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WAMAMI: emergency physicians can accurately identify wall motion abnormalities in acute myocardial infarction☆

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ABSTRACT

Objective: The ability to identify wall motion abnormalities may be useful for emergency clinicians, but is not typically evaluated in point-of-care echocardiograms. We sought to determine if emergency physicians with basic training in emergency echocardiography could identify regional wall motion abnormalities (RWMA) in patients admitted with ST-elevation myocardial infarction (STEMI).
Methods: We prospectively enrolled patients with admitted with STEMI. Resident physicians with basic training in emergency ultrasound, blinded to other patient data, performed a point-of-care echocardiogram to evaluate for RWMA. If present, they also recorded the suspected territory of the RWMA. We calculated test performance characteristics and compared the agreement between point-of-care and comprehensive echocardiogram for RWMA and territory.
Results: 75 patients with STEMI were enrolled, and 62% had a RMWA. RWMA were identified with excellent test performance characteristics (sensitivity 88% (95% CI 75–96); specificity 92% (95% CI 75–99)). There was substantial agreement between the point-of-care echocardiogram and reference standard (K = 0.79; 95% CI: 0.64–0.94).
Conclusions: Emergency physicians with core training in point-of-care echocardiography can accurately identify RMWA.

1. Introduction

1.1. Background

Emergency and critical care point-of-care echocardiography focuses on evaluating ejection fraction and identifying the presence of right ventricular enlargement or a pericardial effusion. Comprehensive echocardiography has an established role to aid in the diagnosis of suspected myocardial infarction and is routinely obtained in confirmed acute myocardial infarction to assess regional and global cardiac function, as well as for mechanical complications [1]. The ability of emergency clinicians to identify a regional wall motion abnormality (RWMA) in clinical practice with point-of-care echocardiography is not well established.

1.2. Importance

Identifying a RWMA in patients with chest pain or suspected acute coronary syndrome (ACS) may help to identify higher risk patients. RWMA can appear within seconds from the onset of myocardial ischemia [2]. Early recognition of potential ischemic changes on echocardiogram could provide clinically useful information and prompt more intensive diagnostic or therapeutic measures.

1.3. Goals of this Investigation

The primary goal of this study was to investigate whether resident emergency physicians with limited, focused training could use point-of-care echocardiography to accurately identify the presence of a RWMA in patients with ST-elevation myocardial infarction (STEMI). A

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secondary goal was to determine if the emergency physicians could determine the expected culprit vessel based on the territory of the RWMA.

2. Methods

2.1. Study design and setting

This was a prospective, observational study of a convenience sample of patients presenting with STEMI. Subjects were enrolled at Maine Medical Center in Portland, Maine. Subjects were recruited from May through December 2015. The Institutional Review Board approved this study.

2.2. Selection of participants

We enrolled a convenience sample of patients who presented with a diagnosis of STEMI by electrocardiogram (ECG). Subjects could be identified by a diagnosis of STEMI as identified by pre-hospital emergency medical services (EMS), by emergency physicians at the study site, or by outside hospital emergency physicians referring patients to our study site for revascularization. Subjects were recruited when a study investigator was available to perform an echocardiogram. These investigators were nine emergency medicine resident physicians who were potentially available to enroll subjects at any time during the study period. Echocardiograms were completed when the investigators were free from other responsibilities. Any adult patient >18 years of age presenting with a STEMI confirmed by ECG was eligible for recruitment. There were no exclusion criteria. Patients with STEMI and the resident physicians provided informed consent to participate in the study.

2.3. Methods and measurements

Each of the resident physicians performing echocardiograms viewed 2 video instructional modules to provide an introduction to identifying RWMA, and completed an online test evaluating echocardiographic clips for RWMA (see Supplementary Material). The residents included five post-graduate year (PGY) 1, three PGY2, and one PGY3 physicians. All the resident physicians had met the recommendations of the American College of Emergency Physicians Emergency Ultrasound Guidelines prior to participating in the study [1]. Each resident had completed at least 25 point-of-care echocardiograms and 150 point-of-care ultrasound studies during their training (range, 150–212). None had training in RWMA identification prior to beginning study-specific training.

Subjects were identified via a paging system that alerted the interventional cardiology team of patients with potential STEMI. A page is triggered by EMS providers alerting the study site hospital of a field diagnosis of STEMI; an emergency physician diagnosis of STEMI at the study site; or by a cardiologist accepting a STEMI from an outside facility. The study investigators were placed in this STEMI cardiac catheterization paging directory. After receiving a page for a potential subject, the investigators approached subjects after they had undergone reperfusion, which could be thrombolytic therapy, percutaneous coronary intervention (PCI), or both. There was a goal time from reperfusion to study investigator ultrasound of 24 h, or as close to the comprehensive echocardiographic study as possible. All patients admitted with a diagnosis of STEMI were eligible for enrolment, regardless of whether they underwent coronary angiography or PCI.

Patients who provided informed consent received a point-of-care ultrasound conducted by a study investigator blinded to the patient's clinical and diagnostic data, other than admission with a diagnosis of STEMI. The investigator obtained apical four-chamber, parasternal long axis, and parasternal short axis views of the heart. These images were acquired using a phased array transducer (Sonosite X-Porte; FUJIFILM Sonosite, Bothell, WA). The study investigator recorded their impression of the presence or absence of a wall motion abnormality as well as the suspected territory affected and corresponding vessel, if they saw a RWMA.

2.4. Outcomes

The primary outcome of the study was the agreement between the study investigator point-of-care echocardiogram and comprehensive echocardiogram for the presence of a regional wall motion abnormality. Comprehensive echocardiograms were routinely obtained in all patients with STEMI. Images were acquired by a cardiac sonographer and interpreted by a cardiologist; both were blinded to the study echocardiogram. If a comprehensive echocardiogram was not obtained, we used the findings from a ventriculogram performed during cardiac catheterization. Agreement for the suspected territory was a secondary outcome. When there was discordance between the comprehensive echocardiogram and the ventriculogram, we used the study performed nearest in time to the study investigator's echocardiogram to measure agreement.

2.5. Analysis

In this population of adult patients presenting to the emergency department with suspected acute myocardial infarction, we anticipated a prevalence of wall motion abnormality of approximately 50%. We hypothesized a kappa of 0.80 and our null hypothesis kappa was 0.50. These specifications required 65 paired ratings to achieve 95% power; therefore, we planned to enroll 74 participants to account for technically limited ultrasounds and other potential barriers to completion of study echocardiograms.

Data were entered into a Microsoft Excel (Microsoft, Inc., Redmond, WA) spreadsheet for review. SPSS v. 24.0 for Windows (SPSS, Inc., Chicago, IL) was used to complete study analyses.

We used descriptive statistics to describe the characteristics of the study population, using numbers and percentages for dichotomous variables and mean or median, as appropriate, for continuous variables. Sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios, and accuracy were calculated with their associated 95% confidence intervals (CIs). The predictive ability of resident-performed echocardiogram for detecting wall motion

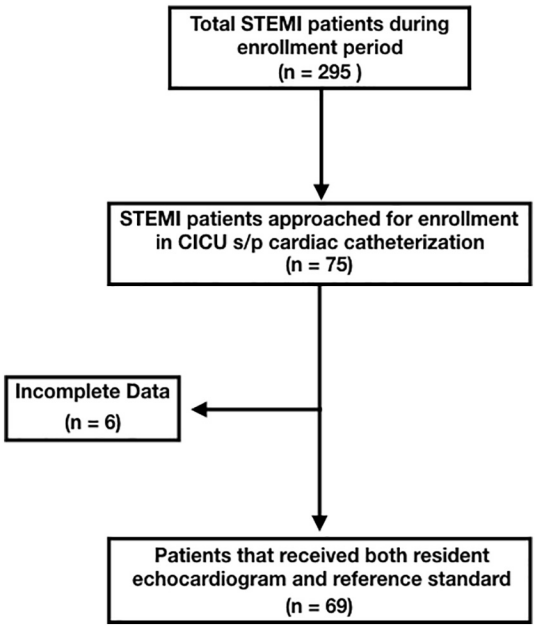

Fig. 1. Study flow diagram.

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Table 1
Characteristics of the study subjects

Characteristics	Number (%)
Age, y, median (range)	65 (31–90)
Male sex	49 (71)
History hypertension	42 (76)
History diabetes mellitus	10 (18)
History coronary artery disease	16 (27)
History coronary artery bypass graft	5 (7)

abnormality was assessed using estimates of the area under the receiver operating characteristic curve (AUROC).

3. Results

3.1. Characteristics of study subjects

Seventy-five patients were enrolled in the study; all provided consent and entered the study. Six were excluded from the analysis: 2 withdrew from the study after images obtained; 1 left against medical advice; in 2 instances the investigator was unable to obtain interpretable images of the heart; and 1 patient had incomplete data on EMR. This left 69 who had data available for analysis (Fig. 1). Table 1 depicts the characteristics of study subjects. Of the subjects included in the analysis, 67 (97%) underwent cardiac catheterization, and 58 (84%) had percutaneous coronary intervention.

3.2. Main results

Forty-three of sixty-nine (62%) of subjects enrolled had a wall motion abnormality identified by the reference standard. Study investigators identified the presence of RWMA with excellent sensitivity and specificity [sensitivity 88% (95% CI 75-96); specificity 92% (95% CI 75-99)]. Overall test performance characteristics are depicted in Table 2. The area under the receiver operating characteristic curve was 0.74 (95% CI 0.61–0.87), as shown in Fig. 2. Process metrics of clinical care and data collection are shown in Table 3. Individual level test performance by study investigator is depicted in Fig. 3. Inter-rater agreement between the point-of-care echocardiogram and the criterion standard for the presence of RWMA was K = 0.79 (95% CI: 0.64–0.94).

3.3. Limitations

This study has several limitations. The study investigators were blinded to the subjects' diagnostic data, including ECG and catheterization results, but they were aware that patients were admitted with a diagnosis of STEMI. This may have influenced their interpretation and increased their suspicion for RWMA. However, only 62% of patients were found to have a RWMA by the reference standard, and the investigators had excellent test performance for identify the affected territory, suggesting that they were not assuming the presence of a RWMA by default. Moreover, the practice of evaluating for RWMA in high-risk patients is likely to mirror real world practice, in which emergency clinicians might prioritize assessment for RWMA in patients with high clinical concern for ACS.

As depicted in Figs. 3, 2 of the study investigators enrolled a majority of the subjects. This was due to the convenience nature of our study and the need for time-sensitive enrollment. These resident physicians were on a rotation where they had more availability to enroll patients. This study does not formally assess study investigator improvement over the course of the study. However, visual inspection of Fig. 3 shows that more errors were made as the study progressed, suggesting that performance was not substantially improved by experience.

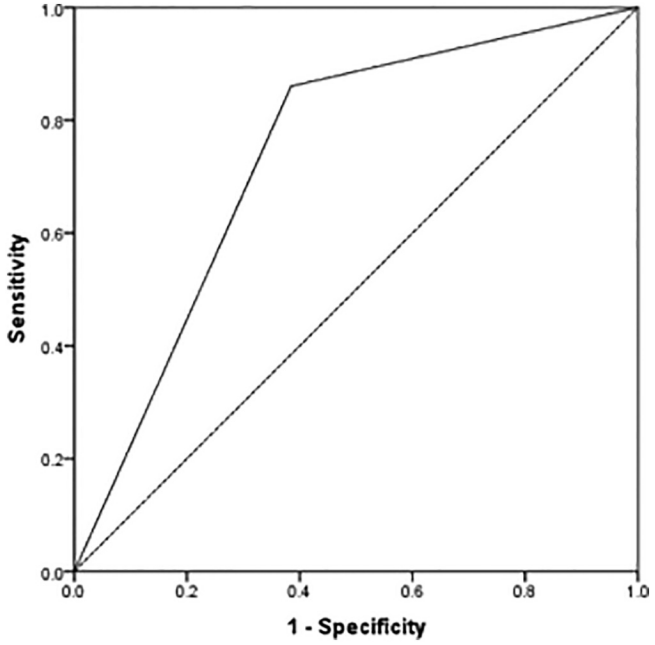

Fig. 2. Receiver operating characteristic curve for the predictive ability of resident echo for wall motion abnormality (AUROC = 0.738, 95% CI: 0.609–0.867, $p < 0.001$).

Another limitation was the lack of internal review for the study investigator images and clips. The investigator documented their interpretation at the bedside and this was compared to the criterion standard findings. The quality and integrity of their cardiac views were not independently evaluated. Each of our investigators did undergo a pre-enrolment evaluation for proficiency in interpretation.

4. Discussion

The core questions in emergency and critical care echocardiography aim to answer three questions: Is a pericardial effusion present? Is the ejection fraction normal? Is the right ventricle enlarged? [3-6] These questions have binary answers, and rapidly provide important diagnostic information to help manage undifferentiated or unstable patients. A strong body of evidence supports these focused uses of point-of-care echocardiography, and proficiency in these indications is recommended by specialty societies [3,7-9].

The data from this study support an extension of the scope and indications for point-of-care echocardiography. Our results indicate that emergency physicians with brief, focused training were able to accurately detect RWMA. Previously, case reports have described the use of point-of-care echocardiography by emergency physicians for the detection of RWMA, along with the potential clinical impact of its use [10]. A small study has shown a brief educational module allowed emergency physicians to recognize RMWA on retrospective review of echocardiograms [11]. Our data provides stronger evidence that evaluation for

Table 2
Pooled test performance characteristics for the presence and localization of a wall motion abnormality

	Test characteristic (95% CI)						
	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Likelihood ratio positive	Likelihood ratio negative	Accuracy
Presence	88% (75–96%)	92% (75–99%)	95% (83–99%)	83% (68–92%)	11.5 (3.1–43.7)	0.13 (0.05–0.29)	90% (80–96%)
Localization	90% (75–97%)	83% (65–94%)	87% (75–94%)	87% (76–94%)	5.4 (2.4–12)	0.13 (0.05–0.32)	87% (76–94%)

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Table 3
Process metrics of clinical care and data collection.

Transferred from outside hospital (%)	16 (23)
Received thrombolytics (%)	22 (32)
Underwent cardiac catheterization (%)	67 (97)
Underwent percutaneous coronary intervention (%)	58 (84)
Peak troponin (median, interquartile range)	2.9 (0.43,5.9)
Time from onset of symptoms to resident echocardiogram (min)	810 (535,1410)
Time from onset of symptoms to comprehensive echocardiogram (min)	1380 (540,2280)
Patients who went on coronary bypass graft procedure (%)	1 (1.4)
Patient deaths during admission (%)	1 (1.4)
Wall motion abnormality present (%)	43 (62)
Anterior	11 (34)
Inferior	23 (54)
Apical	6 (14)
Posterior	1 (2)
Lateral	2 (5)

RWMA can be performed reliably by emergency physicians, and supports expanding the focused questions of point-of-care echocardiography to include assessment for RWMA. Notably, none of the operators in this study had advanced or fellowship training in emergency ultrasound. This suggests greater potential to generalize our findings to other clinicians with training in the core applications of point-of-care echocardiography.

While our study population included patients with STEMI, it is plausible that the ability to detect RWMA would translate to other patients with suspected ACS. Echocardiography has a well-established role in the care of patients with chest pain potentially due to ischemia [12-14]. The most recent American Heart Association guidelines have emphasized greater attention to the management of the high-risk NSTEMI population, who may benefit from an immediate or early invasive strategy [15,16]. The decision to proceed with medical management or a more aggressive interventional approach is not always straightforward. The ability to diagnose a RWMA might potentially identify higher-risk patients that would benefit from an earlier invasive

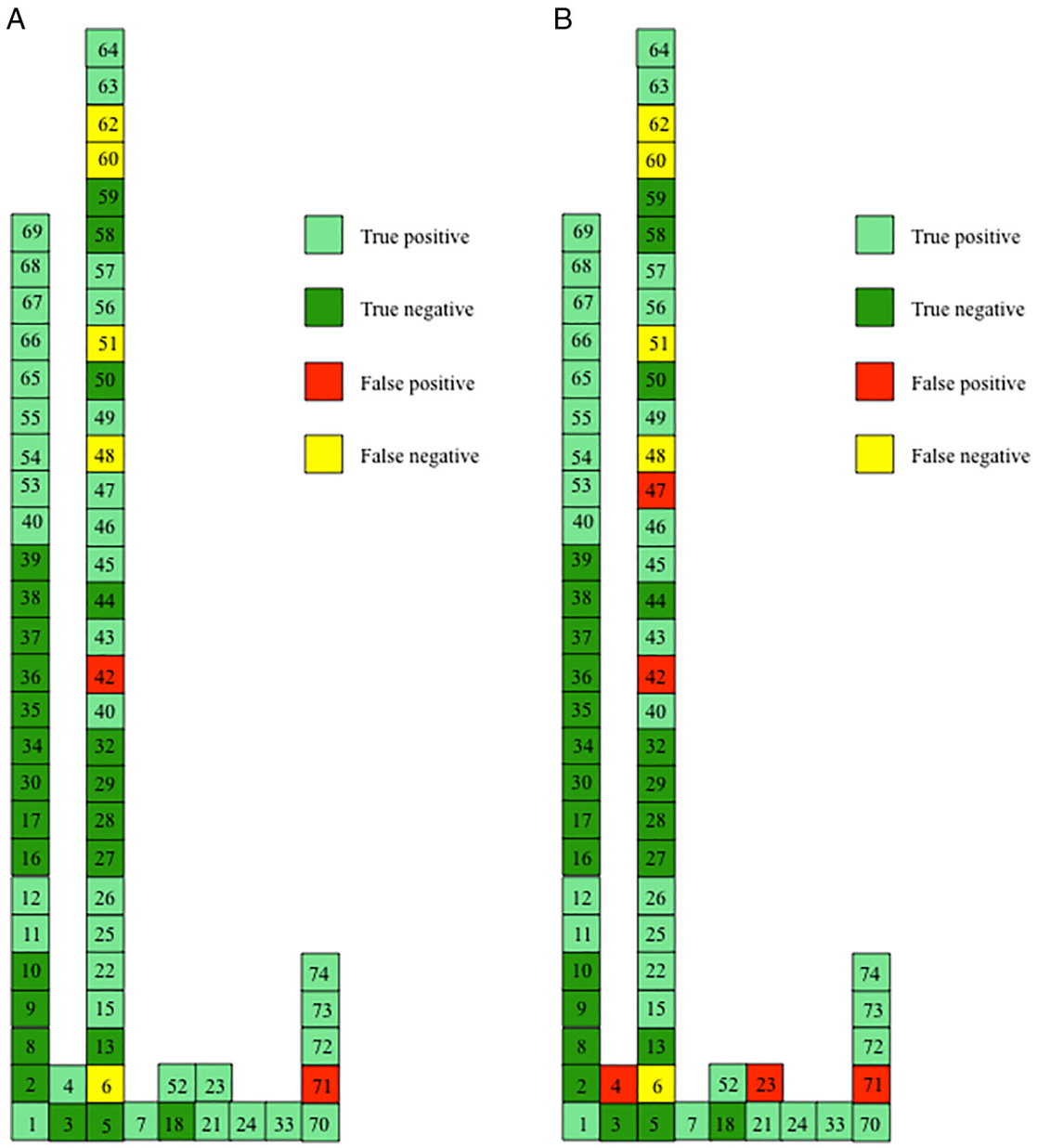

Fig. 3. a. Test performance characteristics for the presence of wall motion abnormality by investigator. b. Test performance characteristics for the localization of the wall motion abnormality.

strategy. Similarly, the ability to detect a RWMA may help differentiate between Type I and Type II NSTEMI patients. Further research will be required to answer these questions and to define the potential role for point-of-care ultrasound. In addition, the introduction of speckle tracking point-of-care echocardiography may also assist in the diagnosis of ACS; while its role in the ED is not yet fully defined, speckle tracking might obviate the need for the operator-dependent diagnosis of RWMA [17].

Another population of ACS patients has the potential to benefit from a point-of-care echocardiogram to evaluate for RWMA: those with active chest pain but an ECG that does not meet AHA criteria for STEMI [10,12-14]. In addition to standard management, including serial ECGs, a point-of-care echocardiogram to assess for RWMA may be useful. Detection of a RWMA corresponding to the ischemic territory suggested by ECG might prompt an interventional cardiologist to proceed with an immediate invasive strategy. Additional study is needed to clarify and demonstrate the role of point-of-care echocardiography in this population.

The ability to diagnose a RWMA offers emergency clinicians another tool to help manage patients with chest pain and suspected ACS. These data support the introduction of focused training in RWMA identification and expansion of the clinical use of emergency and critical care echocardiography.

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None.

Conflicts of interest

None.

Author contributions

PEC, TDS, SCW, and DCM conceived the study and designed the protocol. RMK enrolled subjects. TDS provided statistical advice and performed the statistical analysis. PEC and DCM drafted the manuscript, and all authors contributed to its revision. PEC takes responsibility for the paper as a whole.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2019.03.037.

References

[1] Cheitlin MD, Armstrong WF, Aurigemma GP, et al. ACC/AHA/ASE 2003 guideline update for the clinical application of echocardiography: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/ASE Committee to Update the 1997 Guidelines of the Clinical Application of Echocardiography). Circulation 2003;108(9):1146–62.
[2] Wholgelernter D, Cleman M, Highman HA, et al. Regional myocardial dysfunction during coronary angioplasty: evaluation by two-dimensional echocardiography and 12 lead electrocardiography. J Am Coll Cardiol 1986;7(6):1245.
[3] American College of Emergency Physicians. Ultrasound guidelines: emergency, point-of-care and clinical ultrasound guidelines in medicine. Ann Emerg Med 2017;69:e27–54.
[4] Moore CL, Rose GA, Tayal VS, et al. Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. Acad Emerg Med 2002;9(3):186–93.
[5] Plummer D, Brunnette D, Asinger R, et al. Emergency department echocardiography improves outcome in penetrating cardiac injury. Ann Emerg Med 1992;21:709–12.
[6] Mandavia D, Hoffner R, Mahaney K, et al. Bedside echocardiography by emergency physicians. Ann Emerg Med 2001;8:616–21.
[7] Henneberry RJ, Hanson A, Healy A, et al. Use of point of care sonography by emergency physicians. CJEM 2012;14(2):106–12.
[8] Atkinson P, Bowra J, Lambert M, Lamprecht H, Noble V, Jarman B. International Federation for Emergency Medicine point-of-care Ultrasound Curriculum Guidelines. CJEM 2015;17(2):161–70.
[9] Levitov A, Frankel HL, Blaivas M, et al. Guidelines for the appropriate use of bedside general and cardiac ultrasonography in the evaluation of critically ill patients – part II: cardiac ultrasonongraphy. Crit Care Med 2016;44(6):1206–27.
[10] Frenkel O, Riguzzi C, Nagdev A. Identification of high risk patients with acute coronary syndrome using point-of-care echocardiography in the ED. Am J Emerg Med 2014;32(6):670–2.
[11] Kerwin C, Tommaso L, Kulstad E. A brief training module improves recognition of echocardiographic wall motion abnormalities by emergency medicine physicians. Emerg Med Int 2011;2011:483242.
[12] Douglas PS, Garcia MJ, Haines DE, et al. ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR. 2011 Appropriate use criteria for echocardiography. A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Society of Echocardiography, American Heart Association, American Society of Nuclear Cardiology, Heart Failure Society of North America, Heart Rhythm Society, Society of Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, American College of Chest Physicians. J Am Coll Cardiol 57(9): 1126–66.
[13] Kontos MC, Arrowood MD, Paulsen WHJ, Nixon JV. Early echocardiography can predict cardiac events in emergency department patients with chest pain. Ann Emerg Med 1998;31(5):550–7.
[14] Peels CH, Visser CA, Kupper AJ, et al. Usefulness of two-dimensional echocardiography in patients with acute myocardial ischemia in the emergency room. Am J Cardiol 1982;49:1110–9.
[15] Amsterdam EA, Wenger NK, Brindis RG, et al. 2014 AHA/ACC guideline for the management of patients with non-ST-elevation acute coronary syndromes. Circulation. 2014;130(25):2354–94.
[16] Jneid H, Addison D, Bhatt DL, et al. 2017 AHA/ACC clinical performance and quality measures for adults with ST-elevation and non-ST elevation myocardial infarction. J Am Coll Cardiol 2017;70(16):2048–90.
[17] Reardon L, Scheels WJ, Singer AJ, Reardon RF. Feasibility and accuracy of speckle tracking echocardiography in emergency department patients. Am J Emerg Med 2018;36(12):2254–9.

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