Multicentre study supports the use of lung ultrasound in diagnosing paediatric community-acquired pneumonia

Community-acquired pneumonia (CAP) is a leading global cause of paediatric morbidity and mortality. International guidelines recommend that a chest X-ray (CXR), if needed, is the first choice for diagnosing CAP in children and that lung ultrasounds (LUS) should be limited to pleural effusions.[1,2] However, some clinicians are now suggesting that LUS is an important complementary imaging tool for CXR when evaluating diagnoses of paediatric pneumonia.[3,4]

This international, multicentre, prospective, observational research assessed the accuracy of LUS in diagnosing paediatric CAP in nine European paediatric centres from 1 June 2013 to 31 May 2015. It was approved by the centres' Ethics Committees and signed parental consent was provided. The subjects were aged 1–16 and had been visited in the centres for clinically suspected CAP. We excluded patients who had received prior antibiotic therapy and those with hospital-acquired pneumonia, severe immunosuppression, haemodynamic instability or a previous diagnosis of pneumonia that was confirmed by diagnostic imaging and other radiographic findings. The study sonographers were paediatricians with different levels of ultrasonography experience who underwent a pre-study chest sonography training session that comprised a 4-h lecture on LUS and a practical hands-on imaging session on standard models. Patient histories were taken at baseline, followed by a clinical examination, laboratory testing and LUS and CXR. The CXR was the reference standard for pneumonia. The sonologists were blinded to the posteroanterior CXR results when performing auscultation and LUS and the attending, certified, experienced radiologists were blinded to the auscultation and LUS results. Lung consolidation, multiple isolated/confluent B-lines and pleural effusion on the LUS were the sonographic signs for CAP. The consolidation size or the extent of the pleural effusions was not requested. The CXR lateral views were only obtained if suggested by clinical and radiological findings. Positive CAP cases had a positive LUS, CXR or a final clinical diagnosis and were treated with antibiotics. Negative cases had no clinical or instrumental pathological signs. Comparisons were carried out with the Mann–Witney, Wilcoxon test and chi-square tests, as needed, and analysed with SPSS software, version 21.0 (IBM Corp). A p-value of <0.05 or a not overlapping 95% confidence interval (95% CI) was considered statistically significant.

The diagnosis was confirmed in 601/641 of the initial patients with suspected CAP. LUS was correctly diagnosed in 575 patients with a sensitivity of 97.0% (95% CI 95.3–98.3), specificity of 65.4% (95% CI 44.3–82.8), likelihood ratio (LR) of 0.05 (95% CI 0.03–0.08) for negative results and an overall accuracy of 95.7% (95% CI 93.7–97.2). Just CXR identified 533 diagnoses, with a sensitivity of 88.7% (95% CI 85.8–91.2), specificity of 88.5% (95% CI 69.9–97.6), LR of 0.13 (95% CI 0.1–0.2) for negative results and an overall accuracy of 88.7 (95% CI 85.9–91.1). The total number of tests was 635 if the LUS was followed by the CXR and 689 tests if the order was reversed. In particular, CXR was performed on 34 patients with a negative LUS result and 32 had been correctly diagnosed with CAP. There were 590 correct diagnoses and the accuracy exceeded 98%. All the other possible combinations were equally effective, but required 8% more tests.

LUS resulted in a 10% increase in sensitivity, a three-time smaller negative LR, a higher negative positive value and a higher accuracy than CXR when diagnosing paediatric CAP. The final simulation showed that LUS followed by CXR produced the highest diagnostic yield.

CAP studies have reported great variations in the diagnostic accuracy of these tests. A meta-analysis published in 2018[5] showed that the pooled sensitivity of LUS was significantly higher than CXR, but the pooled specificities were similar. The only multicentre study on point-of-care LUS, involving multiple expert and novice operators,[3] showed an overall sensitivity of 86% and specificity of 89% for diagnosing CAP. Specificity was numerically lower in our study than other studies, but the CIs overlapped with other studies. However, we need to consider differences in inclusion criteria or possible selection bias, as more severe cases were observed in other studies.

We found that 64/575 CAP cases were LUS positive, but CXR negative, possibly because of the absence of lateral CXR views, the failure to detect small lesions and the particular localisation of some lesions. Some sonologist interpretation errors may also have occurred. The 16 cases with negative LUS, but positive CXR, may be explained by lesions not touching the pleura, areas that were difficult to reach using the ultrasound beam or the sonologists' inexperience.[3]

Our final simulation model confirms the need for wise choices when combining LUS and CXR to diagnose paediatric CAP. If LUS were the first followed by CXR, the total number of tests would be 635, while the opposite sequence would increase the total to 689 tests. Using LUS first, then CXR in negative but suspected cases

Abbreviations: CAP, community-acquired pneumonia; CI, confidence interval; CXR, chest X-ray; LR, likelihood ratio; LUS, lung ultrasound.

would save resources, time and radiological exposure, as confirmed by a previous randomised controlled study.[4]

The study strengths were the prospective, international, multicentre design, the largest paediatric population to date, varying disease severity and the involvement of clinical operators. The main limitation was not using a computed tomography scan as the objective radiological reference standard. We did not distinguish between outpatients and inpatients, non-radiologist sonologists were not blinded to clinical information and there was no formally recorded follow-up process. Finally, we also considered early-stage disease LUS signs, which potentially led to a false low specificity, along with LUS signs that were not specific for CAP.

Our data demonstrate the non-inferiority of point-of-care LUS, handled by clinician-sonologists with variable ultrasonography experience, in identifying paediatric pneumonia in comparison to CXR. The findings support using LUS first and only performing CXR when clinically indicated.

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CONFLICT OF INTEREST

None.

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