Advancements in Robotic-Assisted Thoracic Surgery

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KEYWORDS

• Robotic • Thoracic • Lobectomy • Thymectomy • Ivor Lewis
• Esophagogastrectomy

KEY POINTS

- The robotic instruments translate the surgeon's hand movements from the robotic console without need for counteractive adaptation.
- Robotic arms #1 and #2 represent the surgeon's right and left hands, which allows for bimanual dissection and other coordinated movements. A third robotic arm is used to attach a camera, which the surgeon is able to directly control. With the optional fourth arm, a third device (such as a retractor) can be used simultaneously while still being controlled by the surgeon.

Robotic-assisted thoracic surgery (RATS) has become increasingly used as a technique to facilitate less invasive thoracic surgery. As surgical approaches change, it is necessary to understand the impacts these changes have to modify the perioperative care to optimize operative success, safety, and patient satisfaction.

The minimally invasive platform for surgical technique has been in progress for many years. The first thoracoscopy was performed by the Irish physician Francis Richard Cruise in 1865. However, it was the Swedish physician H.C. Jacobeus who first described a detailed description of endoscopic techniques using a cystoscope for the diagnosis and treatment of pleural diseases as early as 1910, thus becoming known as the father of thoracoscopy.[1] This device consisted of a long tube with a light at the distal end, and provided only direct line of sight. It had significant limitations in image magnification, operator-only visualization of the surgical field, and limited functionality of surgical instruments.

VIDEO-ASSISTED THORACOSCOPIC SURGERY

With the addition of video imaging systems using xenon-powered 300 W cold light, smaller fiber optic tubes to enhance light transmission, zero to 30° viewing telescopes,

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and cameras with three-chip image processors, the limitations of poor visual field and operator-only viewing were decreased.[2,3] In addition, accompanying instrument functionality was refined and improved significantly. Video-assisted thoracoscopic surgery (VATS) became commonplace in the early 1990s and has progressed to be a valid and commonly chosen option for the treatment of certain pleural space diseases (eg, pneumothorax, chylothorax, hemothorax, empyema), esophageal diseases, mediastinal lesions, and in benign and malignant pulmonary disease (minor [wedge or segmentectomy] or major [lobar]). Proponents of VATS cite smaller wounds, less postsurgical pain, less blood loss, shorter patient hospital stays, and improved survival in patients with non–small-cell lung cancer with comparable or improved surgical results over open thoracotomy techniques.[4–7]

VATS is, however, limited by several significant issues. The two-dimensional image contributes to lack of depth perception. Ergonomically, the surgeon's hands have to move in large motions, counteractive to the direction of the instrument's tip. Movement of the tip is generated by hand motion and that movement, along with any tremor, is accentuated at the device tip. This can make dissection or maneuvering around vulnerable tissues difficult, dangerous, and potentially jeopardize the success of the operation (eg, lymph node and vessel dissections). Also, with VATS, the instruments pivot at the point of insertion in the chest wall, and excess motion and rubbing of the intercostal nerves can contribute to pain at the portal site.

RATS

The robotic platform was introduced, in part, to remedy some of these issues. The da Vinci surgical robotic system (Intuitive Surgical, Sunnyvale, CA, USA) consists of an operating console for the surgeon and a bedside chassis with three or four robotic arms. The console offers high-definition, three-dimensional optics for clear, magnified viewing, and ergonomic controls for the surgeon's hands. An accompanying line of surgical instruments attach to the robotic arms. These devices are jointed, offering superior maneuverability with 7° of freedom in movement of the instrument tip and 360° of rotation. The robotic instruments translate the surgeon's hand movements from the robotic console without need for counteractive adaptation. Robotic arms #1 and #2 represent the surgeon's right and left hands, which allows for bimanual dissection and other coordinated movements. Another robotic arm is used to attach a camera, which the surgeon is able to control directly. With the optional fourth arm, a third device (such as a retractor) can be used simultaneously while still being controlled by the surgeon. Effectively, this provides the operator the ability to navigate through and operate in the confined spaces of the chest, as well as perform more delicate maneuvers, via the minimally invasive approach.

The robotic platform requires a trained assistant at the patient's bedside to facilitate the surgery. The assistant's responsibilities include changing robotic instruments, introducing and removing sutures, and firing the stapler on pulmonary vessels.

DRAWBACKS TO RATS

Similar to robotic applications in other surgical subspecialties, there are several significant hurdles that have made universal use of this device difficult: cost and training. In regard to cost, the capital cost of acquiring the four-arm robot with two consoles is more than $2,000,000. The maintenance contract approaches $100,000 per year. The instruments are about $2000 each and are limited to 10 uses. The noncapital costs include team-training costs, as well as increased operating room times during the learning process.

Park and Flores[8] compared relative costs for thoracotomy lobectomy, VATS lobectomy, and RATS lobectomy. The average VATS lobectomy cost $1479, the RATS