Editorial

Image-assisted video assisted thoracic surgery (iVATS): an important tool in the armamentarium against lung cancer

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Provenance and Peer Review: This article was commissioned by the editorial office, *Journal of Thoracic Disease*. The article did not undergo external peer review.

Comment on: Cheng YF, Chen HC, Ke PC, *et al.* Image-guided video-assisted thoracoscopic surgery with Artis Pheno for pulmonary nodule resection. J Thorac Dis 2020;12:1342-9.

Submitted Apr 16, 2020. Accepted for publication Apr 29, 2020.
doi: 10.21037/jtd-20-1693
View this article at: http://dx.doi.org/10.21037/jtd-20-1693

Image assisted thoracic surgery is becoming increasingly popular across the world with the advent of technological advances and increasing availability of hybrid operating rooms across the world (1). There is a fast accumulating body of literature both clinical and research comparing the traditional video assisted thoracic surgery approach with image assisted thoracic surgery (2-7). The need to augment traditional approaches is influenced by the growing need to triage the large number of suspicious pulmonary nodules found during screening trials (8-10), majority of the pulmonary nodules deemed concerning for malignancy are either too small or do not have the density to be adequately palpated during resection. Additionally, as the life expectancy improves across the world, we now have a significant proportion of patients who are above the age of 85 years, at risk of malignancy and in need of therapies with minimum morbidity. Therefore, innovative techniques such as iVATS will become standard of care in the near future.

The current manuscript 'Image-guided video-assisted thoracoscopic surgery with Artis Pheno for pulmonary nodule resection' compares the pros and cons between traditional CT room localization and iVATS localization with Artis Pheno and concluded that iVATS provides shorter time from localization to skin incision and fewer complications than CT room localization (11). The authors should be complimented for undertaking the important task of comparing two complimentary techniques and highlighting the advantages of each strategy. Our experience with iVATS and out of OR techniques as an adjunct to nodule localization has been very similar and we have now translated the approach from the research arena to clinical practice (12) .

With the implementation of screening programs at any given time hundreds and thousands of lung nodules are being followed by longitudinal CT scans and creates a significant diagnostic burden. Moreover, with current technology and interventional techniques, it is not possible to reliably distinguish benign from malignant nodules. Several quantitative techniques have been proposed to determine benign from malignant (13-15), but in clinical practice longitudinal follow up (16-18) is the most commonly followed strategy. But as the volume doubling time is variable between solid and subsolid nodules, sometimes follow up scans over several years are needed to determine if a lesion is malignant based on growth potential, even then it may still be too small to biopsy or resect. Therefore, strategies to ensure a histological diagnosis and resection are needed and iVATS allows a targeted resection with minimal complications.

Several marking techniques combining surgery and other modalities such as (ultrasound, fluoroscopy), and markers placed pre-operatively or intraoperatively, such as hookwires, fiducials, microcoils, or radioactive seeds; *Dyes* [methylene blue and indocyanine green (ICG)] and

Molecular targets (flourophores) are being deployed across different institutions and centers across the world (19-22). Depending upon the availability of hybrid OR's and the workflow, the markers can be placed in a CT scan followed by transport of the patient to the OR as a single step procedure during surgery. Each approach has advantages and disadvantages, the current manuscript by comparing both techniques in a well matched cohort demonstrated that the single step approach results in shorter time to incision and localization and less complications (11). This is logical as repositioning and transport from the CT scan to the OR for surgery can result in dislodgement of the markers and development of pneumothorax or bleeding while waiting for their OR time. Additional concerns of spillage and leak of dye into the pleura and adjacent structures can result in confusion at intraoperative localization and mislabeling of the correct spot and therefore utilization of dyes as markers on the out of OR approach utilizing CT scan may be impractical due to unpredictable time between localization and resection.

The authors also explored the utility of newer generation of dyna-CT scanner in nodule localization and found that the Pheno scanners with the ability to accommodate larger patients offered a definite advantage. Patient positioning during iVATS in a hybrid OR is key in keeping the time to incision and localization of the nodule low (11). In our experience, a multidisciplinary presence at the time of initial positioning of the patient on the OR table, and ensuring that all the anesthesia equipment is secured and out of the trajectory of the dyna CT. Clear communication and discussion of plan with the OR team at the beginning of the case can help further decrease the time of the procedure. Sometimes based on patient size, adjustments to the patient's position may be needed as compared to CT scanners which allow as patients weighing upto 500 pounds.

Dr. Cheng *et al.* utilized methylene blue marking using dyna-CT in the OR cohort and coil localization among the CT scan cohort. This approach may have offered a higher success rate 100% *vs.* 96.8% as compared to the OR cohort (11). The coils and other fiducial markers such as T-bars offer a definite advantage over the methylene blue dye as the marker projects over the surface of the lung while spillage of the dye over the surface and pleura can cause ambiguity regarding the exact location of the lesion, additionally two or more coils or T-bars can be placed to mark the boundaries of the lesion. We have found that T-bars can be combined with a dye to mark additional lesions and ICG dye can be injected through the hub of the needle that is used to deploy the T-Bars and can help identify occult lymph nodes (22).

Integration of real time one stop approach using hybrid OR for localization of resection of small nodules, from a patient perspective offers an advantage as the patient undergoes a single procedure utilizing a single anesthetic in the same room, thus obviating the need for a transfer and risk of complications during the transfer and repositioning. The approach even though desirable requires a significant learning curve and a well-trained team (23), however creating a teaching video and phantoms can be used to train technologists and radiologists. This approach can be further augmented by onsite presence of trained individuals during the initial procedures to help trouble shoot any issues. Creating a training manual with a step by step illustration of the whole procedure can be very useful. Radiation dose optimization can be done by limiting the field of view and number of scans.

As we look at translating iVATS to standard of care, we must acknowledge some of the disadvantages of this approach, the most important issue pertains to development of a pneumothorax prior to placement of the fiducial or dye, when this happens the lesion location changes and another scan may be required to re-localize the lesion. Another issue is inability to assess the depth of the fiducial from the surface of the lung, none of the current marking techniques provide this , however using the CT scan images acquired for localization can help determine the exact location of the nodule in reference to the surface of the lung and the distance from the fiducials, thus allowing for successful resection of the nodule and removal of the fiducials.

While we evaluate novel approaches to localize lung nodules, a cost effectiveness analyses comparing the different strategies both in the hybrid OR and the CT scan are needed to fill a major knowledge gap, and also to develop a triage pathway so that patients who are best suited for iVATS are offered the procedure as first line . Developing an algorithm based on nodule location, density, patient size, age, degree of emphysema and surgeon experience will help match the right approach with the right patient and will improve success while mitigating complications. Finally training the next generation of surgeons, anesthesiologists and radiologists is needed as minimally invasive techniques become more desirable and technological advances will allow development of new treatment paradigms that will be routinely seen in the armamentarium of thoracic surgeons

against the fight for lung cancer.

Acknowledgments

Funding: None.

Footnote

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jtd-20-1693). Dr. RRG reports grants from Siemens Healthineers, grants from NIH, grants from Canon Inc., outside the submitted work; Dr. RB reports grants from Siemens, grants from Genentech, Roche, Merck, Verastem, Epizyme, Gritstone, Medgenome, personal fees from Novocure, outside the submitted work; and Patent licensed through BWH (my institution), Equity in an early start up device company-Navigation Sciences.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Gill RR, Bueno R. Image-assisted video assisted thoracic surgery (iVATS): an important tool in the armamentarium against lung cancer. J Thorac Dis 2020;12(5):1766-1769. doi: 10.21037/jtd-20-1693