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COMMENTARY

Artificial intelligence as an emerging diagnostic approach in paediatric pulmonology

Key words: artificial intelligence, children, pulmonology.

Artificial intelligence (AI) is the subset of computer science that covers anything related to making machines smart. Along with machine learning (ML), AI encompasses a wide range of approaches and technologies, including knowledge discovery and data mining methodologies, predictive analytics, advanced statistics for pattern recognition and neurocomputing.

AI technologies and their expanding applications in diagnostics call for constant updates of knowledge and skills. In this commentary, we outline recent breakthroughs in paediatric pulmonology (Fig. 1).

Adventitious sounds, that is, abnormalities superimposed on normal breathing sounds, can be highly variable among patients. This variability may be challenging for identifying lung sounds. Currently, the most frequently used AI techniques are the artificial neural networks (ANN) and the k-nearest (k-nn) neighbor algorithm, which achieve good classification accuracy in recognizing respiratory sounds. However, there are some disadvantages, particularly for ANN which requires computation of an extensive data set to recognize lung sounds efficiently.

A neural network algorithm coupled with an electronic stethoscope recently demonstrated its higher performance in recognizing pathological respiratory sounds from paediatric patients compared to the description obtained by clinicians. In particular, the most significant difference was observed for coarse crackles and rhonchi that seemed to be more often misinterpreted in routine medical practice.[1] Another popular ML model, the support vector machine (SVM), has been previously used in paediatric settings for developing automated cough sound analysis methods to diagnose croup.[2]

This algorithm was also recently applied to develop a wheezing recognition tool from recorded respiratory sounds with a smartphone placed near the mouth, which showed good sensitivity and specificity as well as fair agreement with the clinician's auscultation.[3] Of note, an upgraded pattern recognition system with a two-layer architecture designed for emphasizing differences among signals with similar acoustics was more effective than an ordinary SVM classifier in improving wheezing detection in recorded children's respiratory sounds.[4]

AI algorithms have been implemented and integrated for automated reading of pulmonary function tests (PFT) by reproducing the cognitive abilities of a physician. In a recent study of the Belgian Function Study group, the performance of an unbiased decision tree based on data mining programmes was explored in a population of 968 adults admitted for the first time to a pulmonary practice.[5] Compared to the American Thoracic Society/European Respiratory Society (ATS/ERS) algorithm for the automated data-driven interpretation of PFT (spirometry, plethysmography measurements of airway resistance and lung volumes, and diffusing capacity for carbon monoxide), this novel ML framework demonstrated a higher accuracy in detecting the most common lung diseases (38% vs 68%, respectively) with a significantly higher positive predictive value and sensitivity for chronic obstructive pulmonary disease (COPD), asthma, interstitial lung disease and neuromuscular disorder.

Furthermore, interpretation and diagnostics of PFT have been explored in comparison with experts' performance in a multicentre non-interventional study. Fifty historical patient cases with PFT and clinical information were evaluated from 120 pulmonologists from 16 European hospitals, as well as from a novel AI-based software.[5] This AI-based software interpreted PFT and reached a diagnosis with higher accuracy than individual pulmonologists. For pulmonologists, who precisely interpreted patterns in $74.4 \pm 5.9\%$ and made correct diagnoses in $44.6 \pm 8.7\%$ of the cases, the AI-based software perfectly matched the PFT pattern interpretations (100%) and assigned a correct diagnosis in 82% of cases.[5] These results are promising but require further validation in children, where evidence is still not available.

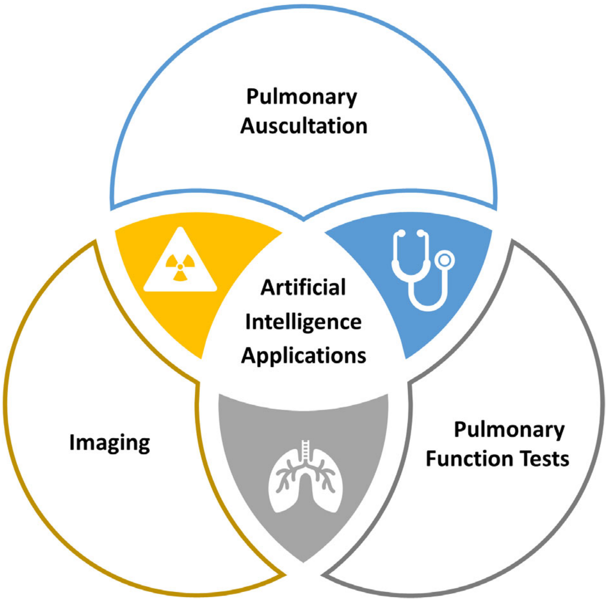

Figure 1 Expanding areas of artificial intelligence (AI) technologies application in paediatric pulmonology.

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AI-based approaches have been increasingly applied to diagnose obstructive lung diseases, showing promising results in the characterization of lung parenchyma as well as the measurement of airway lumen size and wall thickness. Deep learning-based models, a subset of ML in which the computer itself is entrusted with learning the features and classifying the problem (thereby overcoming the human element), have been used to classify textural patterns in computed tomography images and proved to enhance accuracy in the X-ray diagnosis of chest diseases in adults. Their application in medical imaging of the chest improves airway segmentation, which can be useful for the planning of procedures such as bronchoscopy, as well as for detecting airway abnormalities.

While AI for diagnosing respiratory diseases is quickly developing in adults, up to now, its application in children has been limited to the detection of consolidation on chest X-ray images,[6] therefore aiding the diagnosis of pneumonia.[7] However, the opportunities to apply AI technologies in the field of childhood respiratory diseases are quite broad. Apart from supporting the clinician in the detection of radiological findings that are likely to be missed, AI might be useful to screen which tests have to be rapidly evaluated to ensure that children with potentially dangerous imaging findings are seen first, allowing for workflow optimization. Another potential opportunity might be supporting radiologists in paediatric-specific diagnostic challenges when children come to emergency departments in primarily adult-focused settings.

AI in paediatric pulmonology offers promising opportunities to improve diagnostic accuracy, reduce costs and deliver personalized health care. However, several aspects need to be addressed to provide paediatricians with evidence-based recommendations. More research is required to explore the potential of newer generation algorithms and deep learning in large-scale studies. Another overriding priority is developing educational programmes to support healthcare AI. Paediatricians should be trained on how to use AI products and services properly. Moreover, appropriate regulatory processes will be required to develop security measures for sensitive data storage and management to maintain confidentiality. Healthcare systems must adapt to the increasingly digital era of care with adequate budgets and trained staff as well as a robust information technology governance strategy. In this context, further research is required to develop strategies promoting AI integration in daily practice as well as into existing healthcare systems.

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REFERENCES

1 Grzywalski T, Piecuch M, Szajek M, Bręborowicz A, Hafke-Dys H, Kociński J, Pastusiak A, Belluzzo R. Practical implementation of artificial intelligence algorithms in pulmonary auscultation examination. *Eur. J. Pediatr.* 2019; **178**: 883–90.

2 Sharan RV, Abeyratne UR, Swarnkar VR, Porter P. Automatic croup diagnosis using cough sound recognition (Published correction appears in *IEEE Trans. Biomed. Eng.* 2019; **66:** 1491.). *I.E.E.E. Trans. Biomed. Eng.* 2019; **66**: 485–95.

3 Bokov P, Mahut B, Flaud P, Delclaux C. Wheezing recognition algorithm using recordings of respiratory sounds at the mouth in a pediatric population. *Comput. Biol. Med.* 2016; **70**: 40–50.

4 Mazić I, Bonković M, Dzˇaja B. Two-level coarse-to-fine classification algorithm for asthma wheezing recognition in children's respiratory sounds. *Biomed. Signal Process. Control.* 2015; **21**: 105–18.

5 Topalovic M, Das N, Burgel PR, Daenen M, Derom E, Haenebalcke C, Janssen R, Kerstjens HAM, Liistro G, Louis R *et al.*; Pulmonary Function Study Investigators. Artificial intelligence outperforms pulmonologists in the interpretation of pulmonary function tests. *Eur. Respir. J.* 2019; **53:** pii: 1801660.

6 Behzadi-Khormouji H, Rostami H, Salehi S, Derakhshande-Rishehri T, Masoumi M, Salemi S, Keshavarz A, Gholamrezanezhad A, Assadi M, Batouli A. Deep learning, reusable and problem-based architectures for detection of consolidation on chest X-ray images. *Comput. Methods Programs Biomed.* 2020; **185**: 105162.

7 Mahomed N, van Ginneken B, Philipsen RHHM, Melendez J, Moore DP, Moodley H, Sewchuran T, Mathew D, Madhi SA. Computer-aided diagnosis for World Health Organization-defined chest radiograph primary-endpoint pneumonia in children. *Pediatr. Radiol.* 2020; **50**: 482–91.