Anterior Pulmonary Ventilation Abnormalities in COVID-19

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A 66-year-old female patient visited the emergency room due to respiratory distress and was subsequently confirmed positive for coronavirus disease 2019 (COVID-19) using a real-time polymerase chain reaction. At presentation her body temperature was 36.0°C (96.8°F), the white blood cell count and differential were normal with an elevated D-dimer (1371 ng/mL; normal <500 ng/mL). CT pulmonary angiography was performed 2 days after admission showing a few peripheral patchy ground-glass opacities and small areas of consolidation predominantly in both lower lobes (Figure). The percentage extent of COVID-19 pneumonia using freely available MEDIP COVID19 (v1.2.0.0; MEDICALIP Co. Ltd, Seoul, Korea) was 0.93%, and the weight (the percent extent*[CT attenuation + 1000]/1000*1.065g/mL) was 22.5 g (Figure) (1), indicating mild pneumonia. CT pulmonary angiography excluded the presence of pulmonary embolism. The patient was safely discharged home the next day.

To assess regional lung ventilation in this COVID-19 patient, we used a CT-based full-scale airway network (FAN) flow model. In a prior publication, FAN modelled ventilation showed statistically significant agreements with functional imaging data from chronic obstructive pulmonary disease subjects (2). In this case, we mapped the lesion masks segmented by the MEDIP COVID19 to the FAN model geometry to simulate acinar flow alteration induced by COVID-19 infection. The FAN flow model simulated dynamic airway pressure, flow rate and gas concentration changes to demonstrate the ventilation distribution at full inspiration in COVID-19 (see also the Movie [online]).

The FAN flow model showed regional ventilation defects in the upper lobes anteriorly (Figure). The reduced pulmonary ventilation may result from COVID-19-associated airway inflammation beyond CT resolution or microvascular thrombosis (3). Assessing regional ventilation defects may facilitate treatment, monitoring and surveillance of respiratory dysfunction in patients with COVID-19.

Acknowledgement

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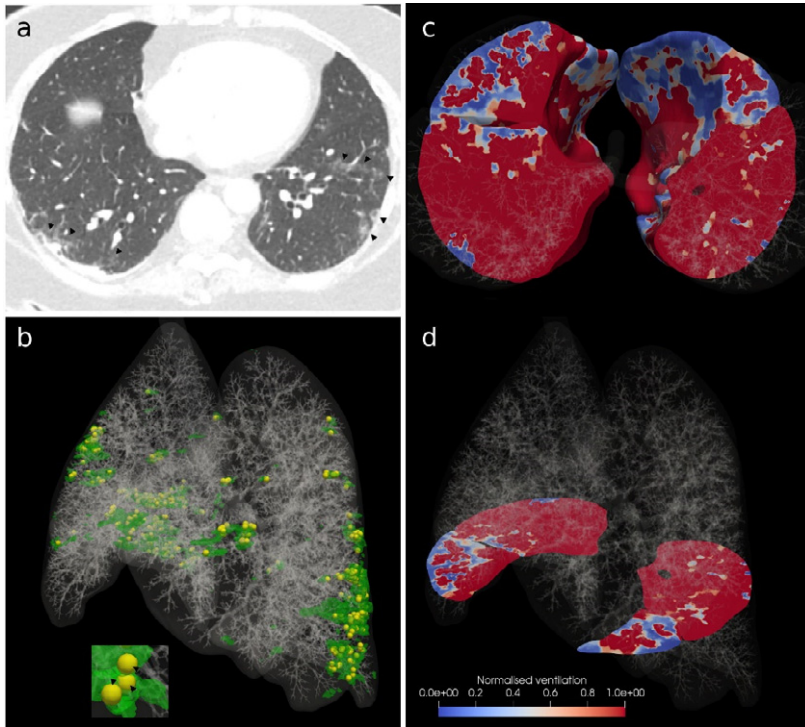
Figure: **(a)** CT images and **(b-d)** pulmonary ventilation map modelled with a full-scale airway network (FAN) flow model in a 66-year-old female with COVID-19 having respiratory distress. (**a**) Chest CT shows focal consolidation in the right lower lobe and small ground-glass opacities in the left lower lobe, (**b**) CT-based FAN flow model geometry was paired with an AI-driven CT analysis tool, MEDIP COVID19, which labels areas of pneumonia while these areas of pneumonia are marked with yellow spheres in the FAN model. (**c, d**) Ventilation distribution map computed with the FAN flow model shows a number of regional ventilation defects anteriorly (blue color) where no gross parenchymal lesions existed (not visible) at routine CTA.