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ORIGINAL ARTICLE

The quality, safety, feasibility, and interpretive accuracy of echocardiographic and lung ultrasound assessment of COVID-19 patients using a hand-held ultrasound

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Abstract

Background: The association between COVID-19 infection and the cardiovascular system necessitates the use of an echocardiogram in this setting. Information on the utilization, safety, and quality of point-of-care cardiac and lung ultrasound using a hand-held device in these patients is scarce.

Aims: To investigate the safety, technical aspects, quality indices, and interpretive accuracy of a hand-held echocardiogram in patients with COVID-19.

Methods: From April-28 through July-27, 2020, consecutive patients with COVID-19 underwent hand-held echocardiogram and lung ultrasound evaluation (Vscan Extend™; GE Healthcare) within 48-h of admission. The operators recorded a series of technical parameters and graded individual experiences. The examinations were further analyzed by a blinded fellowship-trained echocardiographer for general quality, proper acquisition, and right ventricular (RV) demonstration.

Results: Among 103 patients, 66 (64.1%) were male. Twenty-nine (28.2%) patients could not turn on their left side and 23 (22.3%) could not maintain effective communication. The mean length of each echocardiogram study was 8.5 ± 2.9 min, battery usage was 14 ± 5%, and mean operator-to-patient proximity was 59 ± 11 cm. Ninety-five (92.2%) examinations were graded as fair/good quality. A fair agreement was demonstrated between the operator and the echocardiographer for general ultrasound quality (Kappa = 0.329, $p < 0.001$). A fair-good correlation ($r = 0.679$, $p < 0.001$) and substantial agreement (Kappa = 0.612, $p < 0.001$) were demonstrated between the operator and echocardiographer for left ventricular ejection fraction (LVEF), whereas a fair agreement was demonstrated for RV systolic function (Kappa = 0.308, $p = 0.002$). LVEF agreement was also assessed using the Bland-Altman analysis revealing a mean bias of −0.96 (95% limits of agreement 9.43 to −11.35; $p = 0.075$).

Conclusions: Among patients with COVID-19, echocardiography with a hand-held ultrasound is a safe and reasonable alternative for a complete formal study (<10% poor-quality indices). Echocardiogram assessment by the operators during the exam acquisition is reliable for LVEF, while RV systolic function should be subsequently offline reassessed.

KEYWORDS
COVID-19, echocardiography, feasibility studies, physiology, safety, ventricular function

1 | BACKGROUND

The association between cardiovascular disease and morbidity and mortality among hospitalized Coronavirus disease 2019 (COVID-19) patients is well established, with worse outcomes demonstrated among patients with an abnormal echocardiogram.[1,2] In addition, lung ultrasound has proven to be useful in the triage, diagnosis, prognostication, and treatment of patients with COVID-19.[3] Both cardiac and lung ultrasound of patients hospitalized with COVID-19 play a key role in clinical management.[4–6]

Point-of-care ultrasound (POCUS) has evolved considerably and is now increasingly used by different disciplines for numerous clinical objectives.[7] The well-known advantages of POCUS with regard to portability, time-to-diagnosis, focused dynamic exam, bedside evaluations, safety, and the option for repeated follow-up examinations are even more pronounced when addressing the use of hand-held ultrasound devices.[8] These benefits are especially important in the setting of patients with COVID-19, as the possibility of performing a bedside ultrasound examination minimizes the need for patient transfer, with the potential risk of further disease spread among other uninfected patients or health care personnel. In these settings, POCUS with small, inexpensive, hand-held dedicated devices provides an instantaneous, real-time assessment that may have a direct impact on immediate patient diagnosis and management.[8]

On the other hand, the use of hand-held ultrasound devices may involve several limitations, including, limited image optimization, small screen size, and equivocal findings that need confirmation by a high-end device.[8] These potential downsides led to this study that investigates the safety, technical aspects, quality indices, and interpretive accuracy of hand-held echocardiogram and lung ultrasound in patients hospitalized with COVID-19.

2 | METHODS

2.1 | Study setting

This is a prospective study of real-time focused echocardiograms performed by a hand-held device. The study was conducted on consecutive PCR-confirmed COVID-19 patients hospitalized in designated medical wards at a tertiary care medical center from April 28 through July 27, 2020, before COVID-19 vaccines were available. The study was approved by the hospital's Institutional Review Board (IRB; 0138-20-SZMC).

All echocardiographic clips were acquired by cardiologists or intensivists and were later interpreted by a fellowship-trained echocardiographer. Variables including demographics and past medical history were obtained from the medical chart.

2.2 | Study endpoints

The study endpoints included the safety, technical aspects, quality indices, and interpretive accuracy (by the initial operator compared to a fellowship-trained echocardiographer) of hand-held echocardiograms and lung ultrasound in patients hospitalized with COVID-19.

2.3 | Study protocol

Confirmed COVID-19 patients who were hospitalized in designated departments were recruited into the study. Conscious patients consented verbally. In accordance with the IRB approval, patients who were not able to give informed consent underwent an echocardiogram if it was clinically indicated. Patients that refused to participate in the study were excluded. Data included age, sex, body mass index (BMI), chronic comorbidities, COVID-19 presentation, exam characteristics, and hospital course. Technical aspects, including the patient's ability to turn on the left side, and ability to maintain effective communication (i.e. the ability to follow orders and comply with the examination) were also recorded. High-risk patients were defined as those with a room-air saturation of <94%. Routine imaging, laboratory studies, and medical treatment were performed for patients based on the clinical judgment of the treating physician. The study physicians performing the ultrasound examination wore personal protective equipment including a full gown, N95 respirator, face shield, and two sets of gloves. Participants were evaluated by focused cardiac and lung ultrasound within 48 hours of their hospitalization using a hand-held ultrasound device (Vscan Extend™ with Dual Probe; General Electric Healthcare). The cardiac ultrasound was conducted using the sector probe from the apical, parasternal, and substernal views. Valves were evaluated using both 2D and Doppler echocardiograms. Lung ultrasound was completed using the linear probe with a standard 12-location assessment (four quadrants on each anterior hemithorax and two on each posterior hemithorax). The screen brightness was set as 36% for all of the exams.

The acquired video clips were stored in the Digital Imaging and Communications in Medicine (DICOM) format and sent wirelessly to a picture archiving and utilization platform (McKesson Cardiology™, version 14.0 TX, USA) routinely used by the cardiology department.

2.4 | Examination evaluation

Immediately upon examination completion, technical variables, biventricular systolic function, and lung findings were recorded manually at the patient's bedside. Technical variables for the echocardiogram study included heart rate, length of study (minutes; as calculated by the device), battery usage (percentage change), mean distance)cm) between the operator and head of the patient (from the operator's chin to the patient's nose), difficulty, general quality of the study, convenience, satisfaction, safety, and proper RV demonstration. The self-reported assessments of the five latter variables were graded into three groups: good, fair, and poor. The gradings for the difficulty category were the following: not difficult, fairly difficult, and very difficult. Technical variables for the lung ultrasound study included length of study, battery usage, the mean distance between the operator and head of the patient, difficulty, general quality of the study, and operator satisfaction. All were graded according to the above-mentioned scale.

Biventricular systolic function variables included left ventricular ejection fraction (LVEF) and right ventricular (RV) systolic function (dichotomic option). The hand-held lung ultrasound was completed using the linear transducer for B-lines, subpleural consolidations/lung hepatization, and pleural effusions.

The echocardiogram clips were then evaluated and interpreted by a blinded echocardiography fellowship-trained cardiologist (echocardiographer) (AB) using the archiving platform (blinded to the patient's characteristics and operators' assessments) for visual evaluation of technical variables including quality, proper acquisition, RV demonstration, and biventricular systolic function. The variables were graded similarly to the operator evaluation scale and stored in a separate file.

2.5 | Data management

All data obtained in this study were entered into two Microsoft Excel spreadsheets (Microsoft Corporation, Redmond, Washington, United States). One file contained the case identifying number, patient identifiers, patients' characteristics, and the operators' evaluations. The echocardiographer evaluations were inserted into a second file using the patient's identifying number. The two files were later matched.

2.6 | Statistical analyses

Descriptive statistics were used to characterize patients' characteristics and technical variables. Patients' characteristics and technical variables were then presented according to the three echocardiogram quality groups (good-, fair-, and poor-quality) as per the echocardiographer blinded assessment. Comparisons between the groups were tested for differences with chi-square for categorical variables and with Kruskal–Wallis one-way analysis of variance for continuous variables.

LVEF, RV systolic function, and quality assessments of the echocardiographer were set as the gold standard. The operator LVEF assessments were compared to the echocardiographer's assessment for linear correlation using the Pearson correlation coefficient (*r* values <0.3, 0.3–0.5, 0.5–0.7, and ≥0.7 were considered to represent poor, poor to fair, fair to good, and excellent agreement, respectively).

The interrater reliability using the Kappa coefficient was then calculated between the operators' assessments and the echocardiographer's assessment for ultrasound quality (fair-good vs. poor), RV systolic function (normal vs. abnormal), and LV systolic dysfunction using a cutoff of 50% for the LVEF (normal-preserved vs. decreased LV systolic function). Kappa values 0, 0–0.2, 0.21–0.40, 0.41–0.60, 0.61–0.80 and ≥0.81 were considered to represent no agreement, slight, fair, moderate, substantial, and almost perfect agreement, respectively.

LVEF assessment agreement and bias between the operators and the echocardiographer were calculated using the Bland-Altman analysis including mean difference and 95% limits of agreement (according to two standard deviations).

The *p* values of all analyses were calculated. Statistical analyses were performed using SPSS Statistics for Windows version 21 (SPSS Inc., Chicago, IL).

3 | RESULTS

3.1 | Baseline and medical characteristics

A total of 103 patients hospitalized with newly diagnosed COVID-19 were recruited into the study. Four patients refused to participate in the trial and thus were excluded. Male patients constituted 64.1% (n = 66) of the total cohort (Table 1). Their mean age was 60 ± 18 years, with a BMI of 28 ± 6 kg/m^2 and a heart rate of 79 ± 13 beats/min. Twenty-nine (28.2%) patients could not turn on their left side and 23 (22.3%) could not maintain effective communication. Nine (8.7%) patients suffered from chronic lung disease. Seventy-one (68.9) patients were defined as high-risk (room-air saturation <94%).

3.2 | Baseline and medical characteristics according to echocardiogram quality groups (Table 1)

Comparing good- versus fair- versus poor-quality echocardiogram groups, the group with the poor-quality echocardiogram had a higher BMI, history of cerebrovascular accident (CVA), were less able to turn on their left side, had a higher heart rate, lower room-air saturation levels (a higher rate of high-risk patients), a lower proportion of full view echocardiogram completion, and a higher rate of non-invasive and advanced ventilatory support.

3.3 | Echocardiogram technical characteristics (Table 1)

The mean length of each study was 8.5 ± 2.9 min, the battery usage was 14.4 ± 4.9%, and the mean proximity between the operator and head of

TABLE 1 Baseline, clinical characteristics, presentation and in-hospital course and exam technical variables of the study cohort divided into three subgroups according to hand-held echocardiogram quality (good-, fair-, and poor-quality) as per the echocardiographer blinded assessment

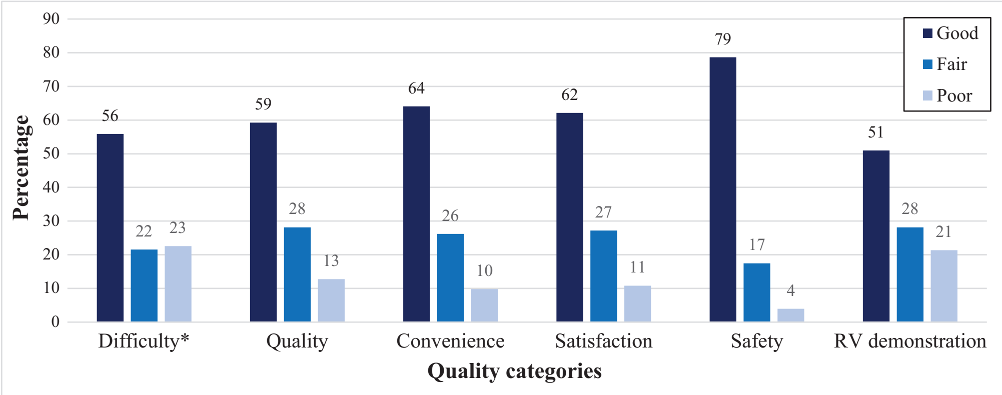
Variable	All $n = 103$	Good quality $n = 45$	Fair quality $n = 50$	Poor quality $n = 8$	p-value[a]
Baseline characteristics					
Age (year), mean ± SD	59.7 ± 18.3	55.4 ± 19.8	62.0 ± 16.2	69 ± 18.0	0.059
Male, *n* (%)	66 (64.1)	28 (62.2)	32 (64.0)	6 (75.0)	0.786
BMI (kg/m^2), mean ± SD	27.9 ± 6.2	26.1 ± 4.9	28.7 ± 6.4	33.5 ± 8.0	**0.007**
Smoker, *n* (%)	16 (15.5)	8 (17.8)	8 (16.0)	0 (0.0)	0.438
Diabetes mellitus, *n* (%)	33 (32.0)	12 (26.7)	19 (38.0)	2 (25.0)	0.451
Hypertension, *n* (%)	40 (38.8)	12 (26.7)	24 (48.0)	4 (50.0)	0.082
Ischemic heart disease, *n* (%)	20 (19.4)	9 (20.0)	10 (10.0)	1 (12.5)	0.876
Cerebrovascular accident, *n* (%)	5 (4.9)	1 (2.2)	2 (4.0)	2 (25.0)	**0.019**
Revascularization, *n* (%)	17 (16.5)	7 (15.6)	9 (18.0)	1 (12.5)	0.903
Heart failure, *n* (%)	12 (11.7)	5 (11.1)	7 (14.0)	0 (0.0)	0.513
Valve replacement/CIED, *n* (%)	6 (5.8)	2 (4.4)	4 (8.0)	0 (0.0)	0.194
Cognitive decline, *n* (%)	23 (22.3)	7 (15.6)	12 (24.0)	4 (50.0)	0.091
Debilitated, *n* (%)	26 (25.2)	9 (20.0)	13 (26.0)	4 (50.0)	0.195
Lung disease, *n* (%)	9 (8.7)	2 (4.4)	6 (12.0)	1 (12.5)	0.397
Chronic inhalation therapy, *n* (%)	7 (6.8)	3 (6.7)	3 (6.0)	1 (12.5)	0.794
Ability to turn left, *n* (%)	74 (71.8)	38 (84.4)	32 (64.0)	4 (50.0)	**0.031**
Effective communication, *n* (%)	80 (77.7)	38 (84.4)	38 (76.0)	4 (50.0)	0.091
COVID-19 presentation					
Heart-rate (bpm), mean ± SD	79.2 ± 13.1	75.9 ± 13.9	80.7 ± 12.4	86.4 ± 9.0	**0.031**
SpO_2 (%), mean ± SD	87.4 ± 11.4	89.8 ± 9.5	85.7 ± 13.1	84.8 ± 7.9	**0.014**
Exam characteristics and technical aspects					
Battery usage (%), mean ± SD	14.4 ± 4.9	13.9 ± 4.5	14.7 ± 5.2	14.9 ± 5.5	0.816
Patient distance (cm), mean ± SD	58.9 ± 10.8	61.6 ± 9.9	56.9 ± 11.2	55.7 ± 12.1	0.108
Length of study (min.), mean ± SD	8.5 ± 2.9	8.0 ± 2.6	8.9 ± 3.2	8.6 ± 3.1	0.405
Full view successful completion, *n* (%)	79 (76.7)	45 (100.0)	30 (60.0)	4 (50.0)	**<0.001**
In-hospital course					
Sinus tachycardia, *n* (%)	16 (15.5)	4 (8.9)	10 (20.0)	2 (25.0)	0.244
Chest X-ray infiltrates, *n* (%)	76 (73.8)	27 (60.0)	42 (82.0)	7 (87.5)	**0.019**
AF/AFL, *n* (%)	13 (12.6)	6 (13.1)	6 (12.0)	1 (12.5)	0.981
Ventilatory support[b], *n* (%)	63 (61.1)	36 (35.6)	19 (38.0)	8 (100.0)	**0.001**
Advanced ventilatory support[c], *n* (%)	26 (25.2)	6 (13.1)	18 (36.0)	2 (25.0)	**0.040**
Mechanical ventilation, *n* (%)	12 (11.7)	3 (6.7)	8 (16.0)	1 (12.5)	0.366

Abbreviations: AF, atrial fibrillation; AFL, atrial flutter; bpm, beats per minute; BMI, body mass index; CIED, cardiac implantable electronic device; cm, centimeter; kg/m^2, kilogram per square meter; min., minute; n, number; SD, standard deviation; SpO2, oxygen saturation.
[a]Good-quality versus fair-quality versus poor-quality.
[b]Includes any use of oxygen support, advanced ventilatory support, and mechanical ventilation.
[c]Includes high flow nasal cannula, non-invasive positive airway pressure support, and invasive mechanical ventilation.

the patient was 58.9 ± 10.8 cm. All predefined echocardiogram views were fully completed in 79 (76.7%) examinations. An average of 2.5 full examinations (including echocardiographic evaluation, 12-view lung ultrasound, and automated LV indices calculations) were completed with a single battery charge.

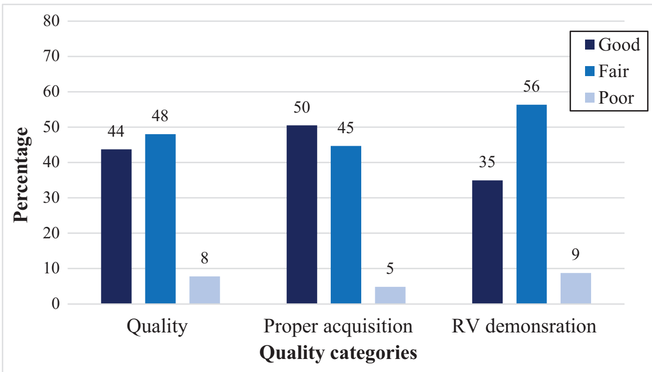
3.4 | Echocardiogram quality and safety indices

None of the unvaccinated operators was infected with COVID-19 during the study. Safety and quality indices as assessed by the operators and the echocardiographer are presented in Figure 1A and B,



Panel (A): Technical variables of hand-held echocardiogram including difficulty, general quality, convenience, satisfaction, safety, and demonstration of the RV as documented manually by the operator at the patient bedside.

*The gradings for the difficulty category were the following: Not difficult, Fairly difficult, and Very difficult.



Panel (B): Technical variables including general quality, proper acquisition, and RV demonstration as documented by the echocardiographer during offline evaluation.

Abbreviation: RV, right ventricle.

FIGURE 1 Quality, utilization, and safety indices of hand-held echocardiogram according to operator and echocardiographer. Parameters were graded into three groups: good, fair, and poor

respectively. Per operator assessments, 79 (76.7%) examinations were rated as having a fair and low level of difficulty, 90 (87.4%) as having a fair and above general quality, 93 (90.3%) as having a fair and above level of convenience, 92 (89.3%) as having a fair and above level of satisfaction, 99 (96.1%) as having a fair and above level of safety, and 81 (78.6%) as having a fair and above proper RV demonstration.

Per echocardiographer assessment, 95 (92.2%) of examinations were graded as having a fair and above general quality, 98 (95.1%) of examinations as having a proper acquisition, and 94 (91.3%) as having a fair and above RV demonstration.

3.5 | Ultrasound study quality assessment correlation and agreement

A fair agreement was demonstrated between the operator and the echocardiographer assessment for general ultrasound quality with a calculated Kappa of 0.329 (standard error of 0.89, $p < 0.001$).

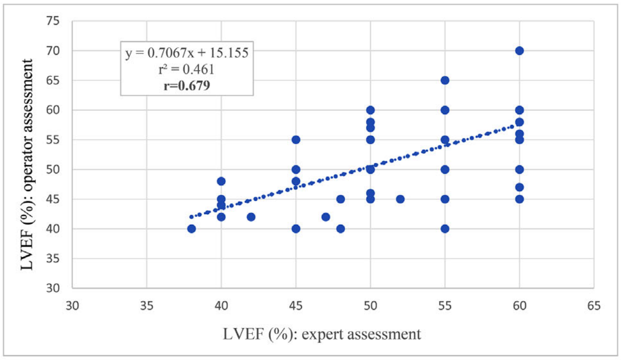
3.6 | LVEF assessment correlations and agreement

As shown in Figure 2A, a fair to good positive correlation was demonstrated between the operator and the echocardiographer assessment for LVEF with a Pearson correlation coefficient of 0.679 ($p < 0.001$). The agreement between the operator and the echocardiographer assessment using a cutoff of LVEF 50% was substantial, with a calculated Kappa coefficient of 0.612 (standard error of 1.00, $p < 0.001$).

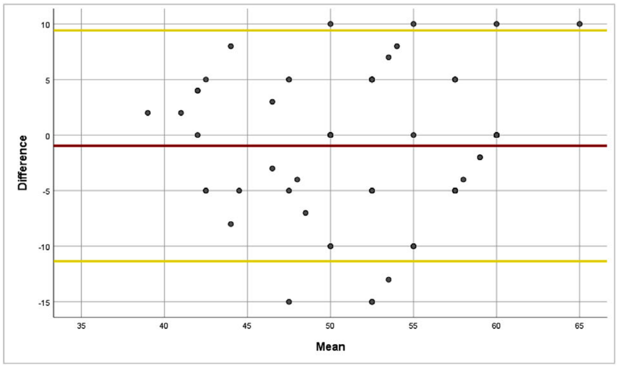
As shown in Figure 2B, LVEF agreement assessment between the operator and the echocardiographer using the Bland-Altman analysis revealed a mean bias of −0.96 ($p = 0.075$) with limits of agreement ranging from 9.43 to −11.35.

3.7 | RV systolic function assessment correlation and agreement

A fair agreement was demonstrated between the operator and the echocardiographer assessment for RV systolic function



Panel (A): LVEF correlation between the operator and the echocardiographer; Pearson correlation coefficient = 0.679 (p<0.001).



Panel (B): LVEF assessment agreement using the Bland-Altman analysis revealed a mean bias of -0.96 as represented by the red line with limits of agreement ranging from 9.43 to -11.35 as represented by the yellow lines (p=0.075).

Abbreviations: LVEF, left ventricular ejection fraction.

FIGURE 2 Left ventricular ejection fraction (LVEF) assessment correlation and agreement between the operator and the echocardiographer

assessment, with a calculated Kappa of 0.308 (standard error of 0.145, $p = 0.002$).

3.8 | Lung ultrasound technical characteristics

The mean length of each lung ultrasound study was 3.4 ± 1.0 min, the battery usage was 6.6 ± 2.8%, and the mean proximity between the operator and head of the patient was 56.2 ± 10.3 cm. All pre-defined lung ultrasound views were fully completed in 80 (77.7%) examinations.

3.9 | Lung ultrasound quality indices

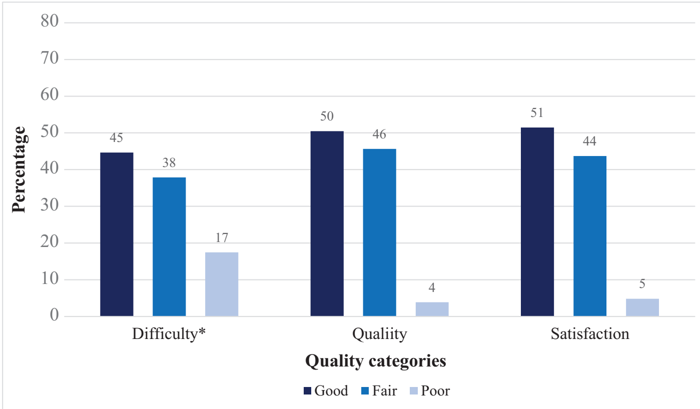
Quality indices as assessed by the operators are presented in Figure 3. Per operator assessments, 85 (82.5%) examinations were graded as having a fair and low level of difficulty, 99 (96.1%) as having a fair and above general quality, and 98 (95.1%) as having a fair and above level of satisfaction.

4 | DISCUSSION

This study was performed prior to the introduction of vaccines against COVID-19, when the fear of infection amongst healthcare workers was very high. The study showed that the use of a hand-held ultrasound device for focused echocardiographic and lung assessments of patients hospitalized with PCR-confirmed COVID-19 infection was found to be feasible and safe, during a time of limited medical resources due to a pandemic.

Point-of-care ultrasound (POCUS) has been established as an important tool during the past decade and is now increasingly used in many clinical settings and by different medical specialists, mainly for diagnosis and procedural guidance.[7] The introduction of smaller and cheaper hand-held devices, as well as the incorporation of artificial intelligence technologies, have addressed some of the challenges associated with POCUS and have extended its applicability.[9–12]

Previous studies have demonstrated the clinical utility of cardiac and lung POCUS for triage, diagnosis, and management of patients with COVID-19.[13–14] Other studies also showed high rates of cardiac and pulmonary abnormalities, as well as the ability to predict a worse outcome in this group of patients.[1,2,15,16] However, most of these studies were performed with full-size standard ultrasound machines. When compared to standard ultrasound machines, hand-held ultrasound devices might be more useful in patients with suspected or confirmed COVID-19 infection, due to their improved mobility and smaller size which allow faster cleaning and decontamination resulting in shorter test time and reduced operator exposure and hence less risk.[17,18] However, a question remains regarding the safety, diagnostic



Technical variables of hand-held lung ultrasound including difficulty, general quality, and satisfaction as documented manually by the operator at the patient's bedside.

* The gradings for the difficulty category are the following: Not difficult, Fairly difficult, and Very difficult.

FIGURE 3 Quality utilization indices of lung hand-held ultrasound according to operator assessment. Parameters were graded into three groups: good, fair, and poor

performance, and accuracy of hand-held devices in the setting of the COVID-19 pandemic.

It has been demonstrated that there is a high diagnostic accuracy of hand-held ultrasound scanners and a good correlation with high-end scanners,[19–21] However, these studies weren't performed in the challenging setting of COVID-19 hospitalized patients. In the current study, less than 10% of examinations were graded by a fellowship-trained echocardiographer as of poor general quality and these were more common in patients with a higher BMI or prior CVA, those who needed ventilatory support, or with unfavorable heart rate and oxygen saturation, and in those that were not able to turn to their left side. The implications of these findings are that repeat examinations using a high-end device due to poor imaging quality will not be necessary for most patients, and that the need for such examinations can be predicted mostly by patient characteristics. In addition, our study demonstrates a good correlation between the echocardiographer and operator LVEF accuracy of interpretation and, albeit to a lesser extent, RV systolic function. A possible reason for the limited RV interpretive accuracy includes the objective challenges involved with performing the procedure and acquiring clips with sufficient quality while simultaneously trying to avoid the risk of infection, especially in the setting of patients with breathing difficulties and pronounced lung artifacts. These findings suggest that real-time LV function assessment in the COVID-19 environment is reliable, however, RV systolic function is less reliable, and offline reassessment of the acquired echocardiogram studies performed with a hand-held device may be required.

Since COVID-19 is highly contagious and imposes a substantial risk of infection and severe disease for healthcare workers,[22,23] society guidelines recommended avoiding unnecessary imaging testing including echocardiogram in an attempt to minimize the risk of infection in healthcare workers.[24,25] Previous studies demonstrated the mean imaging time required for a complete echocardiogram ranging from 24 to 26 minutes.[26,27] In contrast, this study shows a much shorter operator-exposure time with a hand-held device, with a mean length of echocardiogram study of only 8.5 minutes. In addition, subjective measurements of operator safety were found to be good without being immediately next to the patient.

Concerning lung assessment with a hand-held device, this study showed that an operator could stand half a meter from the head of the patient and still obtain quality imaging studies safely. In addition, the entire 12-point lung assessment could be completed in a COVID-19 setting in less than four minutes per patient. Besides not exposing the patient to radiation, lung ultrasound was found to have a higher sensitivity than chest x-ray at identifying COVID-19 when computed tomography was used as the gold standard.[28,29] Handheld ultrasound for lung findings was also found to have a very high correlation with conventional machines.[30] Common lung US findings include an irregular pleura, coalescent/confluent B-lines, consolidations, and air bronchograms.[31] Other researchers have used these findings to develop scoring systems such as CLUE (COVID-19 Lung Ultrasound in the Emergency department) to risk stratify COVID-19 patients either to home, medical ward, or intensive care unit.[32] As suggested by the present study, a hand-held ultrasound device can potentially be utilized for the mentioned lung assessment of COVID-19 patients as an inexpensive, accurate, and instantaneous routine evaluation tool.

5 | LIMITATIONS

One of the limitations of the study is the subjective grading of the examinations in terms of the level of difficulty, general quality, convenience, satisfaction, safety, and proper RV demonstration. The lack of a validated standard of evaluation may limit generalizability to other operators. Also, unlike the echocardiogram assessments, the POCUS lung findings were not compared to an expert or to a gold standard such as chest computed tomography.

Although this was part of a larger project that evaluated the ability of hand-held US to predict outcomes in hospitalized patients with

COVID-19,[2] the study itself did not look at the association between the technical issues and these outcomes. In addition, all of the operators were either cardiologists or intensivists. This may limit the applicability to other physicians who although take care of most inpatients with COVID-19, but may have less experience with advanced cardiopulmonary POCUS applications.

6 | CONCLUSION

Echocardiogram and lung assessment with a hand-held ultrasound device is a safe and reasonable alternative for complete formal echocardiogram in patients with COVID-19 with most cases categorized as of fair/good-quality, proper acquisition, and correct RV demonstration. The operator real-time assessment is reliable regarding LV function, but less reliable regarding RV systolic function and study quality assessment. The results shown here suggest a more liberal use of hand-held devices for POCUS cardiac and lung assessments, as these devices can provide invaluable clinical data while shortening operator-exposure time, when compared to high-end devices, thus minimizing the risk of infection to the operator.

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CONFLICT OF INTEREST

None.

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