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Original Contribution

Can emergency physicians diagnose and correctly classify diastolic dysfunction using bedside echocardiography?☆,☆☆

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ABSTRACT

Objectives: The goal of this study was to determine if emergency physicians (EPs) can correctly perform a bedside diastology examination (DE) and correctly grade the level of diastolic function with minimal additional training in echocardiography beyond what is learned in residency. We hypothesize that EPs will be accurate at detecting and grading diastolic dysfunction (DD) when compared to a criterion standard interpretation by a cardiologist.
Methods: We conducted a prospective, observational study on a convenience sample of adult patients who presented to an urban emergency department with a chief concern of dyspnea. All patients had a bedside echocardiogram, including a DE, performed by an EP-sonographer who had 3 hours of didactic and hands-on echocardiography training with a cardiologist. The DE was interpreted as normal, grade 1 to 3 if DD was present, or indeterminate, all based on predefined criteria. This interpretation was compared to that of a cardiologist who was blinded to the EPs' interpretations.
Results: We enrolled 62 patients; 52% had DD. Using the cardiology interpretation as the criterion standard, the sensitivity and specificity of the EP-performed DE to identify clinically significant diastolic function were 92% (95% confidence interval [CI], 60-100) and 69% (95% CI, 50-83), respectively. Agreement between EPs and cardiology on grade of DD was assessed using κ and weighted κ: $\kappa = 0.44$ (95% CI, 0.29-0.59) and weighted $\kappa = 0.52$ (95% CI, 0.38-0.67). Overall, EPs rated 27% of DEs as indeterminate, compared with only 15% by cardiology. For DEs where both EPs and cardiology attempted an interpretation (indeterminates excluded) $\kappa = 0.45$ (95% CI, 0.26 to 0.65) and weighted $\kappa = 0.54$ (95% CI, 0.36-0.72).
Conclusion: After limited diastology-specific training, EPs are able to accurately identify clinically significant DD. However, correct grading of DD, when compared to a cardiologist, was only moderate, at best. Our results suggest that further training is necessary for EPs to achieve expertise in grading DD.

1. Introduction

Congestive heart failure (CHF) affects approximately 5.7 million people in the United States and was a contributing cause in more than 280,000 deaths in 2008 [1]. Currently, CHF costs the United States $34.4 billion per year in health care costs, medications, and lost productivity [2]. The prevalence of CHF is projected to rise, making this condition of even greater concern for health care in the United States [3].

Diastolic heart failure (DHF) is defined as heart failure with normal (or near-normal) left ventricular ejection fraction, in the absence of other explanatory conditions such as valvular lesions. This condition is also known as *heart failure with preserved ejection fraction* and accounts for approximately half of all patients with clinical heart failure [4,5]. Recent evidence suggests that the prevalence of DHF is increasing, as is the mortality rate of patients with this condition [6]. In patients with known systolic heart failure, the presence of underlying diastolic dysfunction (DD) predicts a worse prognosis [7]. In addition, DD is an independent predictor of adverse outcomes such as in-hospital mortality, increased rate of readmission, and failure of extubation [8–13].

Given the prevalence of this disease, patients with DHF will present to the emergency department (ED) and may benefit from early recognition of this as the etiology of their symptoms. Diastolic dysfunction, alone or in combination with systolic dysfunction, not only has a worse prognosis but may also require alternative treatment strategies,

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especially in patients with more severe diastolic abnormalities [8,11]. For these reasons, rapid identification of these abnormalities has the potential to benefit a subset of dyspneic ED patients.

To our knowledge, only one prior study has assessed emergency physician's (EP's) ability to diagnose DD. This study, published by Ünlüer et al [14], found that the sensitivity and specificity for diagnosis of DD were 89% and 80%, respectively. However, they did not attempt to grade the level of DD. In addition, their diastology examination (DE) did not use tissue Doppler imaging (TDI), which has been previously recommended by the American Society for Echocardiography [15].

The goal of this study was to determine if EPs can correctly perform a bedside DE and properly grade the level of diastolic function after minimal additional training in echocardiography. We hypothesize that EPs will be accurate at detecting and grading DD when compared to a criterion standard interpretation by a cardiologist.

2. Methods

2.1. Study design and setting

This was a prospective, observational study that compared EP's ability to identify and grade diastolic cardiac function to that of a cardiologist board certified in echocardiography. This study was conducted at an urban tertiary-care teaching hospital with more than 120,000 annual ED visits and was approved by the Institutional Review Board.

2.2. Study population

We enrolled a convenience sample of patients who presented to the ED and met the following inclusion criteria: age at least 18 years, a chief concern of dyspnea, and at least 2 potential etiologies for the dyspnea in the treating clinician's differential diagnosis. Exclusion criteria included an electrocardiogram showing an ST segment elevation myocardial infarction, treatment for acute CHF (eg, diuretics, nitroglycerin, noninvasive positive pressure ventilation) more than 30 minutes before enrollment, treating clinician confidence in diagnosis (ie, history, physical examination, and clinical course consistent with a single known underlying problem), refusal of consent, enrollment in the study at a prior ED visit, pregnancy, and incarceration.

Eligible patients were identified by both physicians and research assistants using a standardized screening process. Screening took place when EP-sonographers were available to perform a DE, generally Monday through Friday from 9:00 AM to 5:00 PM. All participants were consented before enrollment. Family members provided consent for patients unable to consent themselves.

2.3. Intervention and data collection

Each patient had a bedside echocardiogram performed by an EP-sonographer (RE, FR). Both EP-sonographers had previous ultrasonography (US) experience before participation in the study, each having performed more than 1000 US examinations, including echocardiograms.

Before commencement of the study, each sonographer received 3 hours of didactic instruction from a cardiologist covering the principles of normal and abnormal diastolic cardiac function, US methods for assessing and interpreting diastolic cardiac function, and technical aspects of performing a DE. Didactic sessions also included hands-on scanning time with a cardiologist. In addition, each sonographer spent 3 hours in the echocardiography reading room interpreting DEs under the direction of a cardiologist board certified in echocardiography. As a final step before enrolling patients, each sonographer performed and interpreted 5 DEs that were reviewed and critiqued by the study cardiologist.

Sonographers were blinded to patients' medical history and results of any laboratory or imaging tests obtained during the index visit.

2.4. DE protocol

All echocardiograms were performed with a Mindray M7 (Mindray Corp, Shenzhen, China) ultrasound machine using a phased-array 2- 4-MHz transducer. Patients were placed in a position of comfort; when possible, this was semirecumbent with head-of-bed elevation between 30° and 45°. A left lateral decubitus position was used in select patients to improve image quality provided that this did not cause discomfort.

The DE was performed as part of a 3-view echocardiogram that also included assessment for presence or absence of pericardial effusion, gross estimation of ejection fraction, gross estimation of Right ventricle:Left ventricle (RV:LV) chamber size, and diameter and collapsibility of the Inferior vena cava (IVC) [16]. Diastology examination parameters were obtained from the apical 4-chamber view and included the following:

1. Peak transmitral inflow velocity in early (E) and late (A) diastole using pulsed-wave Doppler
2. Septal and lateral mitral annular excursion velocity (E'_{sept} and E'_{lat}, respectively) in early diastole using TDI.

2.5. Grading diastolic function

A simplified method for grading diastolic function was developed using the American Society for Echocardiography guidelines [15] in conjunction with the study cardiologist using the peak E velocity; peak A velocity; and the lateral, septal, and average mitral annular excursion velocities (E'_{avg}):

- Normal: $E'_{sept} \geq 8$ *and* $E'_{lat} \geq 10$
- Grade 1: $E'_{sept} < 8$ or $E'_{lat} < 10$ *and* $E/E'_{avg} < 8$ or $E/A < 0.8$
- Grade 2: $E'_{sept} < 8$ or $E'_{lat} < 10$ *and* E/E'_{avg} 8-12 or E/A 0.8-1.5
- Grade 3: $E'_{sept} < 8$ or $E'_{lat} < 10$ *and* $E/E'_{avg} > 12$ or $E/A > 1.5$
- Indeterminate (if any of the following conditions were met): heart rate >100 beats per minute, fusion of E and A waves, presence of pericardial effusion, atrial or ventricular dysrhythmias (other than isolated PACs or PVCs), immobile mitral valve leaflets.

All measurements were made on the spectral Doppler tracings, and calculations were performed by the US machine's cardiology software package. The amount of time required to perform the DE (only parameters unique to the DE not normally acquired during EP echocardiograms) was recorded. A standardized data collection form was used to record all findings of the echocardiogram.

Grade 2 and grade 3 DD were considered clinically significant because both are associated with elevated left ventricular filling pressures and thus are potential causes of dyspnea. Grade 1 DD is generally asymptomatic because left ventricular filling pressure is normal [15].

2.6. Outcome measures

The criterion standard for presence and grade of DD was interpretation of EP-performed echocardiograms by a single cardiologist board certified in echocardiography. The cardiologist was asked to use the same criteria for assessing diastolic function as were used by EPs, and was blinded to all patient information and the EP-sonographers' interpretations.

The primary outcome measure was agreement between EPs and cardiology on classification of diastolic function. This was assessed using κ and linear-weighted κ.

2.7. Statistical analysis

We enrolled 20 dyspneic patients in a pilot study in order to estimate the prevalence of DD in our ED population. All patients in the pilot study had a bedside DE performed by an EP who rated diastolic function as "normal" or "abnormal." Cases rated as "abnormal" by EPs were then reviewed by the study cardiologist who confirmed or refuted this interpretation. Analysis of the pilot data showed a prevalence of DD of approximately 40%.