Application Note

Harnessing novel computed tomography approaches to improve lung cancer surgery

In the United States, lung cancer is a leading cause of mortality, accounting for 1 in 5 cancer-related deaths.[1] This makes the early detection and treatment of lung cancer vitally important. Advances in computed tomography (CT) have made it increasingly easier to diagnose some variants of lung cancer at an earlier stage.[2] This has allowed a growing number of patients to be treated surgically using segmentectomy, a procedure in which much less lung tissue must be removed around the tumor compared to traditional lobectomies.[3] In early-stage non-small-cell lung cancer, segmentectomy has been shown to produce the same oncological outcomes as lobectomy.[4] It may also be a treatment option for patients at high risk of complications from more extensive surgery. Despite its benefits, there are still some challenges with this treatment that could be overcome through the use of improved imaging techniques.

An imperfect approach

Segmentectomy involves the removal of one or more pulmonary segments – an anatomical and functional unit of the lung that is separated from other pulmonary segments by pulmonary intersegmental planes. For the success of the surgery, it is vital to precisely distinguish these pulmonary segments from each other by identifying their intersegmental planes. There are two main approaches for doing so; the bronchial method and the arterial-ligation-alone method.[5] In the bronchial method, CT is used to identify the arterial blood supply to each pulmonary segment. This is quick and straightforward, but often results in inaccuracies. The arterial-ligation-alone method is a more accurate approach but takes place during surgery, requiring both time and technical skill. It would, therefore, be advantageous to have a CT approach that could provide a more detailed anatomical view of each segment prior to surgery.

Delineating segments

In a recent study, Huike Gao and Chao Liu of Jining Medical University examined 128 slice spiral CT images from 30 healthy individuals and 10 patients with pulmonary masses.[6] Using Thermo Scientific™ Amira™ Software, a semi-automated segmentation method was applied to demarcate what they termed as “arteriopulmonary segments,” which encompass the segmental bronchus and segmental artery as well as the intrapulmonary vessels and eighth-order branches of the pulmonary arteries. The data was then used to reconstruct 3D images of these structures

For the healthy subjects, around 90% of pulmonary segments could be easily identified through visual counting. In these segments, each segmental artery closely accompanies the segmental bronchus with no branching of the segmental arteries into the adjacent pulmonary segments; gaps between each of

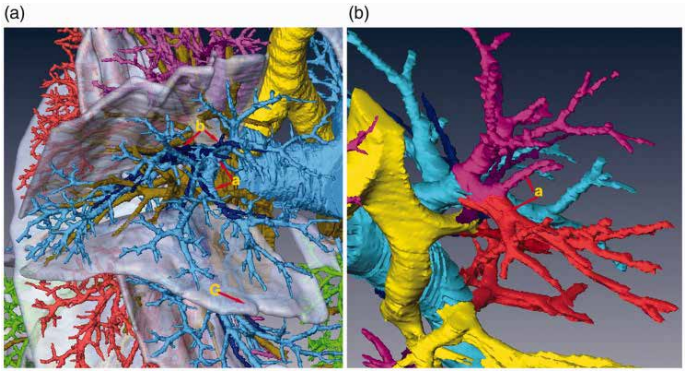

Figure 1. a) Segmental arteries in a pulmonary segment. b) Close-up of the segmental arteries. ***Figure adapted from Reference 6 through CC BY-NC 4.0***

the adjacent segmental arteries were present. However, in the other 10% of segments, segmental arteries entered the adjacent pulmonary segments, which would make them difficult to assess using conventional methods. However, the high resolution of the CT images, together with the 3D reconstructions, allowed for the clear visualization of segmental arteries and segmental bronchi in any anatomical direction, as well as measurement of the pulmonary arteries and the intersegmental vein that surround each segment. Identification of these structures is incredibly important so that these blood vessels can be ligated during surgery. The incorrect identification of overlapping pulmonary arteries could lead to bleeding during surgery and surgical failure.

In patients with pulmonary masses, the spatial location of the mass could be observed in any imaging direction, and Amira Software could be used to quantify the size of the pulmonary mass.

A marked improvement

The research team advocates for this approach, given that it is a great improvement on existing methods, and could be used before and during operations to provide surgeons with detailed anatomical insights to enhance their work.

"Our novel method provided the detailed anatomical structure of every segment before pulmonary segmentectomy. This is a great improvement that can be used to guide operations, even intraoperatively," the authors write in the *Journal of International Medical Research.*

They do, however, note that their semi-automated approach is highly time-consuming, requiring up to two hours of a radiologist's time for every 2-3 segments. At the same time,

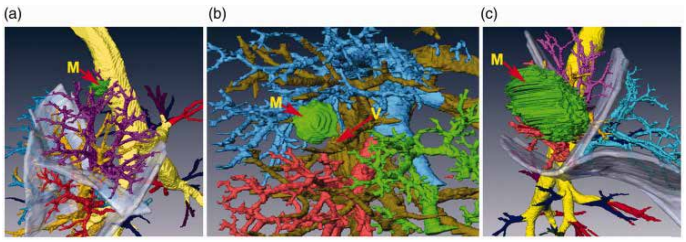

Figure 2. Cancerous masses (green) captured with 3D CT reconstruction. a) Mass located in the bronchial periphery. b) Mass at the edge of the pulmonary segments. c) Mass across two pulmonary segments. ***Figure adapted from Reference 6 through CC BY-NC 4.0***

current fully automated approaches that have been used to identify pulmonary segments have not been accurate enough for clinical use. In the future, a fully automated segmentation method that allows for the demarcation of arteriopulmonary segments would be a much-welcomed development.

Thermo Scientific technology

Gao and Liu used the semi-automated segmentation tools in Amira Software to extract structures of interest in all three anatomical planes. The software enabled them to compute the diameter, length, and angle of the pulmonary arteries, as well as quantify the size of masses in lung cancer patients. Amira Software can provide 2D–5D image visualization, processing, and analysis from multiple modalities, including optical and electron microscopy, CT, and magnetic resonance (MRI). Amira Software is a flexible software solution offering a wealth of built-in tools coupled with the ability to customize its functions to your own specific needs.

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