Robotic Pneumonectomy

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KEYWORDS

• Robotic • Pneumonectomy • Video-assisted thoracoscopy • Lung cancer

KEY POINTS

- Pneumonectomy is considered when a lung-preserving operation is deemed inadequate.
- There is little published experience with robotic pneumonectomy.
- Hilar nodal dissection facilitates access to the three main vascular structures with order of division: superior vein, main artery, and inferior vein.
- Robotic pneumonectomy is an advanced robotic procedure that requires considerable prior robotic experience.

INTRODUCTION: NATURE OF THE PROBLEM

Over the last two decades, minimally invasive lobectomy by video-assisted thoracic surgery (VATS) and more recently robotic assistance has become routine in many centers around the world for early stage non–small cell lung cancer. These minimally invasive techniques have been shown to result in improved postoperative outcomes, such as blood loss and length of stay[1]; to provide equivalent oncologic outcomes[2]; and to be superior for elderly patients[3] and those with reduced pulmonary function.[4] Despite this evidence, recent estimates show that 70% of lobectomies for clinical stage I cancers are still performed by thoracotomy in the highly selected Society for Thoracic Surgeon's database[5] and 6% in the Nationwide Inpatient Sample database.[6] Thus, the idea of approaching a patient who may require a pneumonectomy using VATS or robotic-assisted techniques is likely to be met with some skepticism, a lot of vehemence and hesitation, and disapproving looks from many thoracic surgeons.

Although there has been a rapid expansion in the use of robotic-assisted lung resection, the published experience remains small and limited to several pioneering centers. To date the most advanced centers have produced reports on lobectomy[7–11] and segmentectomy.[12] Outside of two case reports[13,14] there have been no published series on robotic pneumonectomy. This article discusses the indications for minimally invasive pneumonectomy; reviews the robotic set up, surgical approaches, and techniques; discusses the potential benefits and disadvantages of the robotic approach; and suggests a future role of robotic pneumonectomy.

SURGICAL TECHNIQUE

Indications and Patient Selection

The indications for pneumonectomy are the same regardless of approach. The two most common include usually a centrally placed non–small cell lung cancer or extensive hilar nodal disease encasing the proximal hilar structures, particularly the pulmonary artery. Other indications such as synchronous, multilobar disease or metachronous disease in the remaining lobe are less common. Our approach to centrally located lesions is to first attempt to perform a lung-preserving operation, such as a bronchial and/or vascular sleeve resection and consider pneumonectomy as a backup option should lung preservation be ruled out as an option during initial exploration. Because of the relatively uncommon absolute indications to perform pneumonectomy and the potential morbidity regardless of approach, patients should be carefully selected

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both from the standpoint of oncologic need and operative risk. As a result, experience with robotic pneumonectomy is and will remain limited. However, there are instances when this procedure may be indicated and performance via a minimally invasive approach may confer significant benefits perioperatively to patients.

Preoperative Planning

Preoperative planning for all of our lung resections is similar and includes diagnostic computed tomography of the chest to include the adrenal glands, combined computed tomography/positron emission tomography imaging, and pulmonary function tests. For centrally placed tumors where there is a possibility of pneumonectomy, these patients undergo magnetic resonance imaging of the brain, quantitative ventilation-perfusion scan when required, and cardiac evaluation with at least echocardiogram. Bronchoscopy with biopsy and mediastinoscopy is typically performed several days before resection. It is our strong preference to have a confirmed tissue diagnosis before exploration in patients where pneumonectomy is a possibility to minimize any need for intraoperative biopsy.

Preparation and Patient Positioning

Patients are positioned similarly to all open or VATS procedures with the patient in lateral decubitus position following endotracheal intubation and establishment of single lung ventilation. For robotic cases, the operating room table is reversed to put the patient's head at the foot of the bed to allow for positioning of the robot and to allow for the patient's hip to be level with the chest or below (Fig. 1). This positioning allows the robotic camera to move freely from anterior to posterior without catching on the hip. Anesthesia is positioned to the face side of the patient to facilitate access to the double-lumen tube and the robot is positioned over the patient's head. If the bed is not reversed, the robot is positioned with the center column just behind the patient's head at an angle of 10 to 45 degrees from the axis of the patient.[13]

Multiple arm set ups for robotic lung resection have been described. The three-arm with utility incision[13] and a completely portal four-arm approach[14] have been used to complete robotic pneumonectomy.

Three-arm set up

The three-arm set up we currently use has the camera arm and robotic arms 1 and 3 with the number 2 arm stored (Fig. 2). The initial 8-mm port is placed in the sixth interspace posterior axillary line and is used with robotic arm 1. Using the robotic 8-mm camera, the remaining ports are placed under direct visualization based on internal anatomy and external position in the following order: 12-mm camera port along the line between the scapular tip and the anterior superior iliac spine to enter the chest at the top of the diaphragm seen internally, which usually coincides with the eighth or ninth interspace and an 8-mm robotic arm 3 inferior and posterior to the scapular tip at the level of the superior segment. A 12-mm laparoscopic port placed in the midaxillary line to enter the chest

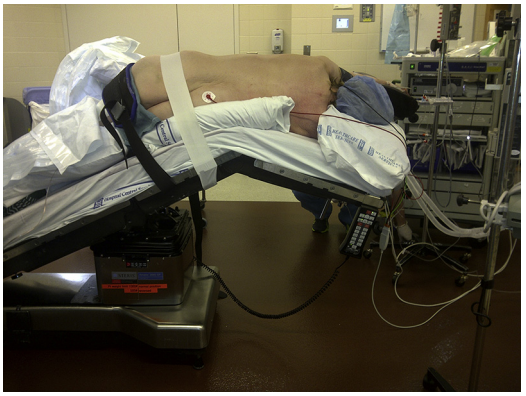

Fig. 1. Patient and table positioning.

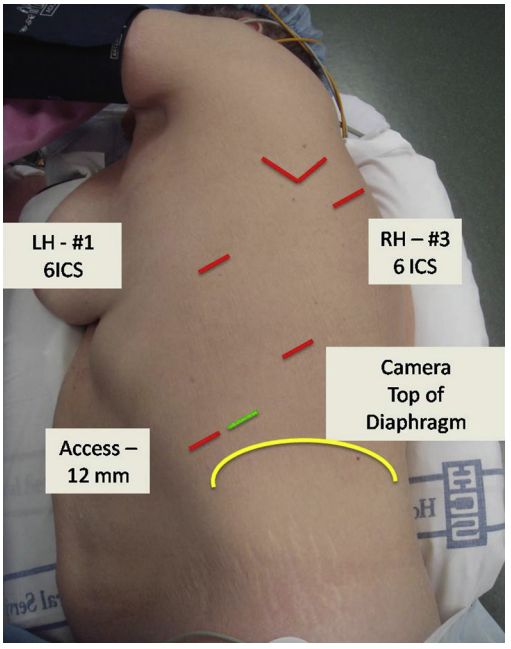

Fig. 2. Sample port placement: three-arm approach. *Yellow curve* indicates the diaphragm, *Red lines* indicates the port sites, *Red "v"* indicates the scapular tip, *Green line* indicates the extension of extraction incision.