Operative Techniques in Thoracic and Cardiovascular Surgery

Robotic Lobectomy

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Lobectomy has the highest cure rate for lung cancer. Current standards define lobectomy as an anatomic resection of the lobe with individual ligation of the vein, artery, and bronchus. Management of the lymph nodes is controversial, but resection and pathological analysis of 11 to 16 nodes including two to three different mediastinal stations and the hilum appear to provide sufficient staging information.[1,2]

In the 1960s lung resection morbidity and mortality were high but improved with greater knowledge of the anatomy and superior surgical, anesthetic, and postoperative care. Video-assisted thoracic surgery (VATS) lobectomy evolved in the early 1990s to an efficient oncologic procedure that appears to have less blood loss, surgically related disability, pain, and hospital stay compared to lobectomy by thoracotomy[3] (Fig. 1). With the introduction of robotics in the later 1990s, lobectomies and minor thoracic procedures were performed initially. The time for procedure completion was long and the early robotic equipment was cumbersome. In the United States, the first thoracic procedures were performed in 2002. Adopting this technology for the lobectomy is slow, likely due to the expense and the knowledge necessary to use the device.

Compared with VATS, robotic thoracic surgery is an advancement in technology, providing a three-dimensional view of the thoracic cavity and the dexterity necessary to carefully perform precision surgical maneuvers in small spaces (Fig. 2). Simply, VATS does not offer these features and as a result may be less appealing to thoracic surgeons. It is estimated that only 5 to 10% of thoracic surgeons perform minimally invasive lobectomies. For some who perform it, VATS lobectomy may not sufficiently address the hilar structures and the mediastinal, lymph node-bearing tissues. As a result, conversions to open thoracotomy are 10 to 15%.[4] Robotic surgery may reduce conversions and simplify minimally invasive thoracic surgery. Furthermore, robotic surgery is at the earliest developmental stage and continued advancements will be made to improve the equipment. The purpose of this article is to provide the reader with the details of a robotic lobectomy with the currently available equipment. With more thoracic surgeons using the technology, robotics will continue to evolve, enhancing the speed, accuracy, and safety of the minimally invasive lobectomy.

The indications for robotic resection are similar to the VATS and open thoracotomy technique, but robotics may, in many cases, be performed without single-lung ventilation and enable the safe resection of larger tumors and additional structures, such as the chest wall and pericardium (Table 1). Comparing the three potential approaches, open thoracotomy, VATS, and robotics, the open thoracotomy approach provides the ability to palpate the extent of the tumor at the expense of increased pain, reduced postoperative pulmonary function, and longer recovery time. Approximately 20 to 30% of patients will recur locally. VATS, on the other hand, provides a better view of the thoracic cavity and still allows some palpation with a reduction in pain, improved postoperative function, and potentially earlier return to preoperative/predisease status.[3] The likelihood for local recurrence and disease-free survival has not been sufficiently determined, given that most studies are retrospective. The robotic approach may potentially further reduce the likelihood for local recurrence as a result of the improved visibility and dexterity, and minimize pain and debility by decreasing the torque on the intercostal nerves adjacent to port sites. Using robotics, resection of the aorto-pulmonary window, hilar, subcarinal, and paratracheal lymph can be performed simply. The left paratracheal area from the left-sided approach is more challenging due to the presence of the aorta, but as techniques and equipment evolve, will likely be achieved as well. As with any device, the capability of the robotic surgical instrument is surgeon and technology dependent.

General Considerations

The currently available Food and Drug Administration approved robotic system is the Intuitive Da Vinci (Sunnyvale, CA; www.intuitivesurgical.com) that comes in two models, the Da Vinci and the Da Vinci S systems (Fig. 3). They are similar in that they have three components: (1) an operating console for the surgeon; (2) a "praying mantis-like" robotic arms chassis from which spring the robotic video unit and three robotic arms; and (3) the electronic communications tower system between the console and the chassis. Compared with the original Da Vinci system, the newer Da Vinci S provides some enhancements. Thoracoport attachments can be connected more easily to the chassis arms and the robotic

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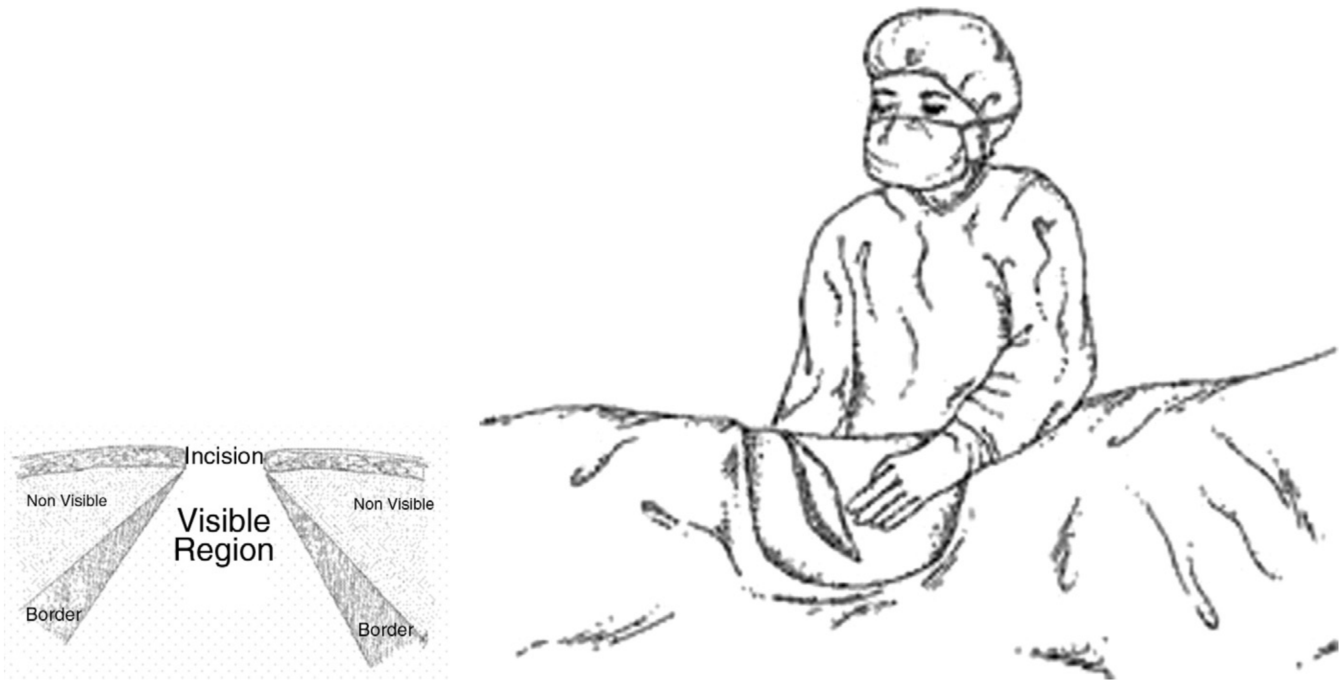

Figure 1 Rigidity of the chest wall hinders ability to visualize thoracic structures through a thoracotomy incision. The view of the mediastinum, hilum, and the lung is dependent on multiple factors: the size of the incision, the choice of intercostal space, the rigidity of the ribs, the surgical removal of a small portion or an entire rib, the ability to achieve single-lung ventilation, the presence of adhesions and/or presence of thoracic pathology, and unyielding bullous/lung disease. Simply, the view in the thoracic cavity can be divided into three regions: the visible region, where visibility is fairly easily achieved; the border region, where visibility is achieved only with significant effort; and the nonvisible region, where even with extensive efforts there is no visibility. With the advent of minimally invasive surgery, the view is only limited by the visualization system utilized (two-dimensional versus three-dimensional and angled versus nonangled viewing systems) and the planning and skills of the surgical team. It is this issue alone that may encourage our move away from the open thoracotomy for the majority of patients, especially those with cancer, where a thorough examination is critical to prognosis and treatment.

arms are collapsible, resulting in less arm collision outside the patient, and adds more functionality over a wider range of movement. In addition, there is a high-definition screen and patient monitoring system within the operator-console. Unfortunately, the detachable and replaceable surgical instruments that attach to the robotic arms are not interchangeable between the two systems. Therefore, owning and servicing both types of units are difficult. The S system is preferable for thoracic surgical purposes as the collapsible arms and a greater range of motion are a benefit for thoracic procedures. Hopefully, new robotic systems will be developed by Intuitive and other technology companies that will provide a less expensive and less cumbersome alternative to the currently available Da Vinci system.

Before performing a robotic lobectomy, the surgeon and the surgical team need to be educated in the technology. Intuitive Inc. offers an educational series in Sunnyvale and at several centers in the United States. These are 1- to 2-day courses and combine instruction in the mechanics as well as animal and cadaver experience. Contacting your Intuitive representative will be the first step to achieving the knowledge and skills necessary to perform the first case, especially since most hospitals now have regulations that will allow only those certified in robotics to perform a procedure. Several companies and institutions are working on simulators but are not yet available for general use.

The final and most important aspect is surgeon proctoring. Your hospital should be encouraged to provide proctoring on each of the thoracic procedures to be performed until each surgeon feels comfortable with the patients, strategies, and the Da Vinci equipment.

Before each case and somewhat unlike other surgical procedures, adequate time should be given for procedure planning. Inappropriate port placement or patient positioning can result in a long frustrating procedure for the entire team. In planning, start with the computed tomogram to select the correct approach for the patient. We routinely perform cervical mediastinoscopy on our patients, widely resecting three to five nodal stations. We recommend the novice team to initially select healthier patients with peripheral lesions less than 2 to 3 cm in size who have not had prior thoracic procedures and no evidence of pleural symphysis on the chest tomogram. The anesthesiologist is critical in this procedure but becomes less important with greater robotic experience. For the first several cases, providing single-lung ventilation is important and for all cases adequate hemodynamic support is essential for a successful procedure. The operating room team is another key element. The experienced scrub nurse/technician and operating room circulator can save time by having the correct equipment available to anticipate issues that may arise. The team should be prepared for a disaster