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Deep-learning algorithm helps to standardise ATS/ERS spirometric acceptability and usability criteria

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Deep-learning models were developed to standardise ATS/ERS spirometric acceptability and usability criteria. This approach reduces the intertechnician variability and provides instant feedback to the user https://bit.ly/3dNFe1i

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ABSTRACT

Rationale: While American Thoracic Society (ATS)/European Respiratory Society (ERS) quality control criteria for spirometry include several quantitative limits, it also requires manual visual inspection. The current approach is time consuming and leads to high intertechnician variability. We propose a deep-learning approach called convolutional neural network (CNN), to standardise spirometric manoeuvre acceptability and usability.

Methods and methods: In 36 873 curves from the National Health and Nutritional Examination Survey USA 2011–2012, technicians labelled 54% of curves as meeting ATS/ERS 2005 acceptability criteria with satisfactory start and end of test, but identified 93% of curves with a usable forced expiratory volume in 1 s. We processed raw data into images of maximal expiratory flow–volume curve (MEFVC), calculated ATS/ERS quantifiable criteria and developed CNNs to determine manoeuvre acceptability and usability on 90% of the curves. The models were tested on the remaining 10% of curves. We calculated Shapley values to interpret the models.

Results: In the test set (n=3738), CNN showed an accuracy of 87% for acceptability and 92% for usability, with the latter demonstrating a high sensitivity (92%) and specificity (96%). They were significantly superior ($p<0.0001$) to ATS/ERS quantifiable rule-based models. Shapley interpretation revealed MEFVC<1 s (MEFVC pattern within first second of exhalation) and plateau in volume–time were most important in determining acceptability, while MEFVC<1 s entirely determined usability.

Conclusion: The CNNs identified relevant attributes in spirometric curves to standardise ATS/ERS manoeuvre acceptability and usability recommendations, and further provides individual manoeuvre feedback. Our algorithm combines the visual experience of skilled technicians and ATS/ERS quantitative rules in automating the critical phase of spirometry quality control.