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Diagnostic Accuracy of Cardiac Point-of-Care Ultrasound in a Tertiary Medical Intensive Care Unit

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OBJECTIVE: Critical care echocardiography (CCE) is a useful tool for managing critically ill patients in intensive care. However, concerns exist regarding the accuracy of CCE examinations because of operator dependence. We sought to evaluate the accuracy of CCE examinations compared with cardiology-performed transthoracic echocardiogram (TTE).

DESIGN, SETTING, AND SUBJECTS: We retrospectively reviewed charts of patients in a medical ICU in a large academic medical center in the United States. We compared CCE examinations performed by a fellow and reviewed by a staff physician between May 5, 2020, and December 31, 2021, to TTE obtained within 24 hours of the CCE examination.

INTERVENTION, MEASUREMENTS, AND MAIN RESULTS: We developed a standardized process for documentation of all CCE examinations performed in the medical ICU. We assessed agreement (kappa statistic), sensitivity and specificity of CCE examination compared with TTE. Features included left ventricle (LV) systolic function, right ventricle (RV) size, RV systolic function, pericardial effusion, mitral insufficiency, tricuspid insufficiency, and aortic insufficiency. The study analyzed 504 pairs of CCE and TTE examinations. Kappa statistics for detecting LV and RV systolic dysfunction, pericardial effusion, and RV size ranged from 0.60 to 0.74. CCE showed high sensitivity and specificity for detecting LV and RV systolic dysfunction and pericardial effusion, with values ranging from 0.85 to 0.99. The kappa statistic for detecting RV dilation was 0.59, with a sensitivity of 0.71 and a specificity of 0.85. In contrast, CCE examinations were nondiagnostic for mitral, tricuspid, or aortic insufficiency in 60–70% of cases, whereas TTE examinations were nondiagnostic in 20–30% of cases. Kappa statistics for mitral, tricuspid, and aortic insufficiency ranged from 0.32 to 0.42.

CONCLUSIONS: CCE is a reliable tool for assessing LV and RV systolic function, pericardial effusion, and RV size. However, CCE may be limited in its ability to detect mitral, tricuspid, or aortic insufficiency.

KEYWORDS: critical care echocardiography; diagnostic accuracy; point-of-care ultrasound

The use of point-of-care ultrasound (POCUS) has dramatically increased as a primary tool in the critical care armamentarium, especially critical care echocardiography (CCE), which has a significant role in the care of critically ill patients (1). Although it is generally regarded as safe and carries the potential to improve patient care, CCE also has the potential to lead to patient misdiagnosis, mismanagement, and potentially even harm if interpreted incorrectly (2).

Current published studies assessing the accuracy of POCUS usually involve either a small number of highly proficient study investigators or a group of trainees who are assessed as part of a specific (often brief) training curriculum.

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KEY POINTS

Question: What is the clinical practice agreement between trainee-performed critical care echocardiography (CCE) and transthoracic echocardiogram (TTE) in the medical ICU?

Findings: Good agreement between CCE and *TTE* was noted for identifying abnormal left and right ventricle (LV and RV) systolic dysfunction and for identifying pericardial effusion (0.60–0.72). Agreement was limited (kappa 0.32–0.42) for identifying valvular abnormalities.

Meanings: Findings of trainee-performed CCE examinations can be effectively applied for LV and RV systolic function and for pericardial effusion, in the context of an established CCE infrastructure. However, ability to detect valvular abnormalities may be limited.

A recent meta-analysis by Yoshida et al (3) assessed the accuracy of CCE for shock, primarily in the emergency department, using clinial diagnosis as a reference standard. Andersen et al (4) conducted a comprehensive review of 51 studies investigating the suitability of POCUS in clinical settings. Their analysis revealed that only six of these studies incorporated greater than 20 practitioners. These studies provide important data, but the results may not be fully applicable in practice since CCE usually involves a heterogeneity of users and examination, interpretation, and oversight processes. Pragmatic studies looking at the accuracy of CCE in clinical practice have drawn variable conclusions about the agreement between the CCE examination (obtained by internists or intensivists) and a gold-standard transthoracic echocardiogram (TTE) (obtained by trained echocardiography technicians and read by cardiologists) (5, 6). The sample sizes for these studies are limited and the time range for comparing CCE to a gold-standard TTE is often prolonged (≥48 hr).

CCE examinations in our ICU are obtained by fellows and reviewed by staff physicians to assess patients with critical illness. Our study describes the clinical practice performance of CCE in our medical ICU (MICU). We aim to evaluate the agreement between trainees' CCE examinations and gold-standard cardiology-based TTE examinations that are conducted within 24 hours of the CCE examination.

MATERIALS AND METHODS

Study Design and Setting

This retrospective review evaluated all CCE studies performed on patients admitted to the MICU between May 5, 2020, and December 31, 2021, at a large academic medical center in the United States. All CCE examinations were performed by either a critical care medicine or pulmonary/critical care medicine fellow and reviewed by a staff physician.

All fellows had completed a 2-day, hands-on POCUS course in addition to a simulator-based CCE course (Ultrasound Mentor, Symbionix, Airport City, Israel). The simulator-based course included didactic videos, hands-on training cases, and a hands-on summative evaluation case. The didactic videos and hands-on cases focused on acquisition of basic CCE views and identification of common pathologies (reduced LV systolic function, dilated RV with reduced function, large pericardial effusion, severe mitral regurgitation). After successful completion of both courses, fellows were permitted to independently acquire ultrasound images in the clinical setting and document interpretations in the electronic medical record (EMR). Each study was overread and revised as needed in an asynchronous manner by an attending.

The attending credentialing process is divided into two categories: basic ultrasonography competency and advanced ultrasonography competency. Basic competency requires the attending to undergo either internal or external POCUS training, which includes a minimum of 5 hours of didactic content, approximately 7.5 hours of standardized patient scanning comprising two examinations for each organ system (heart, lung, abdomen, vascular), and about 7.5 hours of interactive image review. Additionally, attendings must perform a minimum of 20 examinations for each organ system under the direct supervision of a POCUS-credentialed physician. To attain advanced echocardiography credentialing, successful completion of the National Board of Echocardiography examinations CCeEXAM/ASeXAM is obligatory. Notably, six of 10 POCUS-credentialed attending overreaders in this study hold certification in CCE,

and all attendings possessed a minimum of basic competency, as well as more than 5 years of relevant experience at the time of this study.

Providers who perform CCE are instructed to follow a specific protocol for imaging and must document all results in a templated note within the EMR. The protocol includes the following views: parasternal long axis (including color doppler of aortic and mitral valve), parasternal short axis (aortic valve, mitral valve, and papillary muscle level), apical four chamber (including color doppler of tricuspid and mitral valves), subxiphoid four chamber, and inferior vena cava long axis or short axis. Advanced doppler assessments are part of our advanced CCE protocol and are not required as part of the standard protocol. A summary of the protocol used has been previously published (7). Templated notes include the parameters to document and grade the following: left ventricular (LV) systolic function, right ventricular (RV) size and function, pericardial effusion, mitral valve insufficiency, tricuspid valve insufficiency, and aortic valve insufficiency. IVC analysis was not included in this study because of a lack of standardized templates for these data point at the time of data collection. Acquired images are stored in a third party software platform (Agfa, Mortsel, Belgium) and reviewed by one of 10 critical care attending physicians with basic or advanced ultrasound competency. Changes to the templated note can be made by the attending overreader if needed. After the note is overread, the final note and images are transferred to the EMR. The ultrasound systems used during the study period were GE venue (GE, Boston, MA) with all ultrasounds having a phased array and linear array probe.

The study IRB 20-484 "Improving the Accuracy of Focused Cardiac Ultrasound in the ICU through a Quality Assurance System and a Simulation Curriculum" was approved by the institutional review board at Cleveland Clinic on May 1, 2020. Given the minimal risk to the patient, institutional review board waived the need for Informed consent. Procedures were followed in accordance with the ethical standards of the institutional responsible committee on human experimentation and with the Helsinki Declaration of 1975.

Patient Selection

We assessed all patients who were admitted to the MICU and had a documented CCE examination. Patients were included if they also had a TTE performed by an echocardiography technician and interpreted by a cardiologist within 24 hours of the CCE study. The CCE note reviewed for the study was the final note saved in the chart (after any asynchronous addendum by the critical care faculty).

Data Analysis

Parameters of interest from CCE and TTE examinations were extracted from the EMR. Parameters were stored as categorical variables (normal, mildly reduced, moderately reduced, severely reduced) if such a parameter was available. Reports with an ungraded comment (e.g., RV dilation is seen) were classified as "moderate" for that parameter. Reports with a spectrum of severity were categorized as the most severe element listed (e.g., moderate-severe mitral regurgitation was classified as *severe*). Parameters that were not assessed or were not mentioned, or where the reported severity was unclear were categorized as *nondiagnostic*.

We applied Cohen kappa statistic to each parameter to assess the degree of agreement between the CCE and TTE studies. Because each parameter was graded ordinally (e.g., normal, mildly abnormal, moderately abnormal, and severely abnormal), we performed the kappa analysis in three ways: first, using ordinal variables with quadratic weighting. Second, by converting the ordinal variables to a binary set of variables (normal/abnormal). For the binary variable kappa analysis, we defined abnormal as a variable containing "moderate" or "severe" abnormality. Third, given the possibility that one may consider hyperdynamic LV or RV function as abnormal, we also completed a three-group analysis. In this analysis, we defined a patient's LV and RV function as either hyperdynamic, normal (normal or mildly abnormal function), or abnormal (moderate/severely abnormal function). The interpretation of the kappa values was based on data according to Altman (8) (Kappa value < 0.2 = poor, 0.2–0.4 = fair, 0.4–0.6 = moderate, 0.6–0.8 = good, and 0.8–1.0 = very good). Variables classified as "nondiagnostic," were excluded from this analysis. We also converted our binary variables into 2×2 tables of CCE vs. TTE to determine sensitivity, specificity, and likelihood ratios for each parameter, using TTE as the gold standard. Microsoft Excel (2022, Redmond, WA) was used for analysis. All aspects of the Standards for

Reporting of Diagnostic Accuracy Studies (STARD) 2015 statement were reviewed and adhered to in the reporting and the analysis (9).

RESULTS

One thousand two hundred two CCE-TTE examination pairs were identified in the initial data set from May 5, 2020, to December 31, 2021. Five hundred four of these examinations had TTE performed within 24 hours and were included in the analysis. A total of 55 fellows participated in conducting the included examinations under supervision by 10 POCUS-credentialed attending physicians. Patient characteristics are shown in **Table 1**. Forty percent of patients were female. The average age was 61 years old and average body mass index was 30. The average Acute Physiology and Chronic Health Evaluation III score was 83. Out of the 504 studies performed, 55% (277 studies) were conducted for the purpose of evaluating patients with shock or hypotension. On average, the time between admission to the ICU and the CCE examination was 6.5 hours, whereas the time between the CCE examination and the TTE was 9 hours.

When analyzing the agreement between CCE and TTE using ordinal variables, the agreement was good (k = 0.6–0.8) for LV systolic function, RV systolic function, and pericardial effusion, moderate (0.4–0.6) for RV size and mitral insufficiency, and fair (0.2–0.4) for tricuspid and aortic insufficiency (**Table 2**). When analyzing the agreement between CCE and TTE using binary variables (clinically significant abnormality present or absent), the agreement was similar except for tricuspid and aortic valve insufficiency. The agreement for these variables improved from fair to moderate (Table 2). Our three-group analysis yielded the following agreement values (with 95% CIs) for LV function (0.59 [0.52–0.66]) and RV function (0.63 [0.55–0.72]), respectively.

Table 3 shows that the sensitivity and specificity values for detecting LV systolic function were 0.87 and 0.94, respectively. For detecting RV systolic function, the sensitivity and specificity values were 0.85 and 0.94, respectively. The sensitivity and specificity values for detecting pericardial effusion were 0.87 and 0.99, respectively. The sensitivity and specificity for detecting RV size were 0.71 and 0.85, respectively. However, the sensitivity and specificity for detecting mitral, tricuspid, and aortic insufficiency were found to be variable, with values of 0.79 and 0.91, 0.82 and 0.75, and 0.70 and 0.88, respectively. Notably, CCE examinations had a higher rate of nondiagnostic results compared with TTE examinations, particularly in the assessment of valvular function. Up to 60–70% of CCE examinations were nondiagnostic for mitral, tricuspid, or aortic insufficiency, whereas only 20–30% of TTE examinations were nondiagnostic.

The specific data points used in the analysis of agreement are shown in **Figure 1** (**Supplemental Digital Content 1**, http://links.lww.com/CCX/B286).

TABLE 1.
Patient Characteristics

Patient Characteristics	N (%) or Mean (SD)
Total no. of examinations, *n* (%)	504
Age, yr (average, SD)	61.1 (15.1)
Female, *n* (%)	201 (39.9%)
Body mass index, kg/m^2 (SD)	30.4 (8.3)
Race	
White, *n* (%)	308 (61.1%)
African or African American, *n* (%)	171 (33.9%)
Asian, *n* (%)	7 (1.4%)
Multicultural/multiracial, *n* (%)	17 (3.4%)
Admission characteristics	
Time from hospital admission to POCUS examination–d (SD)	4.1 (7.5)
Time from ICU admission to POCUS examination–hr (SD)	6.5 (7.8)
Time between POCUS examination and transthoracic echocardiogram examination–absolute value, hr (SD)	9 (6.7)
Hospital length of stay–d (SD)	17.7 (15.6)
Acute Physiology and Chronic Health Evaluation III score–average (SD)	82.8 (33.3)
Indication for POCUS examination	
Shock or hypotension, *n* (%)	277 (55.0)
Hypoxia or respiratory failure, *n* (%)	84 (16.7)
Pulmonary embolism, *n* (%)	61 (12.1)
Cardiac arrest, *n* (%)	50 (9.9)
Others, *n* (%)	32 (6.3)

POCUS = point-of-care ultrasound.

DISCUSSION

Our research offers insight into the practical use of CCE for cardiac assessment by ICU clinicians. The results

TABLE 2.
Agreement for Critical Care Echocardiography Compared With Corresponding Transthoracic Echocardiogram (*n* = 504 Studies)

Echocardiographic Finding	Nondiagnostic POCUS Examinations, *n* (%)	Nondiagnostic TTE Examinations, *n* (%)	Agreement between POCUS and TTE, Weighted Kappa (95% CI)	Agreement between POCUS and TTE, Cohen Kappa (95% CI)
Left ventricle systolic function	62 (12.3)	20 (4.0)	0.740 (0.68–0.80)	0.693 (0.61–0.78)
RV size	65 (12.9)	40 (7.9)	0.594 (0.52–0.67)	0.550 (0.46–0.64)
RV systolic function	91 (18.1)	64 (12.7)	0.674 (0.59–0.76)	0.612 (0.51–0.71)
Pericardial effusion	69 (13.7)	69 (13.7)	0.603 (0.46–0.74)	0.774 (0.58–0.97)
Mitral insufficiency	305 (60.5)	98 (19.4)	0.424 (0.31–0.54)	0.487 (0.33–0.64)
Tricuspid insufficiency	353 (70.0)	143 (28.4)	0.355 (0.21–0.50)	0.423 (0.25–0.6)
Aortic insufficiency	362 (71.8)	115 (22.8)	0.317 (0.07–0.56)	0.445 (0.18–0.71)

POCUS = point-of-care ultrasound; RV = right ventricle; TTE = transthoracic echocardiogram.

TABLE 3.
Sensitivity, Specificity, and Area Under the Receiver Operating Curve for Critical Care Echocardiography Compared With Corresponding Transthoracic Echocardiogram (*n* = 504 Studies)

Echocardiographic Finding	Sensitivity	Specificity	LR+	LR–	Area Under the Receiver Operating Curve (95% CI)
Left ventricle systolic function	0.87	0.94	14.5	0.14	0.9322 (0.9008–0.9561)
RV size	0.71	0.85	4.9	0.34	0.8224 (0.7793–0.8602)
RV systolic function	0.85	0.94	14.8	0.16	0.9319 (0.9019–0.9551)
Pericardial effusion	0.87	0.99	92.4	0.13	0.9837 (0.9623–0.9947)
Mitral insufficiency	0.79	0.91	9.1	0.23	0.8519 (0.7288–0.9338)
Tricuspid insufficiency	0.82	0.75	3.27	0.24	0.8085 (0.6674–0.9085)
Aortic insufficiency	0.70	0.88	6.07	0.34	0.8684 (0.7713–0.9351)

LR = Likelihood Ratio; RV = right ventricle.

demonstrate that clinicians, including trainees, are capable of accurately evaluating left and right ventricular function with CCE and detecting pericardial effusions with high diagnostic confidence. Nevertheless, the results suggest that the ability to identify valvular abnormalities using CCE in this context is limited.

It is important to note that our study methodology differs from much of the prior research in the field of CCE. Previous studies have often compared the accuracy of CCE in small groups of highly skilled operators or trainees who have undergone specific training programs and have been observed for a short period of time, which can introduce the risk of Hawthorne and observer bias (10). In contrast, our research assessed the actual effectiveness of CCE in an ICU setting for over a year. Although a critical care physician with basic or advanced ultrasound competency reviewed the final report for each CCE study, the images were captured by fellows, as would be expected in any teaching hospital.

There are existing studies available that have assessed CCE in such a pragmatic manner. Festic et al (5) reported in their preliminary results from a similar setting to ours that there was good agreement between CCE assessments of LV, RV, and pericardial effusion

performed by intensivists and the gold-standard TTE for 38 patients, ranging from 60% to 80%. Our study has concluded similar findings with a larger sample size (504 patients). Johnson et al (6) conducted a 6-month prospective observational study to compare the LV function assessments of internal medicine physicians using CCE vs. TTE within 48 hours. The agreement between the two methods in their study was found to be 0.77 (95% CI [0.67–0.87]), which is comparable to the agreement in our study (0.69 [0.61–0.78]). However, our study involved a different setting (ICU), included a narrower time window to TTE (24 hr), and included other parameters beyond LV systolic function. Farsi et al (11) evaluated the accuracy of CCE performed by emergency medicine residents on 205 patients presenting to the emergency department with suspected cardiovascular disease. The study reported similar sensitivity and specificity for detecting pericardial effusion (0.86/0.96) and LV function (0.89/0.96) but higher sensitivity and specificity for detecting RV dilation (0.93/0.98) compared with our findings. This difference may be attributed to the fact that the study only categorized RV dilation as present or absent, without reporting its severity. In our study, patients with "mild dilation" were considered "normal" in our binary model, which may account for the difference in results between the two studies as the groups may not be directly comparable.

It is noteworthy that our study revealed a high proportion of cases where valve abnormalities were not assessed, and a lower level of agreement between CCE and TTE for valve assessment. These findings could be attributed to several reasons, including the fact that assessing valve abnormalities in multiple views can be time-consuming, which can be a limiting factor in the treatment of critically ill patients. In addition, most basic CCE protocols do not prioritize valve assessment (12). Our CCE training (and the protocol) for fellows includes color doppler examination of the valves in each of the basic views, but we do not specifically train fellows how to grade severity of a regurgitant jet. Nonetheless, we assumed that a trained fellow and overreader could distinguish moderate or severe regurgitation from trace or mild regurgitation (or none at all). Although the kappa statistic assessing CCE vs. TTE for tricuspid and aortic insufficiency was fair when assessed in ordinal format, regrouping of these variables into a binary format only improved concordance modestly. This finding suggests that additional attention to this area is warranted.

The existing literature on CCE in critical care and emergency department settings has limited data on valvular assessment (11–13). Based on our findings, we believe that it is crucial for training programs to give more attention to valvular assessment (14). This may include specific training and evaluation of protocols for standardized grading of valvular regurgitation. Such evaluation in CCE is certainly clinically relevant, given the value of early identification and exclusion of significant valvular regurgitation in critically ill patients. In the interval, our results suggest that when any suspicion of valve pathology exists, the threshold should be low to request a diagnostic TTE performed by an expert sonographer technician or cardiologist.

The study has some constraints that need to be considered. First, there is a potential for patient conditions to vary between the time of CCE and TTE, which could result in differences in echo findings and falsely reduce the level of agreement between the two methods. To mitigate this issue, we minimized the maximum time gap between CCE and TTE to 24 hours, which is narrower than the 48-hour interval used in many other comparative studies. The second limitation of our study was the exclusion of CCE studies that did not have a corresponding TTE. The reasons behind clinicians' decisions to order a TTE so soon after a CCE examination were not investigated, but it is possible that the TTE was primarily requested for patients with challenging CCE image acquisition and those with greater illness severity. This type of selection bias could potentially affect our findings by excluding patients with better CCE images and those with less severe illness. Additionally, our study was limited to a narrow set of parameters that we considered to be essential for a basic CCE examination. Although most CCE studies included additional findings such as assessment of cardiac output, estimation of right atrial pressure, or measurement of right ventricular systolic pressure, these parameters were not regularly reported since they were not mandatory elements of our basic CCE assessment report in the EMR.

CONCLUSION

We showed that CCE done by a trainee physician in the medical ICU demonstrates good agreement with cardiology-performed TTE when assessing LV systolic

function, RV systolic function, and pericardial effusion. Other parameters, including valvular assessment, showed limited agreement with TTE and were reported less frequently on CCE assessment. Although abnormal LV, RV, and pericardial effusion findings on CCE carry a high degree of reliability, nondiagnostic or normal valve pathologies should be interpreted with caution. In clinical situations where valve pathology is of concern further investigation with TTE may be prudent. A future direction for programs who offer CCE training should be to ensure standardized training, protocols, and quality assurance for evaluation of valvular regurgitation within the basic CCE examination structure.

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REFERENCES

1. Via G, Hussain A, Wells M, et al: International evidence-based recommendations for focused cardiac ultrasound. *J Am Soc Echocardiogr* 2014; 27:683.e1–683.e33
2. Moore CL, Copel JA: Point-of-care ultrasonography. *N Engl J Med* 2011; 364:749–757
3. Yoshida T, Yoshida T, Noma H, et al: Diagnostic accuracy of point-of-care ultrasound for shock: A systematic review and meta-analysis. *Crit Care* 2023; 27:200
4. Andersen CA, Holden S, Vela J, et al: Point-of-care ultrasound in general practice: A systematic review. *Ann Fam Med* 2019; 17:61–69
5. Festic E, Bansal V, Diaz-Gomez J: 278: Comparison and analysis of results of focused versus standard echocardiograms in critically ill. *Crit Care Med* 2013; 41:A64
6. Johnson BK, Tierney DM, Rosborough TK, et al: Internal medicine point-of-care ultrasound assessment of left ventricular function correlates with formal echocardiography. *J Clin Ultrasound* 2016; 44:92–99
7. Fox S, Dugar S. Point-of-care ultrasound and COVID-19. *Cleve Clin J Med* 2020. https://pubmed.ncbi.nlm.nih.gov/32409431/
8. Cohen JF, Korevaar DA, Altman DG, et al: STARD 2015 guidelines for reporting diagnostic accuracy studies: Explanation and elaboration. *BMJ Open* 2016; 6:e012799
9. Altman DG: *Practical Statistics for Medical Research*. First Edition. London, Chapman and Hall London, 1991
10. Dickson R, Duncanson K, Shepherd S: The path to ultrasound proficiency: A systematic review of ultrasound education and training programmes for junior medical practitioners. *Australas J Ultrasound Med* 2017; 20:5–17
11. Farsi D, Hajsadeghi S, Hajighanbari MJ, et al: Focused cardiac ultrasound (FOCUS) by emergency medicine residents in patients with suspected cardiovascular diseases. *J Ultrasound* 2017; 20:133–138
12. Lau YH, See KC: Point-of-care ultrasound for critically-ill patients: A mini-review of key diagnostic features and protocols. *World J Crit Care Med* 2022; 11:70–84
13. Marbach JA, Almufleh A, Di Santo P, et al: Comparative accuracy of focused cardiac ultrasonography and clinical examination for left ventricular dysfunction and valvular heart disease. *Ann Intern Med* 2019; 171:264–272
14. Hammadah M, Ponce C, Sorajja P, et al: Point-of-care ultrasound: Closing guideline gaps in screening for valvular heart disease. *Clin Cardiol* 2020; 43:1368–1375