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THE INTER-RATER RELIABILITY OF ECHOCARDIOGRAPHIC DIASTOLIC FUNCTION EVALUATION AMONG EMERGENCY PHYSICIAN SONOGRAPHERS

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□ **Abstract—Study Objectives: In a patient with dyspnea and suspected CHF, the evaluation of diastolic function involves: tissue Doppler of the mitral annulus and 2) pulsed wave Doppler of the mitral inflow. We aimed to 1) determine the inter-rater reliability for overall diastolic function and 2) evaluate the reliability of the individual Doppler measurements. Methods: A convenience sample of adult emergency department patients was prospectively enrolled by 8 EPs who had participated in a 1-hour didactic session. Patients were selected if they had a history of CHF or suspected abnormal diastolic function due to chronic hypertension. Diastolic function was considered to be abnormal if Tissue Doppler of the septal e′ was <8 cm/s and if the lateral e′ was <10 cm/s. In cases of discordance, the E/e′ ratio was calculated with ≤8 considered normal and >8 considered abnormal. A Kappa coefficient. Bland-Altman plot and a fixed effect regression model were used in the analysis. Results: Thirty-two patients were enrolled, and 3 (9.4%) were excluded due to technical inadequacy. The inter-rater reliability among sonographers for overall interpretation was very good: $\kappa = 0.86$ (95% CL [0.67, 1.0]). Based on the Bland-Altman plot, was no consistent bias between readers. There was no evidence to conclude that the readings differed among sonographers: septal e′ ($p = 0.77$), lateral e′ ($p = 0.89$) and E ($p = 0.15$). Conclusion: EP sonographers obtained similar Doppler measurements for diastolic function evaluation with very good inter-rater reliability for the assessment of overall diastolic function.**

□ **Keywords—bedside ultrasound; echocardiography; congestive heart failure**

INTRODUCTION

Congestive heart failure (CHF) is comprised of not only systolic, but also diastolic dysfunction. It has been reported that approximately half of all symptomatic patients with heart failure have a preserved ejection fraction (1). A high prevalence of left ventricular hypertrophy and impaired relaxation has been demonstrated in asymptomatic patients with chronic hypertension (2). Early diagnosis and treatment may improve outcomes in patients who have an echocardiographic study done as a screening examination.

In the emergency department (ED), the evaluation of acute pulmonary edema is common. When sonographically assessing a patient with dyspnea, a normal ejection fraction may lead the physician to search for other, noncardiogenic causes of the patient's symptomatology; however, the patient may still have CHF, and in this

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situation an evaluation of diastolic function may be critical to the diagnosis and management. If systolic function was preserved, and the patient's diastolic function was impaired, then the practitioner might be very cautious when administering classic first-line medications for CHF such as diuretics and venodilators. These patients need close monitoring for weakness, dizziness, or syncope due to worsening ventricular filling from these types of pharmacologic interventions. In these cases, slowing the heart rate down with atrioventricular nodal blockade may be more beneficial to the patient to increase the amount of time spent in diastole.

Emergency physicians (EPs) can use focused echocardiography to assess for pericardial effusion, cardiac tamponade, organized left ventricular contractions, estimation of ventricular function and relative chamber size, M-mode assessment for E-point septal separation, and Doppler measurements to determine cardiac index (3–6).

The echocardiographic assessment of diastolic heart failure involves two evaluations in the apical four-chamber view: 1) tissue Doppler evaluation of the mitral valve annulus and 2) pulsed wave Doppler analysis of the mitral valve inflow (7–9). Although tissue Doppler imaging requires technical expertise, the basic principles are similar to standard pulsed wave Doppler imaging. When performing tissue Doppler, the interrogation gate is placed over tissue rather than blood flow. The velocity of tissue movement is slower than that of blood, so the ultrasound machine will change the scale, generally to approximately 0 ± 20 cm/s rather than approximately 0 ± 120 cm/s.

In the evaluation of diastolic function, early and late mitral valve flow velocities are denoted by E and A, respectively, whereas early and late tissue Doppler lengthening velocities are denoted by e′ and a′, respectively. The purpose of this study was to determine if EPs could perform similar tissue Doppler evaluation of the mitral valve annulus and Doppler evaluation of the mitral valve inflow, and if they could obtain an overall assessment of diastolic function with a high inter-rater reliability. The reliability of the individual Doppler measurements used in the assessment of diastolic function was also evaluated.

METHODS

This was a prospective convenience sample study of adult human subjects. The study took place in the ED of a large urban hospital consisting of two sites with approximately 190,000 combined visits per year. The ED has two dedicated ultrasound faculty members, an emergency ultrasound fellowship and 42 postgraduate year (PGY)-1–3 Emergency Medicine residents. Institutional Review Board approval was obtained. Eight EPs (one PGY-2, one PGY-3, two emergency ultrasound fellows, and four attendings) participated. Prior to study initiation, all physicians met the minimum requirements for performing focused bedside cardiac ultrasound based on American College of Emergency Physicians (ACEP) guidelines (2). At our institution, this process included the completion of online lectures and examinations, submission of 25 cardiac ultrasound studies, and a hands-on session. The eight physician sonographers additionally participated in a 1-h didactic session on the evaluation of diastolic function that consisted of 30 min of lecture and 30 min of hands-on training. Each sonographer then submitted five test studies prior to subject enrollment, which were reviewed by an expert sonographer for technical adequacy.

Patients were preferentially selected if they had a history of heart failure or suspected heart failure due to chronic hypertension. Patients were excluded who were unstable, had known dysrhythmias or valvular pathologies, were unable to either lie flat or in the left lateral decubitus position for 10 min, or who refused consent.

Each patient was assessed by two of the sonographers. The sonographers who performed each examination were based on availability. The patient was positioned either lying flat or in the left lateral decubitus position at the discretion of the sonographer. An apical four-chamber view was obtained. All studies were performed with a Sonosite Edge ultrasound machine (FUJIFILM Sonosite, Inc., Bothell, WA) with a 5-1 MHz phased array transducer.

Tissue Doppler was performed by placing the interrogation gate at the septal and lateral mitral annulus, and the septal and lateral e′ waves were measured in cm/s (Figures 1–4). Doppler evaluation of the mitral inflow was performed by placing the gate at the level of the tips of the mitral valve, and the E wave was measured (Figures 5 and 6). For each assessment, a video clip was taken of the positioning of the pulsed wave Doppler gate, followed by a still image of the tracing and of the measurements. One sonographer performed the assessment then closed the study on the ultrasound machine and kept his or her own data sheet so the second sonographer was blinded to the images and interpretations.

Overall interpretations of diastolic function were based on criteria interpreted from the "Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography" in the Journal of the American Society of Echocardiography (9). Diastolic function was considered to be abnormal if the septal e′ was <8 cm/s and if the lateral e′ was <10 cm/s. In cases of discordance of septal and lateral interpretations, the E/e′ ratio was calculated. An E/e' ratio of ≤8 was considered normal and a ratio >8 was considered abnormal