



# Diagnostic Accuracy of Right Ventricular Dysfunction Markers in Normotensive Emergency Department Patients With Acute Pulmonary Embolism

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**Study objective:** We determine the diagnostic accuracy of goal-directed echocardiography, cardiac biomarkers, and computed tomography (CT) in early identification of severe right ventricular dysfunction in normotensive emergency department patients with pulmonary embolism compared with comprehensive echocardiography.

**Methods:** This was a prospective observational study of consecutive normotensive patients with confirmed pulmonary embolism. Investigators, blinded to clot burden and biomarkers, performed qualitative goal-directed echocardiography for right ventricular dysfunction: right ventricular enlargement (diameter greater than or equal to that of the left ventricle), severe right ventricular systolic dysfunction, and septal bowing. Brain natriuretic peptide and troponin cutoffs of greater than or equal to 90 pg/mL and greater than or equal to 0.07 ng/mL and CT right ventricular:left ventricular diameter ratio greater than or equal to 1.0 were also compared with comprehensive echocardiography.

**Results:** One hundred sixteen normotensive pulmonary embolism patients (111 confirmed by CT, 5 by ventilation-perfusion scan) were enrolled. Twenty-six of 116 patients (22%) had right ventricular dysfunction on comprehensive echocardiography. Goal-directed echocardiography had a sensitivity of 100% (95% confidence interval [CI] 87% to 100%), specificity of 99% (95% CI 94% to 100%), positive likelihood ratio (+LR) of 90.0 (95% CI 16.3 to 499.8), and negative likelihood ratio (-LR) of 0 (95% CI 0 to 0.13). Brain natriuretic peptide had a sensitivity of 88% (95% CI 70% to 98%), specificity of 68% (95% CI 57% to 78%), +LR of 2.8 (95% CI 2.0 to 3.9), and -LR of 0.17 (95% CI 0.06 to 0.43). Troponin had a sensitivity of 62% (95% CI 41% to 80%), specificity of 93% (95% CI 86% to 98%), +LR of 9.2 (95% CI 4.1 to 20.9), and -LR of 0.41 (95% CI 0.24 to 0.62). CT had a sensitivity of 91% (95% CI 72% to 99%), specificity of 79% (95% CI 69% to 87%), +LR of 4.3 (95% CI 2.8 to 6.7), and -LR of 0.11 (95% CI 0.03 to 0.34).

**Conclusion:** Goal-directed echocardiography was highly accurate for early severe right ventricular dysfunction identification and pulmonary embolism risk-stratification. Brain natriuretic peptide was sensitive but less specific, whereas troponin had lower sensitivity but higher specificity. CT had good sensitivity and moderate specificity. [Ann Emerg Med. 2016;68:277-291.]

Please see page 278 for the Editor's Capsule Summary of this article.

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## INTRODUCTION

### Background

Pulmonary embolism is an important and challenging clinical condition that may present insidiously or significantly. It can increase pulmonary artery pressures and obstruct outflow from the right ventricle, causing its dilatation. Further deterioration may result in right ventricular ischemic injury and compromised left ventricular function. Only 5% of pulmonary embolisms

present with overt signs and symptoms of shock and are considered massive. These patients are at high risk for morbidity and mortality.<sup>1</sup> The majority of pulmonary embolism patients present without hypotension and shock symptoms.<sup>2</sup>

Patients with normotensive pulmonary embolism have many permutations of clinical characteristics and comorbid conditions. Right ventricular dysfunction is an important prognostic tool for these patients. In the subsequent

**Editor's Capsule Summary***What is already known on this topic*

Assessments of right ventricular function in pulmonary embolism can inform clinical decisions, including the need for thrombolytics and the necessity for inpatient hospitalization. The optimal means of assessing right ventricular dysfunction is unknown.

*What question this study addressed*

This study examined the test characteristics of goal-directed echocardiography (performed by 5 physicians with extra training), brain natriuretic peptide, troponin, and computed tomography in identifying right ventricular function in patients with pulmonary embolism.

*What this study adds to our knowledge*

Goal-directed echocardiography by these physicians exhibited high sensitivity and specificity, and was superior to other tests in detecting or excluding early severe right ventricular dysfunction.

*How this is relevant to clinical practice*

If these findings can be shown to be valid for the typical emergency physician, goal-directed echocardiography will enable emergency physicians to improve management of patients with pulmonary embolism.

discussions, we will be referring to severe right ventricular dysfunction detection by goal-directed echocardiography.

Right ventricular dysfunction is definitively identified with transthoracic echocardiography but can also be assessed with cardiac biomarkers. Elevated serum cardiac brain natriuretic peptide and troponin levels can serve as surrogate markers of right ventricular dilatation and myocardial ischemic injury, respectively.<sup>2,3</sup> Patients without overt signs and symptoms of shock but with latent right ventricular dysfunction can later develop hypotension, cardiorespiratory deterioration, or death despite prompt initiation of anticoagulation at diagnosis. Survivors to hospital discharge may have persistent right heart strain and functional limitations if treated only with standard anticoagulation therapy.<sup>4-7</sup> Not all patients with pulmonary embolism, however, require admission to the hospital. Recent studies and protocols have shown that patients with low-risk pulmonary embolism can be safely sent home (as per Pulmonary Embolism Severity Index and Hestia criteria). In addition, patients without signs or

markers for right ventricular dysfunction can be considered for abbreviated observational monitoring and treatment or outpatient treatment.<sup>8-11</sup>

**Importance**

Risk stratification of normotensive patients with pulmonary embolism can be challenging. The presence of right ventricular dysfunction in pulmonary embolism is a predictor of short-term hemodynamic collapse and long-term morbidity. Ideally, the identification of right ventricular dysfunction can guide clinical management and disposition decisions. Patients with right ventricular dysfunction signs may be considered for interventions beyond anticoagulation, including systemic or catheter-based thrombolysis. Additionally, they may require more intensive clinical monitoring. Patients without right ventricular dysfunction and other low-risk clinical signs may be candidates for shorter hospital stays or may be even discharged from the emergency department (ED), receiving oral anticoagulants.

The right ventricle has a complex shape and function and is best assessed by cardiac magnetic resonance imaging, 3-dimensional echocardiography, and transesophageal echocardiography, but none of these is a feasible first-line option in the critical care or ED setting. Comprehensive echocardiography is the routinely used standard for right ventricular dysfunction assessment. It is usually performed by a certified sonographer and interpreted by a cardiologist but is often not immediately available on evenings, nights, or weekends. It involves multiple technologies, including 2-dimensional, M-mode, and other Doppler modalities (color, pulsed-wave, continuous-wave, and tissue Doppler); however, the primary, fundamental, and time-sensitive clinical goal of echocardiography in the setting of pulmonary embolism is the detection of right ventricular enlargement and right ventricular systolic dysfunction.

The optimal pulmonary embolism risk-stratification tool is both immediately available and accurate. Possible strategies meeting both of these criteria include right ventricular assessment with computed tomography (CT), serum cardiac biomarkers, and goal-directed echocardiography performed by the emergency physician. The assessment of right ventricular dilatation with focused cardiac ultrasonography is supported in the core curriculum and the consensus statement of the American College of Emergency Physicians and American Society of Echocardiography.<sup>12-14</sup> Although many studies support the feasibility and diagnostic accuracy of qualitative assessment of left ventricular function by cardiologists and emergency physicians, the literature is limited on the diagnostic accuracy of emergency physician echocardiography assessment of the right ventricular. Although CT is

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