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Original Contribution

Emergency physician performed tricuspid annular plane systolic excursion in the evaluation of suspected pulmonary embolism

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ABSTRACT

Objectives: The primary objectives were to describe the diagnostic characteristics tricuspid annular plane systolic excursion (TAPSE) for pulmonary embolism (PE) and to optimize the measurement cutoff of TAPSE for the diagnosis of PE. Secondary objectives included assessment of interrater reliability and the quantitative visual estimation of TAPSE.

Methods: This is a prospective observational cohort study involving a convenience sample of patients at an urban academic emergency department. Patients underwent focused right heart echocardiogram (FOCUS) before computed tomographic angiography (CTA) for suspected PE.

Results: A total of 150 patients were enrolled, 32 of whom (21.3%) were diagnosed as having a PE. A receiver operating characteristic curve analysis yielded 2.0 cm as the optimal cutoff for TAPSE in the diagnosis of PE, with a sensitivity of 72% (95% confidence interval [CI], 53-86), a specificity of 66% (95% CI, 57-75), and an area under the curve of 0.73 (95% CI, 0.65-0.83). In patients with tachycardia or hypotension, post hoc analysis demonstrated that FOCUS is 100% (95% CI, 80-100) sensitive for PE, whereas TAPSE is 94% (95% CI, 71-99) sensitive for PE. The intraclass correlation coefficient was 0.87 (95% CI, 0.79-0.93). Emergency physicians with training in echocardiography accurately visually estimated TAPSE, with a κ statistic of 0.94 (95% CI, 0.87-0.98).

Conclusions: Emergency physicians with training in echocardiography can reliably measure TAPSE and are able to accurately visually estimate TAPSE as either normal or abnormal. When using an abnormal cutoff of less than 2.0 cm, TAPSE has moderate diagnostic value in patients with suspected PE. On post hoc analysis, TAPSE and FOCUS appear to be highly sensitive for PE in patients with tachycardia or hypotension.

1. Introduction

1.1. Background

The evaluation of a patient with chest pain or dyspnea in the emergency department (ED) often prompts the emergency physician (EP) to consider the diagnosis of pulmonary embolism (PE). Right ventricular dysfunction (RVD) occurs in 30% to 70% of patients with PE, and the absence of RVD in patients with hemodynamic compromise makes PE an unlikely etiology [1]. In the setting of known PE, findings of RVD have been shown to be associated with increased in-hospital mortality, longer lengths of stay, and the development of pulmonary hypertension [2-4]. Emergency physician–performed focused transthoracic cardiac ultrasound (FOCUS) has been shown to be effective in detecting RVD [2,3,5-7]. However, commonly used FOCUS findings of RVD such as right ventricular enlargement can be challenging to assess, with variable reproducibility among operators [8,9].

Tricuspid annular plane systolic excursion (TAPSE) assesses for RVD by using M-mode to measure the dynamic movement of the tricuspid valve annulus over the course of a contraction [10]. Tricuspid annular plane systolic excursion performed by cardiologists has been shown to be a reliable measure of RVD that correlates well with more complex global measures, such as cardiac magnetic resonance imaging and right heart angiography [11-18]. First described in the cardiology literature in the 1980s [10], TAPSE has been used in the evaluation of right ventricular function in a variety of conditions such as pulmonary hypertension, congestive heart failure, PE, acute respiratory distress syndrome, and cardiac surgery [2,8,12-14,19-29].

1.2. Importance

In the setting of known PE, TAPSE is of significant prognostic utility relative to other measures of RVD, as abnormal values are independently predictive of increased mortality, increased intensive care unit (ICU)

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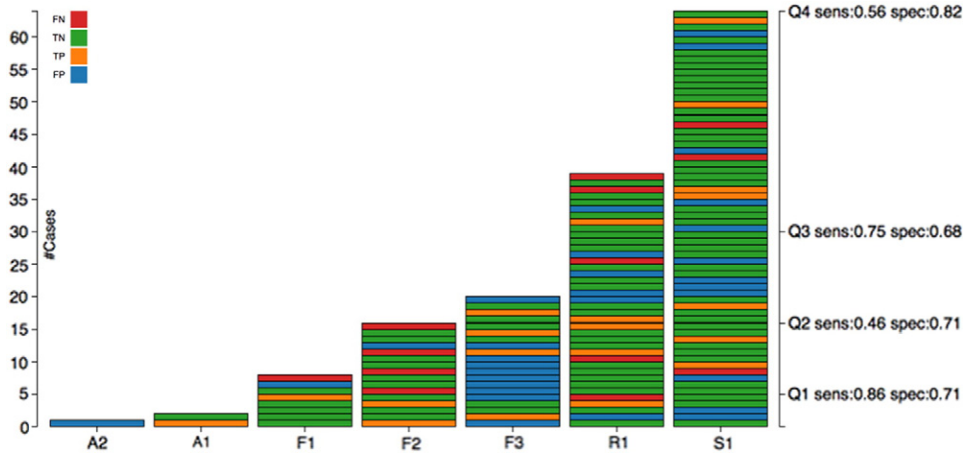

Fig. 1. Test performance characteristics of TAPSE for PE by operator based on a cutoff of 1.7 cm, where values below this were considered a positive test and values equal to or above this were considered a negative test. Diagnostic test results were compared with CTA as the criterion standard. FN, false negative; TP, true positive; FP, false positive; TN, true negative; A, attending; F, fellow; R, resident; S, student.

length of stay, and thrombolysis [2,3,8,29-31]. Tricuspid annular plane systolic excursion has previously been shown to be the least user-dependent measure of RVD [8]; however, this has not been studied among EPs. The use of TAPSE in the diagnosis of PE has not been studied.

1.3. Goals

The primary objectives of this study were to describe the diagnostic characteristics of TAPSE for PE and to optimize the measurement cutoff of TAPSE for the diagnosis of PE, by developing a receiver operating characteristic (ROC) curve. Secondary objectives were 3-fold: first, to assess the interrater reliability when measuring TAPSE among EPs at the bedside; second, to determine the ability to visually estimate TAPSE qualitatively as normal or abnormal before its measurement; and third, to describe the diagnostic characteristics of other measures of right heart strain assessed on FOCUS for PE.

2. Methods

2.1. Study design and setting

This was a prospective, observational convenience sample of FOCUS in ED patients undergoing evaluation for suspected PE from April 2015 to April 2016. This study was approved by the institutional review board and conducted in accordance with the STARD guidelines for reporting diagnostic accuracy studies [32]. Patients were recruited from an urban academic medical center with more than 100 000 annual ED visits.

2.2. Selection of participants

Patients were enrolled when a study investigator was available, often working clinically in the ED. Subjects were eligible if they were adults (18 years or older) undergoing computed tomographic angiography (CTA) for evaluation of possible PE in the ED. Prisoners, wards of the state, and non–English-speaking patients were excluded.

Study personnel were notified about potential subjects by text page alert when a CTA was ordered in the ED. Subjects were then screened for enrollment eligibility in person by research staff, and if deemed eligible, written consent was obtained. Three patients were unable to provide consent at the time of enrollment due to the severity of their illness and were approached for consent later in their hospital stay, as permitted by the institutional review board.

2.3. Methods and measurements

Investigators performed and interpreted FOCUS at the bedside during the patient's ED stay, if possible before the patient underwent CTA. If performed after CTA, echocardiographers were blinded to CTA results. Data were recorded at the bedside using a mobile device that automatically updated a secure database located on the Yale internal network. Investigators included 3 point-of-care ultrasound fellowship trained EPs (CLM, RL, RAT), 4 emergency medicine ultrasound fellows (MKH, AM, JP, and JS), 1 emergency medicine resident (JD), and one medical student (JG) (Fig. 1). Investigators (except for JG) underwent emergency ultrasound training during residency and have significant experience in emergency ultrasound. Before enrolling patients for this study, investigators underwent a standardized 1-hour didactic training session and at least 20 practiced TAPSE measurements before enrolling patients. The medical student, JG, did not have prior experience in point-of-care ultrasound. He underwent a 2-week period of training in point-of-care ultrasound by the co-investigators, performing greater than 50 practice FOCUS examinations before enrolling patients. Investigators were blinded to CTA findings as well as co-investigator echocardiographic results.

FOCUS is a structured right heart echocardiogram that included the measurement of TAPSE and evaluation for other signs of RVD, defined as follows: right ventricular enlargement (appearance of the right ventricle being equal to or greater in size than the left ventricle), septal flattening, tricuspid regurgitation (any regurgitant jet seen on color Doppler in the apical 4-chamber window), or McConnell's sign. Presence of RVD included any of these characteristics, or a TAPSE measurement less than 1.7 cm. Tricuspid annular plane systolic excursion was obtained in the apical 4-chamber view by placing the m-mode cursor along the lateral tricuspid valve annulus and measuring the change in height of the resultant tracing from trough to peak (Fig. 2) [10]. Prior literature has established a testing threshold for TAPSE when diagnosing RVD to be 1.7 cm, meaning that any values equal to or greater than this are considered normal and any values less than 1.7 cm are abnormal [33]. This predefined cutoff value was used for study purposes, although investigators also sought to determine the optimal cutoff for the diagnosis of PE based on the collected data. The criterion standard for diagnosing PE was the presence of a filling defect on CTA consistent with PE as reported by radiology. All patients who were enrolled underwent CTA in the ED.

In a subset of patients, 2 investigators measured TAPSE independently on the same patient to determine interrater reliability. They were blinded to each other's results. These patients were selected based on convenience; if 2 study investigators were present at the

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