 \pm 17$  years (range: 15–95 years).

The most common chief complaint among the study participants was chest pain ( $n = 52$ ), followed by dyspnea ( $n = 32$ ), palpitations ( $n = 10$ ), dizziness/unease associated with hypotension ( $n = 5$ ), and lower limb edema ( $n = 1$ ), as can be seen in Table 1.

The most frequent diagnosis after assessment of medical history, physical examination, and ECG reading was of ACS ( $n = 51$ ), followed by cardiac failure ( $n = 29$ ), pulmonary embolism ( $n = 4$ ), cardiac effusion or cardiac tamponade ( $n = 3$ ), shock of undetermined etiology ( $n = 2$ ), and aortic dissection ( $n = 1$ ). In addition, in 10 patients with arrhythmias (seven with atrial fibrillation, two with ventricular tachycardia, and one with junctional tachycardia), FoCUS was used to assess LV systolic function to assist in guiding therapy (Table 2).

In all patients, it was possible to obtain good-quality images using the ultra-portable FoCUS device.

Of the 90 patients with uncertain initial diagnosis, the suspected clinical diagnosis at admission was confirmed using FoCUS in 28 (31%) of them (Table 3); 19 (68%) patients with cardiac failure, five (18%) with ACS, two (7%) with pulmonary embolism and two (7%) with cardiac tamponade.

In one of the patients with cardiac failure and significant systolic dysfunction in LV, a blood clot was observed in the apical region of LV (Figures 2 - 4).

Furthermore, of these 90 patients with uncertain diagnoses after initial assessment, FoCUS led to a change in the initial diagnosis in 17 (19%) of them (Table 4). In 10 patients with an initial suspected diagnosis of cardiac failure, the ultrasound showed neither systolic dysfunction nor indirect signs of diastolic dysfunction (enlarged left atrium or LV hypertrophy), although it was possible to identify other cardiac causes for the observed cardiac failure (hypertrophic cardiomyopathy and severe aortic stenosis) in two of these patients. In the remaining patients with suspicion of pulmonary embolism (two cases), shock of undetermined etiology (two cases), and cardiac tamponade (one case), FoCUS yielded normal results, ruling out cardiac causes. In the two patients with suspected pulmonary embolism, the suspected diagnosis was of intermediate level and with normal results from the FoCUS exam, this hypothesis was clinically discarded. In one patient with chest pain and suspected ACS, the ultrasound findings were compatible with pericarditis (pericardial thickening associated with discrete stroke); in one patient with suspected aortic dissection, no dilatation of the aorta, dissection lines, or aortic insufficiency were seen in the ultrasound; only significant LV hypertrophy was observed.

Of the 10 patients who arrived at the emergency department with sudden-onset symptomatic arrhythmias (seven with atrial fibrillation, two with ventricular tachycardia, and one with junctional tachycardia), LV systolic dysfunction was observed in four, atrial fibrillation in two, and ventricular tachycardia in two; the remainder showed normal systolic LV function.

In 45 (50%) of the 90 patients with uncertain diagnoses after the initial assessment, the ultra-portable FoCUS did not yield data that confirmed or changed the initial diagnostic hypothesis, and other supporting examinations were necessary.

### Discussion

This study allowed us to demonstrate the great utility of cardiac ultrasound done with ultra-portable equipment at the bedside in a clinical emergency department. It was performed in patients who had no certain diagnosis after assessment of the medical history, physical examination, and ECG reading. The ultra-portable FoCUS allowed to confirm diagnosis of 31% patients, and led to a change in the original diagnosis in 19% patients.

The greatest clinical benefit of using FoCUS in this sample was the confirmation or ruling out of the diagnosis of cardiac failure due to LV dysfunction, because it was possible to diagnose other cardiac diseases (aortic stenosis and hypertrophic cardiomyopathy) as the cause of cardiac failure in two patients.



Figure 1 – Vscan device (GE Healthcare) used in this study.

Table 1 – Chief complaint prompting patients to seek emergency care

Chief complaint	n = 100
Chest pain	52
Dyspnea	32
Palpitations	10
Dizziness/hypotension	5
Lower limb edema	1

In patients with suspected pulmonary embolism, FoCUS permitted a faster diagnosis in approximately half the patients, and consequently therapy was initiated more quickly. The cases with suspected cardiac tamponade were similar: two of three patients had their diagnosis confirmed quickly, and pericardial fluid was drained sooner.

In 10% patients with chest pain and suspected ACS, where ECG reading did not prove the diagnosis, FoCUS showed evidence of contractile segment changes.

This finding, in a patient with a clinical history compatible with myocardial ischemia and no history of prior coronary disease, can be used to confirm the clinical diagnosis of ACS. Furthermore, in one patient, FoCUS showed signs of pericarditis, changing the initial diagnostic hypothesis. Although the percentage of patients with chest pain, normal ECG, and changes in the contractile segments in the ultrasound

Table 2 – Main diagnostic hypotheses after assessment of medical history, physical examination, and ECG reading

Initial Suspected Diagnosis	n = 100
Acute coronary syndrome	51
Heart failure	29
Arrhythmia	10
Pulmonary embolism	4
Cardiac effusion/cardiac tamponade	3
Shock of undetermined etiology	2
Aortic dissection	1

was small, this population is frequently seen in emergency services and there is clear evidence that faster treatment of ACS leads to lower morbidity and mortality<sup>1</sup>. Consequently, this diagnostic tool is of great importance for these patients.

The use of FoCUS in this sample was also important in assessing LV function in patients who arrived with paroxysmal arrhythmias. Especially in atrial fibrillation, the choice of medication for controlling heart rate and pharmacological cardioversion should take into account the presence or absence of LV dysfunction<sup>10</sup>.

The possibility of quickly confirming or excluding a diagnosis in severe cases without needing to wait for more

complex and more time-consuming tests that are not always immediately available in emergency departments is essential, because it allows for early treatment of serious illnesses, such as ACS, aortic dissection, acute cardiac failure, pulmonary embolism, and cardiac tamponade.

In addition, the fact that the examination can be carried out at the bedside in a timely manner, with an easily transportable device and with no need for patient transport, provides the ultra-portable equipment with a unique advantage in rapidly clarifying specific issues and streamlining care in emergency departments. Furthermore,

FoCUS allowed significant numbers of patients to avoid unnecessary and, at times, potentially harmful therapy.

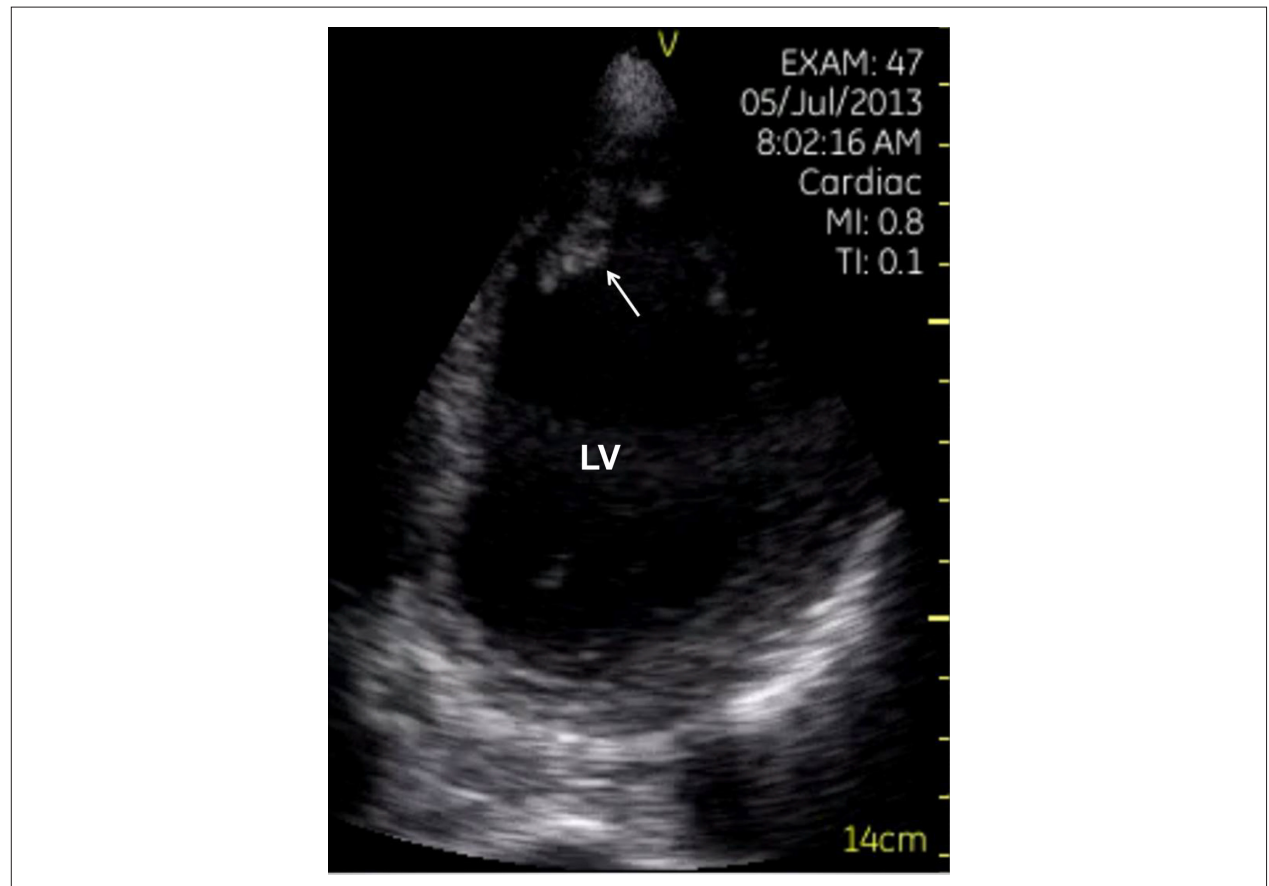
Despite great laboratorial and technical advances, there are still difficulties in the rapid diagnosis of acute and potentially fatal cardiovascular diseases. Approximately 2%–8% patients with ACS are discharged from emergency departments without the correct diagnosis<sup>4</sup>, resulting in increased mortality<sup>5,6</sup>.

Dyspnea is an important symptom that drives patients to seek emergency medical care, and rapid diagnosis of the cause is required<sup>11</sup>. The main causes of dyspnea in these patients are cardiac or pulmonary in origin<sup>12</sup>; however, it is difficult to distinguish between these causes, and the clinical history and physical examination are inconclusive in several cases<sup>13,14</sup>. Although a diagnosis of acute cardiac failure can be made clinically in most cases, a diagnostic doubt may remain in some cases. In this study, the FoCUS allowed for the rapid confirmation or exclusion of the heart as the cause of dyspnea, without the need for time-consuming or detailed diagnostics, such as the evaluation of brain natriuretic peptide (BNP) levels.

Recent studies with the ultra-portable device also demonstrated its usefulness for clinical diagnosis, although they included stable patients who were hospitalized.

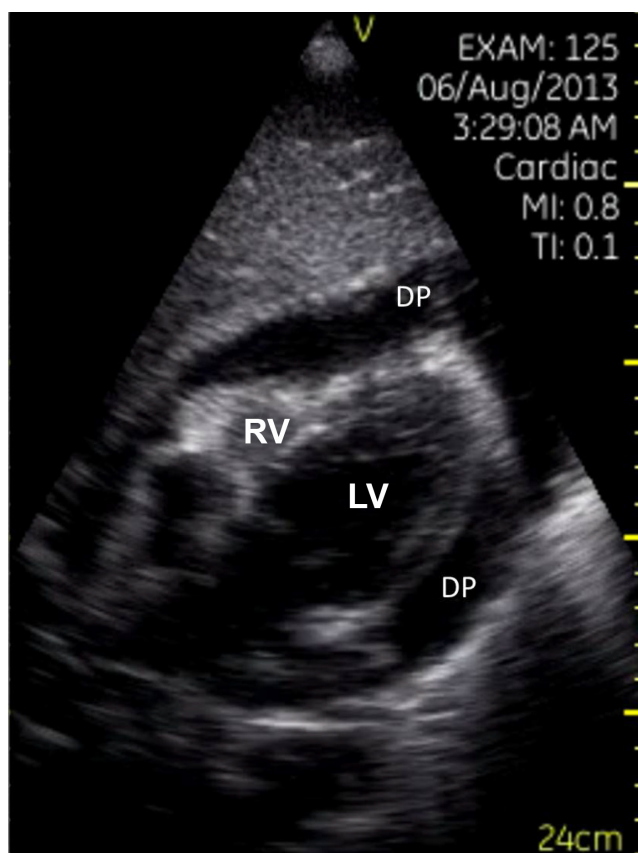
**Table 3 – Patients in whom the initial diagnosis was confirmed by ultra-portable cardiac ultrasound (n = 28)**

Definitive Final Diagnosis	n = 28 n (%)
Heart failure	19 (68)
Acute coronary syndrome	5 (18)
Pulmonary embolism	2 (7)
Cardiac tamponade	2 (7)



**Figure 2 –** Patient complaining of dyspnea. Portable cardiac ultrasound revealed dilated cardiomyopathy with systolic dysfunction of the left ventricle (LV) and a thrombus in apical region (arrow) in the apical window.





**Figure 3** – Significant pericardial effusion (DP) in the subcostal plane showing signs of restricted ventricular filling in a patient with cardiac tamponade. RV: right ventricle; LV: left ventricle.

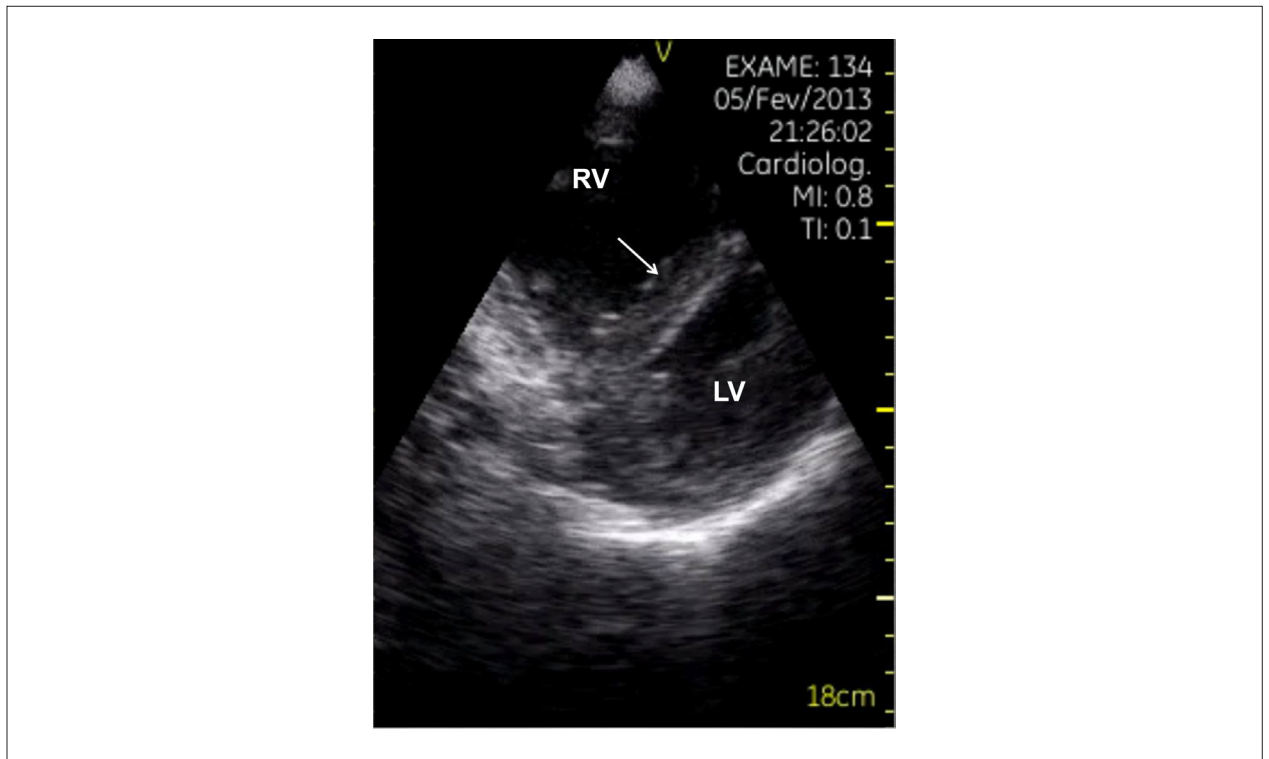
A Norwegian study that included patients admitted to an internal medicine ward, evaluated the use of the device and noted a change in initial diagnosis in 18% patients<sup>15</sup>, a result similar to the one seen in this study; however, the studies were performed with populations with different diseases. FoCUS has also been tested as a tool for resolving clinical doubts in patients admitted to cardiology wards, where it provided good results for most patients in whom it was used, and also was consistent with conventional Doppler echocardiography<sup>16</sup>. Moreover, in the outpatient setting, FoCUS improved the diagnostic accuracy of medical histories and physical examinations in patients with various diseases<sup>17</sup>. It is important to note that, unlike in the present study, in the cited studies, the FoCUS ultrasound was performed by physicians, not ultrasound technicians, indicating that FoCUS does not need to be performed by a specialist.

In contrast with previous studies<sup>15-17</sup>, this was the first study to use ultra-portable FoCUS only in patients who were seen in the emergency department shortly after the assessment of medical history, physical examination, and ECG reading. Furthermore, this study was conducted in a clinical emergency department in a tertiary general hospital

that comprised patients with acute clinical disease of various etiologies (cardiac or otherwise). This excluded the bias involved with an exclusive cardiac emergency ward, where most patients have acute cardiovascular diseases.

FoCUS ultrasound should not be considered a complete Doppler echocardiographic examination<sup>18,19</sup>, and should be used as a tool to assess heart disease in the population<sup>20</sup> or as a complement to physical examination<sup>17,18</sup>, as a targeted examination that addresses a specific concern and improves diagnostic speed and accuracy<sup>18</sup>, exactly as shown in the results of the present study. The aim of performing FoCUS in an emergency scenario is to speed up the main diagnosis, especially when a complete echocardiogram is not immediately feasible. The majority of patients undergoing FoCUS will require a conventional echocardiogram, along with all the structural and hemodynamic measurements offered by this diagnostic, to fine-tune therapy and for medium and long term follow-up.

The ultra-portable device used in this study proved to be effective for obtaining good two-dimensional images and good-quality color flow mapping. The device allowed performing some linear measurements, but cavity measurements were not obtained in our study. The device



**Figure 4** – Dilatation of the right ventricle (RV) and rectification of the interventricular septum in the parasternal view, in a patient with dyspnea and suspected pulmonary thrombosis.

**Table 4** – Patients in whom the diagnostic hypothesis was changed after ultra-portable cardiac ultrasound (n = 17)

Initial diagnostic hypothesis	Diagnosis after ultrasound
Heart failure (n = 10)	COPD (n = 4)
	ARF with hypervolemia (n = 2)
	Pneumonia (n = 1)
	Severe aortic stenosis (n = 1)
	Hypertrophic cardiomyopathy (n = 1)
Pulmonary embolism (n = 2)	Anxiety (n = 1)
	COPD (n = 1)
Shock of undetermined etiology (n = 2)	Pneumonia (n = 1)
	Septic shock (n = 2)
Acute coronary syndrome (n = 1)	Pericarditis
Cardiac tamponade (n = 1)	Dehydration
Aortic dissection (n = 1)	Postprandial angina

*COPD: chronic obstructive pulmonary disease; ARF: acute renal failure.*

does not allow measurements of area and volume, and also does not have continuous or pulsed Doppler; thus, it limits objective measurements, such as LV ejection fraction (Simpson method) or the quantification of valvular stenosis/insufficiency.

Consequently, this study demonstrated that the use of FoCUS in a clinical emergency department allowed for the rapid confirmation or exclusion of diagnostic hypotheses in cases where there was doubt regarding the diagnosis after the assessment of medical history, physical examination, and ECG reading.

### Limitations

This was a descriptive study that did not compare FoCUS with a conventional examination. However, this comparison has already been made in previous studies, validating the use of this new diagnostic tool<sup>16,17,21-23</sup>.

The examinations in this study were performed by a single cardiologist with experience in echocardiography. However, several previous studies have shown that FoCUS performed by physicians who are not specialists in echocardiography is accurate as a complementary investigation to physical examination<sup>15-17,21-27</sup>. In addition, it has been demonstrated that nonspecialist physicians can undergo a brief training to learn how to perform FoCUS<sup>24,28</sup>.

### Conclusion

Ultra-portable cardiac ultrasound used in an emergency department aided in quickly confirming or ruling out clinical

diagnoses and, consequently, beginning treatment more quickly and avoiding inappropriate therapy for incorrect diagnoses. Because this is a descriptive study, it is necessary to perform comparative and randomized studies to confirm these results.

### Author contributions

Conception and design of the research: Mancuso FJN, Siqueira VN, Gois AFT, Carvalho ACC, Campos O; Acquisition of data and Statistical analysis: Mancuso FJN; Analysis and interpretation of the data: Mancuso FJN, Siqueira VN, Moisés VA; Writing of the manuscript: Mancuso FJN, Siqueira VN, Moisés VA, Campos O; Critical revision of the manuscript for intellectual content: de Paola AAV, Carvalho ACC.

### Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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There were no external funding sources for this study.

### Study Association

This study is not associated with any thesis or dissertation work.

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