most people; its use to determine what lung function an individual should expect should also raise alarm. Using specific genes that may explain lung function would be useful and doesn't have the same problem, though the information may still be abused. However, where specific genes are known there is no longer any need to know the "% African" inheritance or any other information on ethnicity. This is the logic that supports the screening of neonates for sickle cell genotypes without regard to reported ethnicity. Unfortunately, there has still been relatively little success in identifying the genes that are believed from family studies to explain around 50% of the variation in lung function. Until this situation improves, genes are of limited use in interpreting lung function. ■

Author disclosures are available with the text of this letter at www.atsjournals.org.

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Finite Element Modeling of Pulmonary Mechanics in Severe Acute Respiratory Distress Syndrome: Explaining the Inclination Angle?

To the Editor:

With great interest, we read the research letter by Marazzo and colleagues (1) in which the effect of changing trunk inclination on respiratory function in patients with coronavirus disease (COVID-19)-associated acute respiratory distress syndrome is described. In our clinical practice, we repeatedly observed such rapid improvement of VTs upon change of trunk position from semirecumbent to supine flat. The rapidity of altered respiratory mechanics does not, in our view, favor a major role for alveolar recruitment but rather a varying distention of different lung areas compatible with a patchy pathomorphological manifestation of COVID-19. This clinical observation led us to hypothesize that different configurations of, for example, fibrotic and emphysematous pulmonary parenchyma differentially influence lung aeration depending on the inclination of the individual patient's trunk.

Therefore, we set out to model diseased COVID-19 lungs using a finite element method–based mathematical pulmonary model using Ansys (2020 R2 ANSYS, Inc.), allowing simulation of distinct geometrical configurations of heterogeneously distributed parenchymal pathomorphology and its related local tissue mechanics (Figure 1). The model consists of five rows and three columns of rectangular blocks, representing a single lung, surrounded by a rigid supporting structure representing the thoracic cage. Each of the 15 blocks is composed of homogeneous material with mechanical properties described as elastic moduli, density, and yield strength as derived from the pathoanatomical literature and related to the modeled pathomorphological state of a specific anatomical lung area: fibrotic, emphysematous, or edematous (2, 3). The diaphragm at the caudal lung border is modeled as a plane with an imposed dynamic force simulating the intraabdominal pressure. The intraabdominal pressure depends on the degree of bed inclination: 8.4 mm Hg for 0°, 9.5 mm Hg for 15°, and 11 mm Hg for 30° of inclination (4). The gravitational force is represented by the *x*- and *y*-components, adapted accordingly for 15° and 30°. To test a representative set of clinically relevant pathomorphological manifestations as pulmonary COVID-19, more than 30 configurations of mechanical properties of the 15 blocks were tested, starting from homogeneous edema with an increasing number of blocks with fibrosis and emphysema in different and opposite positions (caudal versus cranial and dorsal versus ventral).

The output was defined as aeration of the lung, summed over the 15 individual modeled blocks. After simulating all different configurations in three bed inclination angles, it was particularly the modeled phenotype of an edematous lung configurated with both cranial dorsal emphysema (⩾3 blocks) and caudal dorsal fibrosis (⩾3 blocks) that appeared to predict an increase in aeration when changing the bed inclination both from 0° to 15° and from 15° to 30° (Figure 1).

Although this straightforward computational finite element method approach is merely hypothesis generating, it is tempting to speculate whether combining these insights with pulmonary imaging techniques (e.g., computational tomography or electrical impedance tomography) would allow us to further validate our findings on a patient-specific basis. Ultimately, such modeling approach of pulmonary pathomorphological heterogenicity may advance our understanding of more patient-specific mechanical ventilation at an individualized degree of bed inclination in severe acute respiratory distress syndrome. ■

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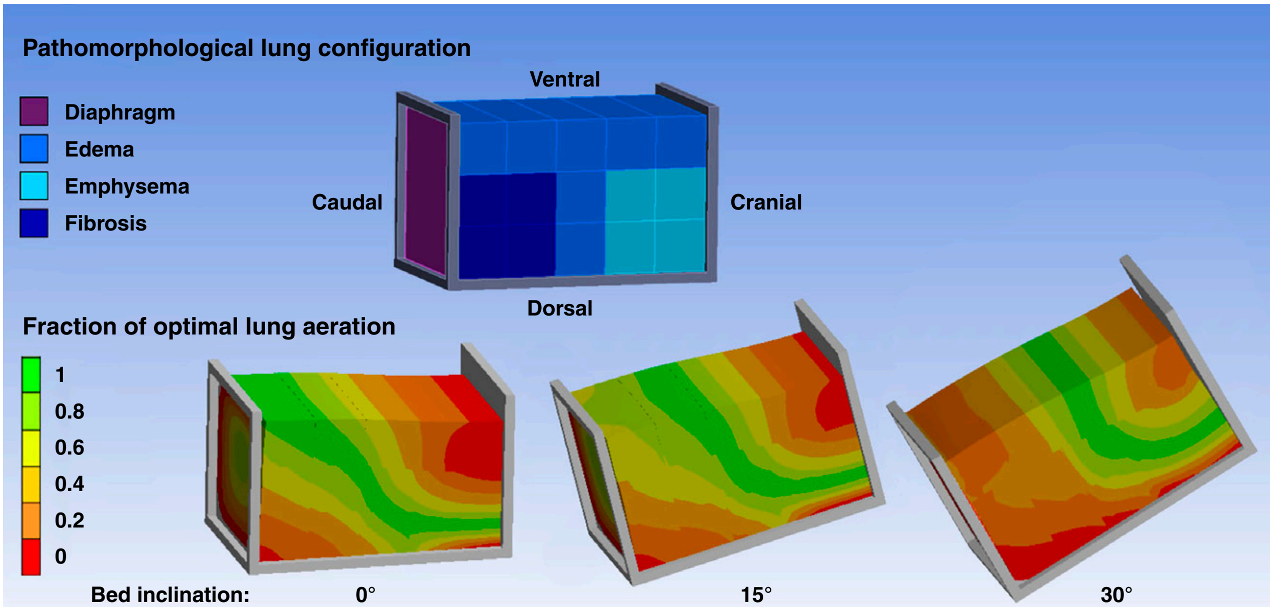

Figure 1. Example configuration of the finite element method lung model (upper part) and representation of the resulting lung aeration in 0°, 15°, and 30° bed inclination (lower part).

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Reply to Oppersma *et al.*

From the Authors:

We thank Dr. Oppersma and colleagues for their interest in our study, in which we described the effects of changes in trunk inclination on respiratory mechanics in mechanically ventilated patients with COVID-associated acute respiratory distress syndrome (ARDS) (1). Reducing trunk inclination from semi-recumbent (40° head-of-bed elevation) to supine-flat (0° head-of-bed elevation) increased markedly (and reversibly) the compliance of the respiratory system, both due to an increase in chest wall and lung compliance. We did not measure changes in lung aeration (end-expiratory lung volume [EELV]); however, we think that the most relevant underlying mechanisms is the decrease in EELV in supine-flat position, favoring a reduction of

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