

AI-BASED PREDICTION OF LUNG TISSUE INVOLVEMENT IS PREDICTIVE OF COVID-19 SEVERITY

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BACKGROUND

- During COVID-19 epidemics several artificial-intelligence neural networks (ANN) systems were developed to classify the risk of disease progression to respiratory failure and death, providing aid for clinical decision.
- Multiple solutions use deep neural networks to classify data from computed tomography (CT) scans from SARS-CoV 2 infected patients, taking advantage of the availability of large public datasets. Artificial neural networks (ANN) allow to classify and segment lung tissue lesions with high sensitivity and specificity.
- However, for optimal results these models should link multiple medical data in a simple model.
- In this study we analysed the in-hospital mortality and mechanical ventilation risk using combination ANN based rapid computed tomography assessment tool and selected clinical variables.
- We aimed to validate this ANN based prediction model across dataset of laboratory and clinical variables also to establish the best fitted model which would include key prognostic variables

METHODS

- Data of 4317 COVID-19 hospitalized patients including 266 cases requiring mechanical ventilation were analysed using newly constructed and locally trained ANN algorithm.
- Enrollment period: 4th of March 2020 to 23rd of January 2022
- ANN based rapid computed tomography assessment tool was trained to map and label the type, localization and volume of the lung tissue involvement among patients with COVID-19.
- For the maximum model simplicity inferred hazards models used only the simplest parameter, namely percentage of the lung tissue involvement which is reflecting the sum of all inflammatory changes in the lung.
- Demographic, clinical, laboratory, and ANN-based lung inflammation data were analysed using proportional Cox Hazards model to estimate in-hospital mortality and mechanical ventilation/intensive care (ICU) admission risk
- The study protocol was approved by the Bioethical Committee of Pomeranian Medical University, Szczecin, Poland (approval number: KB-0012/92/2020).

RESULTS

- Median hospitalization time was 12 (IQR: 8-17 days, 90th percentile of observation time 26 days, 95th percentile 34 days), range from 1 to 173 days. For the patients requiring mechanical ventilation the median time to ICU admission was 4 (IQR: 1-8) days, ranging from 0 to 52 days.
- Overall mortality in the group was 16.93% (n=731), with 73.31% (n=195/266) ICU mortality.

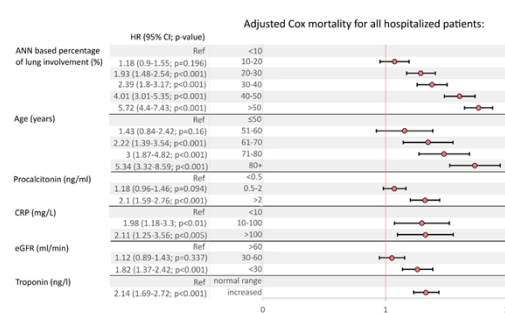


Figure 1. Adjusted multivariate model for the risk of COVID-19 in-hospital mortality

- Overall in-hospital mortality strongly associated with ANN-assigned percentage of the lung involvement, age category, procalcitonin > 2, C-reactive protein level category, estimated glomerular filtration rate and troponin increase above upper limit normal level (Figure 1).
- Risk of mechanical ventilation also associated with ANN-based percentage of lung inflammation, age, procalcitonin > 2 ng/ml, estimated glomerular filtration rate. Interestingly, mechanical ventilation hazards risk model associated with clinical variables, such as diabetes cardiovascular and cerebrovascular disease, and chronic pulmonary disease which were not significant in the model for the overall in-hospital mortality (Figure 2).

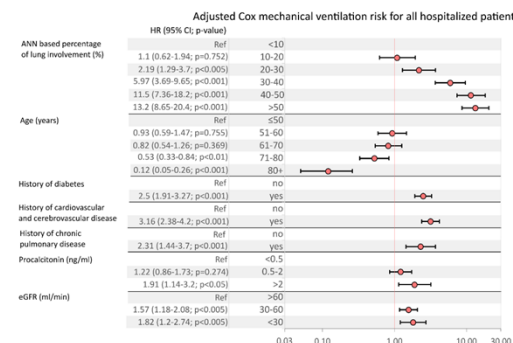


Figure 2. Adjusted multivariate model for the risk of mechanical ventilation

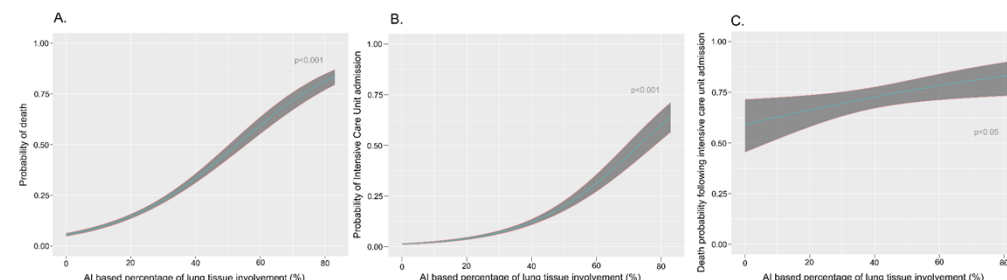


Figure 3. ANN-based percentage of lung involvement and probability of in-hospital death (a), mechanical ventilation and intensive care unit (ICU) admission (b) and ICU mortality (c).

- Probability of in-hospital death increased from 5.47% (95% CI: 4.73-6.32) for individuals without lung inflammatory changes to 81.23% (95% CI: 76.94-84.88) for cases with 80% of lung involvement (Figure 3a).
- Risk of mechanical ventilation rose from 1.25% (95% CI: 0.96-1.62) for cases without pneumonia reaching 59.98% (95% CI: 52.47-67.04) for 80% of lung tissue involvement (Figure 3b).
- Probability of death at ICU increased from 59.07% (95% CI: 45.37-71.49) to 83.01% (95%CI: 73.13-89.76) (Figure 3c).

CONCLUSIONS

- We confirm the utility of the ANN based lung tissue involvement for prediction of unfavourable outcomes in COVID-19, identifying the automatically assessed percentage of the lung involvement as the strongest, independent factor associated with mortality.
- ANN assistants will have to be further developed and validated but are already becoming a valuable tool aiding clinical decisions and identifying patients at the increased risk, which is applicable not only in COVID-19 but also will be highly useful in other diseases.

STUDY LIMITATIONS

- Training of the ANN model predicting lung involvement was based on the manually annotated dataset which limits use of the model beyond the COVID-19 pneumonia.
- Proportional hazards statistics assumes that loss to follow-up is non-informative, however, in the analyzed group loss to follow-up equalled to hospital discharge due to recovery which may result in informative censoring. To avoid this bias, in further analyses we divided the dataset into two groups of patients hospitalized for < 15 and > 15 days – this allowed us to analyse ~70% of cases within the first timeframe and retain the prognostic value of the key factors (follow-up analysis).

ADDITIONAL KEY INFORMATION

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