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Diagnosis of acute myocardial ischemia in patients presenting with chest pain in the emergency department using clinical measures and cardiac ultrasonography: A systematic review

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Abstract

Background: Chest pain is a common cause of emergency department (ED) visits and presents a diagnostic challenge due to its wide range of etiologies. Traditional diagnostic methods, such as electrocardiography (ECG) and cardiac biomarkers, insufficient in early or atypical presentations. Point-of-care ultrasound (POCUS) and transthoracic echocardiography (TTE) emerged as adjuncts for rapid bedside assessment. Our study aims to evaluate the diagnostic accuracy and clinical utility of POCUS and TTE in acute myocardial ischemia in patients presenting with chest pain, dyspnea, or suspected acute coronary syndromes (ACS) in the ED.

Methods: A systematic review was conducted according to PRISMA guidelines. Studies included if assessed adult ED patients using POCUS or TTE for chest pain or cardiopulmonary symptoms. Data extracted on study design, demographics, inclusion criteria, ultrasound protocol, operator type, target conditions, reference standards, and diagnostic outcomes. Seven studies involving 2,727 patients were included.

Results: POCUS and TTE improved diagnostic accuracy, increased physicians' confidence, and reduced time to diagnosis. Sensitivity ranged from 60% to 92%, and specificity from 26% to 99%. The SEARCH 8Es and A–F mnemonic protocols were effective in rapid ED settings. POCUS shows better performance than chest X-ray in identifying pulmonary edema, pleural effusion, and pericardial effusion.

Conclusion: POCUS and TTE are good diagnostic tools in the ED setting for patients with suspected myocardial ischemia. These imaging modalities can enhance diagnostic precision and expedite appropriate management when integrated with clinical and laboratory assessments.

Keywords: Chest Pain; Acute Myocardial Ischemia; Point-Of-Care Ultrasound; Transthoracic Echocardiography; Emergency Department; Diagnostic Accuracy; Acute Coronary Syndrome

1. Introduction

Chest pain is one of the most common causes for emergency department (ED) visits, accounting for millions of cases and posing a diagnostic challenge due to its broad differential diagnoses (Zarama et al. 2024). A small proportion of these patients are diagnosed with acute myocardial ischemia, the consequences of a missed diagnosis is catastrophic, so early and accurate detection is essential (Sweeney et al. 2020). Standard evaluation depends on a combination of clinical history, physical examination, 12-lead electrocardiography (ECG), and cardiac biomarkers, high-sensitivity

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troponins (Sweeney et al. 2020). These conventional tools lack sensitivity during the early stages of ischemia or in patients with atypical presentations (Larson et al. 2007). There is interest in introducing cardiac ultrasonography, such as transthoracic echocardiography (TTE) and point-of-care ultrasound (POCUS), into the diagnostic workup. Cardiac ultrasound gives immediate visual assessment of left ventricular function, regional wall motion abnormalities (RWMA), and other structural findings that can support or refute a diagnosis of ischemia, before ECG or biomarker changes occur (Shiran et al. 2017). RWMA develop within seconds of coronary occlusion and serve as an early marker of myocardial ischemia (Zarama, et al. 2024).

POCUS shows practical benefits in the ED setting, where time and accessibility are important, it reduce diagnostic uncertainty, improve triage, and assist in identifying alternative causes of chest pain (pericardial effusion or aortic dissection) (Ahn, et al. 2017). In SEARCH 8Es protocol, POCUS narrowed the differential diagnosis and improved physicians' confidence in managing patients with chest pain and dyspnea (Ahn, et al. 2017). A–F mnemonic protocol, have feasibility when performed by non-cardiologists in acute care settings (Sobczyk, et al. 2015). Cardiac ultrasound is not currently a standalone test to diagnose myocardial ischemia, its role as a complementary tool in the emergency diagnostic pathway expand. When integrated with clinical measures and laboratory data, cardiac ultrasonography improves diagnostic accuracy, optimize resource utilization, and improve patient outcomes in the ED (Baid, et al. 2022). Our study aims to evaluate the diagnostic accuracy and clinical utility of POCUS and TTE in patients presenting with acute chest pain, dyspnea, or suspected acute coronary syndromes (ACS) in ED settings.

2. Method

This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The study aims to evaluate the diagnostic accuracy and clinical utility of point-of-care ultrasound (POCUS) and transthoracic echocardiography in patients presenting with acute chest pain, dyspnea, or suspected acute coronary syndromes in emergency department (ED) settings.

2.1. Search Strategy and Study Selection

A literature search was conducted across databases (PubMed, Scopus, and Web of Science). Keywords used included: point-of-care ultrasound, focused echocardiography, chest pain, dyspnea, acute coronary syndrome, emergency department, and diagnostic accuracy. The search was limited to articles published in English. References of included articles were screened for additional studies.

We include; prospective or observational studies evaluating adult patients (>18 years) presenting with chest pain, dyspnea, or hemodynamic instability; use of POCUS or echocardiography as a diagnostic tool in the ED; and assessment of diagnostic performance, agreement with final diagnoses, or clinical impact. Studies were excluded if involved pediatric populations, simulation-based training only, or lacked original clinical data.

After title and abstract screening, full texts of eligible studies were reviewed. A total of seven studies met the inclusion criteria (Fig 1). From each included study, the following data were extracted: study design, sample size, patient demographics, inclusion criteria, ultrasound protocol, ultrasound operator, target condition, reference or gold standard test used, and diagnostic outcomes. Data extraction was performed independently by two authors, and discrepancies were resolved by consensus. Systematic review synthesis approach was adopted. Key diagnostic performance measures and clinical implications were summarized and compared across studies to identify findings and variations.

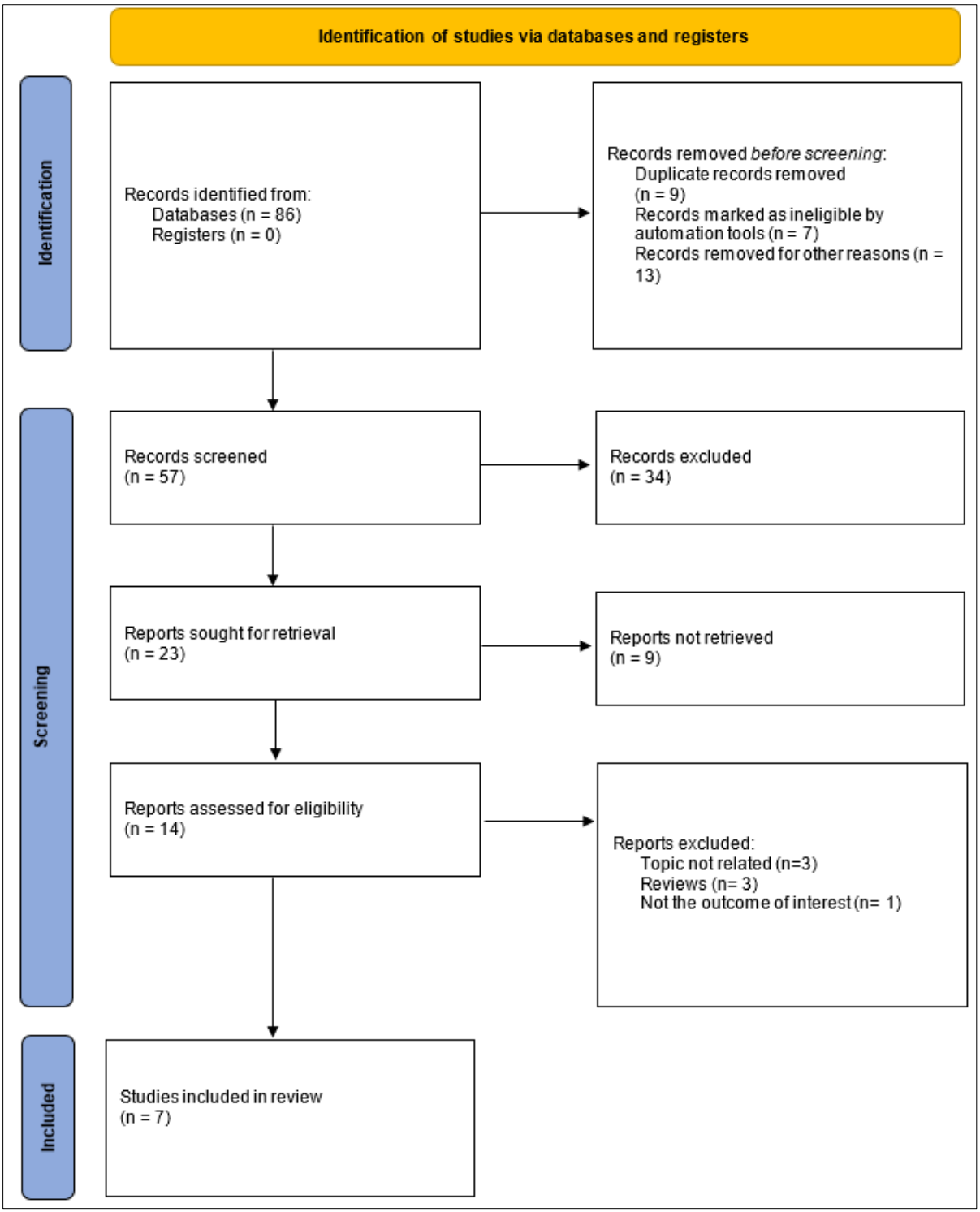

Figure 1 PRISMA consort chart of selection process

3. Result

A total of seven studies were included in this systematic review, with a total sample of 2,727 patients in multiple geographic regions and clinical settings. All studies examined the diagnostic performance of point-of-care ultrasound (POCUS) or focused echocardiography in patients presenting to the emergency department (ED) with acute cardiopulmonary symptoms, chest pain, dyspnea, and suspected acute coronary syndromes (ACS).

The included studies include adult patients, with mean ages ranging from 58 to 68 years. Some studies reported male predominance (Shiran et al., 2016 reported 70% male). Most studies were prospective observational, with one (Shiran et al., 2016) multicenter prospective cohort. The clinical indications included undifferentiated chest pain, dyspnea, hypotension, and suspected ACS or heart failure (Table 1).

All studies assessed POCUS or focused transthoracic echocardiography. The person performing the ultrasound differ: emergency physicians performed the scans in most studies (Ahn et al. 2017; Baid et al. 2022; Buhumaid et al. 2019), cardiologists or trained sonographers in others (Shiran et al. 2017 Lee et al. 2015). In Sobczyk et al., 2015, focused echocardiography was performed by non-specialist residents using a simplified A–F mnemonic protocol.

Ahn et al. (2017) introduced the SEARCH 8Es protocol to diagnose 13 acute cardiopulmonary pathologies which include pulmonary embolism, pneumothorax, pericardial effusion, and heart failure. Baid et al. (2022) focused on acute dyspnea, whereas Shiran et al. (2016) and Lee et al. (2015) examined strain echocardiography for detection of CAD in patients with non-diagnostic ECGs and normal initial troponins. Kountana et al. (2013) compared echocardiography with ischemia-modified albumin (IMA) in detecting unstable angina. Buhumaid et al. (2018) examined the incremental value of POCUS over chest radiography in diagnosis in patients with chest pain and shortness of breath.

Our findings support the utility of ultrasound in the improvement of diagnostic confidence, and to reduce the number of differential diagnoses, and provide rapid bedside assessments. Ahn et al. (2017) reported a reduction in the mean number of differentials (from 2.5 to 1.4 per patient, $p < 0.001$) and an increase in diagnostic confidence scores (from 2.8 to 4.3, $p < 0.001$). Their SEARCH 8Es protocol show agreement with final specialist diagnoses ($\kappa = 0.87$), with sensitivity and specificity exceeding 90%. Baid et al. (2022) found that POCUS had a strong agreement with final diagnoses ($\kappa = 0.668$), mainly for pulmonary edema, pleural effusion, and pericardial effusion. POCUS reduce time to diagnosis (median 16 minutes) compared to conventional workup (170 minutes, $p < 0.001$) (Table 2).

Lee et al. (2015) found that regional longitudinal strain (RLS) was better than visual assessment of wall motion to detect CAD, with sensitivity and specificity of 92% and 77%, respectively. Shiran et al. (2016), found a sensitivity (81%), and specificity (26%), with limited diagnostic utility for ruling out ACS.

Sobczyk et al. (2015) confirm a mnemonic-based focused echo performed by residents. Their findings showed that rapid echocardiography identified regional wall motion abnormalities (RWMA) and other significant cardiac pathology. Kountana et al. (2013) found that echocardiography better than IMA testing in detecting unstable angina. Echo showed a specificity of 89.3% and a negative predictive value (92.6%), and IMA sensitivity (40%) and specificity (28.6%). Buhumaid et al. (2018) found that POCUS had diagnostic value better than chest radiography for most thoracic pathologies, except pneumonia. In patients with normal POCUS, subsequent CXR did not provide additional clinically useful information.

Table 1 characteristics of the included studies

Citation	Study Design	Inclusion Criteria	Study Aim	Person Performing Ultrasound	Gold Standard Test
Ahn et al., 2017	Prospective observational	>18 yrs, chest pain/dyspnea/hypotension/shock	Evaluate SEARCH 8Es protocol for diagnostic utility and confidence	Emergency physicians	Diagnosis by inpatient specialists
Shiran et al., 2016	Multicenter prospective	>45 yrs, chest pain, suspected ACS, no ST changes or elevated troponin	Evaluate 2D longitudinal strain (2DLS) in chest pain triage	Cardiologists trained in echo	Final diagnosis based on full workup (including angiography)
Baid et al., 2022	Prospective observational	>18 yrs, acute dyspnea	Assess PoCUS accuracy and time benefit for acute dyspnea	Emergency physicians trained in PoCUS	Final composite diagnosis by 2 EM consultants
Sobczyk et al., 2015	Prospective observational	Suspected ACS, >18 yrs	Validate focused echo (A-F mnemonic) by non-specialists	Residents (non-echocardiographers)	Cardiologist review and diagnosis
Buhumaid et al., 2018	Prospective observational	>18 yrs, chest pain or SOB, with CXR ordered	Evaluate POCUS in narrowing differentials and compare to CXR	Physician-sonographers (fellowship trained)	Final composite diagnosis
Kountana et al., 2013	Diagnostic comparison	<3h chest pain, normal ECG and troponins	Compare IMA and echo for unstable angina exclusion	Cardiologists (implied)	Angiography/thallium scan/exercise ECG
Lee et al., 2015	Prospective	Acute chest pain, excluded MI, known CAD, valvular, arrhythmias	Evaluate strain echocardiography in CAD diagnosis and 1-month outcomes	Single investigator blinded to results	Coronary angiography or CCTA

Table 2 main findings of included studies

Citation	Demographics	Target Condition	Main Findings	Outcome
Ahn et al. 2017	308 patients, mean age 67.7±19.1 yrs, 184M/124F	Cardiopulmonary causes of dyspnea, chest pain, hypotension	SEARCH 8Es improved diagnostic confidence, reduced differentials	High accuracy (Kappa =0.87), sensitivity 90.9%, specificity 99%
Shiran et al. 2017	605 patients, mean age 58±9 yrs, 70% male	Acute coronary syndrome (ACS)	2DLS had low specificity and was not useful to rule out ACS	Sensitivity 81%, specificity 26%, AUC 0.59
Baid et al. 2022	237 patients, adult, mixed gender	Acute dyspnea	PoCUS showed good concordance with final diagnosis	Kappa =0.668, median diagnostic time: PoCUS 16 min vs final 170 min
Sobczyk et al, 2015	1312 patients, adult, suspected ACS	ACS and other cardiac pathologies	Focused echo with A-F mnemonic effective in non-specialist hands	Confirmed RWMAs in 82.87% with ACS, high usability and reliability
Buhumaid et al. 2019	128 patients, mean age 64±17 yrs	Causes of chest pain and shortness of breath	POCUS reduced differentials and matched composite diagnosis	High specificity; added value of CXR minimal when POCUS normal
Kountana et al. 2013	33 patients, mean age 59.8 ±10.8 yrs, 28M	Unstable angina	Echocardiography better than IMA for diagnosis	Echo; Sens 60%, Spec 89.3%, NPV 92.6%; IMA not reliable
Lee et al. 2015	104 patients, ED chest pain registry	Coronary artery disease (CAD)	RLS better than RWMA, GLS, and pretest probability	RLS; Sens 92%, Spec 77%, AUC =83%, predicted 1-mo events

4. Discussion

This systematic review aimed to evaluate the diagnostic accuracy and clinical utility of POCUS and tTTE in ED patients with acute chest pain and dyspnea. The results of our study are generally consistent with prior research in the field. Compared to the study assessing cardiogoniometry (CGM) as an alternative diagnostic modality to ECG, our study show the practical and better applicability of POCUS in acute coronary syndrome (ACS) evaluation. CGM showed higher sensitivity and specificity than resting ECG but remains limited in use due to equipment availability and interpretative complexity (Ghadrdoost et al. 2015). Our findings support the clinical value of ultrasound, which detect a broader range of cardiopulmonary conditions in real time without reliance on specialized analysis tools.

False-positive activation of catheterization labs due to overreliance on ST-segment changes was reported in a large regional registry, so traditional reliance on ECG may lead to unnecessary invasive procedures (Larson et al. 2007). Our study supports POCUS as a complementary modality capable of improving triage accuracy and reducing unnecessary activations by visualizing mechanical complications or alternate causes of symptoms.

The Fourth Universal Definition of Myocardial Infarction (UDMI) explain the role of high-sensitivity cardiac troponins (hs-cTn) in myocardial infarction (MI) diagnosis, when integrated with clinical and ECG findings (Thygesen et al. 2018). Our study findings align with this diagnostic pathway but show that POCUS provide immediate structural and functional insights that biomarkers cannot deliver, mainly when troponin elevation is equivocal or delayed.

European Society of Cardiology (ESC) guidelines advise integrating hs-cTn assays and rapid diagnosis algorithms but acknowledge the role of non-invasive imaging in equivocal presentations (Collet et al. 2020). Our results improve this guidance by showing that POCUS can act as a frontline tool, mainly when laboratory access is delayed or patient instability limits waiting periods.

A focused review on hs-cTn reiterated its better sensitivity in early MI detection, when serial testing is employed (Lazar et al. 2022). Our study show that structural anomalies which include regional wall motion abnormalities or pericardial effusion, identifiable through POCUS, can direct immediate management before biomarker results are available. Body et al. examined historical features and physical exam findings in chest pain evaluation and found limited diagnostic

reliability in isolation (Body et al. 2010). Our study found that history and exam are foundational, but the addition of POCUS enhances diagnostic certainty and identifies conditions that are not be apparent through symptoms alone.

A review by Dezman et al. confirmed the inadequacy of history and physical exam to roll out ACS, stressing the risk of over-reliance on subjective features (Dezman et al. 2017). Our data support augmenting clinical judgment with real-time imaging to mistakes in the diagnosis of ACS.

In a Brazilian study examined pocket-sized echocardiography, focused cardiac ultrasound altered the initial diagnosis in 17% of patients, a result consistent with our own findings (Mancuso et al. 2014). This support the utility of bedside ultrasound in dynamic ED environments where rapid diagnosis and decision-making are critical.

Our findings are in line with international guidelines that endorse an integrated diagnostic approach for ACS and dyspnea, that includes biomarkers, ECG, and, bedside imaging. Troponin and ECG were indispensable, and POCUS give a distinct advantage in visualizing anatomical abnormalities, assessing cardiac function, and identifying alternative diagnoses. POCUS provides dynamic, point-of-care data that can impact patient management.

Abbreviations

- ACS: acute coronary syndrome,
- AMI: acute myocardial infarction,
- CAD: coronary artery disease,
- CCTA: coronary computed tomography angiography,
- CK: creatine kinase,
- CK-MB: creatine kinase–myocardial band,
- CXR: chest X-ray,
- ECG: electrocardiogram,
- ED: emergency department,
- EF: ejection fraction,
- GRACE: Global Registry of Acute Coronary Events,
- hs-cTn: high-sensitivity cardiac troponin,
- IMA: ischemia-modified albumin,
- MI: myocardial infarction,
- NPV: negative predictive value,
- POCUS: point-of-care ultrasound,
- PPV: positive predictive value,
- RLS: regional longitudinal strain,
- RWMA: regional wall motion abnormality,
- SEARCH 8Es: Sonographic Evaluation of Aetiology for Respiratory difficulty: Chest pain and/or Hypotension using 8 Es,
- SOB: shortness of breath,
- STEMI: ST-elevation myocardial infarction,
- TIMI: Thrombolysis in Myocardial Infarction,
- TTE: transthoracic echocardiography,
- UDMI: Universal Definition of Myocardial Infarction.

5. Conclusion

The diagnostic performance of ultrasound is strong in most of the studies. Kappa values, indicated good agreement. Sensitivity ranged from 60% to 92%, and specificity from 26% to 99%, depending on the target condition and protocol. Several studies confirmed that POCUS can guide early therapeutic decisions and reduce unnecessary imaging and treatment delays.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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