The utility of bedside echocardiography in critically ill COVID-19 patients: Early observational findings from three Northern New Jersey hospitals

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Abstract
Introduction: Cardiovascular complications related to coronavirus disease 2019 (COVID-19) have led to the need for echocardiographic services during the pandemic. The present study aimed to identify the echocardiographic findings in hospitalized COVID-19 patients and their utility in disease management.

Methods: We included patients who were diagnosed with COVID-19 using polymerase chain reaction and those who underwent echocardiographic examination during their hospitalization.

Results: Altogether, 45 patients were evaluated. The mean age was 61.4 ± 12.2 years. Hypertension (n = 29, 64%) and diabetes mellitus (n = 25, 55%) were the most common comorbidities followed by congestive heart failure (n = 11, 24%), coronary artery disease (n = 9, 20%), and valvular heart disease (n = 3, 7%). Eight patients (18%) showed evidence of myocardial injury, as suggested by elevated troponin levels. Brain natriuretic peptide was elevated in 14 patients (36%), and 14 patients had left ventricular dysfunction in the form of reduced ejection fraction (31%). Right ventricular (RV) dilatation was observed in six patients, and five patients had reduced RV ejection fraction. RV pressure and volume overload were observed in three patients. RV thrombus was observed in one patient. Pulmonary pressure was elevated in 10 patients (24%).

Conclusion: Two-dimensional echocardiography can be an important bedside tool for the assessment of cardiovascular abnormalities and hemodynamic status of COVID-19 patients.

1 | INTRODUCTION

The coronavirus disease 2019 (COVID-19) has grown into the largest global healthcare crisis of this century after its emergence in Wuhan in the Hubei Province of China in December 2019. Angiotensin-converting enzyme two surface protein acts as a receptor for severe acute respiratory syndrome coronavirus 2 and is the port of entry into the cell. These receptors are also expressed in the myocardium, reflecting the link between the heart and the virus. Emerging data have shown that this novel virus affects the cardiovascular system in several ways, leading to increased morbidity and mortality. Several case reports and recently published epidemiological data have shown that patients with myocardial involvement and COVID-19 infection exhibit worse outcomes. The effects of this viral infection...
on the cardiovascular system include myocardial infarction, acute exacerbation of heart failure, arrhythmias, and procoagulant effects. Cardiovascular abnormalities related to COVID-19 have led to the need for echocardiographic evaluation of these patients to help in the management and identification of cardiac complications. The present study aimed to identify the echocardiographic findings in COVID-19 patients and their utility in disease management.

2 | METHODS

The present study was conducted between March 15, 2020 and April 15, 2020 during the COVID-19 pandemic in three different hospitals in Northern New Jersey, USA, which is one of geographical hotspots of COVID-19 in the United States. We retrospectively reviewed the charts of patients who were diagnosed with COVID-19 using polymerase chain reaction and underwent echocardiographic examination during admission for COVID-19. All examinations were performed in the patient rooms on the medical floors or in the intensive care units to decrease the risk of infection, which may occur while moving patients from one location to another. The equipment was cleaned before and after the procedures according to the hospitals’ infectious disease control guidelines. All requests for echocardiograms were screened by a cardiologist to limit the examinations to those that were truly needed and appropriate. All measurements and Doppler calculations were performed offline after acquisition of images to minimize patient contact time. Echocardiographic parameters were obtained according to the recommendations by the American Society of Echocardiography (ASE). Philips iE33 (Phillips, Amsterdam, Netherlands) and GE Vivid E9 (GE Healthcare, Chicago, IL, USA) were used to acquire the images. The echocardiographic findings were interpreted by board-certified cardiologists. Six cardiologists from three different hospitals interpreted the echocardiograms. Patient characteristics, medical history, and laboratory data were obtained retrospectively from the Electronic Medical Record Review.

3 | RESULTS

Altogether, 45 patients were included in the present study. The mean age of the included patients was 61.4 ± 12.2 years (range: 28–81 years). Males and females were equally represented in our data (males = 23, females = 22). The most common reason for requesting an echocardiogram was hypoxemic respiratory failure (n = 14), followed by shock (n = 11), acute coronary syndrome (n = 9), thromboembolic phenomenon (n = 6), and malignant arrhythmias (n = 5).

Hispanics constituted 47% of the study population (n = 21), followed by African Americans (27%, n = 12), Caucasians (20%, n = 9), and other races (6%, n = 3). Hypertension (n = 29, 64%) and diabetes mellitus (n = 25, 55%) were the most common comorbidities, followed by congestive heart failure (n = 11, 24%), coronary artery disease (n = 9, 20%), and valvular heart disease (n = 3, 7%). Eight patients (18%) had myocardial injury, as suggested by elevated troponin (n = 44). Brain natriuretic peptide (BNP) was elevated in 14 patients (35.8%) (n = 39). Among the inflammatory biomarkers, the majority (93%, n = 29) had an elevated lactate dehydrogenase (LDH) and ferritin level of 87.8% (n = 33). Elevated D-dimer levels were observed in 24 patients (88%) (n = 27), suggesting that they might be in a prothrombotic state.

Eighteen patients (40%) had a prior echocardiogram for comparison with the present results. Fourteen patients had left ventricular (LV) systolic dysfunction (31%). Among these, seven patients had mild dysfunction (left ventricular ejection fraction [LVEF] 41%–50%), two patients had moderate dysfunction (LVEF 30%–40%), and five patients had severe dysfunction (LVEF < 30%). Ten out of these 14 patients developed new LV systolic dysfunction. Among the four patients with prior LV systolic dysfunction, two patients showed worsening of LVEF. LV thrombosis was not observed in any patient. Regional wall motion abnormalities were observed in two patients. One patient exhibited acute myocardial infarction (AMI) with regional wall motion abnormalities, and another patient had Takotsubo cardiomyopathy. The remaining patients with low ejection fraction had global hypokinesis. None of the patients exhibited pericardial effusion or severe valvulopathy. Six patients had right ventricular (RV) dilatation, and five patients exhibited reduced right ventricular ejection fraction (RVEF). Pressure and volume overload, as demonstrated by flattening of the interventricular septum (IVS) in diastole and systole, were observed in three patients. RV thrombus was observed in one patient, and it was confirmed with computed tomography angiography (CTA) of the chest. This patient also showed McConnell’s sign on echocardiogram (Movie S1). Pulmonary artery systolic pressure (calculated using the modified Bernoulli’s equation) was elevated in 10 patients (24%). Four patients had RV enlargement as well as reduced RVEF. Among these, two patients also exhibited elevated pulmonary pressures. The laboratory data and echocardiographic findings are summarized in Table 1. None of the patients from our study population underwent a transesophageal echocardiogram.

4 | DISCUSSION

The unequal racial distribution in our study possibly reflects the demographics that our institution caters to. However, there have been reports that Hispanic and African American patients are disproportionately affected and have worse outcomes. Hypertension and diabetes mellitus were the most common comorbidities associated with COVID-19 infection in our patients, which is consistent with most of the previously published literature. Inflammatory biomarkers also play an important role in risk stratification of COVID-19 severity and prognostication. Elevated BNP and cardiac troponin have been associated with myocardial injury and poor outcomes. The prevalence of elevated cardiac biomarkers in our study was higher than that observed by Lippi et al (8%–12%). This difference was
A frequent (81%) thromboembolic complication in these patients.8 Data suggest that the incidence of thromboembolism was as high as is a very high risk of thromboembolism including pulmonary embolism (PE) whose diagnosis was aided by echocardiography. There markers has been described previously.2 However, no data are available regarding the echocardiographic findings in these patients. The etiology of LV dysfunction can be multifactorial in these patients. Emerging evidence suggests that an-coagulation could help select a group of patients10 and echocardiography may aid in identifying these patients. Hypoxemia and high positive end-expiratory pressure ventilation requirements in these patients may also lead to RV dysfunction and consequent poor cardiac output. Point of care ultrasound (POCUS) in critical care units can help identify features of RV dysfunction and help in ventilator management to minimize adverse effects on cardiac output.11 As noted in the recent ASE statement, POCUS can be considered the first-line ultrasound examination to determine the need for further detailed echocardiograms.12 Echocardiography can also guide the selection of patients who may benefit from continuous invasive monitoring in the form of right heart catheterization. In the majority of the patients, echocardiograms helped narrow down the differential and provided guidance for management. In patients with shock, echocardiography helped in discerning the etiology of shock and in aiding the management. In patients with acute coronary syndrome, it helped in the detection of wall motion abnormalities and guided therapy.

The most common and clinically significant echocardiography findings in these patients included decreased LVEF and echocardiographic signs of pulmonary embolism. Identification of these conditions assisted in patient management. We recommend using contrast agents in these patients, as they help in better estimation of LVEF and identification of thrombi. In patients with ischemic changes on electrocardiogram and elevated troponins, we found that the echocardiogram was very helpful in decision-making regarding cardiac catheterization versus conservative management. Similarly, in patients with hypoxemia and respiratory distress out of proportion to the radiographic findings, echocardiograms helped us identify RV dysfunction, elevated pulmonary pressures, and RV thrombus. Thus, we could order more definitive tests like CTA to guide further management. In their recently published case series, Zhang et al focused on cardiac ultrasound in COVID-19 patients. Similar to our findings, they reported its utility in the assessment of LV function, suggestion of pulmonary embolism, and identification of myocardial injury and thrombus.13 We recommend following the ASE’s “whom to image, where to image, and how to image” guideline at the institutional level as a guide for the utilization of echocardiographic evaluation to most likely due to the selection bias of performing echocardiograms on the patients suspected to have a cardiac injury. LDH, ferritin, and D-dimer levels were elevated in the majority of our patients. These markers are associated with severe disease, hypercoagulability, and increased mortality.6

Myocarditis based on elevated troponins and inflammatory biomarkers has been described previously.2 However, no data are available regarding the echocardiographic findings in these patients. The etiology of LV dysfunction can be multifactorial in these patients. These patients may exhibit AMI due to plaque rupture secondary to the stress of infection, as was observed in one of our patients who had complete occlusion of the mid-left anterior descending artery and underwent percutaneous intervention. One of the patients in our study population developed stress-related cardiomyopathy secondary to COVID-19 infection. He suffered cardiac arrest with minimal troponin elevation and his echocardiogram showed typical features of Takotsubo cardiomyopathy. Other possible etiological factors for poor LV systolic function in these patients could be myocarditis or prior cardiomyopathy. Two echocardiograms were requested to rule out LV thrombus in patients who presented with acute limb ischemia, but LV thrombus was excluded in both the cases with the use of ultrasound contrast-enhanced LV opacification. It has been hypothesized that arterial thrombosis might result from a coagulation disorder in severely affected COVID-19 patients.7

Our study population contained two patients with pulmonary embolism (PE) whose diagnosis was aided by echocardiography. There is a very high risk of thromboembolism including pulmonary embolism in patients with severe COVID-19 infection. Recently published data suggest that the incidence of thromboembolism was as high as 31% in critically ill patients and pulmonary embolism was the most frequent (81%) thromboembolic complication in these patients.8 In our study, RV thrombus was observed in one patient, which was confirmed with CTA of the chest that showed extensive pulmonary embolism. The patient was treated with low-molecular-weight heparin. Repeat echocardiography after 2 weeks showed near-complete resolution of the thrombus. The second patient with PE was a 28-year-old woman with COVID-19 and no other risk factors. She presented with severe shortness of breath and CTA confirmed extensive bilateral pulmonary embolism after her echocardiogram showed RV dilatation with flattening of IVS. She received tissue plasminogen activator and was eventually discharged home on apixaban. There is a growing consensus that patients with COVID-19 infection have a prothrombotic state. The presence of microthrombi in the pulmonary vasculature has been demonstrated in postmortem studies.9 This finding could explain the elevated pulmonary pressures and RV dysfunction in these patients. Emerging evidence suggests that anticoagulation could help select a group of patients10 and echocardiography may aid in identifying these patients. Hypoxemia and high positive end-expiratory pressure ventilation requirements in these patients may also lead to RV dysfunction and consequent poor cardiac output. Point of care ultrasound (POCUS) in critical care units can help identify features of RV dysfunction and help in ventilator management to minimize adverse effects on cardiac output.11

### TABLE 1 Echocardiographic and laboratory parameters

| Echocardiography findings (n = 45)                      | Number of patients |
|--------------------------------------------------------|--------------------|
| Decreased left ventricular ejection fraction            | 14                 |
| Regional wall motion abnormality                       | 2                  |
| Takotsubo cardiomyopathy                               | 1                  |
| Left ventricular thrombus, pericardial effusion        | 0                  |
| Right ventricular dilatation                           | 6                  |
| Decreased right ventricular ejection fraction           | 5                  |
| Pressure and volume overload                           | 3                  |
| Right ventricle thrombus                               | 1                  |
| Pulmonary hypertension                                 | 10                 |

| Laboratory findings (n = total number of available tests) | Number of patients |
|----------------------------------------------------------|--------------------|
| Elevated brain natriuretic peptide (n = 39)              | 14                 |
| Elevated troponin (n = 44)                               | 8                  |
| Elevated lactate dehydrogenase (n = 29)                  | 27                 |
| Elevated ferritin (n = 33)                               | 29                 |
| Elevated D-dimer (n = 27)                                | 24                 |
provide high-quality care to patients. Echocardiography laboratories throughout the world need to adapt to the changing practice of transthoracic echocardiography in the times of COVID-19 pandemic. A strategy that enables screening of all requested echocardiograms by a physician and performing more focused echocardiograms will help minimize the risk of exposure to the sonographers and avoid inappropriate studies.

Our study has a few limitations. It was an observational retrospective study, and the number of patients was relatively small. As some of the patients in our study population were still hospitalized at the conclusion of our data collection, outcomes could not be assessed. We recommend larger prospective studies to identify the indications and utility of echocardiography in COVID-19 patients.

In conclusion, two-dimensional echocardiography can be an important bedside tool in the assessment of cardiovascular abnormalities and hemodynamic status of COVID-19 patients. When performed in an appropriate group of patients, the echocardiogram is an invaluable tool that can aid in navigating management options.

CONFLICT OF INTEREST
None.

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REFERENCES
1. Vaduganathan M, Vardeny O, Michel T, et al. Renin-angiotensinaldosterone system inhibitors in patients with Covid-19. N Engl J Med. 2020;382:1653–1659.
2. Shi S, Qin MU, Shen BO, et al. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. JAMA Cardiol. 2020;5(7):802.
3. Hooper MW, Nápoles AM, Pérez-Stable EJ. COVID-19 and racial/ethnic disparities. JAMA. 2020;323(24):2466.
4. Guan W-J, Liang W-H, Zhao YI, et al. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. Eur Respir J. 2020;55:2000547.
5. Lippi G, Plebani M. Laboratory abnormalities in patients with COVID-19 infection. Clin Chem Lab Med. 2020;58:1131–1134.
6. Terpos E, Ntanasis-Stathopoulos I, Elalamy I, et al. Hematological findings and complications of COVID-19. Am J Hematol. 2020;95:834–837.
7. Zhang Y, Xiao M, Zhang S, et al. Coagulopathy and antiphospholipid antibodies in patients with Covid-19. N Engl J Med. 2020;382:e38.
8. Klok FA, Kruij M, van der Meer N, et al. Incidence of thrombotic complications in critically ill ICU patients with COVID-19. Thromb Res. 2020;191:145–147.
9. Fox SE, Akmatbekov A, Harbert J, et al. Pulmonary and cardiac pathology in Covid-19: the first autopsy series from New Orleans. DOI: https://doi.org/10.1101/2020.04.06.2005057
10. Tang N, Bai H, Chen X, et al. Anticoagulant treatment is associated with decreased mortality in severe coronavirus disease 2019 patients with coagulopathy. J Thromb Haemost. 2020;18:1094–1099.
11. Peng Q-Y, Wang X-T, Zhang L-N. Using echocardiography to guide the treatment of novel coronavirus pneumonia. Crit Care. 2020;24:143.
12. Drake DH, De Bonis M, Covella M, et al. Echocardiography in pandemic: front-line perspective, expanding role of ultrasound, and ethics of resource allocation. J Am Soc Echocardiogr. 2020;33:683–689.
13. Zhang L, Wang B, Zhou J, Kirkpatrick J, Xie M, Johri AM. Bedside focused cardiac ultrasound in COVID-19 from the Wuhan epicenter: the role of cardiac point-of-care ultrasound, limited transthoracic echocardiography, and critical care echocardiography. J Am Soc Echocardiogr. 2020;33:676–682.
14. Kirkpatrick JN, Mitchell C, Taub C, et al. ASE statement on protection of patients and echocardiography service providers during the 2019 novel coronavirus outbreak. J Am Coll Cardiol. 2020;75:3078–3084.
15. Ward RP, Lee L, Ward TJ, et al. Utilization and appropriateness of transthoracic echocardiography in response to the COVID-19 pandemic. J Am Soc Echocardiogr. 2020;33:690–691.

SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section.

Movie S1. Right Ventricle (RV) focused view showing RV thrombus and McConnell’s sign with hypokinesia of mid and basal walls sparing the RV apex.

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