Simultaneous Imaging of Lung Perfusion and Glucose Metabolism in COVID-19 Pneumonia

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Severe hypoxemia in some patients with coronavirus disease (COVID-19) has been related to loss of hypoxic pulmonary vasoconstriction (1, 2). A 77-year-old male with 6 days of mild respiratory symptoms and no comorbidities was admitted with signs of respiratory failure (Pa_{O_2}/FI_{O_2}: 61 mm Hg/0.36 mm Hg = 169.4 mm Hg; reference values [RVs] of 400–500 mm Hg). Chest computed tomography (CT) showed extensive ground-glass opacities (50–75% right-lung involvement and 25–50% left-lung involvement). Laboratory findings showed a D-dimer concentration of 652 ng/ml (RV < 500 ng/ml) and a C-reactive-protein concentration of 93.5 mg/dl (RV < 0.1 mg/dl). Nasopharyngeal swab test (RT-PCR) results confirmed COVID-19. The standard institutional protocol was initiated with a nasal oxygen catheter (4.0 L/min), antibiotics, dexamethasone, and enoxaparin. The patient required invasive ventilation on the 10th day and died on the 35th day of hospitalization. Lung-perfusion single-photon-emission CT/CT using ^{99m}Tc-labeled macroaggregated albumin (3) and positron emission tomography/CT using ^{18}F-fluorodeoxyglucose (4) were sequentially performed on the third day of hospitalization during the same visit to the Nuclear Medicine Service to simultaneously assess pulmonary perfusion and inflammation. Normal or increased lung perfusion was detected in most of the hypermetabolic areas evidenced by positron emission tomography/CT images (Figure 1). Image quantification was conducted using free, open-source image-processing software (5, 6). Quantification results showed 59% of the total pulmonary perfusion occurring in inflamed lung tissue, which corresponded to 39% of the total anatomic lung volume (Figure 1D). This suggested a high right-to-left shunt fraction in the inflamed areas, which was probably related to loss of hypoxic vasoconstriction, as has been proposed before to occur in COVID-19 pneumopathy (1, 2). The vasoconstriction reflex seemed preserved in a few areas of ^{18}F-fluorodeoxyglucose uptake. Inflammation and loss of hypoxic pulmonary vasoconstriction can be assessed and quantified using the described methodology. Further studies are needed to evaluate its possible clinical uses. ■

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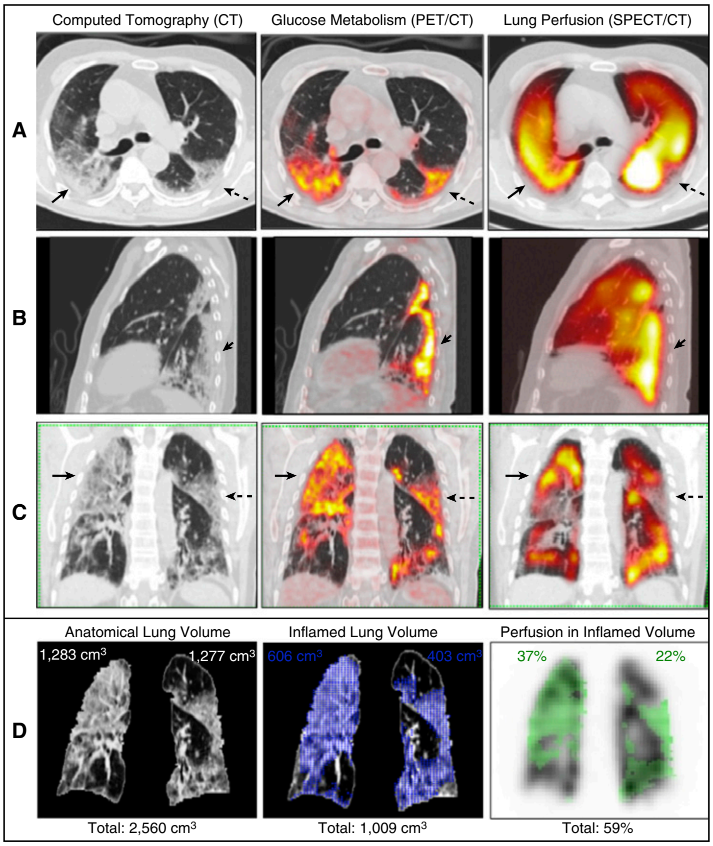

Figure 1. (*A–C*) Axial (*A*), left sagittal (*B*), and coronal (*C*) slices from computed tomography (CT) (left), ^{18}F-fluorodeoxyglucose (^{18}F-FDG) positron emission tomography (PET)/CT (center), and lung perfusion single-photon-emission CT (SPECT)/CT (right). Note normal or increased lung perfusion in most hypermetabolic areas detected by PET/CT (solid arrows) compared with the apparently unaffected lung. The inflammatory abnormalities have a clear predominance in the posterior lung fields and included all consolidations or ground-glass opacities on CT images. In general, the denser the lung parenchyma on CT images, the greater the ^{18}F-FDG uptake on PET images. Hypoperfusion (preserved vasoconstriction) is present in a few areas of ^{18}F-FDG uptake (dashed arrows). (*D*) Corresponding segmented coronal slices, representative of the volumetric quantification, are shown. The segmented lungs obtained from CT images have a total volume of 2,560 cm^3 (pulmonary contour in *D*; left). The maximal standardized uptake value of the ^{18}F-FDG PET/CT images is 11.8. The volume of ^{18}F-FDG uptake, representing total lung inflammation, was segmented using the mediastinal blood pool as the threshold (standardized uptake value = 1.8) and measures 1,009 cm^3 (blue area in *D*; center). This corresponds to 39% of the total anatomic lung volume (right lung: 23%, left lung: 16%). The mask of the segmented volume of ^{18}F-FDG uptake was transferred to the SPECT volume (green area in *D*; right). The counts within this mask were divided by the total counts of the SPECT image. This resulted in 59% of the total counts of lung perfusion occurring in inflamed lung tissue (right lung: 37%, left lung: 22%). Accordingly, 61% of the normal (noninflamed) lungs, which ideally should receive 100% of lung perfusion, receive only 41% of it. Therefore, this quantification estimates the total loss of hypoxic vasoconstriction in this patient. This right-to-left shunt could partially explain the severe hypoxemia of this patient. *See* the details of the image acquisition and quantification in the online supplement.

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