Technology Corner

Augmented Imaging for Peripheral Bronchoscopy

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Introduction:

Traditional guided bronchoscopy modalities include standard fluoroscopy, radial ultrasound, and electromagnetic guidance. Despite evolving technology and tools, biopsy yields have remained around 70% in most studies. Robotic bronchoscopy platforms have emerged as options for peripheral bronchoscopy with the promise of better yields due to their ability to better reach peripheral regions of the lung, along with the ability to maintain vision during sampling, all while having better tip stability especially in the case of eccentric lesions sampling. Despite this promise, the first published studies showed only modest improvement in yield (1,2). There are multiple reasons cited for suboptimal yield; these include poor performance of biopsy tools, local atelectasis that develops during the procedure, and CT-body divergence. Using cone beam CT (CBCT), investigators found that there can be significant divergence in nodule location between the pre-procedure CT imaging and lung during procedure (3). This divergence is largest in the lower lobes, and can be greater than 15mm in distance, easily enough to rend a biopsy attempt spuriously away from the intended target, potentially resulting in a falsely negative result. Accepting tool performance as a constant, it appears that accurate targeting of the nodule is therefore a major determinant of yield. Up until recently, the only surrogates of accurate targeting were fluoroscopy and radial ultrasound (rEBUS). Standard fluoroscopy can only be employed when the nodule is visible, and rEBUS is mainly helpful when the lesion is concentrically positioned around the airway. Further, neither rEBUS or fluoroscopy can provide accurate assessments of distance and angular relationships of the tool with the lesion. The emergence of CBCT has overcome these impediments with detailed imaging and 3D reconstruction, offering real insight into tool-nodule relationship. Unfortunately, CBCT is not readily available at all institutions and is expensive. As a result, other imaging modalities have been developed to achieve the same goals. These modalities use enhanced fluoroscopy images, and thus are less costly and use a much smaller space footprint within the bronchoscopy suite, and therefore allow for broader adaptation by proceduralists.

Background:

Augmented imaging refers to any real time imaging (ie fluoroscopy) being augmented by other imaging sources (ie CT, ultrasound, etc). Multiple imaging modalities can then be fused ("image fusion") simultaneously. Though imaging sources can be real-time or historic, the augmentation is real time. Currently there are several technologies on the market that achieve augmented imaging, however only one, LungVision™ (Body Vision Medical INC, NY) uses intraoperative tomography to augment real-time fluoroscopy. The resultant augmented fluoroscopic imaging contains an overlay of both the airway pathway to the lesion, and the lesion itself (see Fig 1).

Clinical Application:

How we do it

After the patient is anesthetized, a series of fluoroscopy images are performed to achieve CT-body registration. Then, a fluoroscopy spin (typically -50° to +50°) is performed with the nodule at isocenter. After images are reconstructed tomographically, nodule location is updated and the overlay appears for navigation to begin. Once navigation to the nodule is completed, another fluoroscopy spin is performed which gives 3D representation of the nodule with the catheter and/or biopsy tool, and nodule location corrections are performed if needed (see figs 2,3). Catheter and/or biopsy tool location corrections can be made at this time, if necessary, and another spin can be performed to re-image tool-nodule articulation. Once the tool location and projected trajectory is deemed to be adequate, biopsies are done, again using augmented imaging. Though fluoroscopy use is increased during these procedures, cases have shown average doses around 250 mGy, about one tenth that of a cardiac catheterization.

Accuracy

The application of real-time imaging and localization during navigational bronchoscopy has promise, and has been suggested by results from multiple studies. For example, studies that have used advanced navigational technologies in conjunction with real-time CBCT imaging have suggested the additive nature of these technologies compared to their respective individual yields (4). Indeed, published studies using LungVision have shown high localization rates (90-95% using rEBUS and CBCT), albeit with earlier versions of the technology, with yield ranging between 77 and 84% (5,6). This compares well to published rates of robotic bronchoscopy localization (85-90% range) and yield (1,2). It will be interesting to see if merging of augmenting imaging (either CBCT or LungVision) with robotic bronchoscopy will result in higher yield procedures; studies are commencing to evaluate this further.

Conclusion

It is apparent that augmented imaging can play an important role in peripheral bronchoscopy. Though this can be achieved with CBCT, these systems are expensive, have large space footprints, and may be difficult to have access to. Using alternative technologies, such as LungVision, can provide similar imaging with standard fluoroscopy equipment, and can be easily incorporated into the bronchoscopy suite. Further research into the platform itself, as well as combining this platform with robotic technologies is underway.

References:

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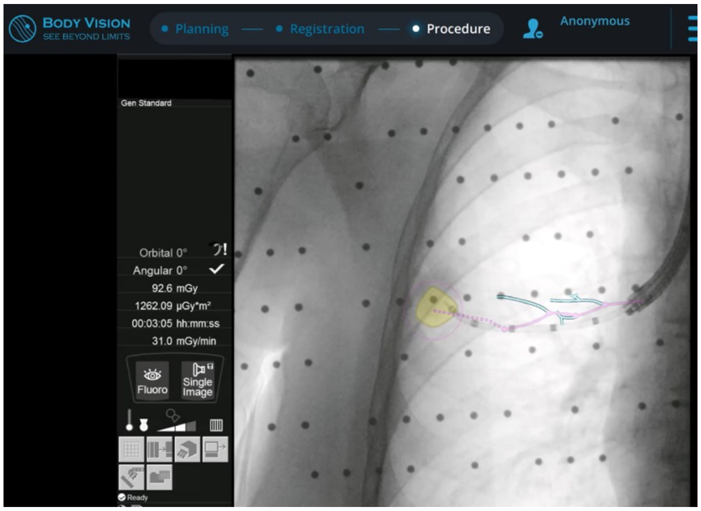

Figure 1: Augmented imaging overlay with pathway and nodule.

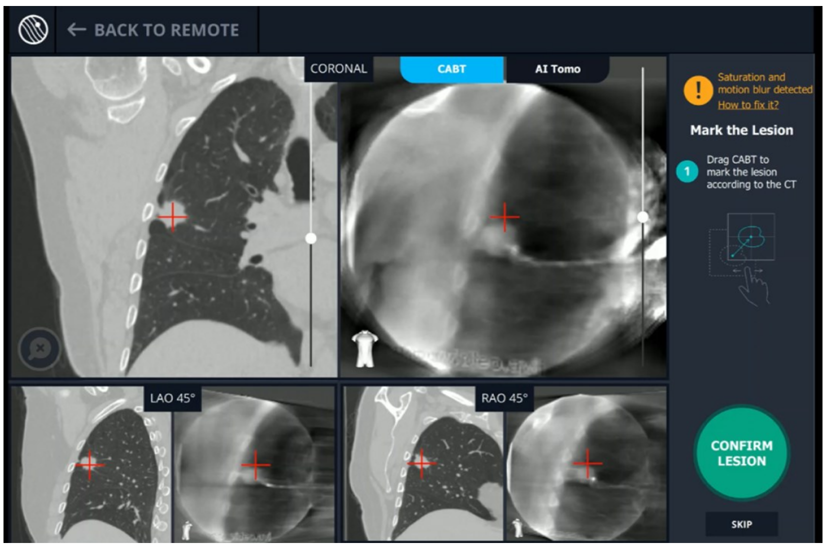

Figure 2: Tomographic reconstruction of nodule with catheter leading into it.

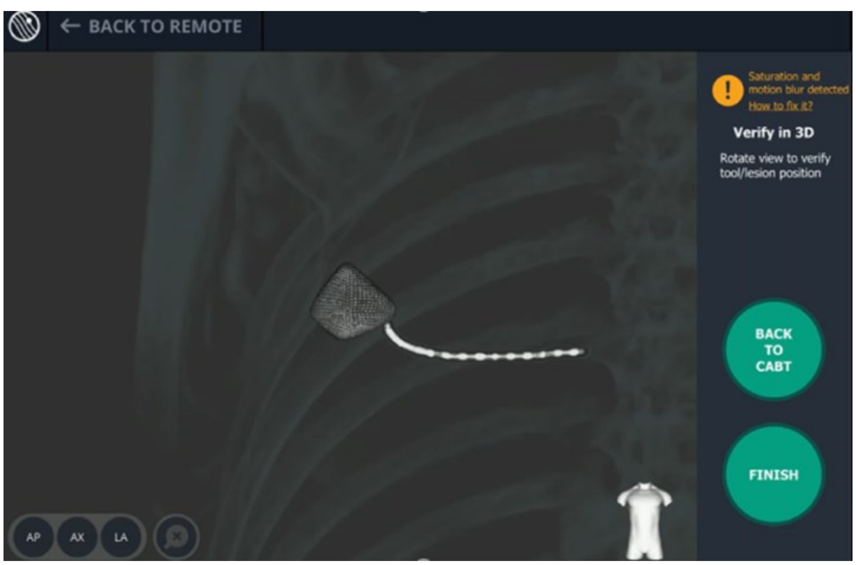

Figure 3: 3D reconstruction of the nodule-catheter relationship.