COVID Information Commons (CIC) Research Lightning Talk

Transcript of a Presentation by Ali Vahdati (East Carolina University, College of Engineering and Technology), August 19, 2021

Title: A Computational Model for Multiscale Investigation of Regional Lung Dynamics

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YouTube Recording with Slides

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Transcript Editor: Elia Bregman

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Transcript

*Slide 1*

Ali Vahdati:

Can you see my slides?

Lauren Close:

Yes.

Ali:

Okay great, thank you for the introduction, Lauren.

Good afternoon everyone, or good morning, depending on where you are. I'll be talking about our NSF-funded project on multi-scale computational modeling of the lung dynamics in COVID-19 patients. This is an interdisciplinary project, and the project team is composed of both engineers and clinicians from the College of Engineering and Technology and Brody School of Medicine of East Carolina University.

*Slide 2*

So, we all know that the COVID-19 pandemic still surges on, especially with this new Delta variant more recently. We also know that the virus can cause extensive damage and progressive changes to the lungs,

among other tissues and organs, particularly in patients with COVID -19 acute respiratory distress syndrome. As you see in this graphic, in the alveoli of the lung, COVID -19 can cause many complex changes such as fibrosis, cell death, and thrombosis formation. Even in healthy lungs our existing knowledge of the microscale and mesoscale mechanics of the lung is still very rudimentary. In part because of the complex hierarchical structure and mechanical properties of the lungs.

*Slide 3*

So, patient-specific CT-based computer modeling of the lung in a diseased state such as COVID -19 can provide new insights into lung dynamics and into the role of mechanics in lung inflammation. This image is from a recent paper we published in the *Journal of Life Sciences*, and it shows that damage to the alveoli of the lung at the microscale can propagate and manifest at the macroscale in complex ways. For example, here you can see that in the image on the left from Perlman's lab, Edema formation in the alveoli can translate into increased tension and stress in the surrounding tissues. At the larger scale, this can lead to changes in the compliance of the lung. In part, due to reduction in the surfactant released, as can be seen in the image on the right from Gaver's group.

*Slide 4*

I would like to also note that the microscale impact of COVID-19 on the aerospace interstitium and capillaries are highly interdependent. As you can see in this graphic, damage to each component of the alveoli, such as the septal wall, can lead to damage to the capillaries and vice versa. I know there is a lot of detail in this graphic, but some of it is beyond the scope of this presentation. So, in the interest of time, if you are interested in more detail about these progressive changes in lung mechanics please refer to this recent publication from our group in the *Journal of Life Sciences*.

*Slide 5*

Now, the first step in patient-specific in silicon modeling of the lung is clinical imaging. In this recent research project, we utilize a 4D-CT imaging technique, which includes lung motion tracking via LEDs. This method can capture 10 CT images or more of the lung during the full breathing cycle and provides more information on lung dynamics compared to a single static CT image. We have imaged five patients so far using this technique and we are using these images to develop patient-specific computer models of the lung. If you are interested in further analyzing this rich imaging data set to answer other research questions, please contact me to discuss collaboration opportunities you can see my email address here on this slide.

*Slide 6*

Analysis of the infected lungs requires that the lungs are isolated from surrounding tissue in CT images using image segmentation, as you can see here in this image. This is an example of a 4D-CT image that we segmented to show where the ground glass regions, ground glass opacities, nodules, consolidation regions, and the aerospace are located. Segmenting these COVID lungs can be difficult- there are a lot of artifacts in the images, especially motion artifacts if the patient is coughing, for example. Ground glass opacities also make segmentation more difficult. So, we developed an efficient semi-automatic segmentation approach to be able to efficiently segment these images using open-source software slicer. You can see a representative result here in this slide. We also submitted an abstract on these

methods to the BMES 2021 annual meeting- that's the Biomedical Engineering Society annual meeting- and the abstract was recently accepted and will be presented in October.

*Slide 7*

At this point, we have developed both finite element microscale and macroscale computer models of the lung dynamics. We are currently coupling the micro-and-macro-scale models and validating these models. Our hope is that these models will advance our mechanistic understanding of lung function in healthy and diseased states and provide a virtual hypothesis testing platform for us and other researchers.

*Slide 8*

These are the two abstracts accepted for presentation at the BMES 2021 annual meeting. I briefly talked about the first one. The second one is focused on better understanding the mechanical behavior of the lung tissue at the microscale and mesoscale, so we can use the appropriate constitutive models and mechanical properties for tissue in our computer models. In this second abstract, we developed a mesoscale lung tissue finite element model and studied the emergent mechanical properties of the tissue based on the available atomic force microscopy measurements.

*Slide 9*

Finally, I would like to acknowledge funding from the NSF the CMMI Division, the Biomechanics and Mechanobiology Program, the co-investigators, my research team, post doctoral fellow Anup Pant, and graduate students Elizabeth Dimbath and Shea Middleton. I also thank the webinar organizers for providing this opportunity for me to present my research. Again, if you have any questions or you are interested in collaboration with our group please reach out to me via my email which is here on this slide vahdatia18@ecu.ecu. Thank you.

Lauren:

Thank you very much that was a fantastic and very interesting presentation, professor. I'm sure our audience has lots of questions for you about your presentation, so as a reminder to the audience we'll be hosting a Q&A session at the end of all of the presentations. In the interim, if you have a question you are certainly welcome to submit those questions in the chat. We'll be addressing them individually at the end of all the presentations.