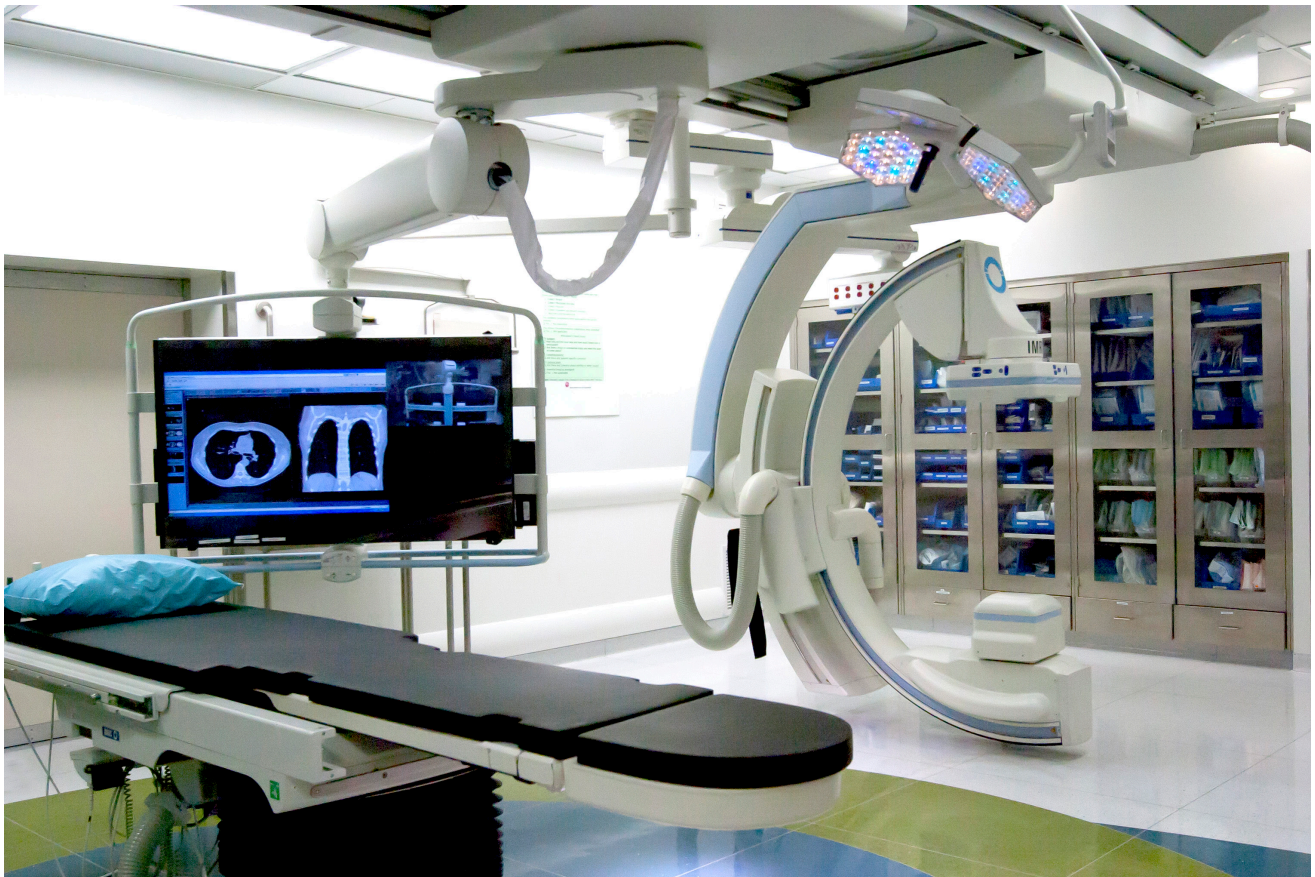


iVATS

Image Guided Video Assisted Thoracic Surgery
A New Surgical Paradigm



BRIGHAM AND
WOMEN'S HOSPITAL

| The Lung Center |



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About iVATS

Video-Assisted Thoracic Surgery, or VATS, is part of the standard of care for removing lung tumors. The surgeon uses minimally invasive techniques to enter into the chest cavity and video technology to explore the lung. However, locating the tumor usually relies on preoperative CT imaging and finger palpation of the lung. This is then followed by surgically resecting, or removing, the lung lesion with a surrounding margin of normal lung tissue. On occasion, the surgeon ends up removing a larger portion of the surrounding normal lung tissue than may be optimal, in order to ensure complete tumor removal.

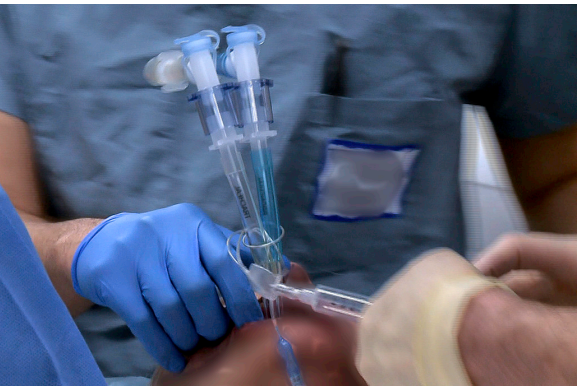
The iVATS procedure has been developed at BWH. The idea behind iVATS is to couple real-time CT imaging of the lung with video technology to locate the tumor and then surgically excise it. With the lung inflated, the patient undergoes CT imaging to definitively identify and locate the suspected tumor, which is then marked by special markers connected to the surface of the lung by sutures. With the lung deflated, these markers guide the surgeon to the precise area in the lung where the tumor is located. This is particularly useful to identify smaller nodules or tumors, which are difficult to locate by visually or finger palpation.

“This is a new application of existing technology that will likely change thoracic surgery techniques and lung cancer treatments for the better,” said Dr. Raphael Bueno. “Past applications of fluoroscopy and angiography—which use a system of guided wires, catheters and a contrast agent—have been used to remove breast tumors and perform catheterizations, but the use of markers or fiducials intraoperatively for treatment of lung cancer is innovative and game-changing.”



Intubation

Intubation is performed in the standard manner. The patient is moved to the lateral decubitus position following this procedure.





Positioning the patient

Achieving the proper initial positioning is essential for both accurate scanning, and fiducial placement.





The patient is secured in the lateral decubitus position.



Adequate support is carefully applied to the area of the arms to create proper extension and positioning.



Place, adjust, and replace.



Once the proper arm and body position has been achieved, the patient is further secured to prevent any shifting in a way that protects the patient from any injuries or inappropriate pressure.



CT/Fluoroscopia

When positioning the patient on the table, it is important to ensure that the patient can safely undergo imaging and that the C-arm can come around the patient without hindrance. It is equally important to center the C-arm with respect to the position of the nodule in the lung.



The expected location of the skin puncture point also needs to be in the field of view of the image acquisition. For example, if the lung lesion is posterior and the expected entry of the fiducial is from the patient's back, then the patient should be positioned such that the posterior aspect is in the center of the x-ray system.



A C-arm CT (also known as a Flat Detector CT) is acquired of the lung lesion.



The C-arm CT protocol used for this study was a 5-second rotation of 200 degrees around the patient, with 248 projection images acquired during the rotation. The average tube voltage was 90kV and the entrance dose at the flat detector was $0.36 \mu\text{Gy}/\text{projection}$.



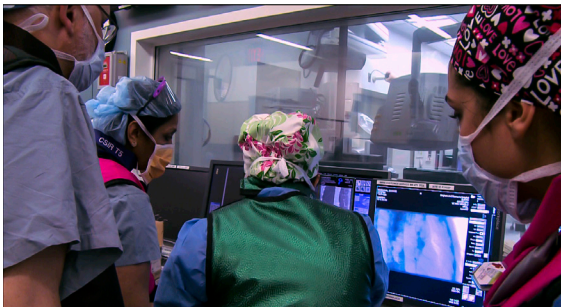
Determining the proper clearance between the imaging arc and the patient.



Adjusting the arm support to allow for smooth clearance of the imaging arc, while still maintaining the proper angles and placement.



Adjustments are made, and imaging is smooth and accurate.



Plotting

Plotting trajectories for the fiducials

A needle guidance software package is used to plan two, 3D needle paths on the C-arm CT image.

The needle path was drawn by clicking a target point and a skin entry point on the C-arm CT image. One target was superior to the lung lesion, and the other target was inferior to the lung lesion. It is important to plan the path of the insertion of the fiducials to both minimize the distance from the surface of the lung to the lesion area and to take into account the direction of any stapling device.



The projection images are then reconstructed to create a 3D computed-tomography-like volume image (C-arm CT) of the patient.





Placing fiducials

The patient is prepped and ready for placement of the fiducials. All initial positioning is maintained.



The lung is selectively occluded endobronchially using the double lumen tube prior to inserting needle and T Bars, but the lung stays up until the time of thoracostomy.



Fiducial preparation.



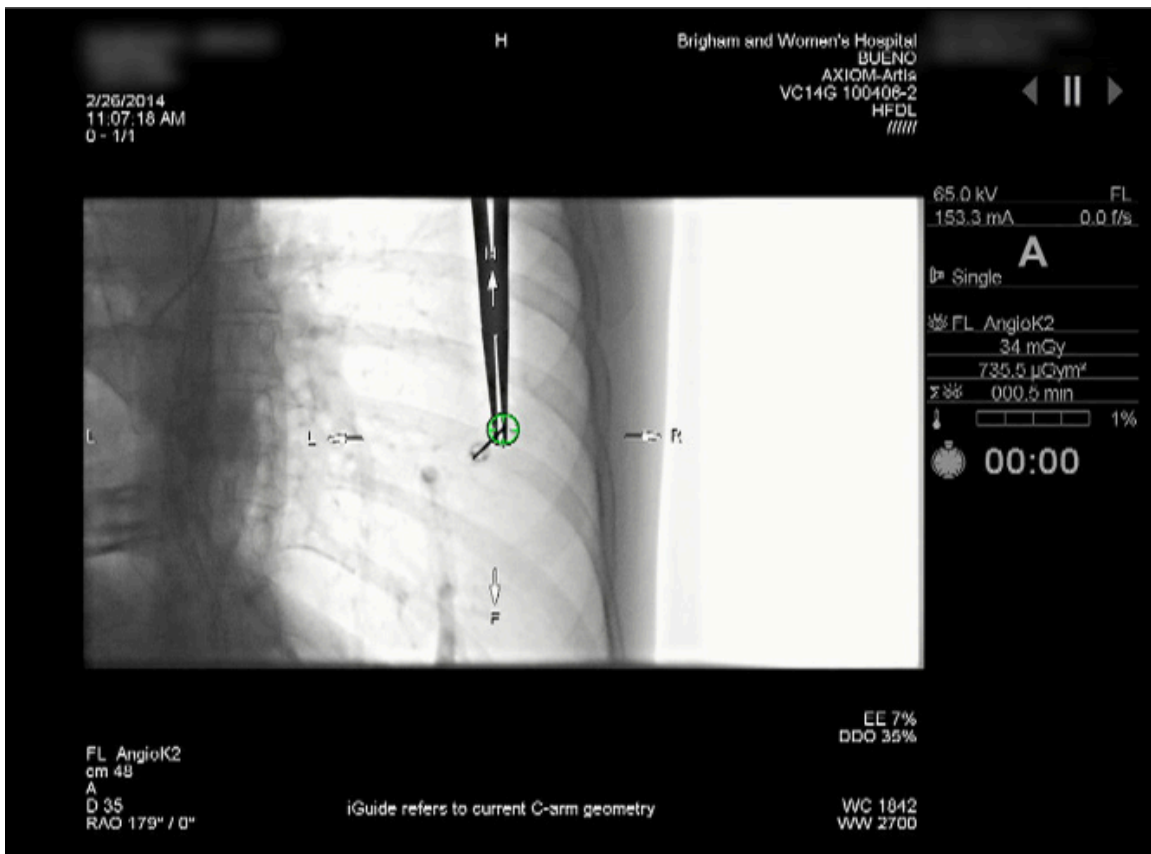
Needle tip used to penetrate the skin surface and deliver the fiducial.

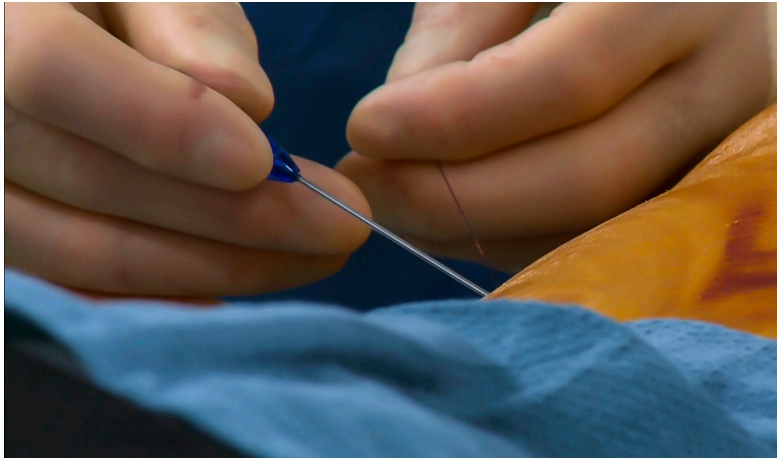


The fiducial (T-bar), which is placed as the marker at the lesion site, is freed up and reinserted into the needle after application of mineral oil to facilitate delivery.



First, the C-arm was rotated such that it was perpendicular to the needle path.
A laser on the detector marks the entry point on the skin.





After the needle has advanced a short distance into the skin, the C-arm would be moved parallel to the needle path to follow the progression of the needle.



The planned needle path is displayed as a dotted line on the fluoroscopic images (pictured below) so that the progress of the needle can be seen. Adjustments can then be made until the track matches the path.





Tethers attached to the T-bars are cut (above); and fiducial positions are confirmed (below).





Surgery

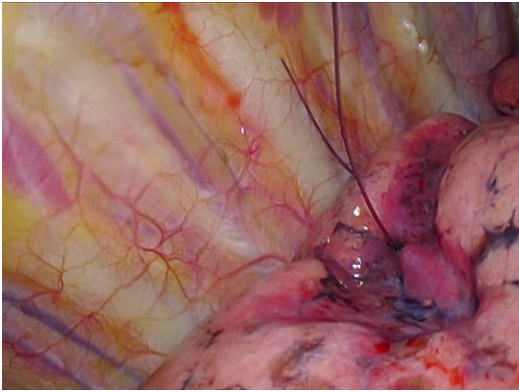
Standard VATS technique.



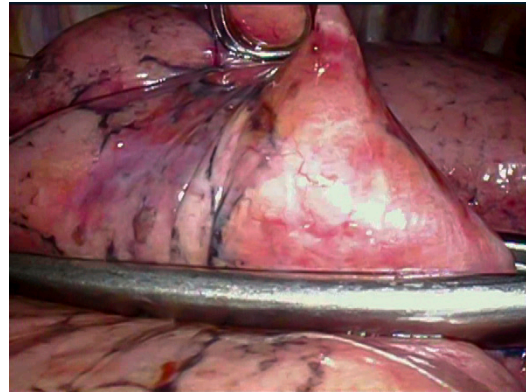
Stapler to be used for lung resection.



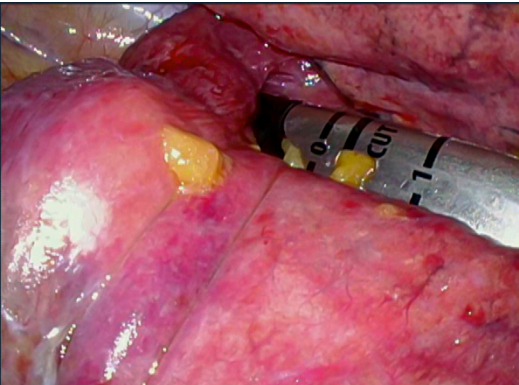
Evaluating lung tissue and lesion location.



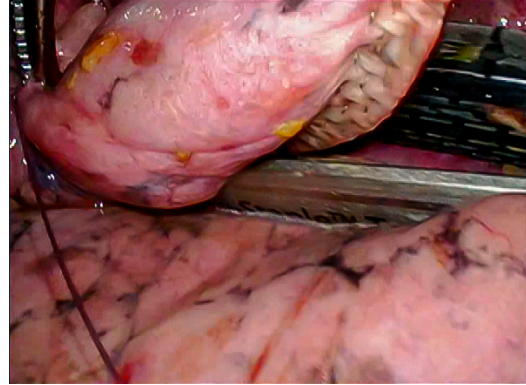
1. Identify the two fiducials that mark the lesion location.



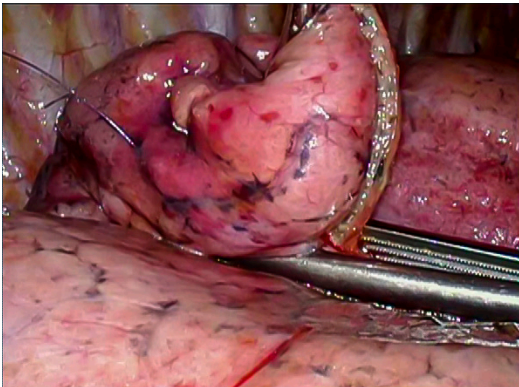
2. Gather the marked lung tissue with adequate margins.



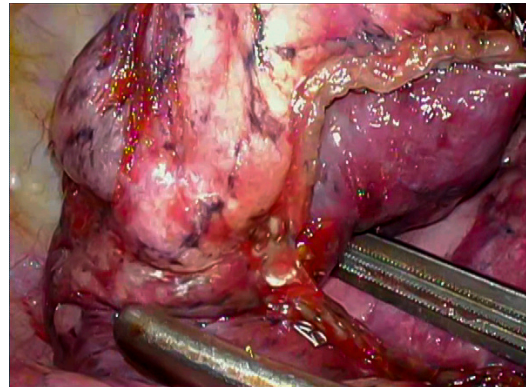
3. Insertion of surgical stapler.



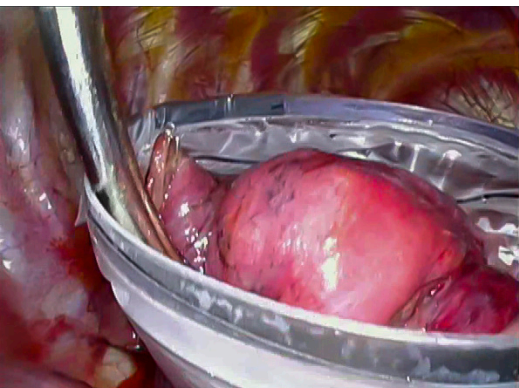
4. First in a series of stapler applications and cuts to resect lesion.



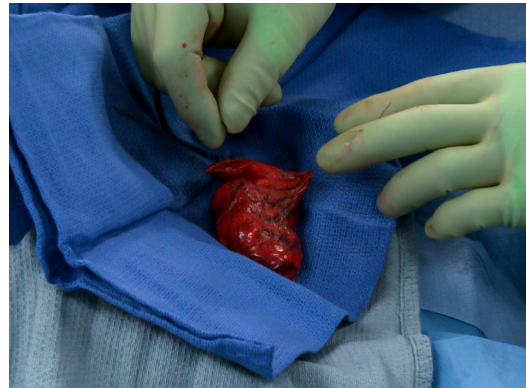
5. Progressive stapler applications and cuts.



6. Final stapler fires and cuts.



7. Specimen placed in endoscopic bag for removal from chest cavity.



8. Confirming presence of lung nodule, fiducials, and gross margins by careful observation and finger palpation, before sending to pathology.



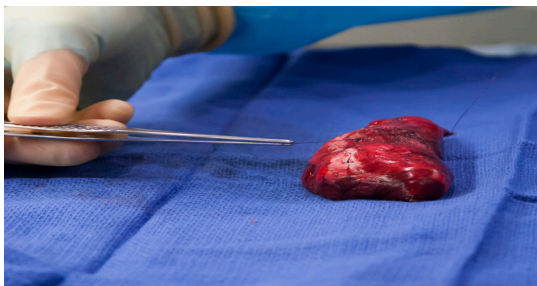
Confirmation of Specimen



The specimen is also scanned (above) for presence of the lung nodule and fiducials in the excised specimen.



The Pathology frozen section lab confirms the diagnosis.



as well as adequate margins of resection.

The incisions are then closed. The patient is awakened and taken to the recovery room.