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Ang, C.Y.S.[a] , Chiew, Y.S.[a] , Wang, X.[a] , Ooi, E.H.[a] , Nor, M.B.M.[b] , Cove, M.E.[c] , Chase, J.G.[d]

Exploring variable observational time windows for patient–ventilator asynchrony during mechanical ventilation treatment

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[a] School of Engineering, Monash University Malaysia, Selangor, Malaysia
[b] Kulliyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia
[c] Division of Respiratory & Critical Care Medicine, Department of Medicine, National University Hospital, Singapore
[d] Center of Bioengineering, University of Canterbury, Christchurch, New Zealand

Abstract
Background and Objective: Patient–ventilator asynchrony (PVA) is prevalent in mechanical ventilation (MV) for critically ill patients and has been associated with adverse patient outcomes. However, studies investigating the associations between PVA and patient outcomes employ differing time windows for PVA evaluation. In this study, machine learning methods are used to quantify the prevalence and magnitude of asynchrony at different time windows, as well as its temporal trends. The study aims to identify the optimal time window for assessing the temporal changes in the asynchrony index (AI) and magnitude of asynchrony (Masyn,avg). Methods: This study uses Convolutional Neural Networks (CNN) and Convolutional Autoencoders (CAE) to detect incidences of PVA and quantify its severity in 30 MV respiratory failure patients with 2722 h of respiratory data. The frequency of PVA and the breath-average magnitude were determined over different time periods, t, where t=0.5, 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 45, 60 min and throughout MV. The AI for the patients was determined using the CNN model. Given an asynchronous breath, the CAEs were used to reconstruct asynchrony-free waveforms. The Masyn,avg was quantified as the difference between the two waveforms. The change in AI (ΔAI) and the change in Masyn,avg (ΔMasyn,avg) for all time windows, t were also calculated for each patient. Results: The median [interquartile range] overall AI and Masyn,avg for the patient cohort are 24.8 [12.9–46.1]% and 37.2 [33.4–45.3]% respectively. Analysis of the patient cohort also shows significant intra-patient variability in AI and Masyn,avg, while the inter-patient variation in AI is greater as compared to Masyn,avg. The cohort mean ΔAI and ΔMasyn,avg exhibit a converging trend with a minima at t=5 min and with values of 5.32 ± 2.37% and 2.80 ± 1.03%, respectively. A time window of t=5 min was preferred for AI and Masyn,avg evaluation as it can capture the granular changes in asynchrony while also being representative of longer temporal trends, thus preventing excessive variations in patient AI and Masyn,avg. Conclusion: Overall, this study provides new insight into both the short- and long-term trends of PVA in MV patients. By understanding these patterns, healthcare providers can enhance the monitoring of MV, leading to more informed and timely intervention. Ultimately, this could lead to improved patient care and outcomes. © 2024 The Author(s)

Author Keywords
Asynchronous breathing; Asynchrony index; Machine learning; Magnitude of asynchrony; Mechanical Ventilation; Temporal trends

Correspondence Address
Ang C.Y.S.; School of Engineering, Malaysia; email: Christopher.Ang@monash.edu

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