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Diagnostic Value of Lung Ultrasonography in COVID-19 Patients Admitted to the Emergency Department

Acil Servise Başvuran COVID-19 Hastalarında Akciğer Ultrasonografisinin Tanısal Değeri

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ABSTRACT

Aim: *The aim of this study was to investigate the diagnostic value of ultrasonographic evaluation of the lungs for COVID-19 pneumonia in patients admitted to the emergency department (ED) with suggestive symptoms.*

Materials and Methods: *A prospective, cross-sectional, observational study was conducted in the ED of Bakirkoy Dr. Sadi Konuk Training and Research Hospital over a 2-month period. A total of 204 adult patients presenting with symptoms suggestive of COVID-19 were included. Data from Lung Ultrasonography (LUS) and Thorax Computed Tomography (CT) were collected for analysis.*

Results: *112 patients had thoracic CT findings consistent with COVID-19 pneumonia. 104 (92.86%) were "LUS positive". The sensitivity of LUS was 93.33%, and specificity was 80%. The positive predictive value was 82.96%, and the negative predictive value was 92%. Patchy B-lines were the most sensitive LUS finding. ROC analysis was performed for two COVID-19 LUS scores: In the patient group, an "LUS score" above 13 had an 80% sensitivity and 52.63% specificity in terms of 14-day mortality. Also, a "Total LUS Score" above 13 had a sensitivity of 79.46% and specificity of 57.89% for 14-day mortality.*

Conclusion: *LUS can assist emergency physicians in triage and clinical decision-making for COVID-19. The total LUS Score offers better specificity and similar sensitivity compared to both, which were associated with poor clinical outcomes. Patchy B-lines (89.3%) and pleural thickening (63.4%) are the most common COVID-19-related findings in LUS. It is recommended to specifically look for these two findings in patients suspected of having COVID-19.*

Keywords: *COVID-19, pneumonia, ultrasonography*

ÖZET

Amaç: *Acil servise (AS) COVID-19 düşündüren semptomlarla başvuran hastalarda akciğerlerin ultrasonografik değerlendirilmesinin, COVID-19 pnömonisi açısından tanısal değerinin olup olmadığının araştırılması amaçlandı.*

Gereç ve Yöntemler: *Prospektif, kesitsel, gözlemsel bir çalışma olarak Bakırköy Dr Sadi Konuk Eğitim ve Araştırma Hastanesi Acil Tıp Kliniği'nde 2 aylık periyotta gerçekleştirildi. Çalışmaya COVID-19'u düşündüren semptomlarla başvuran toplam 204 yetişkin hasta dahil edildi. Akciğer Ultrasonografisi (LUS) ve Toraks Bilgisayarlı Tomografisinden (BT) elde edilen bulgular ve sonuçlar toplandı.*

Bulgular: *112 hastanın Toraks BT bulguları COVID-19 pnömonisi ile uyumluydu. Bunların 104'ü (%92,86) "LUS pozitif" idi. LUS'un COVID-19 tanısında duyarlılığı %93,33, özgüllüğü %80, Pozitif Prediktif Değeri %82,96, Negatif Prediktif Değeri ise %92 olarak belirlendi. Düzensiz B çizgileri en hassas LUS bulgusuydu. İki farklı COVID-19 LUS skoru için ROC analizi yapıldı: Hasta grubunda "LUS skoru"nun 13'ün üzerinde olmasının 14 günlük mortalite açısından duyarlılığı %80, özgüllüğü ise %52,63 idi. "Toplam LUS Skoru"nun 13'ün üzerinde olmasının ise 14 günlük mortalite için duyarlılığı %79,46, özgüllüğü ise %57,89 idi.*

Sonuç: *LUS, acil tıp hekimine COVID-19'da triyaj ve klinik karar vermede yardımcı olabilir. COVID-19 "Toplam LUS Skoru"nun, "LUS Skoru"na göre daha iyi özgüllüğe ve benzer duyarlılığa sahip olduğu ve her ikisinin de kötü klinik sonuçlarla ilişkili olduğu görüldü. Düzensiz B çizgileri (%89,3) ve Plevral Kalınlaşma (%63,4) LUS'ta en sık görülen COVID-19 ile ilgili bulgulardır. COVID-19 şüphesi olan hastalarda bu iki bulgunun aranması önerilir.*

Anahtar Kelimeler: *COVID-19, pnömoni, ultrasonografi*

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INTRODUCTION

While reverse transcription polymerase chain reaction (RT-PCR) analysis is the standard diagnostic method for Coronavirus disease 2019 (COVID-19), RT-PCR tests can fail due to reasons such as incorrect sample collection and insufficient viral material (1). Therefore, thorax computed tomography (CT) imaging is an important noninvasive method for patients admitted to the hospital with respiratory system symptoms suggestive of COVID-19 (2). Some studies have indicated that CT is more sensitive than the initial RT-PCR test (98% to 71% and 88% to 59%) (3,4). There are characteristic CT findings of pneumonia in COVID-19 patients, with the most common being peripheral ground-glass or fine reticular opacities (5).

It is widely accepted that lung ultrasonography (LUS) can be a very effective method for evaluating pulmonary pathologies (6). Its role in diagnosing pneumonia has been demonstrated in numerous studies (7). While CT is considered the gold standard imaging modality for pneumonia, several studies have indicated that LUS is more advantageous than standard imaging for diagnosing pneumonia (8-10).

Lung ultrasonography (LUS) has emerged as a potential tool in diagnosing COVID-19 and assessing the severity of lung damage, particularly in countries with a high number of COVID-19 cases (11). The advantage of conducting imaging at the patient's bedside is that it eliminates the need to transfer the patient to another department. Moreover, using LUS as a triage method upon admission can help differentiate between low-risk patients (without lung involvement) and high-risk patients (with lung involvement), thereby reducing the risk of hospital-acquired infections. Additionally, LUS may be preferred for monitoring the response to treatment and the progression of COVID-19 in patients, as it avoids repeated exposure to radiation.

Patchy B-lines, pleural thickening, subpleural consolidation, large consolidations, and hepatization have been described as common findings in LUS for COVID-19 in the literature (12–15).

In this study, the aim was to investigate whether evaluating the lungs using ultrasonography has diagnostic value in patients admitted to the Emergency Department with suspicious findings for COVID-19.

MATERIALS and METHODS

Ethical Considerations

This prospective, cross-sectional, observational study was conducted at the Bakirkoy Dr. Sadi Konuk Training and Research Hospital Emergency Department. Before the study, approval was obtained from the Hospital Clinical Research Ethics Committee (Decision Number: 2020/228, Date: May 2020). Informed consent was obtained from all participants. The study adhered to the principles outlined in the Declaration of Helsinki.

Study Design

The study involved adult patients who visited the Adult ED between June 15, 2020, and August 15, 2020, with symptoms suggestive of COVID-19. Inclusion criteria in our study were having evidence of suspicion of COVID-19 at the time of the visit, being over 18 years of age, and providing signed informed consent. Exclusion criteria included the inability to undergo CT, LUS, or swab sample for RT-PCR analysis due to patient incompatibility, lack of consent, or discontinuation during the study. A total of 204 patients were included in the study. Thorax CT scans and LUS results were collected. One hundred twelve patients whose Thorax CT scan at the time of admission was deemed compatible with COVID-19 were placed in the Case Group, while 92 patients without COVID-19 findings on CT were placed in the Control Group.

Variables and Measurements

The researcher who conducted LUS had completed both the Basic and Advanced Ultrasound Courses offered by the Emergency Medicine Association of Turkey (EMAT) in the past 2 years. The ultrasound device used was Sonosite Edge II, along with a high-frequency linear probe (7-15 MHz). CT imaging was performed using a 64-slice Siemens SOMATOM Perspective CT device in the ED.

The data collection form was used to gather data in a standardized manner. It included demographic information, positive findings, their respective locations for each lung in LUS and CT imaging, final diagnoses, mortality rates, and length of hospital stay.

Study Procedure

LUS imaging was conducted with patients in a sitting position if they were capable, and in supine and lateral positions for those unable to sit. A total of 12 distinct areas were assessed (2 anterior, 2 lateral, and 2 posterior for each half of the thorax) following the "6-zone model" (5).

Pleural thickening, subpleural consolidation, large consolidations, hepatization, patchy B-lines, and pleural effusion findings were assessed. The locations of each finding were documented in the data collection form.

Since pleural effusion is not included among the pathological LUS findings of COVID-19, the study noted the number of areas with the other 5 findings (ranging from 0-12). The LUS Score was calculated by counting all areas with any findings, totaling 60 points. Following the scoring system established by Soldati et al. (16), the

was also calculated by assigning each area a score between 0-3 points, with 0 points indicating normal and 3 points indicating a fully affected area.

Nasopharyngeal and oropharyngeal swab samples were collected from the patients and sent for RT-PCR analysis. Thoracic CT imaging data of the patients were also collected. According to international reports (17), patients with CT findings consistent with COVID-19 evaluated as CO-RADS 4-5 were considered. CT involvement was categorized based on visual evaluation as mild, moderate, or severe (18). <10% (mild), 10-25% (moderate), and >25% (severe) were used to assess the severity of involvement. Additionally, various CT findings such as multiple peripheral GGO, crazy paving, peripheral consolidation, air bronchograms, reversed halo sign/perilobular pattern were examined separately in CT scans, as defined by the Society: Glossary of Terms for Thoracic Imaging (19). The areas where these CT findings were observed were recorded according to the total number of affected areas.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation or median (minimum-maximum) based on normal or non-normal distributions. Categorical variables were presented as absolute values and percentages. The distributions were evaluated using Kolmogorov-Smirnov and Shapiro-Wilk tests. The Student's t-test was employed for normally distributed data. Pearson's test was used for parametric data, while Spearman's rho test was utilized for nonparametric data in correlation analysis. For group comparisons, the Mann-Whitney U test was applied to continuous variables, and the Pearson $\chi 2$ test and Fisher's Exact test were used for categorical variables. Diagnostic adequacy, sensitivity, and specificity were determined through ROC analysis. A statistical significance level of alpha was set at $p < 0.05$. The statistical analysis was conducted using IBM SPSS version 25.

RESULTS

COVID-19 was suspected in 259 patients at the time of the visit. 55 patients were not included in the study because they did not meet the inclusion criteria. 112 patients were diagnosed with COVID-19 based on thorax CT findings. 92 patients without COVID-19 findings on thorax CT were included in the Control Group. LUS was performed on all patients in both groups (Figure 1).

The comparison of the case and control groups in terms of demographic data, physical examination findings, and vital findings was presented in Table 1.

Fifty-three (47.3%) patients were categorized as "mild", 45 (40.2%) as "moderate", and 14 (12.5%) as "severe". Among the COVID-19 patients with "mild severity" based on CT scans, 46 (86.8%) were identified as positive with LUS.

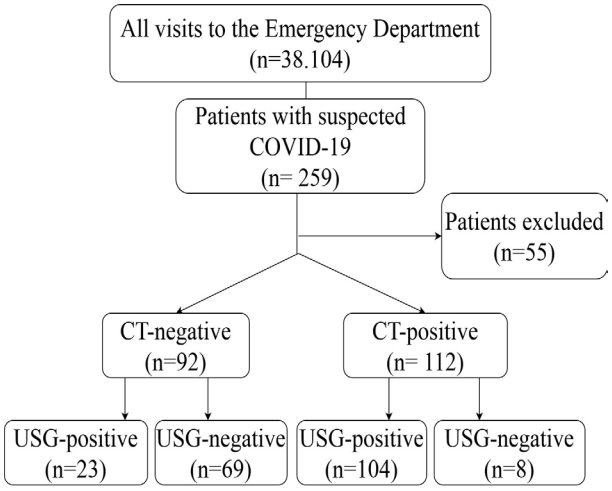

Figure 1. Flowchart of the study

Additionally, 44 (97.8%) patients in the "moderate" group and all 14 (100%) patients in the "severe" group tested positive with LUS. Within 14 days, 3 (5.7%) patients with "mild" findings, 4 (8.9%) with "moderate" findings, and 6 (42.9%) with "severe" findings passed away.

In the Case Group, the first RT-PCR result after admission was positive in 47 patients (42%) and negative in 57 patients. RT-PCR results of 8 patients could not be obtained. RT-PCR was positive in 44 patients (42.3%) in the LUS positive Case Group and 3 patients (37.5%) in the LUS negative Case Group. There was no statistically significant difference between the groups.

No significant difference was found in terms of demographic characteristics, chronic diseases, symptoms, physical examination findings, intubation, and 14-day survival between LUS-positive and LUS-negative patients in the Case Group.

In the evaluation of COVID-19 positive and negative patients based on the LUS findings, a statistically significant difference was observed in terms of Patchy B-lines, pleural thickening, and subpleural consolidation ($p \leq 0.001$). Regarding the evaluation of CT findings, a statistically significant difference was noted in terms of multiple peripheral GGO, crazy paving, and air bronchograms (p values < 0.001, < 0.001, and 0.009, respectively) (Table 2). The correlation results were presented in Table 3.

Relationship Between Scores and the Severity of Disease

In the Case Group, the mean LUS score of LUS-positive patients (assessed on a scale of 0-36 points), was 13.86 ± 8.786, while the mean total LUS score, evaluated on a scale of 0-60 points, was 15.85 ± 11.611. Among these patients, 46 individuals classified as "mild" based on CT findings had a mean LUS score of 11.634 ± 7.934 and a mean total

Table 1. Analysis of demographic data, physical examination findings, and vital signs in case and control groups.

	Control n Mean±SD	Study n Mean ±SD	t	95% CI		p
				Lower	Upper	
Age (years)	61.47±20.168	62.37±17.214	0.338	-4.347	6.144	0.736
SBP (mmHg)	134.32±29.37	130.38±24.742	-1.04	-11.543	3.662	0.308
Pulse (beat/min)	87.89±24.454	95.04±22.991	2.136	0.546	13.761	**0.034**
	Median (min-max)	**Median (min-max)**				**p**
Respiratory Rate (min)	14 (13-40)*	16 (13-36)*				**<0.001**
Body Temperature (^{0}C)	36.15 (36-38)*	36.5 (36-40)*				**<0.001**
sPO_2	98 (65-100)*	96 (70-100)*				**0.005**
DBP (mmHg)	74.5 (32-158) *	76 (20-141)*				0.351
	Control n (%)	**Study n (%)**				**p**
Gender Female	35 (38)	45 (40.2)				0.756
Heart Disease	34 (37)	36 (32.1)				0.471
DM	23 (25)	27 (24.1)				0.883
HT	31(33.7)	48 (42.9)				0.181
Lung Disease	20 (21.7)	19 (17)				0.388
Malignancy	5 (5.4)	21 (18.8)				**0.005**
Shortness of Breath	30 (32.6)	66 (58.9)				**<0.001**
Cough	18 (19.6)	59 (52.7)				**<0.001**
Fever	8 (8.7)	45 (40.2)				**<0.001**
Pleuretic Pain	5 (5.4)	16 (14.3)				**0.038**
Sputum	2 (2.2)	9 (8)				0.166$^+$
Taste Loss	1 (1.1)	3 (2.7)				0.629$^+$
Smell Loss	1 (1.1)	3 (2.7)				0.629$^+$
Rales	10 (10.9)	19 (17)				0.215
Rhonci	2 (2.2)	0 (0)				0.202$^+$
Coarse LS	15 (16.3)	51 (45.5)				**<0.001**
US Positive	23 (25)	104 (92.9)				**<0.001**
Intubation	10 (10.9)	9 (8)				0.488
14 Day Survival	86 (93.5)	99 (88.4)				0.214

Mann-Whitney U, median (minimum-maximum), +Fisher's Exact Test, The Student's t-test was used to evaluate the normally distributed data,* ***SD:* *Standard deviation,* ***CI:*** *Confidence Interval,* ***SBP:*** *Systolic Blood Pressure,* ***DBP:*** *Diastolic Blood Pressure,* ***US:*** *Ultrasonography,* ***DM:*** *Diabetes Mellitus,* ***HT:*** *Hypertension,* ***LS:*** *Lung Sounds*

Table 2. Positivity of Lung Ultrasound (LUS) and Computed Tomography (CT) Findings in the Case and Control Groups.

US Finding	**Control Group n (%)**	**Study Group n (%)**	**p**
Patchy B Lines	20 (21.7)	100 (89.3)	**<0.001**
Pleural Thickening	12 (13)	71 (63.4)	**<0.001**
Subpleural Consolidation	4 (4.3)	29 (25.9)	**<0.001***
Large Consolidations	1 (1.1)	6 (5.4)	0.131*
Hepatisation	1 (1.1)	4 (3.6)	0.381*
Pleural Effusion	11 (12)	6 (5.4)	0.09
CT Finding	**Control Group n (%)**	**Study Group n (%)**	**p**
PMGGO	8 (8.7)	106 (94.6)	**<0.001**
Crazy Paving	4 (4.3)	37 (33)	**<0.001***
Air Bronchograms	7 (7.6)	23 (20.5)	**0.009**
Peripheral Consolidations	12 (13)	20 (17.9)	0.347
Reverse Halo Sign	0 (0)	1 (0.9)	1*
Pleural Effusion	13 (14.1)	12 (10.7)	0.459

Fisher's Exact Test.* ***LUS:* *Ultrasound,* ***CT:*** *Computed Tomography,* ***PMGGO:*** *Peripheral Multiple ground-glass opacities*

Table 3. Correlation of various parameters with LUS scores and number of areas with patchy B lines

CORRELATION	LUS Score		Total LUS Score		NA with Patchy B Lines	
	r_s	p	r_s	p	r_s	p
Respiratory Rate	0.18	0.057	0.226	**0.017**	0.199	**0.036**
sPO_2	-0.307	**0.001**	-0.314	**0.001**	-0.304	**0.001**
Body Temperature	0.164	0.083	0.181	0.056	0.079	0.41
Lymphocyte	-0.194	**0.041**	-0.203	**0.032**	-0.186	**0.05**
Procalcitonin	0.177*	0.062	0.131*	0.17	0.126*	0.185
NA with PMGGO	0.419	**<0.001**	0.458	**<0.001**	0.292	**0.002**
NA with Crazy Paving	0.463*	**<0.001**	0.503*	**<0.001**	0.442*	**<0.001**
NA with Air Bronchograms	0.236	**0.012**	0.253	**0.007**	0.115	0.229
NA with Peripheral Consolidations	0.244	**0.01**	0.238	**0.012**	0.082	0.387
NA with Reverse Halo Sign	-0.094	0.325	-0.102	0.284	-0.07	0.463
NA with Pleural Effusion	0.301	**0.001**	0.321	**0.001**	0.219	**0.021**
Severity on the CT	0.34*	**<0.001**	0.341*	**<0.001**	0.222*	**0.019**
CORRELATION	**NA with PMGGO**		**NA with Crazy Paving**		**Severity on the CT**	
	r_s	p	r_s	p	r_s	p
Respiratory Rate	0.001	0.993	0.231	**0.014**	0.108	0.258
sPO_2	0.004	0.971	-0.244	**0.01**	-0.122	0.199
Body Temperature	-0.169	0.076	0.111	0.246	0.114	0.23
Lymphocyte	-0.066	0.491	-0.161	0.09	-0.083	0.383
Procalcitonin	0.196	**0.039**	0.397	**<0.001**	0.252	**0.007**
Patchy B Lines	0.296	**0.002**	0.239	**0.011**	0.155	**0.102**
Pleural Thickening	0.231	**0.014**	0.212	**0.025**	0.225	**0.017**
Subpleural Consolidation	0.236	**0.012**	0.357	**<0.001**	0.271	**0.004**
Large Consolidations	0.08	0.401	0.176	0.063	0.105	0.27
Hepatisation	0.117	0.219	0.086	0.366	0.272	**0.004**
LUS Score	0.419	**<0.001**	0.472	**<0.001**	0.329	**<0.001**
Total LUS Score	0.458	**<0.001**	0.491	**<0.001**	0.315	**0.001**

Pearson's correlation coefficient.* ***rs:* *Spearman's correlation coefficient.* ***LUS:*** *Lung Ultrasound,* ***CT:*** *Computed Tomography,* ***PMGGO:*** *Peripheral Multiple ground-glass opacities,* ***NA:*** *Number of areas*

LUS score of 12.87 ± 10.402. For the 44 patients classified as "moderate" based on CT findings, the mean LUS score was 14.36 ± 8.908, and the mean total LUS score was 16.25 ± 11.277. The mean LUS score for the 14 patients classified as "severe" was 19.57 ± 8.812, and the mean total LUS score was 24.36 ± 12.768.

Patients who survived for 14 days had a mean LUS score of 12.11 ± 8.857 and a mean total LUS score of 13.77 ± 10.978. A statistically significant correlation was observed between the LUS score and 14-day survival (r = -0.19, p = 0.029), as well as between the total LUS score and 14-day survival (r = -0.22, p = 0.01).

The area under the curve of the "LUS score" was 0.702 (95% CI: 0.634-0.764) in the ROC analysis conducted between patients with and without 14-day survival, with a threshold value determined as ≤13 according to the Youden index point. The sensitivity was 80%, and the specificity was 52.63%. Similarly, the area under the curve of the "Total LUS score" was 0.711 (95% CI: 0.643-0.772) with a threshold value set at ≤13 based on the Youden index point. The sensitivity was 79.46%, and the specificity was 57.89% (Figure 2).

Outcomes

The median length of hospital stay for LUS-positive Case Group patients was 7 days (range 0-45), with a 14-day survival rate of 87.5% (91 patients). Among the 8 patients with negative LUS, the median hospital stay was 6.5 days (range 0-24), and the 14-day survival rate was 100%.

Sensitivity and Specificity of Lung Ultrasound in COVID-19

In our study, the sensitivity of LUS in detecting patients with thoracic CT scans positive for COVID-19 was 93.33%, specificity was 80%, positive predictive value (PPV) was 82.96%, and negative predictive value (NPV) was 92%.

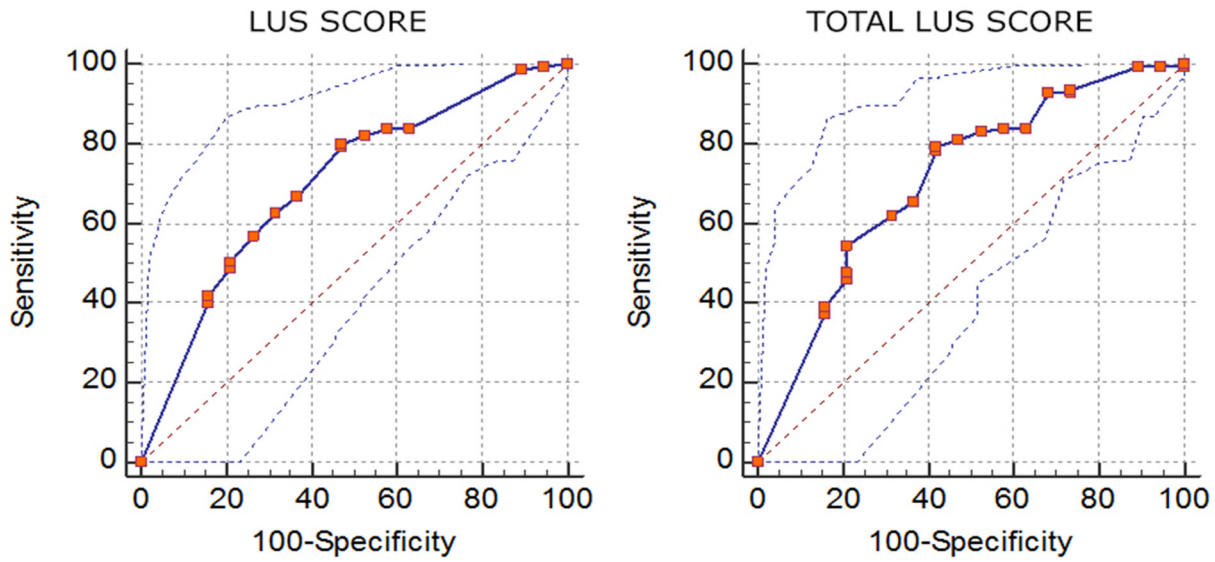

Figure 2. ROC Analysis of LUS Score and Total LUS Score

Table 4. Diagnostic accuracy measures of LUS and COVID-19 LUS findings

Measure	Value	95% CI
Sensitivity %	93.33	87.29 - 97.08
Specificity %	80	71.52 - 86.88
Positive Likelihood Ratio	4.67	3.23 - 6.75
Negative Likelihood Ratio	0.08	0.04 - 0.16
Prevalence %	51.06	44.48 - 57.62
Positive Predictive Value %	82.96	77.11 - 87.56
Negative Predictive Value %	92	85.4 - 95.76
Accuracy %	86.81	81.8 - 90.86
Measure	**Value (95% CI)**	
	Patchy B Lines	**Pleural Thickening**
Sensitivity %	90.32 (83.71-94.9)	73.2 (65.45-80.03)
Specificity %	82.14 (73.78-88.74)	88.46 (80.71-93.89)
Positive Likelihood Ratio	5.06 (3.39-7.56)	6.34 (3.69-10.89)
Negative Likelihood Ratio	0.12 (0.07-0.21)	0.3 (0.23-0.39)
Prevalence %	52.54 (45.96-59.06)	59.53 (53.26-65.59)
Positive Predictive Value %	84.85 (78.94-89.32)	90.32 (84.46-94.13)
Negative Predictive Value %	88.46 (81.64-92.97)	69.17 (63.12-74.63)
Accuracy %	86.44 (81.4-90.54)	79.38 (73.91-84.15)
	Subpleural Consolidation	**Hepatization**
Sensitivity %	57.44 (50.17-64.47)	50.91 (44.1-57.69)
Specificity %	95.83 (89.67-98.85)	98.92 (94.15-99.97)
Positive Likelihood Ratio	13.78 (5.24-36.24)	47.35 (6.71-334.05)
Negative Likelihood Ratio	0.44 (0.37-0.52)	0.5 (0.44-0.57)
Prevalence %	67.01 (61.28-72.39)	70.29 (64.89-99.87)
Positive Predictive Value %	96.55 (91.41-98.66)	99.12 (94.07-99.87)
Negative Predictive Value %	52.57 (48.37-56.74)	46 (42.64-49.4)
Accuracy %	70.1 (64.49-75.31)	65.18 (59.61-70.45)

According to the statistical analysis of the LUS findings associated with COVID-19, the finding with the highest sensitivity was Patchy B-lines (90.32%, 95% CI: 83.71%-94.9%). The two findings with the highest specificity were hepatization (98%, 95% CI: 92.95%-99.97%) and subpleural consolidation (95.83%, 95% CI: 89.67%-98.85%). The finding with the highest PPV was hepatization (99.12%, 95% CI: 94.07%-99.87%), and the finding with the highest NPV was Patchy B-lines (88.46%, 95% CI: 81.64%-92.97%) (Table 4).

DISCUSSION

COVID-19 is an infectious respiratory disease caused by SARS-CoV-2. The epidemic level of the disease has led to strain on health resources in many countries, making it necessary to evaluate all methods that can guide diagnosis and treatment (5). Severe pneumonia and/or ARDS are seen in approximately 20% of COVID-19 patients (20,21), for which Thorax CT can be used for follow-up and treatment management (4). It has been reported that ground-glass opacities (GGO) are seen most frequently in thorax CT in COVID-19 (22–24). In our study, the most common finding was multiple peripheral GGO (94.6%), consistent with the literature. Vetrugno et al. (5) suggested the use of "6-zone model" in LUS for COVID-19. This protocol was utilized in our study, and it was found to be practical and suitable for implementation in the ED.

The most common finding in our study was patchy B-lines, which had the highest sensitivity, accuracy, and NPV. Pleural thickening was the most prevalent finding (63.4%) with the second-highest specificity. Consolidations, crucial LUS findings in pneumonia, were rare in COVID-19 cases. While Sezgin et al. (24) and Unlukaplan et al. (25) noted consolidations at a high frequency in pneumonia cases assessed with LUS, they were seldom observed in our study.

Hepatization is a significant finding in LUS for pneumonia (7). In the study by Sezgin et al. (25), hepatization was observed in 67.3% of pneumonia cases. In our study, the specificity of hepatization as a finding was determined to be 98.92%. Additionally, hepatization had the highest PPV at 99.12% (95% CI: 94.07% - 99.87%).

In the study by Lu et al. (27), it was observed that the severity of COVID-19 pneumonia is correlated with the sensitivity, specificity, and diagnostic value of LUS. In the study by Bonadia et al. (28), it was found that the prevalence of LUS findings was related to the increase in mortality and the need for ICU admission. In the study by Benchoufi et al. (29), the severity of CT involvement was found to be correlated with the prevalence of LUS findings. In our study, it was observed that as the severity of CT involvement increased, LUS positivity increased. Fourteen-day survival was found to be positive in all LUS-negative COVID-19 patients. Accordingly, mortality is lower in patients who are COVID-19 positive but do not have LUS findings.

In the study by Pan et al. (30), it was shown that the progression of COVID-19 is associated with CT findings. The study by Wu et al. (31) concluded that the clinical severity of the disease and CT findings were related. Similarly, the severity of CT findings was correlated with the clinical severity of the patients in our study.

The diagnostic accuracy of LUS in pneumonia is over 90% (5). It has high sensitivity (94.1%) but low specificity (84.8%) in viral pneumonia with 86.5% PPV and 93.3% NPV (32). In the study by Lu et al. (27), LUS demonstrated a sensitivity of 68.8%-100.0%, specificity of 76.2%-92.9%, and diagnostic accuracy of 76.7%-93.3%, respectively. In our study, we observed that the sensitivity and specificity of LUS in detecting COVID-19 were both high.

In our study, the LUS was calculated for each patient as previously described in the literature and was found to be associated with 14-day mortality. Additionally, to the best of our knowledge, this is the first study in the literature where the value of Total LUS Score was calculated.

In similar studies in the literature, some chronic diseases and clinical conditions were frequently used as exclusion criteria (14,28,33,34). Although it is widely believed that underlying chronic lung disease and sequelae changes may affect the evaluation of LUS findings in patients with suspected COVID-19, the diagnostic value of LUS was found to be high in our sample, including patients with comorbidities. In this respect, it is thought that LUS could be used with high success in the diagnosis of COVID-19 pneumonia, even in clinical settings where patient selection is not possible, such as EDs. In our study, the rate of negative first RT-PCR results was high in the Case Group. Therefore, repetitive tests may be necessary in cases of clinical suspicion.

The strengths of our study were as follows: Chronic diseases were not used as exclusion criteria, all findings were evaluated separately for each area, and LUS scores have been shown to be effective in predicting the clinical severity of COVID-19.

The limitation of our study is that it is a single-center prospective study conducted in an ED by a single LUS performer.

Conclusion

In patients with suspected COVID-19 and lung involvement, LUS is a cost-effective, easily applicable, and repeatable method with high sensitivity and specificity. It may assist physicians in triage and clinical decision-mak-

ing without posing a risk to the patient. The "Total LUS score" parameter, defined for the first time in the literature, and the "LUS score" parameter previously defined in the literature were found to be associated with poor clinical outcomes. In patients with suspected COVID-19, it is recommended to pay special attention to Patchy B-lines and pleural thickening findings in LUS.

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