Initial consecutive experience of completely portal robotic pulmonary resection with 4 arms

Robert J. Cerfolio, MD, FACS, FCCP, Ayesha S. Bryant, MD, MSPH, Loki Skylizard, MD, and Douglas James Minnich, MD, FACS

Background: Many general thoracic surgeons are learning robotic pulmonary resection.

Methods: We retrospectively compared results of completely portal robot lobectomy with 4 arms (CPRL-4) against propensity-matched controls and results after technical changes to CPRL-4.

Results: In 14 months, 168 patients underwent robotic pulmonary resection: 7 had metastatic pleural disease, 13 had conversion to open procedures, and 148 had completion robotically (106 lobectomies, 26 wedge resections, 16 segmentectomies). All patients underwent R0 resection and removal of all visible lymph nodes (median of 5 N2, 3 N1 nodal stations, 17 lymph nodes). The 106 patients who underwent CPRL-4 were compared with 318 propensity-matched patients who underwent lobectomy by rib- and nerve-sparing thoracotomy. The robotic group had reduced morbidity (27% vs 38%; $P = .05$), lower mortality (0% vs 3.1%; $P = .11$), improved mental quality of life (53 vs 40; $P < .001$), and shorter hospital stay (2.0 vs 4.0 days; $P = .02$). Results of CPRL-4 after technical modifications led to reductions in median operative time (3.7 vs 1.9 hours; $P < .001$) and conversion (12/62 vs 1/106; $P < .001$). Technical improvements were addition of fourth robotic arm for retraction, vessel loop to guide the stapler, tumor removal above the diaphragm, and carbon dioxide insufflation.

Conclusions: The newly refined CPRL-4 is safe and yields an R0 resection with complete lymph node removal. It has lower morbidity, mortality, shorter hospital stay, and better quality of life than rib- and nerve-sparing thoracotomy. Technical advances are possible to shorten and improve the operation. (J Thorac Cardiovasc Surg 2011;142:740-6)

The increasing use of robotic surgical systems worldwide is undeniable. A recent article in *The Wall Street Journal*[1] addressed the problems of learning robotic surgery and also the issue of credentialing for surgeons already in practice. Similarly, an article in *The New England Journal of Medicine*[2] in August 2010 estimated the cost of the expanding use of robotic surgery in other specialties. The benefit that any new surgical technique offers should be demonstrated in carefully designed prospective studies; however, the rapid paradigm shift toward minimally invasive surgery, such as video-assisted thoracoscopic surgery (VATS) and robotic surgery, has occurred without any prospective, randomized trials. The lack of equipoise makes these types of trials unlikely. Robotics is rapidly growing because of the improvements in 3-dimensional visualization, the technical advantages of small-wristed instruments, and the ability to perform an outstanding lymph node dissection. Studies have shown the safety of robotic pulmonary resection, but none have compared outcomes with those of rib-sparing, nerve-sparing thoracotomy.[3-6] In this study, we report our experience with robotic pulmonary resection with a newly modified technique that features a completely portal (all small incisions) 4-arm robotic operation (CPRL-4) with carbon dioxide insufflation and compare the short-term outcomes with those of patients undergoing resection through a rib- and nerve-sparing thoracotomy. Importantly, this is not a selected series but rather a consecutive series of patients who had clinically apparent resectable non–small cell lung cancer. Therefore patients who underwent VATS lobectomy were not chosen as a comparison group, because it was only offered to selected patients (those with tumors <4 cm and without N1 disease).

MATERIALS AND METHODS

This is a retrospective cohort study of a consecutive series of patients entered into a prospective database during a 14-month period who underwent attempted completely portal robotic pulmonary resection. Patients had apparent resectable lesions that were biopsy proven or were highly suspect for non–small cell lung cancer. All operations were performed by

From the Division of Cardiothoracic Surgery, University of Alabama at Birmingham, Birmingham, Ala.

Disclosures: The principle investigator of this study (R.J.C.) has lectured for Intuitive (Sunnyvale, Calif); however, Intuitive had no role in the study design, conduct, data analysis, or drafting of the manuscript or its results. R.J.C. has the following financial relationships: Intuitive, speaker; E Plus Health Care, speaker; Ethicon, speaker and consultant; Neomend, consultant; Millicore, speaker and consultant; Medela, speaker and consultant; Closure/J&J, consultant; OSI Pharm, speaker; Atrium, consultant and speaker; Oncotech, speaker; Covidien, speaker; and Precision, consultant and speaker. A.S.B. and L.S. have no financial disclosures to report. D.J.M. is a consultant and speaker for SuperDimension.

Received for publication March 21, 2011; revisions received June 1, 2011; accepted for publication July 14, 2011; available ahead of print Aug 16, 2011.

Address for reprints: Robert J. Cerfolio, MD, FACS, FCCP, Professor of Surgery, Chief of Thoracic Surgery, JH Estes Family Endowed Chair for Lung Cancer Research, Division of Cardiothoracic Surgery, University of Alabama at Birmingham, 703 19th St S, ZRB 739, Birmingham, AL 35294 (E-mail: rcerfolio@uab.edu).

0022-5223/$36.00

doi:10.1016/j.jtcvs.2011.07.022

Abbreviations and Acronyms

CPRL-4 = completely portal robotic lobectomy with 4 robotic arms
SF-12 = 12-item Short Form Health Survey
VATS = video-assisted thoracoscopic surgery

a single general thoracic surgeon (R.J.C.) at a single academic center. Almost all patients who in the past would have been offered resection through a thoracotomy (patients who had undergone computed tomographic scanning, integrated positron emission tomographic and computed tomographic scanning, and pulmonary function and cardiac stress testing and who were mediastinal [N2] lymph node negative and had adequate cardiopulmonary reserve, as previously described by us[7,8]) were now offered robotic resection. The only patients who were not offered robotic surgery who in the past would have been offered thoracotomy were those who had tumor in the segmental bronchus or more proximal, those who had chest wall involvement that required rib resection, and those who refused a robotic operation. Neither the size of the lesion, its location, the presence of N1 disease, nor the use of preoperative radiation or chemotherapy contraindicated the offer of robotic pulmonary surgery in this study.

The nerve- and rib-sparing thoracotomy that was used in this series for the matched control patients has been previously described by us elsewhere.[9-12] It has been corroborated by other centers as less painful than standard thoracotomy.[13,14] This type of thoracotomy technique was compared with the newly developed completely portal four arm robotic technique (CPRL-4) described in Appendix 1 (Figure 1).

Conversions from a completely portal robotic technique to an open technique were done for several reasons. A time limit of approximately 4 hours (as we learned how to do the operation) was set to prevent patient injury from prolonged anesthesia and to limit both operating room personnel and surgeon frustration. After 4 hours, patients had conversion to open surgery or to VATS if the operation was not near completion. Other indications for opening were bleeding that could not be controlled robotically and the inability to enter the pleural space because of pleural symphysis.

The University of Alabama at Birmingham's institutional review board approved this protocol as well as the prospective database used to collect information for this study. Patient consent was waived for inclusion in this individual study; however, consent was both required and obtained to enter patient data into the prospective database.

Definitions

Morbidity was defined according to The Society of Thoracic Surgeons database's definitions (version 2.8), with the exception of air leak. Operative mortality was defined as death from any cause within 30 days after surgery or before discharge. The operative time was defined as the time from skin incision until skin closure and thus included all robotic docking and undocking times, along with time spent waiting for frozen-section analysis. A numeric pain score was assessed on a scale ranging from 0 (no pain) to 10 (extreme pain). Quality of life was defined as the subject's functioning and well-being in the physical, psychologic, and social domains in relation to disease and treatment. In this study, the participants' quality of life was measured with the 12-item Short Form Health Survey (SF-12) with supplemental questions about pain control.[15] The SF-12, a validated shorter alternative to the 36-item survey, consists of a physical component summary and a mental component summary.[16-18] Subjects completed the SF-12 preoperatively and at both 3 weeks and 4 months postoperatively either at a clinic appointment or by mail. SF-12 scores were computed separately for the physical and mental components of the survey and compared with adjusted values, with 50 representing the average or norm-based score. Quality of life information was obtained from patients at both 3 weeks and 4 months after surgery.

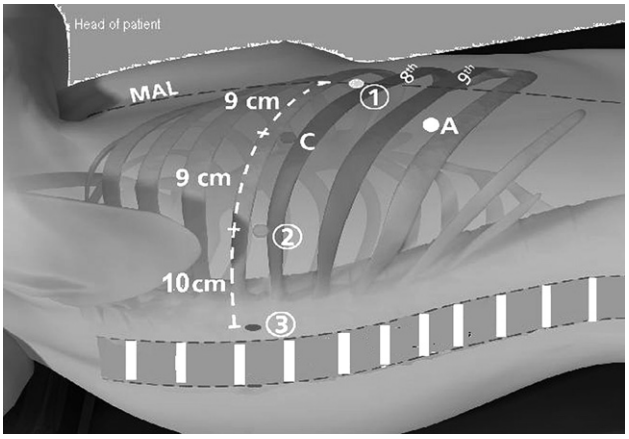

FIGURE 1. The completely portal robotic lobectomy with 4 robotic arms technique developed in this study is shown. It features entering the pleural space with a 5-mm port anteriorly in the midaxillary line *(MAL)* over the top of the 7th rib and then using a 5-mm video-assisted thoracoscopic surgery camera to enable the surgeon to make all other incisions on the basis internal anatomy. The *circled numbers* represent the robotic arms used, *C* indicates the camera port, and *A* indicates the 15-mm access port (which can also be placed between the camera and robotic arm 2 if space is not adequate more anteriorly). Note that robotic arm 3 is a 5-mm port, robotic arm 2 is an 8-mm port, the camera can be an 8- or 12-mm port, depending on the camera used, and robotic arm 1 is a 12-mm port. The area with the *dashed lines* is the area in which no incisions are made and is the most posterior third of the area between the mid spine and the posterior edge of the scapula.

Statistical Analysis

Data were exported from Excel (Microsoft Corp, Redmond, Wash) to SAS v. 9.1 (SAS Institute, Inc, Cary, NC) software. Descriptive statistics were used to estimate the frequencies of the categoric variables and the medians of the continuous variables. Differences between study groups were assessed with the use of 2-sided Fisher's Exact tests and χ^2 tests for categoric variables and of independent sample Student *t* tests for normally distributed continuous variables.

Propensity score analysis was carried out in this study to estimate the probability that a patient might undergo a robotic procedure versus thoracotomy to eliminate the effects of lack of randomization and selection bias.[19] A logistic regression analysis of several preoperative variables (laterality of tumor, preoperative Eastern Cooperative Oncology Group performance status, sex, age [± 5 years], forced expiratory volume in 1 second [± 5%], smoking status, history of neoadjuvant therapy, and size of the tumor resected) was performed to generate a single propensity score for each patient. Patients selected for matching were selected from a database of more than 3000 patients (595 elective lobectomies) operated on between 2006 and 2009 by the same general thoracic surgeon who performed all the robotic operations, CPRL-4 procedures, and thoracotomies in this study (R.J.C.).

RESULTS

Between February 2010 and April 2011, a total of 168 patients underwent attempted robotic pulmonary resection for clinically staged resectable disease. There were 55 patients