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EDITORIAL

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Lung ultrasound for evaluation of pediatric COVID-19 infection: What we already know, what we need to investigate now, and what we can expect in the future

Understanding of the underlying pathogenesis and clinical findings of coronavirus disease 2019 (COVID-19) is rapidly evolving since its initial presentation as an outbreak of severe respiratory illness in Wuhan, Hubei province, China in December 2019.[1–4] Simultaneously, recognition of the characteristic imaging findings of acute COVID-19 infection in pediatric patients has been advancing substantially with various imaging modalities. To date, the majority of published investigations of the imaging findings of pediatric COVID-19 infection have focused on chest radiography (CXR) or computed tomography (CT) findings, because these are the most widely used and proven imaging modalities for evaluating lung disorders.[1,3,5,6] Thinking outside of the box, Musolino and colleagues[7] have explored the feasibility, safety, and utility of lung ultrasound for the evaluation of pediatric COVID-19 infection and reported their findings in this issue of the *Journal*.

Despite inherent limitations (mainly stemming from small patient population, substantial number of excluded patients, and lack of gold standard for confirming ultrasound findings in all included cases), the authors' study provides a step toward better understanding the role of ultrasound in diagnosing and monitoring pediatric COVID-19 infection. Although the results are somewhat expected and in keeping with already known findings described with other imaging modalities, the most important aspect of the authors' findings is the confirmation that ultrasound is technically feasible for detecting pleuropulmonary abnormalities associated with pediatric COVID-19 infection, such as peripherally located consolidations and pleural effusions, specifically by recognizing the ultrasound findings of B lines, consolidations, and effusions.[7] As the authors concluded, it is plausible that perhaps ultrasound can be used to monitor these "sonographically visible" pleuropulmonary abnormalities in children with COVID-19 infection instead of CXR or CT, which are associated with potentially harmful ionizing radiation exposure in the vulnerable pediatric population. In addition, it is reassuring to know that none of pediatricians who performed the ultrasounds in this study contracted COVID-19 infection, confirming the safety of performing ultrasound for the operator in this clinical setting.[7]

At the present time, perhaps the next logical step is to focus on what we need to investigate now. The authors' study provides much food for thought for future research. First, it would be important to investigate the utility and diagnostic accuracy of ultrasound: that is, whether ultrasound can actually provide a complete assessment of lung abnormalities associated with COVID-19 infection in children by direct correlation with the current gold standard, such as CT. For example, the two most frequently observed lung abnormalities in pediatric COVID-19 infection are ground-glass opacity and consolidation. Although consolidation can be detected with ultrasound, often it is only visible if the consolidation is located in the peripheral portion of the lungs. Furthermore, ground-glass opacity would be challenging to visualize with ultrasound. Second, the authors reported that pleural irregularities and simple pleural effusions were the two most commonly found abnormalities in their study population. However, these two pleural abnormalities have not been frequently detected on previously published studies of pediatric COVID-19 infection focusing on CXR and CT findings.[1,3–6] Interestingly, although the "pleural irregularity" that the authors described in their study is not well-visualized on the provided figure, perhaps, this finding may be better detected with real-time ultrasound; future studies, with less patient selection bias and larger patient population, confirming this finding will be important. Finally, direct correlation between the clinical status of affected pediatric patient and changes in ultrasound findings in different disease severity and various time points of infection (acute phase, subacute phase, resolution, and long-term follow-up period) will be beneficial to demonstrate the clinical utility of ultrasound as a monitoring tool in pediatric patients with COVID-19 infection.

Now that Musolino et al. have opened Pandora's box for investigating pleuropulmonary abnormalities associated with pediatric COVID-19 infection with ultrasound, what can we expect in the future? Although the future is unknown, it is difficult to imagine that ultrasound will be used as an initial imaging modality for evaluating pediatric patients with COVID-19 infection, particularly patients with mild or no symptoms. It may be more realistic to predict that ultrasound, as a noninvasive and radiation-free imaging modality, may play a potentially useful role in monitoring and detecting complications of peripherally located consolidation from COVID-19 infection that have been previously identified on CXR or CT. With the recent advent of contrast-enhanced ultrasound, a promising new ultrasound technique, perhaps the lung and the sonographic findings of pediatric COVID-19 infection can be better visualized; this may be an exciting area for future investigation. Finally, with the increasing recognition of pediatric patients with multisystem inflammatory syndrome in children (MIS-C), a presumed postinfectious sequela of pediatric COVID-19 infection, ultrasound (echocardiogram) may be crucial for diagnosis and follow-up imaging assessment of children

with MIS-C who often present with heart failure (left ventricular systolic dysfunction), coronary artery dilatation, pulmonary edema, and pleural effusion.[8–10]

Stepping outside the box of conventional approach to imaging, diagnosis, and management brings both challenges and opportunities. Despite some challenges and limitations in their study, the authors have provided us with an important stepping stone of information that may yield new opportunities to improve our understanding, diagnosis, and management of COVID-19 infection in pediatric patients in the future.

AUTHOR CONTRIBUTIONS

Edward Y. Lee: Conceptualization (equal); project administration (equal); writing original draft (equal); writing review and editing (equal). Abbey J. Winant: Conceptualization (equal); project administration (equal); writing original draft (equal); writing review and editing (equal).

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REFERENCES

1. Foust AM, Phillips GS, Chu WC, et al. International expert consensus statement on chest imaging in pediatric COVID-19 patient management: imaging findings, imaging study reporting and imaging study recommendations. *Radiol Cardiothorac Imaging*. 2020;2(2):e200214.
2. Foust AM, Johnston PR, Kasznia-Brown J, et al. Perceived impact of COVID-19 on pediatric radiology departments around the world: WFPI COVID-19 task force survey results from 6 continents. *Radiol Cardiothorac Imaging*. 2020;2(5):e200422.
3. Foust AM, McAdam AJ, Chu WC, et al. Practical guide for pediatric pulmonologists on imaging management of pediatric patients with COVID-19. *Pediatr Pulmonol*. 2020;55(9):2213-2224.
4. Foust AM, Winant AJ, Chu WC, Das KM, Phillips GS, Lee EY. Pediatric SARS, H1N1, MERS, EVALI, and now coronavirus disease (COVID-19) pneumonia: what radiologists need to know. *AJR Am J Roentgenol*. 2020;215(3):736-744.
5. Pakray A, Walker D, Figacz A, et al. Imaging evaluation of COVID-19 in the emergency department. *Emerg Radiol*. 2020;27(6):579-588.
6. Steinberger S, Lin B, Bernheim A, et al. CT features of coronavirus disease (COVID-19) in 30 pediatric patients. *AJR Am J Roentgenol*. 2020;215(6):1303-1311.
7. Musolino A, Supino M, Buonsenso D, et al. Lung ultrasound in the diagnosis and monitoring of 30 children with coronavirus disease 2019. *Pediatr Pulmonol*. In press.
8. Foust AM, Winant AJ, Restrepo R, Liszewski MC, Plut D, Lee EY. Private tour guide to pediatric coronavirus disease of 2019 and multisystem inflammatory syndrome in children in 10 minutes: what thoracic radiologists need to know. *J Thorac Imaging*. 2021;36(1):24-30.
9. Blumfield E, Levin TL, Kurian J, Lee EY, Leszewski MC. Imaging findings in multisystem inflammatory syndrome in children (MIS-C) associated with coronavirus disease (COVID-19). *AJR Am J Roentgenol* . 2020;16:1-11.
10. Winant AJ, Blumfield E, Liszewski MC, Kurian J, Foust AM, Lee EY. Thoracic imaging findings of multisystem inflammatory syndrome in children (MIS-C) associated with COVID-19: what radiologists need to knowRadiol. *Cardiothorac Imaging*. 2020;2(4).