



Image guided Video Assisted Thoracoscopic Surgery (iVATS)

assisted by cone beam CT and 3D live needle guidance

Patient history

This is a 63-year-old male with a 30 pack year smoking history, bilateral ground glass opacities and previous right video-assisted thoracoscopic surgery (VATS) upper lobectomy and superior segmentectomy for four separate early stage lung adenocarcinomas (all histologically distinct lesions) resected a year earlier. The right upper lobe contained a T2N0 (2cm) papillary subtype adenocarcinoma, a 0.4cm focus of minimally invasive adenocarcinoma and a 0.6cm focus of adenocarcinoma-in-situ while the superior segment contained a T1N0 (1cm) acinar subtype adenocarcinoma. On follow-up imaging, a ground glass lesion in his left lower lobe had gradually increased in size to 1.5cm and he also had a separate indeterminate left upper lobe ground glass lesion that remained stable in size (0.8cm).

As he already had diminished lung function from his previous operation and now had two separate lesions of concern in the left lower and upper lobe, he was offered a parenchymal sparing lung resection for both lesions via image-guided VATS using intra-operative cone beam CT localization to maximize adequate margins of resection, particularly for the upper lobe lesion that was deep in the lung parenchyma.

Procedure

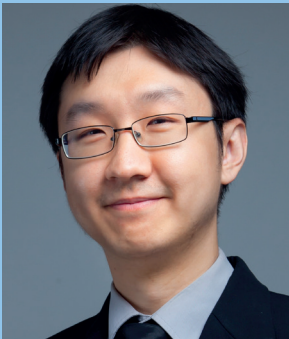
The patient underwent both the localization and VATS procedures in a hybrid operating room. After double lumen endotracheal tube intubation, the patient was placed in a right lateral decubitus position. The ceiling mounted C-arm system of the hybrid operating room Allura FlexMove was centered on the patient to include the region of interest. A cone beam CT scan was acquired using the 8-second roll protocol XperCT Abdomen Roll, while temporarily suspending mechanical ventilation in end expiration. Using the cone beam CT data, both the lower and upper lobe lesions were identified. Needle paths for both lesions were then sequentially planned by defining the target and skin entry points by using the XperGuide software. The patient was cleaned and draped, and a 21 gauge co-axial needle was inserted under fluoroscopic guidance using automatically selected fluoroscopic views of the planned needle path, augmented by the 3D segmented lesion overlay to the lower lobe lesion. Once the co-axial needle was in position, a repeat cone beam CT scan was performed to ensure that the needle was in a position close to the lesion.

0.2ml of 5mg/ml indocyanine green dye was injected at this site, followed by the deployment of a Kopan's hookwire. The localization procedure was then repeated for the upper lobe lesion. At the conclusion of the localization procedure, a final cone beam CT scan was performed to provide information about the position of both hookwires in relation to their respective lesions.

The ceiling mounted C-arm was then moved to its parking position to allow for the VATS resection to be performed without obstruction. A 3-port VATS approach was used to

gain entry into the chest. Wedge resections of both lesions were performed using endoscopic stapler devices, guided by the hookwire and indocyanine green dye marking. A systematic lymph node dissection was then performed.

Final histopathology of the resected specimens showed that the lower lobe wedge resection was a T1N0 (1.3cm) acinar subtype adenocarcinoma with a 1.1cm parenchymal resection margin and the upper lobe wedge resection was a separate T1N0 (0.7cm) acinar subtype adenocarcinoma with a 1.1cm parenchymal resection margin.



Dr Boon-Hean Ong, MBBS, FRCSEd (CTh), FAMS

Dr Ong is a Consultant and the Director of Thoracic Surgery at the National Heart Centre Singapore. He has been actively involved in the application of cutting-edge technology and novel treatment strategies to improve outcomes for thoracic surgery patients, including the use of cone beam CT for image-guided video-assisted thoracoscopic surgery and endobronchial interventions.

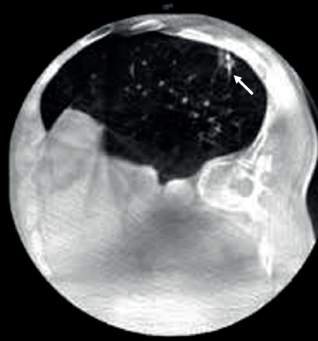


Dr Apoorva Gogna, MBBS FRCR FAMS

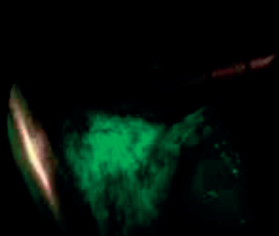
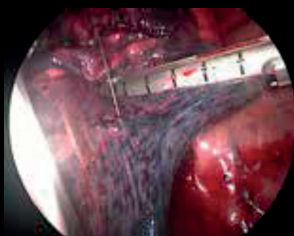
Dr Apoorva is a Senior Consultant Interventional Radiologist and Director of Intervention and Medical Devices Research at Singapore General Hospital. He graduated from National University of Singapore and has received advanced Specialty training in the United States and Japan. His special interests are in the image-guided minimally-invasive treatment of hepatobiliary, renal and lung tumours. He is actively involved in multiple clinical and research collaborations to enhance patient outcomes.

Conclusion

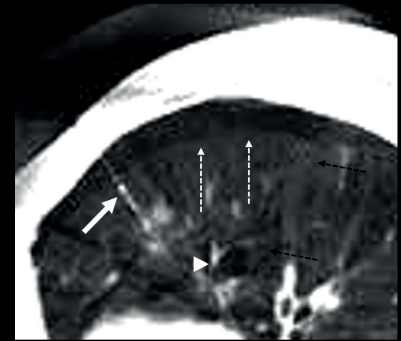
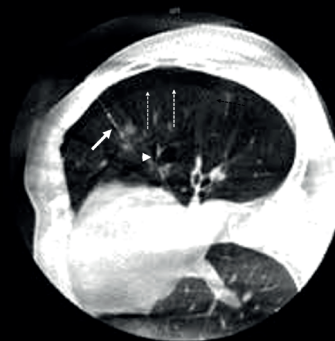
Using the cone beam CT in the hybrid operating room, multiple non-palpable lesions can be successfully localized and resected with adequate margins in a single-stage procedure that improves patient experience and simplifies the workflow compared to the conventional approach of having localization and VATS resections done in a staged manner.



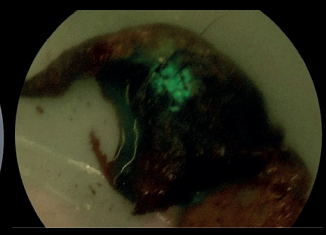
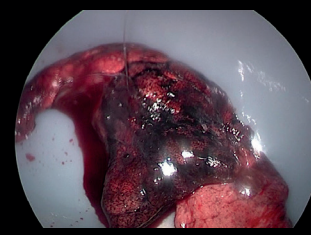
(Left) Chest CT performed preoperatively in supine position shows a 1.5cm ground glass opacity (black arrow) in the subpleural lateral basal segment of left lower lobe, without adjacent pleural thickening. Without localisation, this lesion may be difficult to identify on VATS once the lung is deflated. (Middle, detail right) Cone-beam CT performed in right lateral decubitus position on the operating table in suspended end-expiration shows the tip of the Kopan's hookwire (white arrow) traversing the ground glass opacity.



(Left) Wedge resection of left lower lobe lesion performed with endostapler using both the Kopan's hookwire and ICG dye as a guide to ensure the entire lesion was resected with a clear margin. (Right) Final specimen of the left lower lobe wedge resection demonstrating that both the Kopan's hookwire and area of maximum ICG intensity was removed



(Left) A 0.8cm ground glass opacity is located deep in the parenchyma (black arrow). Note the small pulmonary cyst (arrowhead) and the major fissure (black dashed arrows). Intrapulmonary landmarks can be helpful in re-confirming positions of important structures once the patient is scanned intraoperatively in a different position. (Middle, detail right) Intraoperative CBCT shows the Kopan's wire (thick arrow) traversing the GGO. Note the interim development of a small pneumothorax (thin dashed arrows) which did not significantly affect needle positioning. The major fissure (black dashed arrows) is faintly seen. The small pulmonary cyst (arrowhead) was helpful in reconfirming the major fissure location.



(Left) Wedge resection of left upper lobe lesion performed with endostapler using both the Kopan's hookwire and ICG dye as a guide to ensure the entire lesion was resected with a clear margin. (Right) Final specimen of the left upper lobe wedge resection demonstrating that both the Kopan's hookwire and area of maximum ICG intensity was removed.



Results from case studies are not predictive of results in other cases.
Results in other cases may vary.

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