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Accuracy of Emergency Physicians for Detection of Regional Wall Motion Abnormalities in Patients With Chest Pain Without ST-Elevation Myocardial Infarction

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Abbreviations

ACS, acute coronary syndrome; CI, confidence interval; ECG, electrocardiography; ED, emergency department; EP, emergency physician; FOCUS, focused cardiac ultrasound; MI, myocardial infarction; RWMA, regional wall motion abnormality; STEMI, ST-elevation myocardial infarction; US, ultrasound; USAP, unstable angina pectoris

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Objectives—Our aim was to evaluate the accuracy of emergency physicians (EPs) in the detection of regional wall motion abnormalities (RWMAs) using focused cardiac ultrasound (FOCUS) in patients suspected of non–having ST-elevation myocardial infarction.

Methods—We prospectively enrolled patients with chest pain. Three EPs underwent didactics and hands-on-training, of 3 hours each, by an experienced cardiologist, on detecting RWMAs using 2-dimensional echocardiography. They performed a FOCUS examination to evaluate for RWMAs and recorded the echo images. Our reference standard for the detection of RWMAs was accepted as a blinded cardiologist review of the prerecorded video clips. We calculated the corrected sample size and inter-rater agreement between the EPs (82 and 0.83, respectively). The analysis of the study was performed on 89 patients.

Results—Eighty-nine patients with chest pain were screened. Emergency physicians demonstrated the detection of RWMAs with good sensitivity and even excellent specificity: 76.9% (95% confidence interval [CI], 56.4%– 91.0%) and 92.1% (95% CI, 82.4%–97.4%), respectively. The accuracy of FOCUS was 87.6% (95% CI, 79.0%–93.7%). The area under the curve from a receiver operating characteristic curve analysis, which evaluated the EPs' rate of detecting the presence or absence of RWMAs, was 0.845 (95% CI, 0.753–0.913).

Conclusions—Our study results suggest that EPs with training in bedside echocardiography can accurately rule in patients with RWMAs in suspected non–ST-elevation myocardial infarction cases.

Key Words—chest pain; echocardiography; emergency department; focused cardiac ultrasound; non–ST-elevation myocardial infarction

Chest pain is one of the most common causes of visits to the emergency department (ED) and accounts for approximately 10% of the annual ED admissions in the United States. Acute coronary syndrome (ACS) is considered in 10% to 15% of these patients. Despite all diagnostic tests, approximately 1.1% to 2.1% of patients with ACS are discharged from the ED without a diagnosis.[1–3]

Due to limitations in the history, physical examination, and electrocardiography (ECG), accurate identification of patients at risk among the low-risk cases is difficult in the ED. Additionally, serial cardiac markers cause substantial time delays.[4] However, Agewall et al[5] showed that an increase in serum troponin levels may result from nonischemic myocardial cell damage. The diagnosis of ST-elevation myocardial infarction (STEMI) can be made by ECG unless the patient is in shock. Truly, the most difficult situation for the emergency physician (EP) is to make a decision in the non-STEMI group.

Echocardiography is recommended by international European Society of Cardiology guidelines to support the diagnosis of non-STEMI by detecting a new regional wall motion abnormality (RWMA).[6,7] Previously, the literature showed that studies have been published to evaluate RWMAs using echocardiography. However, most of these studies were performed by cardiologists who evaluated echocardiographic findings in patients with STEMI.[8] Although, the literature shows sufficient studies in this regard by cardiologists, the same is not being adequately explored by EPs.

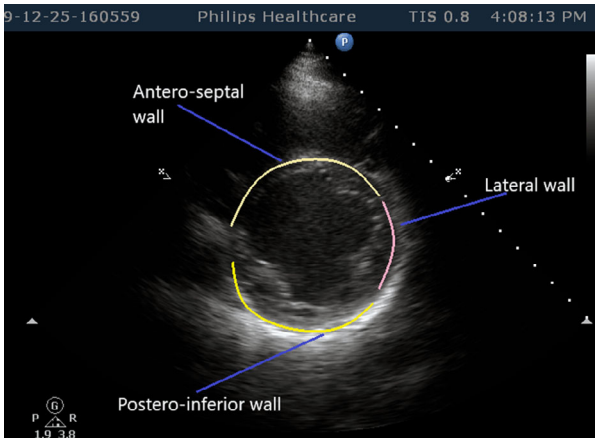
The use of ultrasound (US), though, is common among EPs in the ED (eg, focused assessment with sonography for trauma) for assessments of patients with trauma, inferior vena cava assessments in hypovolemic patients, and the rapid US for shock and hypotension protocol in critical patients. Previous studies have reported focused cardiac ultrasound (FOCUS) examinations performed by EPs for detection of pericardial fluid,[9] evaluation of left ventricular systolic dysfunction,[10] and other conditions[11,12] with a high accuracy rate, but there are very few studies showing the ability of EPs to interpret ischemic RWMAs.[8,13–16] Therefore, in this study, our aim was to evaluate the accuracy of the EPs in the detection of RWMAs using bedside echocardiography in patients with chest pain suspected having of non-STEMI.

Materials and Methods

The study data were collected prospectively in the ED of a training and research hospital having a capacity of 700 beds, where 180,000 to 200,000 patients are admitted to the ED annually. The study was approved by the Ethics Committee of the hospital. A total of 3 EPs with 5 years of experience in bedside US participated in this study. They have attended a 2-day point-of-care US course organized by the Emergency Physicians Association of Turkey, which was accredited by European Accreditation Committee for Continuous Medical Education. The course had theoretical and hands-on training about point-of-care cardiac, lung, and hepatobiliary US and also the focused assessment with sonography for trauma. They underwent didactics and hands-on training, of 3 hours each, by an experienced cardiologist, on detecting RWMAs using 2-dimensional echocardiography before the study. An RWMA is considered on a FOCUS examination when hypokinesis, akinesis, and dyskinesis are noted.[17] Hypokinetic segments thicken less than 30% in systole and indicate a dysfunctional myocardium. Akinetic segments do not thicken at all. Dyskinetic segments actually bulge away from the center of the left ventricle in systole.[17] These definitions are derived from the guidelines of the American Society of Echocardiography.[18] After the training period, the EPs performed 25 cases, each with and without supervision; however, all were evaluated by the cardiologist through recorded videos.[8,14]

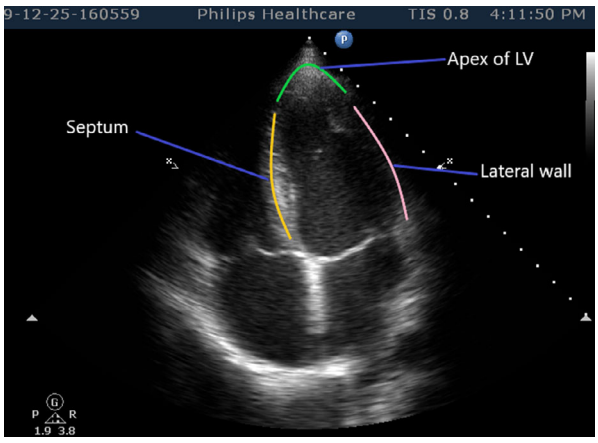
From July 2019 to October 2019, nonpregnant patients older than 18 years presenting with chest pain, a HEART (history, ECG, age, risk factors, and troponin) score of at least 4,[19] and a probable diagnosis of ACS were approached for participation in the study consecutively. Patients with chronic heart failure, tachycardia, or bradycardia were excluded from our study. Among those who consented, EPs performed FOCUS examinations using an HD 11XE US machine (Philips Healthcare, Andover, MA) machine with a 3.5-MHz convex phased array transducer, obtaining B-mode static and dynamic views (parasternal long-axis, parasternal short-axis, apical 4-chamber, and 2-chamber), a procedure that took less than 5 min (Figures 1 and 2 and Videos 1 and 2). We evaluated anterior, inferior, and apical walls on the parasternal long-axis view, anteroseptal, lateral, and posteroinferior walls on the parasternal short-axis view, anterolateral, septal, and apical walls on the apical 4-chamber view, and anterior and posteroinferior walls on the apical 2-chamber view. A routine chest pain evaluation was also performed in all the patients, according to the American Heart Association/American College of

Figure 1. Parasternal short-axis view. Regional wall motion abnormalities can be detected in all walls except the apical wall in this view.



Cardiology guidelines,[20] after completion of FOCUS. Thereafter, patients underwent a formal cardiology consultation (blinded to the study but not to the clinical condition of the patient) in the ED. Another cardiologist who had not consulted or examined the patients in the ED reviewed all the recorded clips after completing the data collection retrospectively. Our reference standard for the detection of RWMAs was accepted as the review of the prerecorded video clips by the cardiologist, who was blinded to the decisions of the EPs. The same cardiologist reviewed all the clips.

Figure 2. Apical 4-chamber view. Regional wall motion abnormalities in the apical, lateral, and septal walls can be detected in this view.



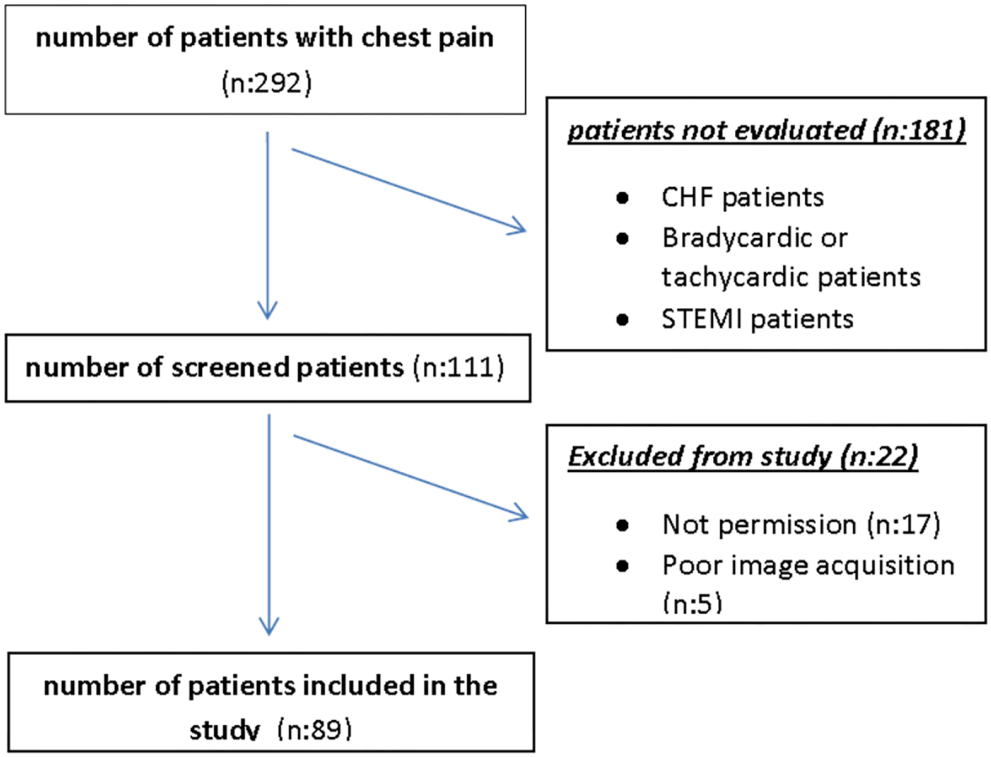
For statistical analyses, a preliminary analysis was performed with the data obtained from a total of 10 patients assessed by 3 EPs before the study. A power analysis with calculation of the *k* statistic in comparing the 3 EPs' results was conducted with reference to the sample size formula of Buderer[21] and MedCalc (MedCalc Software bvba, Mariakerke, Belgium). The sensitivity and specificity were expected to be 90% with a dropout rate of 5%. We calculated the corrected sample size to be 82 and perfect interrater agreement between the EPs (0.83 with an SE and a 95% confidence interval [CI] of 0.11 and 0.61–1.00, respectively) before the study. A normality analysis of continuous measures was performed by the Kolmogorov–Smirnov analysis, Shapiro–Wilk test, and Q-Q plots. The sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, positive predictive value, negative predictive value, and accuracy of FOCUS were calculated and analyzed by MedCalc along with calculation of the *k* statistic in comparing the results of the 3 EPs. Continuous variables are reported as means with standard errors and 95% CIs where applicable. The maximum type 1 error was 0.05 in the study, and the level of significance was accepted at $P < .05$.

Results

During the study period from July 2019 to October 2019, 292 patients were admitted to the ED with the chief symptom of chest pain; 181 patients with chronic heart failure, tachycardia, bradycardia, or STEMI on ECG were excluded from evaluation. A total of 111 patients underwent screening. The number that was excluded amounted to 22, of whom 17 refused to give informed consent, and cases had a poor image acquisition; therefore, the analysis of the study was performed on 89 patients. A diagram of the study is depicted in Figure 3.

The median age of the study population was 57.9 years (range, 26–95 years). The respective female and male numbers were 25 of 89 (28.1%) and 64 of 89 (71.9%). The most common risk factors were hypertension, smoking, and a history of myocardial infarction (MI), coronary artery bypass grafting, or cerebrovascular disease. Table 1 shows other demographic data. There were 25 of 89 (28.1%)

Figure 3. Study flow diagram. CHF indicates congestive heart failure.



patients with a diagnosis of non-STEMI/unstable angina pectoris (USAP); elevated troponin levels were detected in 19 (21.3%) patients. These patients were admitted to the coronary intensive care unit after coronary angiography.

A left ventricular RWMA was evaluated in patients presenting to the ED with a suspected provisional diagnosis of acute coronary artery disease without ST-segment elevation on 12-lead ECG. Our reference standard cardiologist reports were kept for reference. Among 26 patients (16 patients with a history of MI or coronary artery bypass grafting, 8 patients with a diagnosis of non-STEMI/USAP, and 2 patients with a prior left bundle branch block on ECG), EPs detected RWMAs in 20, and the remaining 6 had false-negative findings. Among the remaining 63 patients, EPs did not detect RWMAs in 58 patients, whereas 5 had false-positive findings (Table 2). We have demonstrated that the detection of RWMAs had good sensitivity and even excellent specificity: 76.9% (95% CI, 56.4%–91.0%) and 92.1% (95% CI, 82.4%–97.4%), respectively. The positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, and accuracy of the study were 80.0% (95% CI, 62.7%–90.5%), 90.6% (95% CI, 82.7%–95.1%), 9.69 (95% CI, 4.07–23.07), 0.25 (95% CI, 0.12–0.51), and 87.6% (95% CI, 79.0%–93.7%), respectively (Table 3).

The area under the curve from a receiver operating characteristic analysis, which evaluated the EPs' rate of detecting the presence or absence of RWMAs, was 0.845 (95% CI, 0.753–0.913). This value was found to be statistically significant ($P < .0001$; Figure 4). The inter-rater agreement (weighted κ) between the interpretations of EPs and official reports for the detection of RWMAs was 0.69 (95% CI, 0.53–0.86; Table 3).

Discussion

Recent studies have described a short training module that enabled EPs to identify RMWAs.[8,14] Similarly,

Table 1. Characteristics of the Study Patients

Characteristic	Value
Median age (range), y	57.9 (26–95)
Male, n (%)	64/89 (71.9)
Hypertension, n (%)	45/89 (50.6)
Diabetes mellitus, n (%)	18/89 (20.2)
Dyslipidemia, n (%)	21/89 (23.6)
Smoking, n (%)	45/89 (50.6)
Previous MI/CABG or CVD, n (%)	38/89 (42.7)
Family history (<65 y), n (%)	32/89 (36.0)
Patients with RWMAs, n (%)	26/89 (29.2)
Troponin-positive patients, n (%)	19/89 (21.3)
Patients with non-STEMI/USAP, n (%)	25/89 (28.1)
ECG, n (%)	
Normal	67/89 (75.3)
No ST depression but LBBB, LVH, or repolarization changes	5/89 (5.6)
ST depression/elevation not due to LBBB, LVH, or digoxin	17/89 (19.1)

CABG indicates coronary artery bypass grafting; CVD, cerebrovascular disease; LBBB, left bundle branch block; and LVH, left ventricular hypertrophy.

we have shown that by providing focused training in bedside US, successful results can be achieved. A number of recent studies have been performed by EPs, either as small case series or in patients with STEMI.[8,15] Croft et al[8] performed a study on 69 patients with STEMI. However, in our study, FOCUS examinations were performed on patients without STEMI, although they were at risk for ACS.

Electrocardiographic changes noted in patients with non-STEMI are usually in the form of ST-segment depression, transient ST-segment elevation, or T-wave inversion. Sometimes the initial ECG results of patients may even be normal. A normal ECG result, however, does not exclude ACS and can be seen in 1% to 6% of patients.[22,23] Early diagnosis of acute myocardial ischemia is important, which can avoid delays in definitive management and prevent adverse outcomes.[13] Echocardiographic wall motion

Table 2. Detection of RWMAs by EPs

Detection of	Detection of RWMAs by Cardiologist		
RWMAs by EPs	Present	Absent	n (%)
Present	20	5	25 (28.1)
Absent	6	58	64 (71.9)
n (%)	26 (29.2)	63 (70.8)	89 (100)

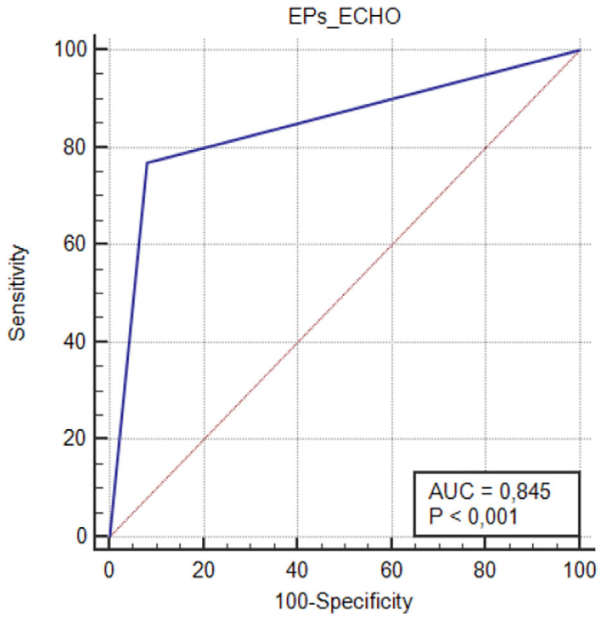
Table 3. Test Performance Characteristics for the Presence of RWMAs

Statistic	Value	95% CI
Sensitivity, %	76.9	56.4–91.0
Specificity, %	92.1	82.4–97.4
Positive likelihood ratio	9.69	4.07–23.07
Negative likelihood ratio	0.25	0.12–0.51
Positive predictive value, %	80.0	62.7–90.5
Negative predictive value, %	90.6	82.7–95.1
Accuracy, %	87.6	79.0–93.7
κ	0.69	0.53–0.86

abnormalities have been documented to precede electrocardiographic abnormalities resulting from coronary occlusion.[24–26] In a prospective observational study, Parato et al[27] followed patients who presented to the ED with chest pain and whose ECG results were normal. Thereafter, 49 patients had a diagnosis of ACS. The diagnosis in 32.6% of these patients was made by a left ventricular wall motion abnormality on echocardiography.

In a subgroup analysis of our study, 15 of 25 patients with a diagnosis of USAP/non-STEMI had normal ECG results. Echocardiography, which was evaluated by the cardiologist in 12 of these

Figure 4. Receiver operating characteristic curve for RWMA detection by EPs. AUC indicates area under the curve.



patients, had no RWMA findings. Also, EPs correctly identified 11 (91.6%) of these patients. Otherwise, in 4 of 10 patients who had ischemic findings on ECG, the presence of RWMAs was indicated by the cardiologist on echocardiography; also, EPs identified all of them correctly (100%). In addition, 6 of these 10 patients did not have RWMAs on echocardiography, whereas EPs identified 4 of 6 (66.6%) correctly, and 2 of them had false-positive findings.

Chest pain is also a class I indication for using comprehensive echocardiography in patients presenting with that symptom because of suspected acute myocardial ischemia when the baseline ECG is nondiagnostic.[28] In a prehospital study, Bergmann et al[16] evaluated patients with suspected ACS who also did not have ST-segment elevation on ECG. They achieved successful results. The most important difference in their study was that they excluded patients with a history of MI.[16]

Usually troponin levels are elevated 2 to 4 hours after symptoms.[20] In our study, troponin values of 6 patients with USAP/non-STEMI were normal. Although 1 of these patients had an RWMA on echocardiography, 5 patients did not have RWMAs. The EPs evaluated these 6 patients correctly.

On the basis of echocardiographic findings, low sensitivity indicates that in cases of non-STEMI, RWMAs cannot be excluded in at-risk patients with FOCUS examinations performed by EPs. On the other hand, high specificity in the presence of RWMAs allows these patients to be ruled in easily by EPs. In this situation, we opine it will be useful to us in the recognition and treatment of patients with suspected non-STEMI/USAP. Similarly, case reports by Frenkel et al[15] described the use of point-of-care echocardiography in the detection of RWMAs, along with the potential clinical impact regarding its use. In patients at high risk of non-STEMI/USAP (eg, hemodynamic instability, life-threatening arrhythmias, or cardiogenic shock), guidelines emphasize management, which is an immediate or an early invasive strategy.[29]

Potential sources of error in our study included the possibility of patient sampling (convenience sampling). Our study had to be done with consecutive patient selection, which might have introduced a selection bias. Also, 3 EP investigators enrolled all the patients. To generalize our results, a study would need to be conducted with more than 3 investigators and increased patient enrollment. Our patient population was small, and the results of our study should be externally validated by a large number of patients with another study team.

Another limitation of our study was that we did not the evaluate wall motion abnormality's cause or age; we only evaluated whether there was a wall motion abnormality. There are some conditions other than non-STEMI that causing RWMAs. We did not differentiate or exclude them.

In conclusion, the use of a high-specificity test in patients with suspected acute coronary disease without ST-segment elevation on ECG allows an early diagnosis and management plan for these patients. This not only reduces the length of stay in the ED but also decreases the comorbidity of patients with a non-STE ECG. We believe that FOCUS can be easily used by EPs for this purpose. In this regard, studies with a bigger sample size can improve FOCUS's accuracy.

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