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Variability in Point-of-Care Lung Ultrasound Findings in Pediatric COVID-19 Patients

A Multicenter Case Series

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Abstract: Point-of-care ultrasound (POCUS) has been described as a useful tool for identification of coronavirus disease 2019 (COVID-19) in adults and children. Although several case reports describe POCUS findings in children with COVID-19, to our knowledge, there have been no published multicenter case series describing the large heterogeneity in lung POCUS findings in pediatric COVID-19. This series includes 7 symptomatic patients with COVID-19 who had a lung POCUS performed at 6 institutions by pediatric emergency attendings and fellows. The findings were variable, ranging from no findings to the appearance of B-lines, pleural abnormalities, consolidations, and a pleural effusion. Further studies are needed to improve our understanding, characterization, and prognostic correlation of POCUS findings in this novel disease in children.

Key Words: point-of-care ultrasound, COVID-19, SARS-CoV-2, lung ultrasound

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CASE 1

A 4-year-old boy with Prader-Willi syndrome, asthma, and obstructive sleep apnea requiring BiPAP use at night was brought to the emergency department (ED) in May 2020 in Northern California for 3 days of worsening cough, shortness of breath, fever, and wheezing. Symptoms were initially unrelieved with albuterol and budesonide use at home. In the ED, his temperature was 36.4°C, heart rate of 108 beats per minute, respiratory rate of 28 breaths per minute, blood pressure of 117/64 mm Hg, and an oxygen saturation of 97%. On physical examination, the patient was nontoxic appearing. Lung auscultation revealed adequate air movement, bilateral coarse lung sounds, no wheezing, and no visible retractions. A chest x-ray reviewed by a radiologist suggested multifocal pneumonia of the left lung without a pleural effusion (Supplemental Fig. 1, <http://links.lww.com/PEC/A829>).

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Point-of-care ultrasound (POCUS) of the lungs did not show any significant B-lines, lung consolidation, effusion, or pleural irregularity (Fig. 1). A severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) polymerase chain reaction (PCR) test returned positive. The patient was treated with oral dexamethasone and albuterol. He was admitted to the pediatric intensive care unit (PICU) for monitoring on room air and home BiPAP settings at night. In addition, a viral respiratory panel returned positive for rhinovirus and pertussis. The patient was discharged after a 1-day hospitalization on azithromycin and prednisolone.

CASE 2

A 13-month-old previously healthy girl presented to an ED in Southern California in May 2020 with 4 days of fever, cough, and loose stool. Vital signs demonstrated a temperature of 36.6°C, heart rate of 127 beats per minute, respiratory rate of 28 breaths per minute, and oxygen saturation of 100% on room air. On examination, the patient was nontoxic appearing, in no respiratory distress. The lungs were clear with symmetric air entry bilaterally. A chest x-ray performed 2 days before presentation had no focal consolidation concerning for pneumonia. Lung POCUS demonstrated faint B-lines posterobasally (Fig. 2). The patient remained in no distress with normal oxygen saturations and was discharged home from the ED. A SARS-CoV-2 PCR test returned positive.

CASE 3

A 19-year-old woman with a history of systemic lupus erythematosus (SLE) and obesity presented to an ED in Georgia around July 2020 with shortness of breath, chest pain, and fever for 1 day. She had been discharged 2 days earlier after hospitalization for a SLE exacerbation. Vital signs demonstrated a temperature of 38.4°C, heart rate of 112 beats per minute, blood pressure of 135/81 mm Hg, respiratory rate of 48 breaths per minute, and an oxygen saturation of 96%. The patient appeared ill and in respiratory distress. Examination demonstrated tachypnea with accessory muscle use and decreased breath sounds at the lung bases bilaterally. Supplemental oxygen was administered via nasal cannula at 3 L/min with improved comfort and decreased respiratory effort. A chest x-ray demonstrated a normal cardiac silhouette, peribronchial cuffing, trace bilateral pleural effusions, and scattered hazy opacities in the lower lung fields consistent with multifocal pneumonia (Supplemental Fig. 2, <http://links.lww.com/PEC/A829>). Lung POCUS demonstrated diffuse B-lines and consolidation at the lung bases bilaterally, with an effusion seen in the right posterior lung field (Fig. 3). A SARS-CoV-2 PCR test returned positive. The patient was admitted to the PICU where she continued to receive supplemental oxygen via nasal cannula and was treated with

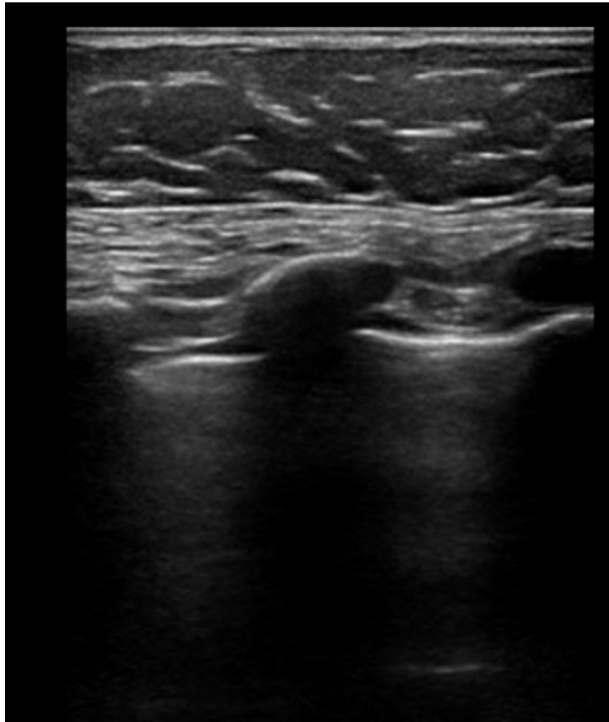


FIGURE 1. Longitudinal lung ultrasound images of 4-year-old patient with a history of Prader-Willi syndrome with fever, cough, and shortness of breath for 3 days with no notable abnormalities.

vancomycin, ceftriaxone, prednisone, and hydroxychloroquine. The patient was discharged home on hospital day 4.

CASE 4

A 17-year-old adolescent boy with no significant medical history presented to an ED in Pennsylvania in September 2020 with 8 days of worsening productive cough and fatigue in setting of subjective fever, sore throat, loss of taste, and smell. He was seen by his primary care physician and prescribed azithromycin for clinical pneumonia. His temperature was 36.4°C, heart rate of 97 beats per minute, respiratory rate of 20 breaths per minute, blood pressure 131/64 mm Hg, and an oxygen saturation of

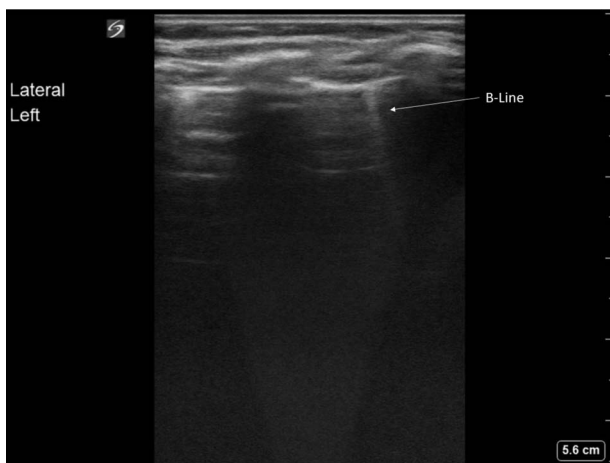


FIGURE 2. Longitudinal lung POCUS of a 13-month-old patient with 4 days of fever, cough, and loose stool showing a faint B-line.

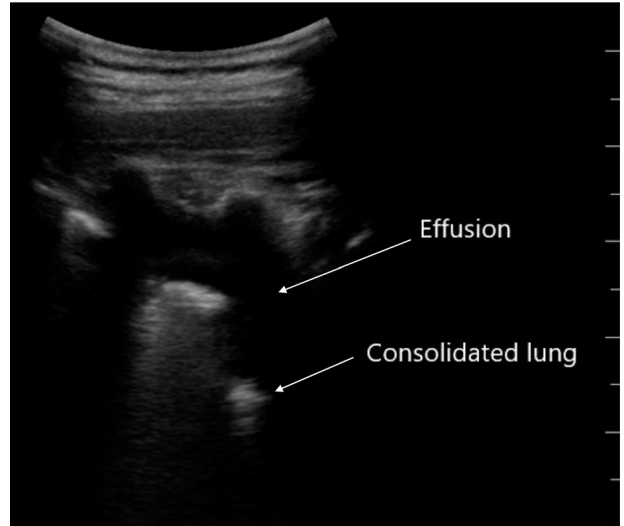


FIGURE 3. Longitudinal lung POCUS of a 19-year-old patient with SLE with shortness of breath and fever showing multiple B-lines, an effusion, and consolidated lung.

97%. His lung examination was notable for decreased aeration at the bases, worse on the left. A chest x-ray showed patchy bibasilar airspace opacities (Supplemental Fig. 3, <http://links.lww.com/PEC/A829>). Point-of-care ultrasound was performed afterward for educational purposes and was significant for bilateral scattered B-lines in the left posterior, axillary, and anterior fields and confluent B-lines in the right posterior lung fields (Fig. 4). A SARS-CoV-2 PCR test returned positive. He was discharged home with supportive care.

CASE 5

A 5-year-old boy with a history of asthma presented to an ED in Minnesota in September 2020 with cough and difficulty breathing worsening over the past 24 hours despite albuterol treatment in setting of rhinorrhea and sore throat. Vital signs demonstrated a temperature of 36.9°C, heart rate of 151 beats per minute, respiratory rate of 60 breaths per minute, blood pressure of 102/88 mm Hg, and an oxygen saturation of 86%. On physical examination, the patient was ill appearing and in respiratory distress with intercostal retractions. There were symmetric, diffuse wheezes and



FIGURE 4. Longitudinal lung POCUS image with a curvilinear transducer of a 17-year-old male patient with 8 days of productive cough, subjective fevers showing bilateral confluent B-lines and a thickened pleura.

diminished air entry bilaterally. A chest x-ray was obtained demonstrating increased peribronchial markings and patchy atelectatic/infiltrative change of the right middle lobe (Supplemental Fig. 4, <http://links.lww.com/PEC/A829>). Point-of-care ultrasound demonstrated bilateral scattered B-lines, primarily at the lung bases in the posterior fields (Fig. 5). A SARS-CoV-2 PCR test returned positive. The patient was admitted to the PICU where therapies included heated high-flow nasal cannula, methylprednisolone, albuterol intravenous magnesium, and remdesivir. The patient was discharged on hospital day 4.

CASE 6

An 18-year-old man with no significant medical history presented to an ED in Southern California in November 2020 with an 8-day history of fever, cough, congestion, diarrhea, and new onset of difficulty breathing. The patient tested positive for COVID-19 by rapid antigen testing 4 days before presentation. Vital signs demonstrated a temperature of 37.0°C, heart rate of 88 beats per minute, blood pressure of 150/81 mm Hg, respiratory rate of 24 breaths per minute, and an oxygen saturation of 95%. On physical examination, the patient appeared nontoxic but mildly tachypneic. The lungs were clear with symmetric air entry bilaterally. A chest x-ray was obtained demonstrating patchy areas of hazy opacity bilaterally (Supplemental Fig. 5, <http://links.lww.com/PEC/A829>). Lung POCUS demonstrated bilateral confluent B-lines (“light beam sign”), worse at the lung bases in the posterior lung fields (Fig. 6). The patient was able to do light activities in the ED maintaining oxygen saturations of 94% and higher. The patient was discharged home with strict return precautions.

CASE 7

A 13-year-old obese adolescent boy presented to an ED in Southern California in July 2021 with 7 days of fever and 3 days of cough, difficulty breathing, shortness of breath, abdominal pain, and diarrhea. Vital signs demonstrated a temperature of 39.4°C, heart rate of 117 beats per minute, respiratory rate of 40

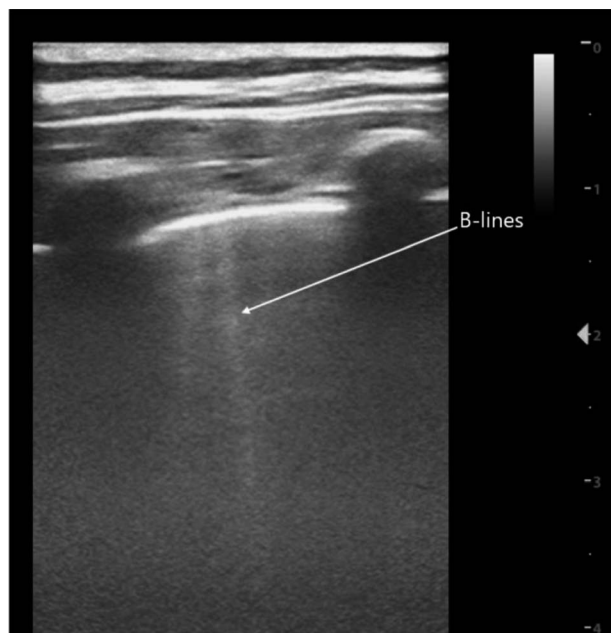


FIGURE 5. Lung POCUS image of a 5-year-old patient with a history of asthma with cough and difficulty breathing for 1 day showing scattered B-lines.

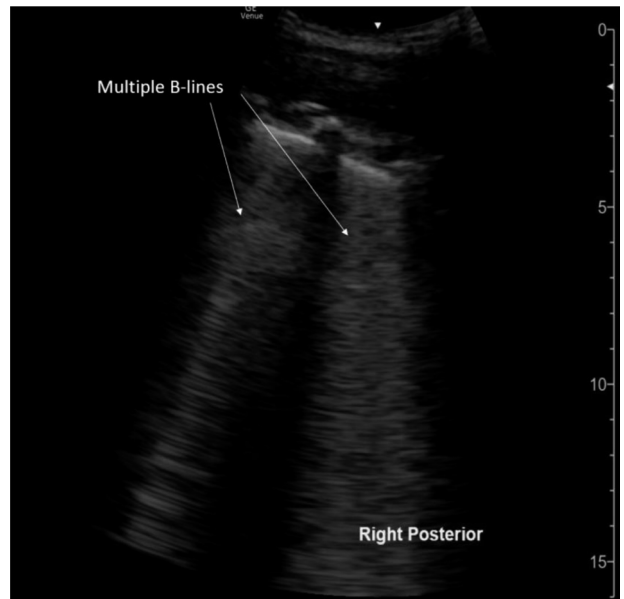


FIGURE 6. Longitudinal lung POCUS of an 18-year-old patient with 8 days of fever, respiratory distress, and viral symptoms showing coalescing B-lines.

breaths per minute, and oxygen saturation of 91% on room air. On examination, the patient was ill appearing and in moderate respiratory distress. The lungs were clear with decreased air entry bilaterally. Lung POCUS demonstrated confluent and scattered B-lines in all lung fields (Fig. 7). A chest x-ray obtained showed diffuse bilateral patchy opacities (Supplemental Fig. 6, <http://links.lww.com/PEC/A829>). A SARS-CoV-2 PCR test was positive. The patient required admission to the PICU after failing high-flow nasal cannula, with a maximum respiratory support of BiPAP. The patient received dexamethasone and remdesivir while inpatient in addition to enoxaparin for prophylactic anticoagulation. The patient was discharged on hospital day 7 on rivaroxaban with hematology and infectious disease follow-up.

TECHNIQUE

In each case, lung POCUS was performed using a linear high-frequency or curvilinear transducer. Cases 3, 4, 6, and 7

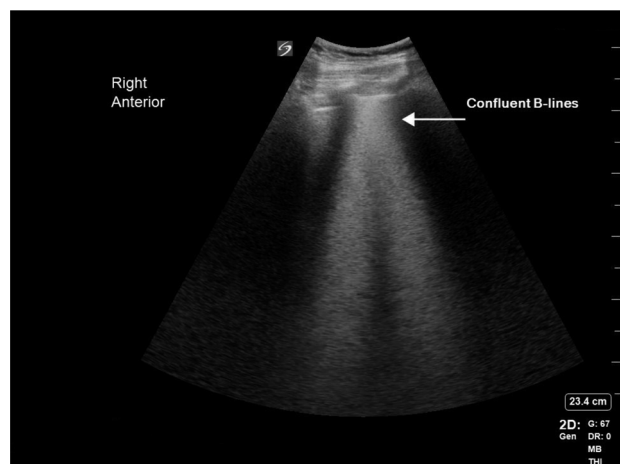


FIGURE 7. Longitudinal lung POCUS of a 13-year-old patient with 7 days of fever and 3 days of cough, difficulty breathing, and shortness of breath showing confluent B-lines.

required a curvilinear transducer because of body habitus. A high-frequency (13–6 MHz, 15–6 MHz or similar) linear transducer is useful for visualizing the anterior pleural line but has limited depth penetration, whereas a low-frequency (5–2 MHz, 8–3 MHz or similar) curvilinear transducer can be helpful for imaging the dependent lung regions, especially in larger patients.¹ The examinations were completed with the patient sitting upright or supine, using a POCUS system and performed according to each institution's scanning protocol.² For younger patients, it was helpful for the parents to hold the patient close to their chest while evaluating the posterior lung fields. Each hemithorax was visualized in the anterior, lateral, and posterior regions in the sagittal/coronal and/or transverse planes. Findings were standardized in patterns similar to those described by Caiulo et al.³ Cases 4, 6, and 7 were carried out by credentialed pediatric emergency medicine physicians, whereas all other cases were by performed by providers who have completed ultrasound fellowship training. In addition, all ultrasound images underwent quality assurance review by ultrasound fellowship-trained physicians either at the time of encounter or shortly after with no discrepancy in the point-of-care interpretation. Cases 1, 3, 5, 6, and 7 had an ultrasound before x-ray to facilitate clinical care and limit the presence of ancillary staff in patient rooms or the transfer of patients to the radiology department, which can be an important consideration given risks of infectivity.⁴

REVIEW OF THE LITERATURE

First described in China in December 2019, COVID-19 has resulted in a global pandemic causing significant morbidity, mortality, and healthcare system strain worldwide. Lung POCUS has emerged as an important tool in both diagnosis and follow-up, with international expert consensus recommending it as part of a clinician's toolbox in diagnosing and triaging patients with COVID-19 pneumonia.^{5–7} Lung POCUS has been shown to be a safe, accessible, low-cost, and effective tool for clinicians managing both children and adults with COVID-19.^{2,8} There have been studies showing better test characteristics for pneumonia compared with chest radiographs when there is a disagreement between the 2 modalities,^{9,10} with a recent observational study in Turkey suggesting that lung ultrasound is more sensitive in pediatric patients during the early stages of COVID-19 and in mild cases.¹¹ To our knowledge, there have been no published multicenter case series describing the heterogeneity of pediatric lung ultrasound findings. This series attempts to fill that gap by illustrating point-of-care sonographic findings in a diverse sample of symptomatic cases presenting to pediatric EDs across the United States.

Studies addressing CT findings in children with COVID-19 pneumonia have demonstrated that the periphery of the lung in the subpleural region is the most affected area, making ultrasound an ideal tool for lung evaluation given its ability to clearly display subpleural lesions.^{12,13} However, large pediatric studies focusing on COVID-19 and POCUS are lacking. Most discuss highly nonspecific B-lines and pleural abnormalities as the most common sonographic signs, with no pathognomonic finding.^{2,14,15} This mirrors recommendations seen in the adult literature, where expert consensus suggests similar findings in addition to consolidations to help diagnose COVID-19 pneumonia.³ In both populations, there remains significant and consistent intercase diversity, likely due to differences in settings, patient populations, number of lung zones examined, level of operator expertise, machine or transducer used, and severity of illness.^{16,17}

This multicenter case series continues to highlight the heterogeneity in clinical presentations and in lung POCUS findings associated with COVID-19 in children. Five of these 7 patients had abnormal B-lines, and 2 of the 7 had pleural line abnormalities. Similar to other case series in pediatric COVID-19, consolidations

were seen in a minority of patients, and effusions were rare.¹⁸ Cases 4 and 7 demonstrated confluent B-lines with 1 patient requiring ICU level care and the other able to be discharged home from the ED. Case 5 had only scattered B-lines and required admission to the ICU. This echoes an observational cohort study by Giorno et al¹⁹ who found 5 of 34 children had significant lung ultrasound findings with few or no respiratory symptoms, despite a probable association with disease severity. It is currently unknown why younger COVID-19 patients have such discordance between appearance on imaging and symptomatology.

CONCLUSIONS

To our knowledge, this is the first multicenter case series describing patients seen by pediatric emergency medicine providers from across the United States that highlights the diverse sonographic appearance of COVID-19 in pediatric patients. More studies are needed to gain a broader understanding of sonographic findings in younger COVID-19 patients to determine whether POCUS may be helpful in medical decision making or correlates with disease severity and prognosis.

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