Efficacy of Transthoracic Echocardiography for Diagnosing Heart Failure in Septic Shock

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Abstract: *Background:* Cardiac dysfunction occurs in up to 80% of patients with septic shock. Transthoracic echocardiography (TTE) is an ideal tool for the detailed characterization of cardiac function. Its feasibility is perceived to be poor in critically ill patients, but this has never been studied. To address this question, the authors evaluated the efficacy of TTE to diagnose heart failure in septic shock. *Methods:* This was a retrospective study. Patients admitted to the intensive care unit with septic shock and who had a TTE within 72 hours of intensive care unit admission were identified by a computer algorithm and validated by chart review. Echocardiography images were reviewed by a single cardiologist blinded to clinical outcomes. Clinical information was collected from patients' medical record. *Results:* Seventy-six patients met the studies' inclusion criteria. The feasibility of TTE to calculate left ventricular ejection fraction was 90% and to assess diastolic function was 74%. Significant mitral regurgitation or aortic stenosis was the most frequent impediments for the assessment of diastolic function. Seventy-four percent of all patients showed some type of cardiac dysfunction (left or right ventricular systolic dysfunction and/or left ventricular diastolic dysfunction). In regression analyses, TTE feasibility was not impacted by factors previously associated with poor image acquisition: high body mass index, mechanical ventilation, tachycardia, advanced age or high severity of illness. *Conclusions:* This study demonstrated that TTE is a useful tool to assess myocardial function in critically ill patients and suggested its potential to assist in the management of patients with septic shock.

Key Indexing Terms: Transthoracic echocardiography; Septic shock; Diastolic function; Septic cardiomyopathy; Heart failure. **[Am J Med Sci 2014;347(4):295–298.]**

Septic cardiomyopathy is estimated to occur in up to 80% of patients with septic shock.[1,2] Yet, a paucity of information is known of its diagnostic criteria, implications for clinical management and its capacity to predict patient mortality. In addition to left ventricular (LV) systolic impairment, recent studies have suggested that diastolic dysfunction may be a potent predictor of sepsis-associated mortality.[3,4] To date, the majority of echocardiographic studies in critically ill patients have focused on the use of transesophageal echocardiography.[2,5,6] The main obstacle to routine characterization of LV function in critically ill patients is the identification of a noninvasive and cost-effective diagnostic method. Transthoracic echocardiography (TTE) is a reliable, noninvasive tool to comprehensively assess cardiac function.[7,8] However, its feasibility is still perceived to be poor in critically ill patients.[9–11] Despite this perception, there is no study that directly addresses the feasibility of TTE as a diagnostic modality in critically ill patients. Our objective was to address the efficacy of TTE for the quantitative characterization of heart failure in patients with septic shock.

We performed a retrospective analysis of consecutive patients with septic shock in whom a TTE was performed within 72 hours of admission to the intensive care unit (ICU). We hypothesized that the efficacy of TTE to comprehensively assess cardiac function would be high, independent of factors thought to be associated with poor image acquisition including mechanical ventilation status, high body mass index (BMI >25), age, tachycardia and severity of illness.[9–11] With the growing use of echocardiography in the ICU setting, such an evaluation of efficacy is crucial for the cost-effective use of this diagnostic modality in critically ill patients.[12]

MATERIALS AND METHODS

Between May 1, 2009, and July 1, 2011, patients admitted to the ICU with septic shock were identified by a computer algorithm that cross-referenced the International Classification of Disease 9th revision code for septic shock (785.2) with an electronic medical record history of TTE. We included all patients who underwent a TTE within 72 hours of their admission to the ICU. To validate this analysis, a chart review was conducted for all identified patients. Septic shock was defined as evidence of the systemic inflammatory response to infection and persistent hypotension (systolic blood pressure < 90 mm Hg) despite fluid resuscitation or the requirement for vasopressor medications to maintain blood pressure for greater than 1 hour after ICU admission.[13] An institutional review board approval (approval number 4947) was obtained; data were collected and analyzed in compliance with the Health Insurance Portability and Accountability Act.

Echocardiograms were captured by experienced sonographers and stored in the hospital picture acquisition and communication system. Five-beat digital captures were obtained for all views. Doppler tracings were acquired at end-expiration with a sweep speed of 75 mm/s. All measurements were averaged over 5 consecutive cardiac cycles. A single cardiologist (ASB), blinded to clinical outcome, reviewed all the TTEs. LV systolic dysfunction was defined as an ejection fraction (EF) $< 50\%$, measured by Simpson method.[7] Right ventricular (RV) function was qualitatively assessed.[7] Diastolic function was determined using the recommendations issued by the American Society of Echocardiography.[8] Left atrial dilatation (area > 20 cm^2) was used to assess the chronicity of diastolic dysfunction.[7] Detailed patient information, such as demographics, clinical course, vitals, laboratory values and pharmacologic data from the day of the TTE, were also collected. Severity of illness was based on a patient's Acute

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Physiology and Chronic Health Evaluation (APACHE) II score on the day of ICU admission.

RESULTS

Inclusion criteria were met in 76 patients. Patient characteristics are displayed in Table 1.

TABLE 1. Patient characteristics

Characteristic demographics	Value
Total No. patients	76
Age (yr), mean ± SD	70 ± 13
Gender, % (N)	
Male	39 (30/76)
Female	61 (46/76)
Race/ethnicity, % (N)	
Caucasian	71 (54/76)
Hispanic/Latino	7 (5/76)
Asian/Pacific Islander	15 (11/76)
African-American	4 (3/76)
Time from ICU admission to TTE (day), mean ± SD	1.1 ± 1
Height (cm), mean ± SD	166 ± 11
Weight (kg), mean ± SD	80 ± 25
BMI (kg/m^2), mean ± SD	30 ± 8
History of cardiac disease	
CAD, % (N)	21 (16/76)
HTN, % (N)	55 (42/76)
Positive troponin T (>0.3 ng/mL), % (N)	54 (27/50)
APACHE II score (day 1 ICU), mean ± SD	28 ± 8
Mechanically ventilated, % (N)	54 (41/76)
Heart rate (bpm), mean ± SD	95 ± 24
Heart rate range (bpm)	71–119
Sinus rhythm, % (N)	91 (69/76)
Vasopressor/inotrope on day of echocardiogram, % (N)	79 (60/76)
28-day mortality	38 (29/76)
Hospital mortality	55 (42/76)
Echocardiographic characteristics	
Feasibility of quantitative LV assessment	90 (68/76)
Ejection fraction (%), mean ± SD	55 ± 17
LV dysfunction, % (N)	35 (24/68)
Evidence of wall motion abnormalities, % (N)	17 (12/71)
Valvular abnormalities, % (N)[a]	24 (18/75)
Feasibility of RV assessment, % (N)	99 (75/76)
RV dysfunction, % (N)	31 (23/75)
RV systolic pressure (mm Hg), mean ± SD	41 ± 12
Total assessed for diastolic function, % (N)	65 (49/76)
Feasibility of diastolic assessment, % (N)	74 (36/49)
Diastolic dysfunction, % (N)	53 (19/36)
Left atrial area > 20 cm^2 in patients with diastolic dysfunction, % (N)	42 (8/19)
E/E', mean ± SD	12 ± 6
Prevalence of any cardiac dysfunction, % (N)	74 (26/35)

[a] Valvular abnormalities include ≥ moderate mitral or aortic stenosis/regurgitation.

ICU, intensive care unit; TTE, transthoracic echocardiography; APACHE, Acute Physiology and Chronic Health Evaluation; bpm, beats per minute; LV, left ventricular; RV, right ventricular; CAD, coronary artery disease; HTN, hypertension.

TTE was performed on average 1 day after the onset of sepsis. At the time of TTE, 54% patients were mechanically ventilated, and 79% were on vasopressor/inotropic support on the day of the TTE. Troponin was measured in 50 patients and was elevated (>0.3 ng/mL) in 54% of these patients. Two thirds of patients were either obese or overweight according to their BMI. The mean APACHE II score on admission was 28 ± 8. Overall, 28-day mortality for the sample group was 38% with a hospital mortality of 55%.

TTE demonstrated high efficacy for the diagnosis of cardiac function in critically ill patients. Adequate windows for cardiac assessment were obtained in 99% patients; in 1 patient, the heart could not be visualized by TTE. EF could be quantitatively determined in 90% patients (68/76) and was abnormal in 35% (24/68); the mean EF was 55 % ± 17%. Wall motion abnormalities were present in 17% of patients (12/71). RV function was assessed in 99% patients and was impaired in 31% (23/75). Diastolic parameters were collected in 65% patients (49/76). In 74% of these patients (36/49), diastolic function could be determined; it was abnormal in 53% (19/36). An example of the parameters used to determine diastolic dysfunction is displayed in Figure 1. The left atrium was dilated in 42% (8/19) of patients with diastolic dysfunction. Significant mitral regurgitation or aortic stenosis was the most frequent impediments for the assessment of diastolic function (10/13 patients).

In regression analyses, TTE feasibility was not impacted by BMI ≥ 25, mechanical ventilation, age ≥ 65 years, tachycardia (heart rate > 100 beats per minute) or severity of illness (APACHE II ≥ 25). In the 35 patients in whom all parameters could be assessed, 74% showed some type of cardiac dysfunction: LV or RV systolic dysfunction or diastolic dysfunction.

DISCUSSION

To our knowledge, this is the largest study, to date, to directly address the efficacy of TTE for the diagnosis of heart failure in critically ill patients with septic shock. From our analysis, we demonstrated a high efficacy of TTE for evaluating cardiac function: 90% for the determination of LV systolic function, 99% for RV systolic function and 74% for LV diastolic function. Obesity, mechanical ventilation, tachycardia, advanced age or more severe illness did not alter feasibility. These results highlight the potential for TTE to aid clinicians in the management of septic shock. Routine use of TTE in septic patients provides a noninvasive tool to assess morphologic and hemodynamic aspects of cardiac function, allowing for real-time clinical adjustment of the balance of volume expansion, inotropic or vasopressor support. It may also facilitate further characterization of septic cardiomyopathy, by allowing repeated comprehensive assessments with minimal patient discomfort.

Our results also confirmed the high prevalence of cardiac dysfunction during septic shock, occurring in 74% patients. As suggested in previous studies, the prevalence of systolic impairment was high during the initial 72 hours of septic shock with 1/3 of patients presenting with LV systolic dysfunction.[5]Similarly, there was a high prevalence of diastolic dysfunction in our patient cohort, concordant with previously published prospective studies.[3,5] Unfortunately, diastolic parameters were not acquired in all patients. Because these parameters became part of the standard TTE examination at the beginning of the study period, there may have been a delay in the implementation of this practice in routine. It is