


RESEARCH ARTICLE

Point-of-care lung ultrasound findings in the pediatric emergency clinic during the COVID-19 pandemic

Esra Türe MD¹  | Muhammet Furkan Korkmaz MD² | Fatma Dilşad Aksoy MD² |
Başak Ceylan Demirbaş MD² | Burcu Menekşe MD² | Mehtap Çiftçi MD² |
Merve Korkmaz MD²

¹Department of Pediatric Emergency, Bursa City Hospital, Bursa, Turkey

²Department of Pediatrics, Bursa City Hospital, Bursa, Turkey

Correspondence

Esra Türe, MD, Department of Pediatric Emergency, Bursa City Hospital, 16110 Nilüfer-Bursa, Turkey.
Email: dresrature@hotmail.com

Abstract

Purpose: To describe our experience concerning lung ultrasound (LUS) in the pediatric emergency clinic, and to investigate the diagnostic value of LUS in coronavirus disease-2019 (COVID-19).

Methods: Patients aged under 18 admitted to the pediatric emergency clinic with suspicion of COVID-19, who underwent point-of-care LUS and from whom COVID-19 reverse transcription polymerase chain reaction (RT-PCR) samples were collected, were included in the study.

Results: Point-of-care LUS was performed on 74 patients in the emergency room. LUS findings were more sensitive than chest X-ray in the early stages of the disease and in mild cases. Involvement was observed at LUS despite RT-PCR being negative in some symptomatic patients with a COVID-19 contact history.

Conclusions: We think that LUS can be beneficial in terms of identifying patients with lung involvement and staging their severity in this new disease in pediatric emergency clinics. The procedure is noninvasive, rapid, reproducible, and low cost, involving simple sterilization. Based on the current literature and our own practical experience, we think that increased use of point-of-care LUS can protect patients from unnecessary radiation and treatment delays during the COVID-19 pandemic.

KEYWORDS

COVID-19, pandemic, pediatric, pneumonia, point-of-care lung ultrasound

1 | INTRODUCTION

Patients with pneumonia caused by a new type of coronavirus infection appeared in Wuhan city in the Chinese province of Hubei in early December 2019, after which the disease spread rapidly and worldwide.¹ The World Health Organization named the disease caused by the new infection “coronavirus disease-2019” (COVID-19).² The clinical symptoms of COVID-19 can range from a mild, self-limiting flu-like syndrome, to acute respiratory distress syndrome (ARDS), and life-threatening multiorgan failure, and interstitial pneumonia.³

Numerous previous studies have shown that lung ultrasound (LUS) is capable of detecting interstitial lung disease and subpleural consolidations.⁴⁻⁶ In addition, evidence from recent studies has confirmed the usefulness of LUS in the diagnosis, management, and follow-up of patients with COVID-19 pneumonia.⁷⁻⁹

Although several studies have investigated LUS in adult patients with COVID-19, the literature for the pediatric age group is limited. The purpose of this study is to report our experiences concerning LUS in the pediatric emergency clinic, to investigate the diagnostic value of LUS in COVID-19, and to gather evidence

and contribute urgently needed information by retrospectively examining the point-of-care LUS findings of patients with fever or cough admitted to our pediatric emergency clinic with suspected COVID-19.

2 | MATERIALS AND METHODS

Patients aged under 18 admitted to the pediatric emergency clinic with suspected COVID-19 between March 15, 2020 and May 10, 2020, who underwent point-of-care LUS, and from whom COVID-19 reverse transcription polymerase chain reaction (RT-PCR) samples were collected, were included in the study. Patient data were retrieved from patient files and the hospital automation system. Age, sex, COVID-19 contact history, LUS findings, COVID-19 RT-PCR results, and chest X-ray (CXR) findings were recorded. Patients not undergoing RT-PCR or LUS, or with symptoms other than fever or cough were excluded from the study.

Sonographic lung evaluations were performed by a single operator (pediatric emergency specialist) with 4 years' experience of point-

of-care LUS using a LOGIQ P9 (GE Healthcare, Wauwatosa, Wisconsin) ultrasound (US) device. LUS was performed using personal protective equipment and with all requisite precautions being taken against infection transmission. The US device was disinfected after each patient. A low-frequency convex probe was used to evaluate lung parenchymal structures, and a high-frequency linear probe was used to evaluate the pleural line. LUS was performed with patients in the sitting or supine positions, depending on their age. If the patient was in the sitting position, 14 segments of both hemithoraces, including anterior (superior/inferior), lateral (superior/inferior), and posterior (superior/medial/inferior) segments were examined. If the patient was in the supine position, eight segments including anterior (superior/inferior) and lateral (superior/inferior) segments were examined. LUS findings such as pleural thickening, pleural irregularity, subpleural consolidation, B lines, and white lung were recorded.

Statistical analysis was performed on Statistical Package for the Social Sciences for Windows Version 20.0 software. Categorical variables were expressed as n (%), while mean \pm SD was used for continuous variables with normal distribution, and median (lower-upper limit) values for continuous variables without normal distribution.

TABLE 1 Epidemiologic and clinical characteristics, and X-ray and LUS findings of the COVID-19 RT-PCR-positive and -negative patients

	COVID-19 RT-PCR positive (n = 24)	COVID-19 RT-PCR negative (n = 50)	Total (N = 74)	P
Epidemiological features				
Female n (%)	8 (33.3%)	21 (42%)	29 (39.2%)	>.05
Male n (%)	16 (66.7%)	29 (58%)	45 (60.8%)	>.05
Age (mo)	134 \pm 51.93	101.36 \pm 45.45	112.15 \pm 39.31	.023
Patients with COVID-19 contact in the family	19 (79.2%)	38 (76%)	57 (77%)	>.05
Symptoms				
Fever	4 (16.7%)	5 (10%)	9 (12.2%)	>.05
Cough	7 (29.2%)	27 (54%)	34 (45.9%)	>.05
Fever + cough	13 (54.2)	18 (36%)	31 (41.9%)	>.05
CXR findings				
Normal	10 (41.7%)	37 (74%)	47 (63.5%)	.01
Consolidation	8 (33.3%)	8 (16%)	16 (21.6%)	>.05
Peribronchial thickening	4 (16.7%)	5 (10%)	9 (12.2%)	>.05
Interstitial infiltration	2 (8.3%)	0	2 (2.7%)	>.05
LUS findings				
Normal	6 (25%)	37 (74%)	43 (58.1%)	<.001
Patients with LUS findings	18 (75%)	13 (26%)	31 (41.9%)	<.001
Pleural irregularity	18 (75%)	13 (26%)	31 (41.9%)	<.001
Pleural thickening	18 (75%)	13 (26%)	31 (41.9%)	<.001
B line (focal)	3 (12.5%)	5 (10%)	8 (10.8%)	>.05
B line (focal and confluent)	13 (54.2%)	8 (16%)	21 (28.4%)	<.001
White lung	13 (54.2%)	8 (16%)	21 (28.4%)	<.001
Subpleural consolidation	16 (66.7%)	12 (24%)	28 (37.8%)	<.001

Abbreviations: COVID-19, coronavirus disease-2019; CXR, chest X-ray; LUS, lung ultrasound; RT-PCR, reverse transcription polymerase chain reaction.

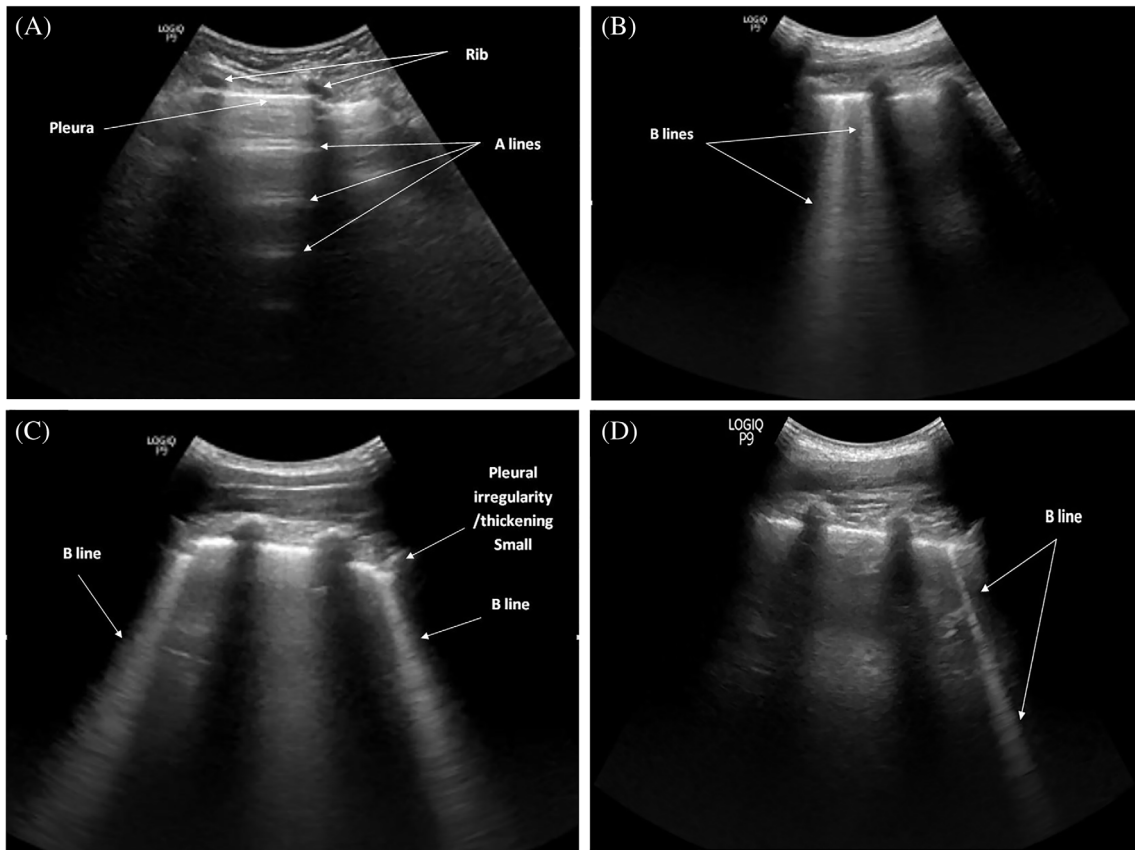


FIGURE 1 A, Normal lung sonogram. B, Focal B lines. C, Focal B lines, pleural thickening/irregularity, and small subpleural consolidation. D, Focal B lines

Descriptive analyses were used to analyze the distribution and frequency of data, and the Chi-square test was used to compare two independent groups. The independent *t* test was used to compare mean values in two independent groups. Significance was set at $<.05$ for all statistical analyses.

3 | RESULTS

A total of 74 patients were included in the study. Fifty-seven (77%) patients had histories of contact with a COVID-19-positive family member. RT-PCR results were positive in 24 (32.4%) cases and negative in 50 (67.6%). Patients' epidemiological and clinical characteristics, and CXR and LUS findings are shown in Table 1.

Comparison of the LUS findings of the groups with positive and negative RT-PCR results revealed significantly greater LUS findings in 18 (75%) of the 24 positive patients ($P = .001$). Examination of the CXRs of the 31 patients with LUS findings revealed statistically significant findings in 27 (87.1%) ($P = .001$). Four (12.9%) patients had LUS findings, but normal CXRs.

LUS findings were determined in 31 (41.9%) patients, all of whom exhibited pleural thickening and irregularity. US images from patients with pleural thickening and irregularity are shown in Figure 1C, Figure 2A,C,D, and Figure 3D. B lines were observed in 29 (93.5%) of

the 31 patients with LUS findings, these being focal in 8 (27.6%) cases and confluent in 21 (72.4%). US images from patients with focal B lines are shown in Figures 1B-D and 2A,B,D, and images from patients with confluent B lines are shown in Figures 2C and 3C. White lung findings were observed in 21 (72.4%) patients with LUS findings, and subpleural consolidation areas of various sizes in 28 (90.3%). US images from patients with a white lung appearance are shown in Figures 2B,C and 3A-C, and from patients with subpleural consolidation areas in Figures 2A-C and 3A,B,D. Bilateral involvement was determined in 17 (54.8%) of the 31 patients with LUS findings, right lung involvement in 11 (35.5%), and left lung involvement in three (9.7%).

Influenza RT-PCR results in the emergency department were negative in all patients. No patients underwent thoracic computed tomography (CT). Treatment was started in all patients with LUS findings. No patients required intubation or intensive care unit hospitalization.

4 | DISCUSSION

This study examines the point-of-care LUS findings of patients admitted to our pediatric emergency department with a suspicion of COVID-19 and with fever or cough. LUS findings were found to be more sensitive than CXR in the early stages of the disease and in mild cases. In addition, involvement was observed at LUS despite RT-PCR

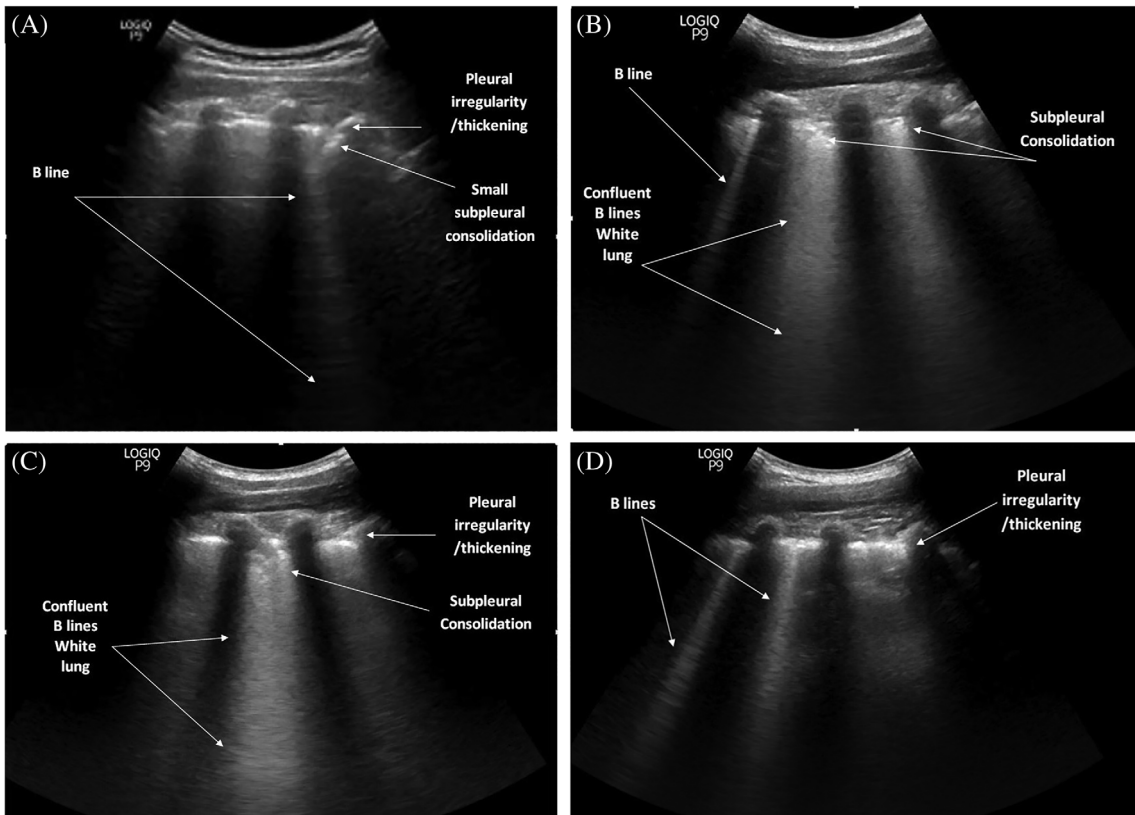


FIGURE 2 A, Focal B lines, pleural thickening/irregularity, and small subpleural consolidation. B, Focal and confluent B lines, subpleural consolidation, and white lung appearance. C, Pleural thickening/irregularity, subpleural consolidation, and white lung appearance. D, Pleural thickening/irregularity and focal B lines

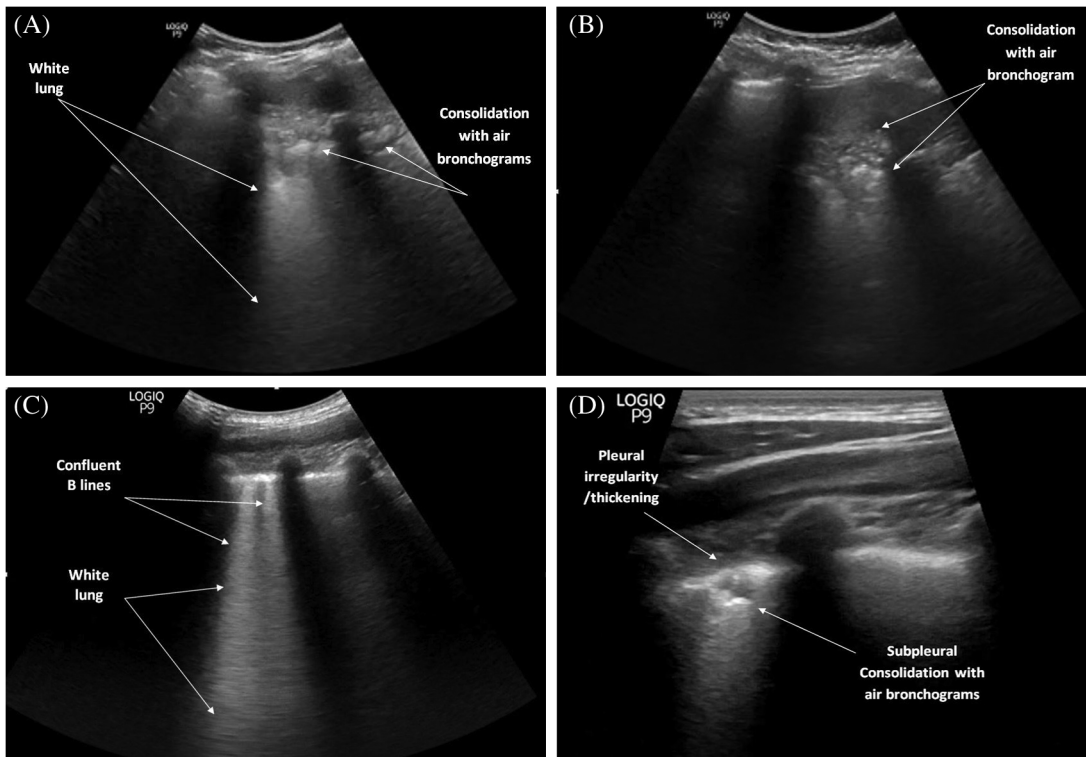


FIGURE 3 A, Lung ultrasound (LUS) shows white lung appearance and consolidations with air bronchograms. B, LUS shows consolidations with air bronchograms. C, Confluent B lines and white lung appearance. D, LUS image of pleural thickening/irregularity and consolidations with air bronchograms obtained using a linear transducer

being negative in some symptomatic patients with a COVID-19 contact history.

Studies in recent years have shown that LUS can detect interstitial lung disease, subpleural consolidations, and ARDS.^{4,10} The fact that LUS can be performed quickly at the bedside, can reduce the use of tomography and CXR and can eliminate patient exposure to radiation, and its inexpensive, rapid, noninvasive, and reproducible nature have further encouraged its use in lung evaluations during the COVID-19 pandemic.^{11,12} Since the most important area of involvement of COVID-19 is the pulmonary system, LUS performed by a trained physician can be useful in triage, the classification of disease severity, and treatment planning in the emergency department and intensive care unit.

LUS findings in patients with COVID-19 are similar to those commonly described in other types of pneumonia.¹³ Subpleural consolidations with indirect symptoms such as pleural thickening and irregularities, loss of A-lines and an increase in B-lines due to pulmonary diseases all occur. B-lines in COVID-19 pneumonia can appear in both separate and confluent forms, and B-line clusters can give the appearance of a glowing white lung and radiate in the form of rays that maintain their brightness without fading to the edge of the screen. These artifacts represent typical signs of the disease, but can also be observed in other interstitial diseases of various etiologies.¹⁴ Musolino et al¹⁵ described vertical B artifacts, white lung areas, subpleural consolidations, and pleural irregularities as the main findings in pediatric COVID-19 pneumonia in their LUS evaluation of 10 children. In another study involving a limited number of pediatric patient, Denina et al¹⁶ detected small subpleural consolidations and B-lines were detected. In agreement with the previous literature, we also detected pleural thickening and irregularity, B lines (focal and confluent), a white lung appearance, and subpleural consolidation in COVID-19 pneumonia.

Although CXR has traditionally been used for the diagnosis of lung diseases, it may not be able to detect early-stage COVID-19 pneumonia.¹⁷ Weinstock et al¹⁸ examined CXRs obtained from symptomatic patients with confirmed COVID-19 and found that CXRs were normal in 58.3% of patients, and normal or only mild findings at CXR in 89%. They concluded that there was no guarantee that CXR results would be normal. Denina et al¹⁶ compared CXR and LUS findings in children and described them as compatible. Although CXR was normal in the present study, four (12.9%) patients had LUS findings. This suggests that point-of-care LUS will be useful in detecting early stage pneumonia in addition to mild COVID-19 pneumonia and in terms of initiating early treatment, especially in childhood.

RT-PCR has become the standard evaluation method for the diagnosis of COVID-19 infection according to current diagnostic criteria.¹⁹ However, the rates of false-positive or false-negative results are still unclear.²⁰ Thoracic CT is often recommended as a screening tool for adult patients with suspected COVID-19 pneumonia.²¹ Fang et al²² reported higher sensitivity for thoracic CT than RT-PCR in patients with COVID-19 pneumonia (98% vs 71%, respectively, $P < .001$). Those authors also concluded that thoracic CT should be used in COVID-19 screening for patients with clinical and epidemiological

features compatible with COVID-19. Ai et al²³ investigated the correlation between thoracic CT and RT-PCR and similarly found that more than 70% of patients with negative RT-PCR tests exhibited typical CT findings. In our clinic, we evaluated patients using CXR and LUS instead of thoracic CT in order to minimize radiation exposure in pediatric patients. Studies show that LUS findings are quite consistent with thoracic CT findings of COVID-19 pneumonia and that LUS constitutes an alternative imaging method for identifying characteristic lesions.^{24,25} Consistent with the existing literature, positive LUS findings were detected in 13 (26%) of 50 patients with negative RT-PCR in the present study. Due the false-negative results produced by RT-PCR, rapid and accurate diagnostic methods are urgently needed to identify, isolate, and treat COVID-19 as rapidly as possible. The use of thoracic CT is limited, particularly in childhood and among pregnant women, due to the effect of radiation. This suggests that LUS can represent a useful method for detecting lung abnormalities in children with COVID-19 in the early stages, and that it can be used for screening, as an ancillary diagnostic method, and for patient follow-up.

There are a number of limitations to the present study. First, the research presents observational data from a single center. The fact that LUS was performed by a single sonographer also resulted in a limited sample size. In addition, our patients admitted to the pediatric emergency clinic with suspected symptomatic COVID-19 underwent LUS at the time of admission. This meant that the number of patients who were positive for RT-PCR was relatively low. Larger multicenter studies are therefore now needed to establish protocols for the use of point-of-care LUS in pediatric emergency clinics. Despite these limitations, our study is one of the largest to examine the use of point-of-care LUS in the COVID-19 pandemic in children.

We conclude that as a noninvasive, rapid, and reproducible procedure, also involving ease of sterilization and low costs, LUS can be useful in identifying patients with lung involvement and in staging their severity in this new disease in pediatric emergency clinics. Based on the current evidence concerning COVID-19 and our own practical experience, we think increased use of point-of-care LUS during the COVID-19 pandemic can protect patients from unnecessary exposure to radiation and treatment delays.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Esra Türe  <https://orcid.org/0000-0002-1015-1764>

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How to cite this article: Türe E, Korkmaz MF, Aksoy FD, et al. Point-of-care lung ultrasound findings in the pediatric emergency clinic during the COVID-19 pandemic. *J Clin Ultrasound*. 2021;49:85-90. <https://doi.org/10.1002/jcu.22947>