European Cystic Fibrosis Society

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Cystic Fibrosis Research News

Title:
3D Printing and the Cystic Fibrosis Lung

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What was your research question?
Can 3D printing technology enhance patient and provider education in cystic fibrosis?

Why is this important?
It can be difficult for patients with cystic fibrosis (CF) and their care providers to visualize the complex changes in airways anatomy that is a key part of the disease. By having a clearer picture of the abnormal airway dilation that is characteristic of CF, also known as bronchiectasis, people can be better informed and patients can be more engaged with their care. However, due to the intricate shapes of lung anatomy and bronchiectatic airways, traditional ways of making three-dimensional models through machining or casting and molding can be very expensive and time consuming. The cutting-edge technology of 3D printing has potential to address this need.

What did you do?
In Mirza e al, a collaborative team of pulmonologists, 3D printing technologist, and radiologist report on using 3D printing to create a transparent lung model from the computed tomography (CT) scan of a young adult patient with advanced CF. The model was printed using material jetting, a technology in which thin layers of colored liquid plastic polymer are deposited by 3D printer micro-nozzles, which are then hardened by curing with ultra-violet light, and successive layers are then built up to produce a three-dimensional model (Figure 1). In this lung model, the pulmonary arteries carrying deoxygenated blood into the lungs were depicted as blue (the usual convention for blood with low oxygen), the pulmonary veins carrying oxygenated blood back to the heart as red, the airways as white, and other lung tissues as clear. The see-through nature of the model clearly shows the abnormal airways and their relationships with pulmonary blood vessels in this CF patient. The model demonstrates marked dilated rounded areas of bronchiectasis (also known as cystic bronchiectasis) in the patient's right upper lobe that contains a collection of fungal infection.

What did you find?
This physical model readily shows phenomenon that can be difficult to visualize on a computer screen, the traditional way to view CT images, such as constriction of blood vessels in areas of more marked

lung disease. This 3D print is being used to help educate medical trainees in CF disease at Stanford Medical School and will also be used for patient education.

What does this mean and reasons for caution?

3D printing is a part of the digital revolution in medicine that promises to advance CF patient care in multiple ways. As in this example, providing more clear educational tools can help improve training and patient engagement.

Although standard chest CT will be sufficient and standard of care for most patients, 3D printing in special cases can help to add value. Current limitations to wider adoption of 3D printing in lung diseases include limited availability of expertise, technology, and cost. One reason for caution in creating 3D printed models, particularly in pre-treatment planning, is that skilled technologists and physicians work closely to ensure imaging information is translated into a model accurately, without distortion or important omissions. As 3D printing becomes more wide-spread as a part of the continued digital revolution in medicine and industry, costs are expected to decrease with economies of scale.

What's next?

3D printing can facilitate the rapid development of new medical educational tools and is a way to build patient-specific custom prostheses. Having physical recreations of a particular patient's diseased anatomy could help physicians better prepare for potential complicated procedures including bronchoscopy and surgeries, such as prior to lung transplant. While this technology has yet to become widely available and implemented, the work of Mirza et al is a forward step toward these goals.

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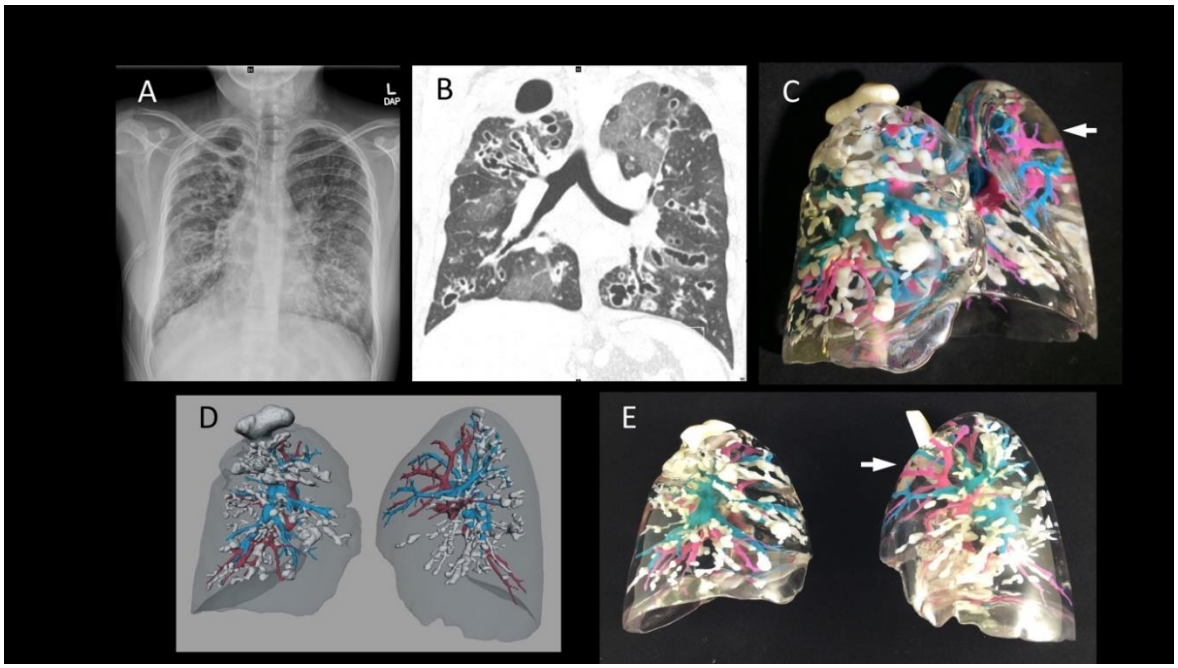

Figure 1: From imaging to patient specific 3D model of cystic fibrosis
A). Chest radiograph of upper lung zone predominant bronchiectasis and airways thickening
B). CT more clearly showing bronchiectasis
C). 3D printed model
D). Computer 3D rendering of standard tessellation language (STL) model prior to printing
E). 3D printed lungs seen in the same respective lateral views. The arrows show an area of relative normal lung in the left upper lobe.