*Cite as: Riccabona M, Laffan E: Chest and lung ultrasound in childhood: applications, role, value and limitations. J Ultrason 2018; 18: 281–283.*

# Chest and lung ultrasound in childhood: applications, role, value and limitations

Michael Riccabona[1], Eoghan Laffan[2]

*[1] Department of Radiology, Division of Pediatric Radiology, Medical University of Graz, Graz, Austria*
*[2] Department of Radiology, Children's University Hospital Dublin, Dublin, Ireland*

*Correspondence: Prof. Michael Riccabona, Department of Radiology, Division of Pediatric Radiology, University Hospital LKH Graz, Auenbruggerplatz 34, A-8036, Graz, Austria; e-mail: michael.riccabona@klinikum-graz.at*

DOI: 10.15557/JoU.2018.0040

Chest and, in particular, lung ultrasound (LUS) has been an established tool in children for decades. Sonographic assessment of the heart (echocardiography) was actually one of the first applications of ultrasound (US). Other chest US uses that have been recognized for a long time and became part of many standard US textbooks include an assessment of the thymus and mediastinum, pleural effusions, consolidations, diaphragmatic movements and sometimes tumours in adults and children[(1–9)].With time, other applications have been gradually introduced, such as chest wall assessment, including the ribs (especially the cartilaginous portion e.g. for rib anomalies), sternum (e.g. fractures), the musculoskeletal system (e.g. agenesis of the pectoralis muscle) and US of thoracic soft tissue masses, such as lymph nodes, vascular malformations or the breasts[(5,9,10)]. Chest US can be also used to assess the thoracic vessels for catheter-related thrombosis or embolism. There are multiple accessible sonographic windows for all these applications. In neonates, the non-ossified parts of the thoracic cage allow for further sonographic windows.

Over the last decade, pulmonary assessment has become the passionate focus of new sonographic applications, initially through the adult sub-specialties of intensive care and emergency medicine. Various LUS artifacts, previously dismissed for the most part by radiologists, have become valuable in the ability to draw conclusions about underlying lung conditions. Numerous phenomena have been described and various new terms and signs have been defined, such as A and B lines, seashore sign, sliding sign, bat sign, comet-tail artifact and lung point etc.[(4,7,11–13)]

The drive by our clinical colleagues was likely through increased availability of portable US machines and the ability to rapidly scan at the bedside, so-called point of care ultrasound (POCUS). Conventional imaging techniques were not always accessible or readily available, and LUS became an alternative option where the confidence in the diagnostic accuracy of the standard chest radiograph for certain conditions, such as childhood pneumonia, is lower than desired[(14,15)]. Numerous recent studies show the applicability and findings of LUS in neonatal respiratory distress syndrome, transitory tachypnoea of the newborn (TTN, former called "wet lung") and other lung diseases[(16–25)]. Furthermore, LUS has been shown useful for finding small consolidations in the lung periphery, depicting small effusions, and even diagnosing pneumothorax[(2,3,5,9,26,27)].

However, with all these advances there is one intrinsic problem. Most of these recent studies looked at a pre-selected patient group, trying to answer a specific clinical question, with intrinsic bias through patient selection. Only very limited systemic, unbiased blinded and randomized studies are available compared to the gold standard, i.e. CT of the lung. A recent meta-analysis of LUS in neonatal RDS also confirms this bias, demonstrating that whatever US may show with a very high sensitivity if performed properly covering the entire chest, the specificity remains low when taking all possible lung conditions into account[(28–30)]. Selection bias and study design (non-random or non-sequential participants) may lead to an over-estimation of diagnostic accuracy. In general, tachypnoea in a premature or a full-term newborn remains a diagnostic challenge for our clinical colleagues, at times maintaining a differential diagnosis rather than being specific, thus it is understandable that new imaging options allowing for a rapid bedside differentiation are pushed – sometimes overestimating their reliability, but still helpful in the individual situation with respect to the clinical symptoms & information.

Examples and causes for potential misreading are as follows:

- In small children with immature lung architecture, atelectasis occurs very quickly, as frequently seen on CT and MRI scans under anaesthesia. LUS can detect these peripheral lung lesions better than chest radiograph, but not all peripheral lesions equal pneumonia.
- US also cannot cover regions deeper to the aerated lung surface. Thus, it is unlikely that LUS will detect central or perihilar processes, or rounded pneumonia. In older children, the scapulae might prevent complete visualization of all areas, despite attempted upper limb maneuvers. Deeper vessels and the position of the tracheal tube cannot be consistently or sufficiently assessed by US.
- There is also a likely widespread general publication bias with regard to both LUS, as well as POCUS in general. Based on anecdotal experience, our clinician colleagues probably do not publish all their US diagnostic interpretation errors, such as epididymitis versus testicular torsion, or pneumothorax versus emphysema / air trapping, or cavitation versus empyema.

All these aspects have to be considered when performing and interpreting a chest US or LUS. It is difficult to state definitively that LUS can replace all chest radiographs or CTs. LUS can potentially reduce the number of chest radiographs, both as a follow-up or as a first-line investigation supporting the initial clinical suspicion, helping to evaluate management before and during treatment, or supplementing other imaging techniques. POCUS has arguably even greater potential in remote areas or developing countries. Nevertheless, before its potential can be completely judged, superior clinical research needs to be performed, with better-designed, unbiased, randomized studies, greater statistical power, clearly outlined definitions of conditions and clinical questions to be answered, and looking at efficacy and treatment/ prognosis implications. It might be that a redefinition of some conditions may be needed in the future, e.g. "consolidation" and "atelectasis", due to the latest LUS findings. The natural history of respiratory tract infections may also need to be reconsidered, in that some small pneumonic consolidation may be far more common than known previously; it could represent almost a normal or incidental manifestation of a lower respiratory tract infection, and thus does not need to be considered as serious as it traditionally has been. It could be also argued whether we do need to look for it as often as we do.

In summary, LUS has its important role, but should be applied with caution considering the restrictions and limitations. LUS must be performed skillfully and adequately, then helping to minimize radiation burden by diagnosing many conditions and reducing the need for plain films – though sometimes differential diagnosis will be difficult and bias from clinical expectation may occur.

## References


1. Gassner I, Geley TE: Ultrasound of the neonatal thorax. In: Donoghue V (ed.): Radiological imaging of the neonatal chest. Medical Radiology (Diagnostic Imaging). Springer, Berlin Heidelberg 2008: 197–225.
2. Mathis G (ed): Chest sonography. 3rd edition, Springer-Verlag, Heidelberg 2011.
3. Liu J, Liu F, Liu Y: Lung ultrasound for the diagnosis of severe neonatal pneumonia. Chest 2014; 146: 383–388.
4. Riccabona M, Sorantin E, Fotter R: Application of functional m-mode sonography in pediatric patients. Eur Radiol 1998; 8: 1457–1461.
5. Riccabona M: Ultrasound of the chest in children. Eur Radiol 2008; 18: 390–399.
6. Riccabona M: Ultrasound of the chest. In: Riccabona M (ed.): Pediatric ultrasound. Requisites and applications. Springer, Berlin-Heidelberg 2014: 189–212.
7. Riccabona M: Sonographie des Früh- und Neugeborenen-, bzw. Säuglingsthorax. In: Riccabona M, Beer M, Mentzel HJ (eds): Bildgebung des Thorax bei Neugeborenen und Kleinkindern. Springer, Heidelberg 2018: 31–42.
8. Schweigmann G, Gassner I: Mediastinum. In: Riccabona M (ed.): Pediatric Imaging Essentials. Thieme, Stuttgart-New York 2013: 56–65.
9. Trinavarat P, Riccabona M: Potential of ultrasound in the pediatric chest. Eur J Radiol 2014; 83: 1507–1518.
10. Glass RB, Norton KI, Mitre SA, Kang E: Pediatric ribs: a spectrum of abnormalities. Radiographics 2002; 22: 87–104.
11. Copetti R, Cattarossi L: The 'Double lung point': an ultrasound sign diagnosis of transient tachypnoea of the newborn. Neonatology 2007; 91: 203–209.
12. Lichtenstein D, Mezière G, Biderman P, Gepner A: The comet-tail artifact: an ultrasound sign ruling out pneumothorax. Intensive Care Med 1999; 25: 383–388.
13. Martelius L, Heldt HL, Lauerma K: B-Lines on Pediatric Lung Sonography. J Ultrasound Med 2016; 35: 153–157.
14. Levinsky Y, Mimouni FB, Fisher D, Ehrlichman M. Chest radiography of acute paediatric lower respiratory infections: experience versus interobserver variation. Acta Pædiatrica 2013: e310–e314.
15. Hagaman JD, Rouan GW, Shipley TR, Panos RJ: Admission chest radiograph lacks sensitivity in the diagnosis of community-acquired pneumonia. Am J Med Sci 2009; 337: 236–240.
16. Soldati G, Copetti R, Sher S: Sonographic interstitial syndrome: the sound of lung water. J Ultrasound Med 2009; 28: 163–174.
17. Ahuja CK, Saxena AK, Sodhi KS, Kumar P, Khandelwal N: Role of transabdominal ultrasound of lung bases and follow-up in premature neonates with respiratory distress soon after birth. Indian J Radiol Imaging 2012; 22: 279–283.
18. Avni EF, Cassart M, de Maertelaer V, Rypens F, Vermeylen D, Gevenois PA: Sonographic prediction of chronic lung disease in the premature undergoing mechanical ventilation. Pediatr Radiol 1996; 26: 463–469.
19. Avni EF, Braude P, Pardou A, Matos C: Hyaline membrane disease in the newborn: diagnosis by ultrasound. Pediatr Radiol 1990; 20: 143–146.
20. Copetti R, Cattarossi L, Macagno F, Violino M, Furlan R: Lung ultrasound in respiratory distress syndrome: a useful tool for early diagnosis. Neonatology 2008; 94: 52–59.
21. Liu J: Lung ultrasonography for the diagnosis of neonatal lung disease. J Matern Fetal Neonatal Med 2014; 27(8): 856–861.
22. Lovrenski J: Lung ultrasonography of pulmonary complications in preterm infants with respiratory distress syndrome. Ups J Med Sci 2012; 117: 10–17.
23. El-Malah HE-DGM, Hany S, Mahmoud MK, Ali AM: Lung ultrasonography in evaluation of neonatal respiratory distress syndrome. Egyptian Society of Radiology and Nuclear Medicine 2015; 46: 469–474.
24. Liu J, Wang HY, Fu W, Yang CS, Huang JJ: Diagnosis of neonatal transient tachypnoea and its differentiation from respiratory distress syndrome using lung ultrasound. Medicine (Baltimore) 2014; 93: e197.
25. Vergine M, Copetti R, Brusa G, Cattarossi L: Lung ultrasound accuracy in respiratory distress syndrome and transient tachypnea of the newborn. Neonatology 2014; 106: 87–93.

26. Ding W, Shen Y, Yang J, He X, Zhang M: Diagnosis of pneumothorax by radiography and ultrasonography: A meta-analysis. Chest 2011; 140; 859–866.
27. Lichtenstein DA, Mezière G, Lascols N, Biderman P, Courret JP, Gepner A *et al.*: Ultrasound diagnosis of occult pneumothorax. Crit Care Med 2005; 33: 1231–1238.
28. Hew M, Corcoran JP, Harriss EK, Rahman NM, Mallett S: The diagnostic accuracy of chest ultrasound for CT-detected radiographic consolidation in hospitalised adults with acute respiratory failure: a systematic review. BMJ Open 2015; 5: e007838.
29. Hiles M, Culpan AM, Watts C, Munyombwe T, Wolstenhulme S: Neonatal respiratory distress syndrome: Chest X-ray or lung US? A systematic review. Ultrasound 2017; 25: 80–91.
30. Pereda MA, Chavez MA, Hooper-Miele HC, Gilman RH, Steinhoff MC, Ellington LE *et al.*: Lung ultrasound for the diagnosis of pneumonia in children: A meta-analysis. Pediatrics 2015; 135: 714–722.