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Early View

Original research article

Focused lung ultrasound to predict respiratory failure in patients with symptoms of COVID-19. A multicentre prospective cohort study

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Title page

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Abstract

Background: In this study we aimed to assess if a focused lung ultrasound examination predict the need for mechanical ventilation admission to an intensive care unit, high-flow oxygen treatment, death of COVID-19 within 30 days and 30-day all-cause mortality in patients with clinical suspicion of COVID-19 or PCR-verified SARS-CoV-2 infection.

Methods: A multicenter prospective cohort trial was performed. Film clips from focused lung ultrasound examinations were recorded and rated by blinded observers using different scoring systems. A prediction model was built and used to test relationship between lung ultrasound scores and clinical outcomes. Diagnostic performance of scoring systems was analyzed.

Results: A total of 3,889 film clips of 398 patients were analyzed. Patients who had any of the outcomes of interest had a significantly higher ultrasound score than those who did not. Multivariable logistic regression analyses showed that lung ultrasound predicts mechanical ventilation (RR 2.44, 95% CI 1.32 – 5.52), admission to intensive care (RR 2.55, 95% CI 1.41 – 54.59) and high-flow oxygen treatment (RR 1.95, 95% CI 1.5 – 2.53) but not survival when adjusting for sex, age and relevant comorbidity. There was no diagnostic difference in AUC-ROC between a scoring system using only anterolateral thorax zones and a scoring system that also included dorsal zones.

Conclusion: Focused lung ultrasound in patients with clinical suspicion of COVID-19 predicts respiratory failure requiring mechanical ventilation, admission to intensive care units and high-flow oxygen. Thus, focused lung ultrasound may be used to risk stratify patients with COVID-19 symptoms.

Introduction

The COVID-19 pandemic has put a high load on health care systems, as many patients need immediate evaluation for respiratory failure related to pulmonary damage from SARS-CoV-2 infection. In frontline medical facilities like emergency departments or dedicated COVID-19 clinics, the high number of patients requires efficient, fast and reliable management. Most patients with COVID-19 can be managed out of hospital, but around 10–30% need hospitalization and 7% mechanical ventilation [123]. These numbers inflict careful allocation of resources to ensure that patients at high risk of respiratory failure are admitted to a service that can provide life-saving treatment, such as nasal oxygen administration, high-flow oxygen treatment or mechanical ventilation when needed. Conversely, patients at low risk of respiratory failure could be treated out of hospital or admitted to less resource-intensive services.

Assigning COVID-19 patients to the proper treatment and observation intensity requires a precise, safe and applicable clinical tool that can predict the development of respiratory failure. Multiple prediction systems have been developed and validated in large cohorts [456]. Most of these include imaging, such as a chest X-rays or a Computed Tomography (CT), and scanning of the lungs to assess the degree of damage. While highly relevant, these image modalities are problematic in relation to COVID-19, as CT scanning capacity is limited, and in-hospital transportation of isolated infectious patients to scanning facilities poses a risk of contaminating other patients and health care personnel. Chest X-rays can be recorded at bedside, but the need for dedicated radiographical staff constricts their use in high-stress situations. Furthermore, supine chest X-ray images are often difficult to interpret. Therefore, there is a clear need for a fast and easy image modality suited to COVID-19 demands.

Focused lung ultrasound (FLUS) is performed at the patient's bedside by the attending physician. Thereby, the risk of the virus spreading is reduced, and the result of the examination is readily available for clinical decision making [7]. FLUS has shown excellent diagnostic accuracy in multiple respiratory conditions, including the diagnosis of COVID-19, but its ability to predict future respiratory failure remains to be studied in a larger study [89].

Consequently, we primarily aimed to study the capability of FLUS to predict the initiation of mechanical ventilation in patients hospitalized with symptoms of, or confirmed, SARS-CoV-2 infection. Secondarily, we aimed to study FLUS's capability to predict initiation of high-flow oxygen therapy, admission to intensive care unit and death in the same population. Thirdly, we wanted to assess the performance of different FLUS scoring systems.

Methods

Study Design

The study was designed as a multicenter prospective cohort trial. The study was approved by the local ethical committee, RM: 1-10-72-1-20, and the Danish Health Authority, SST nr. 31-1521-377 and registered on clinical-trails.org, NCT04327674. The manuscript adheres to the STROBE reporting guidelines [10].

Setting

Twelve hospitals participated in the study. Inclusion spanned March 2020 to mid-June 2020, which was during the first wave of the COVID-19 pandemic in Denmark.

Participants and Recruiting

All adult patients (age > 18 years) with symptoms of COVID-19 or PCR-confirmed SARS-CoV-2 infection who had a FLUS examination performed when visiting an emergency department or when being admitted to an internal medicine department or a dedicated COVID-19 clinic were eligible for inclusion. Participants were included by convenience, as attendance of a physician able to perform the FLUS examination was not available at all times. Patients were excluded if FLUS was performed after the onset of any of the outcome variables or if they took part in the study at a previous visit or admission.

Data Sources and Variables

Data on age, sex, vital parameters, comorbidity, mechanical ventilator treatment, 30-day mortality, admission to intensive care facilities, oxygen administration, treatment limitations, laboratory results and results from nasal or tracheal PCR to SARS-CoV2 were performed as part of normal

clinical routine and extracted from electronic patient files. Comorbidity was classified according to the risk of death of COVID-19 [11]. Patients were registered as comorbid if they had COPD, HIV, diabetes, heart failure, hypertension, obstructive sleep apnea, asthma, atrial fibrillation, ischemic heart disease, chronic renal failure, dementia, liver cirrhosis, hemiplegia, rheumatoid arthritis, alcohol abuse, hyperthyroidism, metastasized cancer or obesity.

Sonographic Data

The FLUS examinations were performed on the anterior and lateral chest zones and, if patients were able to sit, at the dorsal zones according to a standardized generic 14-zone protocol endorsed by the European Respiratory Society[12]. The choice of the ultrasound apparatus, transducer and pre-set was made at the discretion of the operator. Film clips were recorded from each zone and later analyzed according to an international standard for lung ultrasound in COVID-19 by observers blinded to any other data [13]. In this scoring system, zones were rated as 0 if the pleural line was intact and if A-lines (horizontal artifacts) were present in the lung parenchyma. A score of 1 was given if the pleural line was indented and vertical white areas were present. A score of 2 was given if the pleural line was broken and sub-pleural lesions associated with white vertical areas were present. Finally, a score of 3 was given if the scanned area showed dense and large white lung findings. For each patient, all available zones (right and left anterior, lateral, and dorsal zones) were scored (0–3) and summed up in a single mean, mean-FLUS, that reflects the total affection of the lungs. The mean-FLUS score was used as the primary sonographic variable.

Alternative Sonographic Scoring Systems

When only aggregates of the FLUS scores were considered, patients with severe affection in only one lobe would have a low score. It was expected that such patients would have a high risk for respiratory failure, and therefore, the FLUS examinations were reclassified: 1) Highest FLUS score

in any zone (i.e., a score on two in one zone and zero in all other zones resulted in a maximum score of 2). 2) FLUS score = 3 in any zone (i.e., binary, positive if the patient had one or more zones with a score of 3, but negative if the patient did not have any zone scoring 3). 3) Count of zones with a score of 3. 4) Count of zones with a score of 2. 5) Mean-FLUS score of anterior and lateral chest zones only (FLUS data from dorsal zones were expected to be missing in some patients with respiratory distress who were unable to sit. A subgroup analysis was performed on the film results from the anterior and lateral zones only, leaving the posterior zone out.) 6) Other studies report a simple sum of zones ignoring any missing zones and to compare with these studies a total sum was analyzed.

Prediction analyses and receiver operating characteristic analyses comparing areas under the curve were performed for these different FLUS scoring systems to explore potential differences on the subpopulation that who had no missing ultrasound data. Furthermore, was the effect of choice of transducer evaluated.

Outcome Variables

The need for COVID-19-related mechanical ventilation was the primary endpoint of interest. Secondary outcomes were COVID-19-related admission to intensive care, high-flow oxygen treatment, 30-days mortality and all-cause 30-day mortality.

Bias

The FLUS scoring was blinded to any baseline or outcome variables. Interrater variability in the analysis of FLUS data was blindly assessed on video clips from 25 randomly selected patients, 174 film clips by two observers

Study Size

As all patients were included during the first wave of the COVID-19 pandemic, no prior studies were available for sample size calculation.

Statistical Methods

Continuous variables were assessed for parametric distribution with quartile-quartile plots. Medians, interquartile ranges or means and standard deviations and ranges were reported according to parametric distribution. Students' t-test or Mann-Whitney U test was used as it was considered appropriate to evaluate differences between groups. The statistical significance was set to 5%. All data were handled in Excel (Microsoft) and REDCap (hosted at Aarhus University). All analyses were performed using Stata 14.2 (StataCorp, USA).

Building Prediction Models

Prediction models were based on multivariable logistic regression and preselected variables. The variables were sex, age, relevant comorbidity, oxygen administration and the mean-FLUS score. The selection of these variables was based on published data and clinical experience available to the study group during the study design stage. Explanatory variables were examined to decide cut-points, scales or the need for transformation. Variables were limited and prioritized to avoid overfitting or underfitting, respecting the study population size. Every included variable required at least 15 events.

The dependent variable was the primary outcome of interest: the COVID-19-related need for mechanical ventilation in the main analysis. Secondary outcomes were analyzed using the same logistic regression model, except for the outcome on high-flow oxygen treatment. The explanatory

variable on oxygen administration was considered closely related to the outcome and was thus excluded from this analysis.

Additional Analysis Based on COVID-19 Status

The entire study population was divided into subgroups based on positive and negative SARS-CoV-2 PCR tests at the time the FLUS, and all prediction models were performed on these subgroups to evaluate the difference in FLUS prediction capability.

Results

Participants

In total, 417 patients were recruited, but ultrasound film clips were available for analysis in only 398 of these. Some 57% had a positive SARS-CoV-2 PCR test. None of the patients had the outcome of interest before the FLUS examination was performed. Demographic data, baseline clinical data and outcome data for the study population are described in Table (1). In total, 17 patients (4.3%) ended up receiving mechanical ventilation due to COVID-19.

FLUS Result Summary

Among the 398 patients, 3,889 FLUS film clips were analyzed. FLUS was done with a curvilinear transducer and abdominal preset with frequency on 4 and focus point at 8 cm in 197(49.5%) of the patients and with a phased array transducer with a frequency on 3.4 and a focus point at 9 cm in 201(50.5%). The mean-FLUS findings from the different scanning zones are shown in Table (2). The mean-FLUS scores had non-parametric distribution and median was 0.59, IQR 0.14 – 1.25, n = 398. In the SARS-CoV-19-negative patients, the mean-FLUS score was 0.21, IQR 0 – 0.71, n = 160, versus 0.88, IQR 0.38 – 1.63, n = 227, in the positive ones, $p < 0.001$. Mean-FLUS scores were

higher for patients who received mechanical ventilation, were admitted to intensive care units, were treated with high-flow oxygen and died within 30 days, when compared with patients who did not meet these outcomes (Figure 1).

FLUS Prediction of Outcome

In the primary outcome analysis, a one-unit increase in the continuous mean-FLUS score was the only variable that independently predicted a future event of ventilator treatment, RR 2.44, 95% CI 1.32 – 5.52, per unit increase in FLUS score, $p < 0.001$, when adjusting for age, sex, comorbidity and non-high-flow oxygen administration. In the univariable analysis, the relative risk for ventilator treatment was 2.84, 95% CI 1.69 – 4.77, $p < 0.001$. In addition, in the univariable analysis, the need for non-high-flow oxygen administration predicted ventilator treatment, RR 3.63, 95% CI 1.38 – 9.53, p = 0,009, but age, sex and comorbidity did not.

Regarding secondary outcomes, a unit increase in the mean-FLUS score independently predicted intensive care admission, RR 2.55, 95% CI 1.41 – 54.59, $p < 0.001$, and high-flow oxygen treatment ,RR 1.95, 95% CI 1.5 – 2.53, $p < 0.001$. No other variables included in the multivariable logistic regression models or the univariable analysis were able to predict these events.

Conversely, FLUS did not independently predict all-cause 30-day mortality, RR 0.96, 95% CI 0.61 – 1.51, p = 0.85, or 30-day mortality related to COVID-19, RR 1.14, 95% CI 0.7 – 1.88, p = 0.6, in the multivariable analysis. Only age, RR 1.07, 95% CI 1.04 – 1.10, $p < 0.001$, and RR 1.08 95% CI 1.04 – 1.11, $p < 0.001$, and sex, male gender, RR 2.33, 95% CI 1.2 – 4.54, p = 0.013 and RR 2.69, 95% CI 1.24 – 5.83, p = 0.012, were statistically significant, predicting variables to all-cause 30-day mortality and 30-day mortality related to COVID-19. Detailed results from the analyses are shown in Supplementary Table (1).

Interrater Variability

The regression of agreement between observers showed a good linear correlation, $R^2 = 0.7$ (Figure 2). The Bland–Altman plot of the median rating difference in the FLUS score and the average FLUS score showed little discrepancy between the two observers. The variability was statistically larger as the average score increased ($y = 1.39 – 0.2$, $p = 0.01$). Kappa scores from the individual scanning zones showed moderate agreement, with an average score of 0.4 (Supplementary Table 9).

Additional Analysis of FLUS Scoring Systems

Uni- and multivariable logistic regression analyses with the maximum FLUS score, number of zones scoring higher than two and number of zones scoring higher than three predicted the future event of mechanical ventilation, intensive care admission and high-flow oxygen administration (Table 4 and Supplementary e-Tables 2–5). The FLUS analysis of the anterior and lateral chest scanning zones (right 1, 2, 3, 4 and left 1, 2, 3, 4), excluding the posterior zones, showed prediction results similar to the entire FLUS scanning that Included the posterior zones, as shown in Supplementary e-Table (6).

The area under the curve receiver operating characteristics (AUR ROC) on the 129 patients who had all zones scanned are shown in Figure (3). For the primary outcome, mechanical ventilation, the AUC ROC for the mean FLUS score and the total sum FLUS was 0.94, 95%CI 0.85 – 1. AUC ROC of FLUS score from the anterior and lateral zone only was likewise 0.95, 95%CI 0.86 – 1 AUC ROC was lower of the scoring systems that classified the presence of one zone scoring ≥3, 0.79, 95%CI 0.46 – 1, the number of zones scoring ≥2, 0.88, 95%CI 0.75 – 1 and for the number of zoner scoring >3, 0.79, 95%CI 0.79, 95%CI 0.46 – 1- Test for difference, $p<0.001$. Testing for difference between transducer type the AUC ROC was 0.93, 95%CI 0.82 – 1, for the curvilinear transducer and 0.66, 95%CI 0.5 – 0.81, for the phased array transducer, $p=0.005$.

Finally, in the patients who were known as SARS-CoV-19-positive at the time of the FLUS examination, the multivariable logistic regression found that FLUS predicted the need for mechanical ventilation, RR 1.89, 95% CI 1 – 3.6, p = 0.05, intensive care admission, RR 1.98, 95% CI 1.06 – 3.69, p = 0.03, and high-flow oxygen treatment, RR 2.17, 95% CI 1.38 – 3.43, p = 0.001,: Supplementary e-Table (7). Likewise, in patients with a yet-to-know SARS-CoV-19 status at the FLUS examination timepoint, FLUS predicted future intensive care admission, RR 3.56, 95% CI 1.57 – 8.08, p > 0.001, and mechanical ventilation, RR 7.07, 95% CI 1.87 – 31.77, p < 0.001. Similar to the main analysis, FLUS did not predict COVID-19-related 30-days mortality or all-cause 30-day mortality regardless of known SARS-CoV-19 status at the scanning time: Supplementary e-Table (8).

Discussion

In hospitalized patients with suspected or PCR-verified SARS-CoV-2 infection, a FLUS examination predicted the need for mechanical ventilation, intensive care admission and high-flow oxygen administration when adjusting for sex, age and comorbidity. FLUS did not predict 30-day mortality due to COVID-19 or mortality due to any other cause.

FLUS is performed at bedside by the attending physician. Besides minimizing the risk of contamination by eliminating the need for in-hospital patient transport, FLUS provides immediate images of the lungs that are essential in evaluating COVID-19's severity [14]. The affection of the lung may lead to respiratory failure, which is the primary cause of death in COVID-19 cases [4 6]. Even in patients with a low symptom burden, rapid onset or aggravation of respiratory failure is possible. In a patient with COVID-19 infection without respiratory failure or with low-intensity lung affection, for instance, abnormalities found using FLUS, may lead to a change in management

because such a patient is at high risk of developing respiratory failure. In addition to informing the patient and relatives that the risk of COVID-19 infection is severe, the level of patient monitoring could be adjusted accordingly [7], and intensive care or wards that are able to handle patients with respiratory failure could be warned that a patient is likely to arrive. Performing a FLUS examination may thus have substantial impacts for both patients and the health care system, while only minimal resources would be used as FLUS is quickly performed [15].

Different FLUS scanning protocols exist. Common to all protocols is that several chest areas are examined and evaluated [16] [13]. Typical COVID-19 FLUS findings include pleural abnormities, sub-pleural consolidations and b-lines in the lung parenchyma [17]. A standardized method to analyze and grade findings was developed, and we used this system to analyze film clips [13]. In particular, analyzing the anterior and lateral zones seemed to be just as accurate as including the dorsal zones. This finding is surprising, as the lower dorsal parts of the chest are favorite zones for lobar pneumonia and contrasts other findings in COVID-19[18]. We speculate that a diffuse distribution of lung lesions may resemble what is seen in ARDS with the anterolateral zones involvement and may explain the relationship between FLUS and the need for mechanical ventilation.

The use of FLUS during the COVID-19 pandemic has been recommended [15], multiple trials have studied triage and risk stratification for respiratory failure [9] [19] [20] [21] [22] [23] [24] [25] [26] [27]. These studies found results comparable to ours but are all in smaller samples or in single-center designs. Other reports have studied FLUS's ability to diagnose COVID-19 or to guide ongoing intensive care treatment [28][15]. Our study was not designed to assess the diagnostic yield of FLUS compared to the SARS-CoV-2 PCR test because such a test is easily available in our setting. Furthermore, a normal FLUS examination does not exclude COVID-19.

Our study has several limitations. First, the number of events was small, even though the population size is the largest studied so far. Few events potentially led to overfitting the regression models, leading to more conservative estimates, but the signal that FLUS was the only predictor of respiratory deterioration was consistent among all the models we developed. Second, even though our study was prospective and multi-centered in design, COVID-19 restrictions allowed only for inclusion by convenience, which potentially caused selection bias. Third, FLUS was performed according to the operators' preferences. All FLUS operators were regular users of FLUS or other point-of-care ultrasound examinations, but the selection of transducer and pre-set was at the discretion of the operator. Film clips recorded with a phased-array transducer could potentially reduce the image quality of the pleural line and subpleural consolidations and we difference in ROC AUC between transducers. However, few film clips were unanalyzable, and the free selection of transducer is therefore likely to further support generalizability. Fourth, our study included a mixed population of undiagnosed patients with COVID-19 symptoms and a population of patients diagnosed with COVID-19. A subgroup analysis showed lower predicting capability in patients already diagnosed with COVID-19; this is likely due to the disease being more advanced in these patients. Fifth, interrater variability was assessed on a random selection of film clips, not on the entire population. Finally, and most importantly, it must be remembered that FLUS examines pleural and peripheral lung parenchymal lesions only. The findings are not specific to COVID-19, but may also be found in other conditions, such as non-COVID-19 pneumonia, heart failure and acute respiratory distress syndrome caused by other conditions [29] [30]. Conversely, patients can be SARS-CoV-2 PCR-positive without a clinically significant lung pathology and no FLUS findings. Thus, FLUS is not a stand-alone diagnostic test or risk-stratification tool, as many other factors must be included in the decision-making process.

In conclusion, our results demonstrate that FLUS is an independent predictor of respiratory failure requiring mechanical ventilation, admission to intensive care or high-flow oxygen treatment in patients with symptoms of COVID-19 or a positive SARS-CoV-2 PCR test. This sets FLUS as an important tool to stratify the risk of respiratory failure during the COVID-19 pandemic.

Variable	Obs, n	Mean or %.	Std. Dev. Or %
Study information			
Patients included in study	415		
Patients excluded due to no lung ultrasound film clips available analysis.	17	4%	
Patients analysed.	398	96%	
Site one, n, %	201	50.5%	
Site two, n, %	82	20.6%	
Site three, n, %	69	17.3%	
Site four, n, %	46	11.6%	
Demographics			
Age, years	387	67.8	15.8
Weight, kg	242	78.4	19.7
Height, cm	246	171.6	10.1
Sex, Woman	398	189	47.5%
Clinical data			
Systolic blood pressure, mm.hg	386	130.7	22.0
Diastolic blood pressure, mm.hg.	383	74.5	13.5
Peripheral oxygen saturation	387	95.3	3.3
Heart rate, beats pr. minute	381	85.1	18.4
Respiratory frequency, breaths pr. minute	386	20.3	5.1
Supplementary oxygen doses, liters pr. minute	364	1.7	3.3
Biochemical data			
Ferritin, ug/L	175	986.0	1183.6
Hemoglobulin, mmol/L	384	7.7	1.4
C-reactive Protein, mg/L	381	64	66
Leukocytes, count $x10^9$/L	385	9.0	5.1
Lymphocytes, count $x10^9$/L	374	1.4	1.3
Monocytes, count $x10^9$/L	299	0.6	0.4
Neutrophils, count $x10^9$/L	379	6.7	4.6
Estimated glomerular filtration rate, ml/min	272	69.6	23.3
Carbamide, mmol/L	291	7.2	5.8
Creatinine, umol/L	385	98.0	92.3
Natrium, mmol/L	385	138.5	4.2
Potassium, mmol/L	382	3.8	0.5
Fibrin D-Dimer, mg/L(FEU)	263	2.4	4.6
Pro-brain natriuretic peptide. BNP, ng/L	155	706.4	2418.1
Troponin I (HS), ng/L	75	211.0	1120.1
Troponin T (HS), ng/L	93	68.9	349.1
Glucose, mmol/L	249	7.4	3.0
Hemoglobulin A1c, mmol/mol	160	44.5	13.2
pH-arterial.	301	7.5	0.1

pCo2-arterial, kPa	297	5.0	1.3
pO2-arterial, kPa	132	10.2	3.1
Base excess, mmol/L	133	1.3	4.8
Hydrogen carbonate, mmol/l	300	25.2	4.7
Lactate-arterial, mmol/L	275	1.5	0.9
Ultrasound equipment			
General Electric's Vivid S60	398	201	51%
General Electric's LogiQ S8	398	151	38%
Sonosite X-porte	398	46	12%
Phased array transducer with cardiography pre-set	398	201	51%
Curvilinear transducer with abdominal pre-set	398	197	49%
Outcome data			
COVID-19 positive. PCR-test, n (%)	398	227	57%
Overall mortality 30-days after admission, n (%)	398	47	11.8%
COVID-19 related mortality 30-days after admission, n (%)	398	28	7%
Admission to intensive care, n (%)	398	21	5.3%
COVID-19 positive admission to intensive care, n (%)	398	19	4.8%
Ventilator treatment, n (%)	398	18	4.9%
COVID-19 positive ventilator treatment care, n (%)	398	17	4.3%
High-flow oxygen treatment, n (%)	398	56	14%
COVID-19 positive, high-flow oxygen treatment, n (%)	398	51	12.8%
Nasal oxygen treatment, n (%)	398	159	43.3%
COVID-19 positive, nasal oxygen treatment, n (%)	398	117	29.4%

Table 1: Demographic, vital parametres, blood test results and endpoints in the study population.

Scanning zone	FLUS score				
	0. The pleural line is continuous and regular. Horizontal artifacts are present.	1. The pleural line is indented. Below the indent, vertical areas of white are visible.	2. The pleural line is broken. Below the breaking point, small-to-large consolidated areas appear with associated areas of white below the consolidated area.	3. The scanned area shows dense and largely extended white lung with or without larger consolidations.	Missing. No film recorded or ultrasound not performed in zone.
Right 1, n (%)	262 (65.8)	59 (14.8)	45 (11.3)	29 (7.29)	3 (0.75)
Right 2, n (%)	250 (62.8)	80 (20.1)	43 (10.3)	23 (4.8)	2 (0.5)
Right 3, n (%)	185 (45.5)	67 (16.8)	99 (24.9)	22 (8.3)	14 (3.5)
Right 4, n (%)	197 (49.5)	87 (21.9)	69 (17.3)	27 (6.7)	18 (4.5)
Right 5, n (%)	70 (17.6)	30 (7.5)	27 (6.8)	6 (1.5)	265 (66.6)
Right 6, n (%)	98 (24.6)	21 (5.3)	11 (2.8)	2 (0.5)	266 (66.9)
Right 7, n (%)	111 (27.9)	15 (3.8)	4 (1)	2 (0.5)	266 (66.8)
Left 1, n (%)	276 (67.1)	52 (13.1)	50 (12.6)	25 (6.3)	4 (1)
Left 2, n (%)	247 (62.1)	60 (15.1)	60 (15.1)	23(5.8)	8 (2)
Left 3, n (%)	166 (41.7)	74 (18.6)	103 (25.9)	42 (10.6)	13 (3.3)
Left 4, n (%)	200 (50.3)	57 (14.3)	81 (20.3)	39 (9.8)	21 (5.3)
Left 5, n (%)	82 (20.6)	18 (4.5)	23 (5.8)	6 (1.5)	269 (67.6)
Left 6, n (%)	99 (24.9)	18 (4.5)	14 (3.5)	0 (0)	267 (67.1)
Left 7, n (%)	114 (28.6)	11 (2.8)	6 (1.5)	0 (0)	267 (67.1)

Table 2: FLUS scorings results from the thoracic scannings zones.

	Univariate logistic regression					Multivariate logistic regression				
	Relative Risk	Std. Err	95% CI.		p-Value	Relative Risk	Std. Err	95% CI.		p-Value
Mechanical ventilation	2.84	0.75	1.69	4.77	<0.001	2.44	0.77	1.31	4.52	0.005
Intensive care unit	2.85	0.73	1.73	4.71	<0.001	2.55	0.76	1.42	4.6	0.002
High-flow oxygen treatment	2.06	0.27	1.59	2.66	<0.001	1.95	0.26	1.5	2.53	<0.001
30-days mortality due to COVID-19	1.77	0.37	1.17	2.67	0.007	1.14	0.29	0.7	1.88	0.601
30-days all-cause mortality	1.51	0.24	1.10	2.06	0.01	0.95	0.22	0.61	1.51	0.853

Table 3: Uni- and multivariable logistic regression analysis of capability to predict primary outcome and secondary outcomes of median FLUS score. Age, sex, comorbidity and non-high-flow oxygen treatment are included as co-variates in the multivariate analysis. In this analysis FLUS was the only variable that predicted need for mechanical ventilation, admission to intensive care unit and high-flow oxygen treatment. FLUS did not predict 30-days mortality or 30-days mortality due to COVID-19. Age was the only positive predictor for these in a multivariable logistic regression.

Mechanical ventilation										
	Univariate logistic regression					Multivariate logistic regression				
	Relative Risk	Std. Err	95% CI.		p-value	Relative Risk	Std. Err	95% CI.		p-value
Median FLUS score	2.84	0.75	1.69	4.77	<0.001	2.44	0.77	1.31	4.52	0.005
Highest FLUS score in any zone	2.97	1.03	1.5	5.9	0.002	2.22	0.8	1.1	4.51	0.028
FLUS score >3 in any of the zones	5.42	2.67	2.06	14.25	<0.001	3.54	1.84	1.27	9.83	0.015
Count of FLUS zones scoring 3	1.48	0.04	1.4	1.58	<0.001	1.46	0.09	1.29	1.66	<0.001
Count of FLUS zones scoring 2	1.31	0.09	1.14	1.5	<0.001	1.38	0.11	1.18	1.61	<0.001
Median FLUS score, anterior and lateral zones only	2.96	0.76	1.79	4.89	<0.001	2.63	0.77	1.47	4.69	0.001
Total sum of FLUS	1.12	0.02	1.09	1.17	<0.001	1.12	0.03	1.08	1.18	<0.001

Table 4: Uni- and multivariate logistic regression analysis of different FLUS scoring systems capability to predict need for mechanical ventilation.

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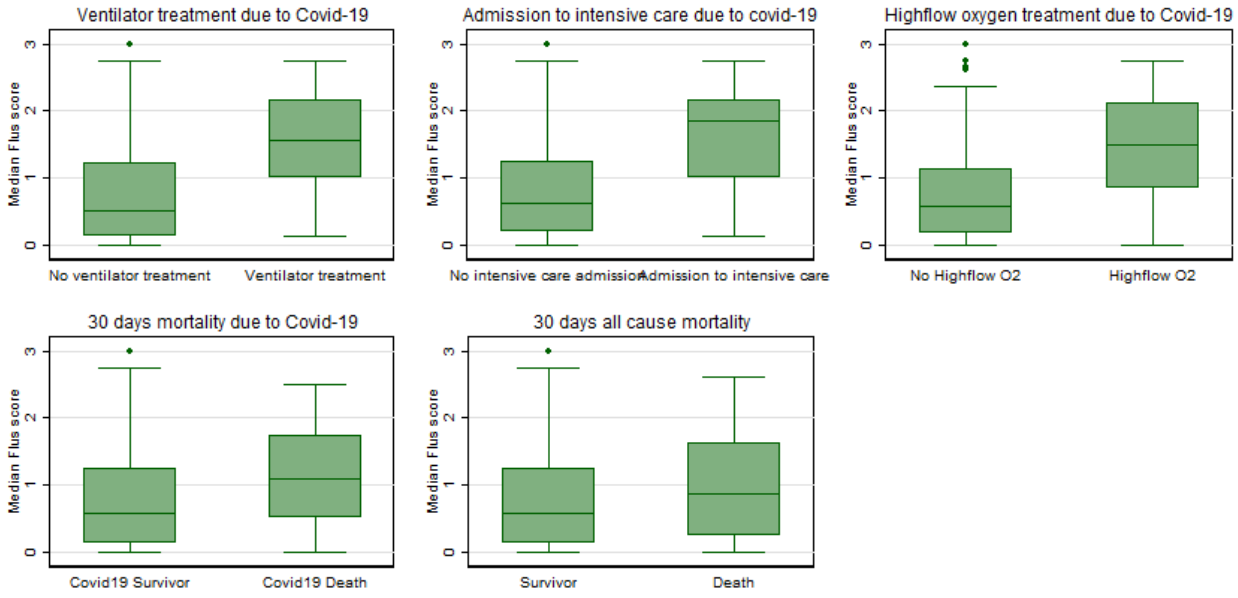

Figure 1: Median FLUS scores in the different endpoints. Statistically significant higher FLUS score was found in patients who received mechanical ventilation, $p<0.001$, were admitted to intensive care, $p<0.001$, were treated with high-flow oxygen, $p<0.001$, in patients who died of COVID-19, $p=0.004$ and in patients who died of any cause, $p=0.01$.

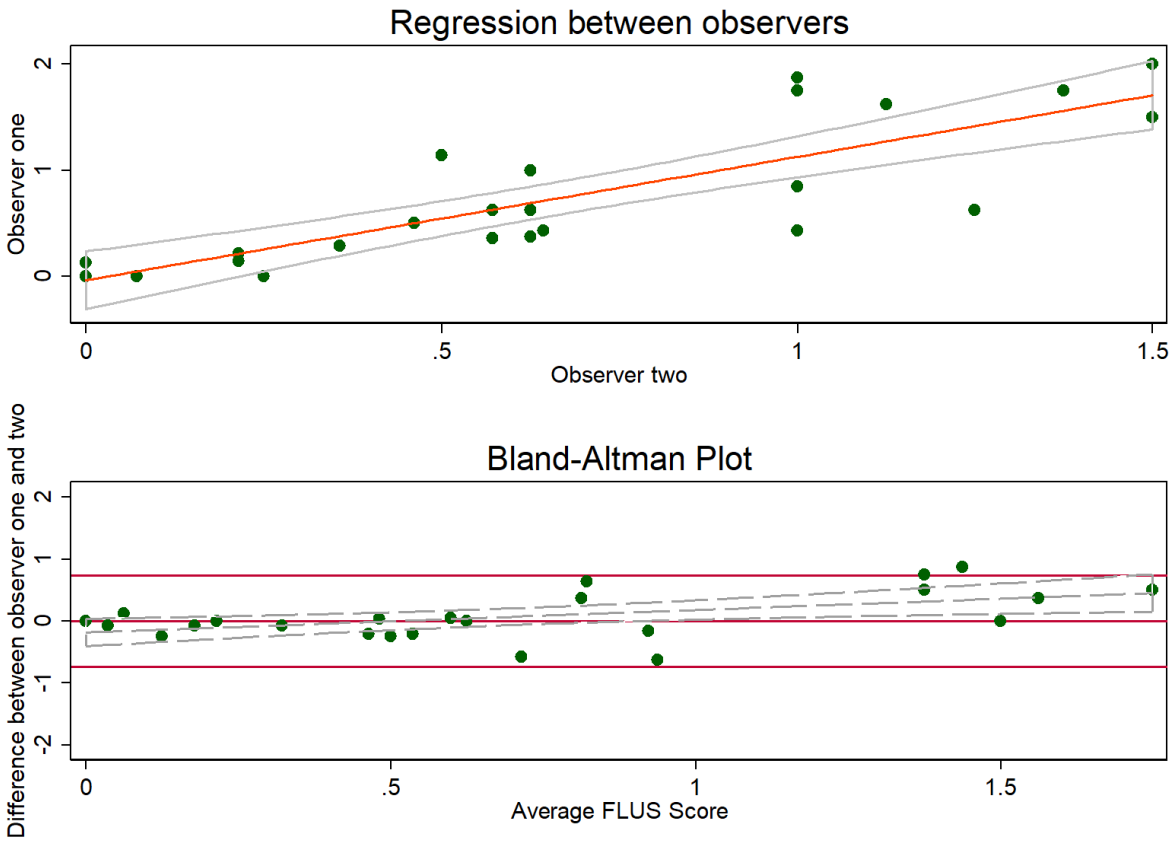

Figure 2: Correlation and Bland-Altman plot of median FLUS scores in randomly selected patients by two blinded observers. Little and clinical insignificant difference in scores is seen even though there is a trend (α:0.36, p=0.01) with increasing difference as average FLUS score increase.

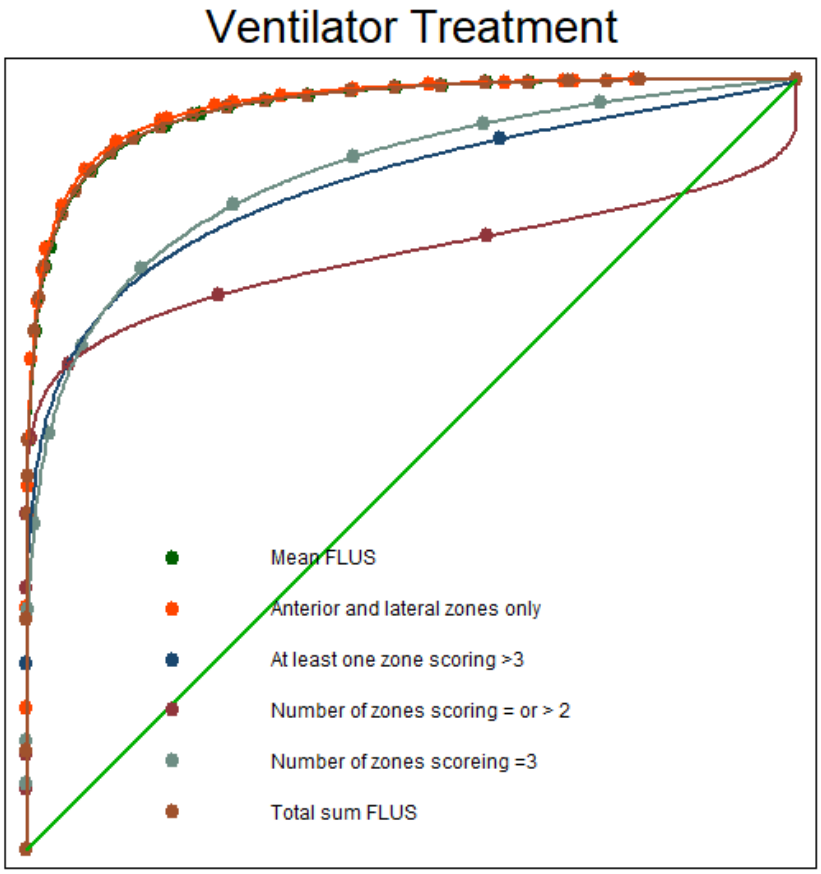

Figure 3: Receiver operating characteristics of different scorings systems. The median FLUS score and total sum from all zones and the median FLUS score from the anterior and lateral zones, had higher area under the curve then other scoring systems.

Supplementary tables

	Univariate logistic regression					Multivariate logistic regression				
	Relative risk	Std. Err	95% CI.		p-Value	Relative risk	Std. Err	95% CI.		p-Value
Ventilator treatment due to COVID-19										
Median FLUS score	2.84	0.75	1.69	4.77	<0.001	2.44	0.77	1.31	4.52	<0.001
Age	1.00	0.01	0.97	1.03	0.96	1.00	0.02	0.97	1.03	0.99
Sex, Man	1.38	0.67	0.54	3.55	0.50	1.05	0.50	0.41	2.66	0.92
Oxygen administration	3.63	1.79	1.38	9.54	0.01	1.75	0.95	0.60	5.10	0.31
Relevant comorbidity	All had comorbidity, omitted from analysis									
Admission to intensive care due to COVID-19										
Median FLUS score	2.85	0.73	1.73	4.71	<0.001	2.55	0.77	1.42	4.60	<0.001
Age	2.85	0.73	2.85	0.73	0.67	1.00	0.01	0.97	1.03	0.93
Sex, Man	1.60	0.74	0.64	3.95	0.31	1.27	0.58	0.52	3.11	0.60
Oxygen administration	2.64	1.21	1.07	6.50	0.03	1.30	0.64	0.50	3.43	0.59
Relevant comorbidity	All had comorbidity, omitted from analysis									
High-flow oxygen treatment										
Median FLUS score	2.06	0.27	1.59	2.66	<0.001	1.53	0.24	1.13	2.07	0.01
Age	1.01	0.01	0.99	1.03	0.24	1.01	0.01	1.00	1.03	0.15
Sex, Man	1.64	0.43	0.98	2.74	0.06	1.24	0.30	0.77	1.98	0.38
Oxygen administration	4.76	1.57	2.50	9.07	<0.001	3.49	1.21	1.76	6.90	<0.001
Relevant comorbidity	All had comorbidity, omitted from analysis									
30-day mortality due to COVID-19										
Median FLUS score	1.77	0.37	1.17	2.67	0.01	1.14	0.29	0.69	1.88	0.60

Age	1.07	0.02	1.04	1.11	<0.001	1.08	0.02	1.04	1.11	<0.001
Sex, Man	1.96	0.76	0.91	4.21	0.09	2.69	1.06	1.24	5.83	0.01
Oxygen administration	3.00	1.14	1.42	6.32	<0.001	2.71	1.10	1.22	6.02	0.01
Relevant comorbidity	3.75	3.77	0.52	26.93	0.19	0.80	0.80	0.11	5.68	0.83
30-day all-cause mortality										
Median FLUS score	1.51	0.24	1.10	2.06	0.01	0.96	0.22	0.61	1.51	0.85
Age	1.06	0.01	1.04	1.08	<0.001	1.07	0.02	1.04	1.10	<0.001
Sex, Man	1.18	0.33	0.69	2.03	0.54	2.33	0.79	1.20	4.55	0.01
Oxygen administration	1.82	0.59	0.97	3.43	0.06	1.97	0.67	1.01	3.85	0.05
Relevant comorbidity	2.02	1.16	0.65	6.25	0.22	0.74	0.50	0.20	2.75	0.65

Supplementary e-table 1: Uni- and multivariate logistic regression of pre-analytic selected variables and their relative risk for 30-days mortality due to COVID-19, 30-days all-cause mortality, intensive care admission, ventilator treatment, high-flow oxygen treatment and non-high-flow oxygen administration.

FLUS score = 3 in any of the scanning zones					
Ventilator treatment due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score =3	5.42	2.67	2.06	14.25	0.00
Multivariate logistic regression					
FLUS score =3	3.54	1.84	1.27	9.83	0.02
Age	1.00	0.02	0.97	1.03	0.92
Sex, Man	1.11	0.52	0.45	2.79	0.82
Oxygen administration	2.33	1.21	0.84	6.45	0.10
Relevant comorbidity	All had comorbidity				
Admission to intensive care					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score =3	5.60	2.68	2.19	14.30	0.00
Multivariate logistic regression					
FLUS score =3	3.86	1.92	1.46	10.21	0.01
Age	1.00	0.02	0.97	1.03	0.94
Sex, Man	1.39	0.62	0.58	3.35	0.47
Oxygen administration	1.74	0.82	0.69	4.39	0.24
Relevant comorbidity	All had comorbidity				
High-flow oxygen treatment due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score =3	2.75	0.69	1.68	4.48	0.00
Multivariate logistic regression					
FLUS score =3	1.62	0.39	1.01	2.59	0.05
Age	1.01	0.01	1.00	1.03	0.10
Sex, Man	1.33	0.32	0.83	2.12	0.24
Oxygen administration	4.20	1.41	2.17	8.11	0.00
Relevant comorbidity	All had comorbidity				
30-day mortality due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score =3	2.65	0.95	1.31	5.35	0.01
Multivariate logistic regression					
FLUS score =3	1.87	0.65	0.94	3.70	0.07
Age	1.08	0.02	1.05	1.12	0.00
Sex, Man	2.91	1.14	1.34	6.29	0.01
Oxygen administration	2.59	1.00	1.21	5.53	0.01
Relevant comorbidity	0.73	0.73	0.10	5.19	0.75

30-day all-cause mortality					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score =3	2.04	0.56	1.19	3.48	0.01
Multivariate logistic regression					
FLUS score =3	1.65	0.53	0.88	3.11	0.12
Age	1.07	0.02	1.04	1.10	0.00
Sex, Man	2.35	0.80	1.21	4.56	0.01
Oxygen administration	1.73	0.57	0.91	3.29	0.09
Relevant comorbidity	0.67	0.46	0.18	2.54	0.56

Supplementary e-table 2: Relative risk from uni- and multivariate binary regression analysis of FLUS score > 3 in any of the scanning zones.

Count of FLUS zones scoring 3					
Ventilator treatment due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by number of zones	1.37	0.11	1.18	1.59	0.00
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.00	0.02	0.97	1.04	0.77
Age	0.98	0.46	0.39	2.47	0.96
Sex, Man	2.75	1.33	1.06	7.11	0.04
Oxygen administration	1.37	0.11	1.18	1.59	0.00
Relevant comorbidity					
Admission to intensive care					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by number of zones	1.48	0.05	1.40	1.58	0.00
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.46	0.10	1.29	1.66	0.00
Age	1.00	0.02	0.98	1.03	0.77
Sex, Man	1.14	0.46	0.52	2.50	0.75
Oxygen administration	1.76	0.72	0.79	3.92	0.17
Relevant comorbidity					
High-flow oxygen treatment due to COVID-19					
	Relativ Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by number of zones	1.45	0.14	1.21	1.75	0.00
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.62	0.39	1.01	2.59	0.05
Age	1.01	0.01	1.00	1.03	0.10
Sex, Man	1.33	0.32	0.83	2.12	0.24
Oxygen administration	4.20	1.41	2.17	8.11	0.00
Relevant comorbidity	All had comorbidity				
30-day mortality due to COVID-19					
	Odds Ratio	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by	1.16	0.11	0.97	1.39	0.109

number of zones					
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.10	0.11	0.9	135	0.353
Age	1.08	0.02	1.04	1.12	0
Sex, Man	2.75	1.08	1.27	5.95	0.01
Oxygen administration	2.75	1.05	1.3	5.83	0.008
Relevant comorbidity	0.79	0.79	0.11	5.61	0.82
30-day all-cause mortality					
	Relativ Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by number of zones	1.13	0.08	0.98	1.3	0.097
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.08	0.11	0.89	1.31	0.45
Age	1.07	0.02	1.03	1.09	<0.001
Sex, Man	2.29	0.78	1.78	4.46	0.015
Oxygen administration	1.89	0.6	0.97	3.44	0.06
Relevant comorbidity	0.71	0.48	0.19	2.68	0.62

Supplementary e-table 3: Relative for outcomes using a FLUS scoring system counting number of zones with a score on three.

Count of FLUS zones scoring 2					
Ventilator treatment due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by number of zones	1.31	0.09	1.14	1.5	<0.001
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.37	0.11	1.18	1.61	<0.001
Age	0.99	0.02	0.97	1.02	0.496
Sex, Man	1.31	0.60	0.53	3.23	0.553
Oxygen administration	2.97	1.40	1.18	7.05	0.02
Relevant comorbidity	All had comorbidity				
Admission to intensive care					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by number of zones	1.3	0.08	1.14	1.47	<0.001
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.39	0.08	1.22	1.56	<0.001
Age	0.99	0.01	0.96	1.01	0.324
Sex, Man	1.55	0.68	0.65	3.66	0.313
Oxygen administration	2.29	0.99	0.97	5.38	0.057
Relevant comorbidity	All had comorbidity				
High-flow oxygen treatment due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by number of zones	1.31	0.07	1.17	1.47	<0.001
Multivariate logistic regression					
FLUS score, RR increase by number of zones	1.59	0.07	1.02	1.31	0.01
Age	1.01	0.01	0.99	1.03	0.23
Sex, Man	1.27	0.29	0.8	2.02	0.302
Oxygen administration	4.01	1.36	2.07	7.8	<0.001
Relevant comorbidity	All had comorbidity				
30-day mortality due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score, RR increase by	1.15	0.08	0.99	1.32	0.06

number of zones					
Multivariate logistic regression					
FLUS score, RR increase by number of zones	0.99	0.09	0.82	1.18	0.88
Age	1.08	0.02	1.04	1.11	<0.001
Sex, Man	2.84	1.12	1.31	6.16	0.008
Oxygen administration	3	1.13	1.43	6.29	0.004
Relevant comorbidity	0.8	0.8	0.11	5.72	0.825
30-day all-cause mortality					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score,RR increase by number of zones	1.10	0.06	0.98	1.24	0.099
Multivariate logistic regression					
FLUS score, RR increase by number of zones	0.94	0.07	0.79	1.11	0.46
Age	1.07	0.02	1.04	1.10	<0.001
Sex, Man	2.38	0.8	1.22	4.61	0.011
Oxygen administration	2.02	0.64	1.08	3.77	0.028
Relevant comorbidity	0.67	0.44	0.19	2.45	0.548

Supplementary e-table 4: Relative risk of a FLUS scoring system counting number of zones with a score on 3.

FLUS total sum of all zones					
Ventilator treatment due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	1.13	0.02	1.09	1.17	<0.001
FLUS score	1.12	0.03	1.07	1.19	<0.001
Age	1	0.02	0.97	1.03	0.97
Sex, Man	0.91	0.41	0.38	2.19	0.83
Oxygen administration	2.52	1.18	1.01	6.29	0.05
Relevant comorbidity	All had comorbidity				
Admission to intensive care					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	1.13	0.01	1.11	1.16	<0.001
Multivariate logistic regression					
FLUS score	1.14	0.02	1.10	1.19	<0.001
Age	0.99	0.01	0.97	1.03	0.97
Sex, Man	1.18	0.44	0.57	2.46	0.65
Oxygen administration	1.89	0.8	0.83	4.31	0.13
Relevant comorbidity	All had comorbidity				
High-flow oxygen treatment due to COVID-19					
	Relativ Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	1.09	0.02	1.05	1.13	<0.001
Multivariate logistic regression					
FLUS score	1.05	0.02	1.02	1.1	0.006
Age	1.01	0.01	0.99	1.03	0.19
Sex, Man	1.18	0.29	0.73	1.9	0.5
Oxygen administration	3.74	1.28	1.91	7.31	<0.001
Relevant comorbidity	All had comorbidity				
30-day mortality due to COVID-19					
	Odds Ratio	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	1.05	0.02	1	1.1	0.03
Multivariate logistic regression					
FLUS score	1.02	0.03	0.96	1.08	0.6
Age	1.08	0.02	1.04	1.11	<0.001
Sex, Man	2.72	1.08	1.26	5.92	0.01
Oxygen administration	2.84	1.09	1.34	6.02	0.006
Relevant comorbidity	0.83	0.83	0.12	5.92	0.85

30-day all-cause mortality					
	Relativ Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	1.04	0.02	1	1.08	0.03
Multivariate logistic regression					
FLUS score	0.99	0.02	0.94	1.04	0.66
Age	1.07	0.02	1.04	1.09	<0.001
Sex, Man	2.35	0.8	1.21	4.57	0.012
Oxygen administration	1.98	0.64	1.05	3.73	0.04
Relevant comorbidity	0.72	0.48	0.2	2.66	0.63

Supplementary e-table 5: Relative risk of a FLUS scoring system counting sum of zones.

FLUS for anterior and lateral scanning zones					
Mechanical ventilation due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	2.87	0.76	1.71	4.83	<0.001
Multivariate logistic regression					
FLUS score	2.49	0.78	1.35	4.6	0.003
Age	1	0.01	0.97	1.03	0.982
Sex, Man	1.04	0.5	0.41	2.66	0.923
Oxygen administration	1.72	0.93	0.6	4.98	0.314
Relevant comorbidity	All had relevant comorbidity				
Admission to intensive care					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	2.96	0.76	1.79	4.89	<0.001
Multivariate logistic regression					
FLUS score	2.7	0.8	1.5	4.84	0.001
Age	1	0.01	0.97	1.03	0.951
Sex, Man	1.27	0.58	0.52	3.1	0.598
Oxygen administration	1.21	0.61	0.48	3.24	0.644
Relevant comorbidity	All had relevant comorbidity				
High-flow oxygen treatment due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	2.05	0.28	1.59	2.66	<0.001
Multivariate logistic regression					
FLUS score	1.52	0.23	1.16	2.06	0.006
Age	1.01	0.01	1	1.02	0.153
Sex, Man	1.24	0.29	0.77	1.97	0.372
Oxygen administration	3.5	1.21	1.77	6.91	<0.001
Relevant comorbidity	All had relevant comorbidity				
30-day mortality due to COVID-19					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	1.76	0.37	1.17	2.66	0.007
Multivariate logistic regression					
FLUS score	1.16	0.29	0.71	1.90	0.553
Age	1.07	0.02	1.04	1.11	<0.001
Sex, Man	2.67	1.05	1.23	5.8	0.013
Oxygen administration	2.68	1.09	1.2	5.95	0.013
Relevant comorbidity	0.79	0.79	0.11	5.58	0.812

30-day all-cause mortality					
	Relative Risk	Std. Err	95% CI.		p-Value
Univariate logistic regression					
FLUS score	1.51	0.23	1.1	2.06	0.01
Multivariate logistic regression					
FLUS score	0.99	0.22	0.63	1.56	0.982
Age	1.07	0.02	1.04	1.09	<0.001
Sex, Man	2.31	0.79	1.18	4.51	0.014
Oxygen administration	1.93	0.66	0.98	3.78	0.056
Relevant comorbidity	0.73	0.5	0.2	2.76	0.65

Supplementary e-table 6: FLUS from anterior and lateral scanning zones without dorsal zones.

	Univariate logistic regression					Multivariate logistic regression				
	Relative risk	Std. Err	95% CI.		p-Value	Relative risk	Std. Err	95% CI.		p-Value
Ventilator treatment due to COVID-19										
FLUS score	1.90	0.62	1.01	3.59	0.05	1.89	0.62	1.00	3.59	0.05
Age	0.99	0.02	0.96	1.03	0.71	1.00	0.02	0.96	1.03	0.81
Sex, Man	1.07	0.56	0.39	2.96	0.90	0.96	0.50	0.34	2.69	0.94
Oxygen administration	3.03	1.92	0.88	10.49	0.08	Omitted because of collinearity				
Relevant comorbidity	Omitted because of collinearity									
Admission to intensive care due to COVID-19										
FLUS score	2.00	0.63	1.08	3.72	0.03	1.98	0.63	1.06	3.69	0.03
Age	0.99	0.02	0.96	1.03	0.74	1.00	0.02	0.96	1.03	0.88
Sex, Man	1.21	0.61	0.45	3.27	0.70	1.12	0.57	0.41	3.04	0.83
Oxygen administration	3.18	2.00	0.93	10.91	0.07	Omitted because of collinearity				
Relevant comorbidity	Omitted because of collinearity									
High-flow oxygen treatment										
FLUS score	1.68	0.24	1.28	2.22	<0.001	Omitted because no patients in this group received high-flow oxygen treatment				
Age	1.01	0.01	1.00	1.03	0.14					
Sex, Man	1.40	0.35	0.86	2.27	0.18					
Oxygen administration	3.04	0.98	1.62	5.70	<0.001					
Relevant comorbidity										
30-day mortality due to COVID-19										
FLUS score	1.69	0.45	1.00	2.85	0.05	1.33	0.39	0.75	2.37	0.33
Age	1.06	0.02	1.02	1.10	<0.001	1.07	0.02	1.03	1.11	<0.001
Sex, Man	3.14	1.70	1.09	9.07	0.03	5.13	3.09	1.58	16.69	0.01
Oxygen administration	2.97	1.61	1.02	8.62	0.05	2.60	1.41	0.90	7.51	0.08
Relevant	All had comorbidity					All had comorbidity				

comorbidity										
30-day all-cause mortality										
FLUS score	1.69	0.45	1.00	2.85	0.05	1.33	0.39	0.75	2.37	0.33
Age	1.06	0.02	1.02	1.10	<0.001	1.07	0.02	1.03	1.11	<0.001
Sex, Man	3.14	1.70	1.09	9.07	0.03	5.13	3.09	1.58	16.69	0.01
Oxygen administration	2.97	1.61	1.02	8.62	0.05	2.60	1.41	0.90	7.51	0.08
Co-morbidity	All had comorbidity					All had comorbidity				

Supplementary e-table 7: Prediction analysis based on the subgroup who were known COVID-19 positive before the FLUS examination was performed.

	Univariate logistic regression					Multivariate logistic regression				
	Relative risk	Std. Err	95% CI.		p-Value	Relative risk	Std. Err	95% CI.		p-Value
Ventilator treatment due to COVID-19										
FLUS score	3.76	1.78	1.48	9.51	0.01	7.70	5.57	1.87	31.77	<0.001
Age	1.00	0.03	0.95	1.06	1	0.95	0.04	0.87	1.04	0.25
Sex, Man	1.17	1.16	0.17	8.16	0.87	1.15	1.25	0.13	9.75	0.90
Oxygen administration	Omitted because of collinearity									
Relevant comorbidity	1.01	1.15	0.11	9.45	1.00	Omitted because of collinearity				
Admission to intensive care due to COVID-19										
FLUS score	3.11	1.20	1.46	6.63	<0.001	3.56	1.49	1.57	8.08	<0.001
Age	1.00	0.02	0.96	1.05	0.90	0.98	0.03	0.93	1.03	0.41
Sex, Man	1.14	0.92	0.24	5.49	0.87	0.86	0.65	0.19	3.82	0.84
Oxygen administration	Omitted because of collinearity									
Relevant comorbidity	0.72	0.61	0.14	3.81	0.70	Omitted because of collinearity				
30-day mortality due to COVID-19										
FLUS score	1.38	0.74	0.48	3.96	0.55	0.67	0.56	0.13	3.41	0.63
Age	1.09	0.04	1.02	1.17	0.01	1.09	0.04	1.02	1.16	0.01
Sex, Man	0.68	0.48	0.17	2.74	0.58	0.93	0.64	0.24	3.61	0.92
Oxygen administration	9.50	6.07	2.72	33.22	<0.001	3.23	2.15	0.87	11.91	0.08
Relevant comorbidity	2.56	2.70	0.32	20.24	0.37	Omitted because of collinearity				
30-day all-cause mortality										
FLUS score	1.82	0.35	1.25	2.64	<0.001	0.33	0.21	0.10	1.12	0.08
Age	1.06	0.01	1.03	1.09	<0.001	1.07	0.02	1.03	1.11	<0.001
Sex, Man	0.69	0.26	0.33	1.43	0.32	1.06	0.47	0.45	2.52	0.89
Oxygen administration	4.65	2.63	1.54	14.07	0.01	2.46	0.96	1.14	5.27	0.02
Relevant	2.69	1.58	0.85	8.51	0.09	0.98	0.68	0.25	3.80	0.98

comorbidity										

Supplementary e-table 8: Prediction analysis based on the subgroup who had unknown COVID-19 status at the time point the FLUS examination was performed. Analysis of high-flow oxygen treatment is omitted because no patient received this treatment in this subgroup.

Zone	N	Agreement	Expected agreement	Kappa	p-value
Right 1	25	64.00%	40.80%	0.39	<0.001
Right 2	25	68.00%	34.40%	0.51	<0.001
Right 3	25	64.00%	29.44%	0.49	<0.001
Right 4	25	72.00%	40.48%	0.53	<0.001
Right 5	11	63.64%	40.50%	0.39	0.04
Right 6	11	72.73%	60.33%	0.31	0.05
Right 7	11	63.64%	48.76%	0.29	0.05
Left 1	25	68.00%	40.80%	0.46	<0.001
Left 2	25	80.00%	48.32%	0.61	<0.001
Left 3	22	36.36%	26.45%	0.14	0.13
Left 4	23	65.22%	35.73%	0.46	<0.001
Left 5	11	54.55%	47.11%	0.14	0.26
Left 6	11	72.73%	61.98%	0.28	0.09
Left 7	11	72.73%	74.38%	-0.06	0.69

Supplementary table e9: Agreement and kappa values from the scanning zone. Rated by two independent readers on randomly selected patients.