Robotic Thoracic Surgery
Technical Considerations and Learning Curve for Pulmonary Resection

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KEYWORDS

• Robotic surgery • Lung cancer • Video-assisted thoracic surgery

KEY POINTS

- Robot technology offers more intuitive movements, greater flexibility, and high-definition three-dimensional vision, which facilitates complex minimally invasive surgery with a potentially shorter learning curve than for video-assisted thoracic surgery (VATS).
- Robot technology for lung cancer resection and lymph node dissection seems to offer comparable radicality and safety to VATS and open surgery.
- Variables within robotic thoracic techniques include the number of incisions/arms, use of a utility incision for major lung resection, and use of CO_2 insufflation.

Videos of Vats wedge resection of the left upper lobe, Isolation and resection of the tight upper vein, Isolation and resection of the right upper artery, Isolation and resection of the bronchus for the right upper lobe, Isolation of the vein from the middle lobe, Isolation and resection of the bronchus for the middle lobe, and Isolation and resection of the middle lobe arteries accompany this article at http://www.thoracic.theclinics.com/

The introduction of laparoscopic techniques was one of the major advances in twentieth-century surgery. Video-assisted thoracoscopic surgery (VATS) for lobectomy is an established approach to resectable lung cancer, characterized by reduced pain, fewer complications, and shorter postoperative stay compared with thoracotomy, although controversy persists regarding its oncologic equivalence to open surgery.[1–4] Furthermore, because of its limited field of view, restricted freedom of movement, and poor ergonomics, VATS lobectomy is a demanding procedure with a potentially long learning curve for surgeons and an approach that has not yet become the standard of care.

Robot-assisted surgery was introduced in the mid-1990s. One of its aims was to overcome the limitations of thoracoscopic surgery. Retrospective series of robotic lobectomy for lung cancer suggest that robot-assisted approaches offer comparable radicality and safety to VATS and open surgery. More intuitive movements, greater flexibility, and high-definition three-dimensional vision overcome limitations of VATS and may encourage wider adoption of robotic surgery for lung cancer, particularly as more early stage cases are diagnosed by screening. High capital and running costs, limited instrument availability, and long operating times are important disadvantages. However, a recent study suggests that rational multidisciplinary use of a robotic system coupled with optimization of postoperative patient management may improve cost effectiveness.[5] Entry of competitive alternatives into the marketplace should also drive down costs. Studies are required to assess quality of life, morbidity, oncologic radicality and cost

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effectiveness. This article focuses on technical considerations of incorporating the robotic system for minimally invasive thoracic surgery and the expected learning curve for major lung resection.

COMPONENTS OF THE TELEROBOTIC SURGICAL SYSTEM

The only commercially available robotic system for thoracic surgery is the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA), a master/slave device consisting of four components (Fig. 1): (1) the robotic arms, (2) the surgeon's console, (3) the Insite vision system with a true three-dimensional high-definition endoscope providing a high-resolution binocular view of the surgical field, and (4) the EndoWrist instrument system capable of seven degrees of freedom and two degrees of axial rotation. The surgeon sits at the console, observes the operating field through binoculars, and manipulates the "master" instruments inserted through trocars placed through small, non–rib-spreading incisions. Manipulations of the master instruments are transmitted by the robot system into precise instrument movements inside the patient, with tremor filtration. The three-dimensional view largely compensates for the absence of haptic feedback.

TECHNIQUES FOR PULMONARY RESECTION

Techniques for robotic lobectomy vary in terms of the number of incisions and the use of a utility incision (VATS-based). The Milan group uses a four-arm system: three robot arm ports and a utility incision.[6] Other authors[7,8] in New York and Pisa started out using three arms, but subsequently adopted a four-arm technique. Dilewsky[9] and Cerfolio[10] use a four-arm, "total port" approach and make a utility incision only at the end of the procedure to insufflate the chest cavity with CO_2. The position of the utility incision (mainly to remove the surgical specimen) varies with surgeon preference. Veronesi[6] and Park[7] use a fourth intercostal space incision, whereas Dilewsky and coworkers[9] and Cerfolio and coworkers[10] introduced a lower supradiaphragmatic incision to reduce pain and facilitate the extraction of large tumors. Gharagozloo and coworkers[11] use a hybrid robotic-VATS technique. An important technical limitation of robotic surgery is that dedicated staplers, attachable to the robotic arms, are not yet available, so that the assistant surgeon has to maneuver staplers at the operating table. For the total port approach a fifth nonrobotic, assistant's port is required for passage of endovascular staplers.

PREOPERATIVE ASSESSMENT AND INDICATIONS

The indications for robotic lobectomy do not differ from those for VATS lobectomy. Patients must have adequate cardiopulmonary reserve, and lesions that are resectable by lobectomy or segmentectomy. However, as they gained experience,

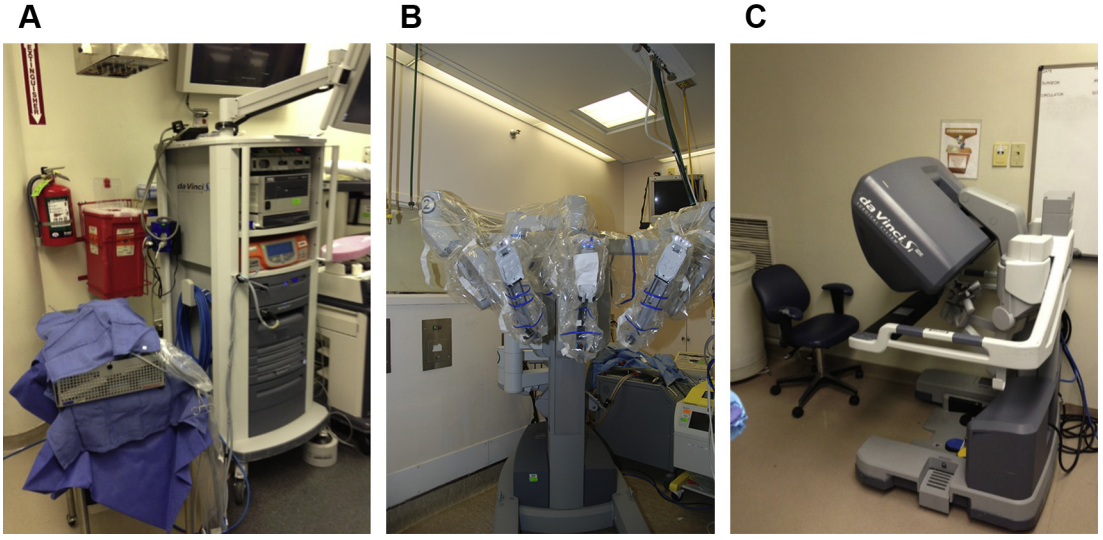

Fig. 1. The only currently commercially available robotic system for thoracic surgery is the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA), a master/slave device consisting of four components: the robotic arms (*A*), the surgeon's console (*B*), the Insite vision system with a true three-dimensional high-definition endoscope providing a high-resolution binocular view of the surgical field (*C*). (*Courtesy of* Intuitive Surgical, Sunnyvale, CA; with permission.)