Robotic Lobectomy

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Outline

- Background
- Technical Details of Robotic Lobectomy
  › SI Robot
  › XI Robot
- Outcomes
  › Comparison with VATS
Robotic Features

- 3-dimensional camera system gives a more superior and stable image to the surgeon
- 7 degrees of freedom of the EndoWrist robotic instruments allows truly intuitive bimanual dissection of hilar structures
Getting Started With Robotics

- Case observations
- Cadaver training
  › Include the planned bedside assistant
- OR team training
  › Nurses, surgical technicians
- Proctored cases
- Learning curve
  › Experienced, consistent bedside assistant
History of Robotic Lobectomy

- 2002-2004: Several small series reported (1-5 patients)
- 2006: Memorial Sloan-Kettering published results for their first 34 patients
- 2009-2011: Results of several larger series reported (100-200 patients)
- 2012-: Multicenter and Database studies published (1000s of patients)
Robotic assistance for video-assisted thoracic surgical lobectomy: Technique and initial results

Bernard J. Park, MD, Raja M. Flores, MD, and Valerie W. Rusch, MD

Objectives: There is little experience with telerobotic assistance for video-assisted thoracic surgical lobectomy. We developed a technique for robotic assistance during video-assisted thoracic surgical lobectomy and report our initial results.

Methods: Video-assisted thoracic surgical lobectomy with the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, Calif) was attempted in 34 patients (median age, 69.0 years; age range, 12-85 years). Robotic instruments were used for individual dissection of the hilar structures through 2 thorascopic ports and a 4-cm utility incision without rib spreading. Data on patient characteristics and perioperative results were collected prospectively.

Results: Robot-assisted video-assisted thoracic surgical lobectomy was accomplished in 30 patients (19 female and 11 male patients). Every type of lobectomy was performed. Four (4/34 [12%]) patients required conversion to thoracotomy. The majority of patients had non–small cell lung cancer (32/34 [94%]), and 1 patient each had a typical carcinoid tumor and an extranodal B-cell lymphoma. Every patient underwent an R0 resection. The median number of lymph node stations dissected with robotic assistance was 4 (range, 2-7). Operative mortality was 0%, with no in-hospital or perioperative deaths. Nine (26%) patients experienced National Cancer Institute Common Toxicity Criteria for Adverse Events version 3.0 grade 2 or 3 complications. The median chest tube duration was 3.0 days (range, 2-12 days), and the median length of stay was 4.5 days (range, 2-14 days). The median operative time was 218 minutes (range, 155-350 minutes).

Conclusions: Robot assistance for video-assisted thoracic surgical lobectomy is feasible and safe. The utility and advantages of robotic assistance for video-assisted thoracic surgical lobectomy require further refinement and study of the technique.

<table>
<thead>
<tr>
<th>TABLE 1. Patient characteristics and perioperative results (n = 34)</th>
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<tbody>
<tr>
<td>(Median age (y))</td>
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<tr>
<td>M/F sex</td>
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<tr>
<td>Tumor location</td>
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<tr>
<td>RUL</td>
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<td>LUL</td>
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<td>LLL</td>
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<td>RLL</td>
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<tr>
<td>RML</td>
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<tr>
<td>Median tumor diameter (cm)</td>
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<td>Tumor histology</td>
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<tr>
<td>NSCLC</td>
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<tr>
<td>Typical carcinoid</td>
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<tr>
<td>MALT</td>
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<tr>
<td>Pathologic stage (NSCLC, n = 32)</td>
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<tr>
<td>T1 N0 M0 (IA)</td>
</tr>
<tr>
<td>T2 N0 M0 (IB)</td>
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<tr>
<td>T1 N1 M0 (IIA)</td>
</tr>
<tr>
<td>T2 N1 M0 (IIB)</td>
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<tr>
<td>Median operative time (min)</td>
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<td>Median room time (min)</td>
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<tr>
<td>Median chest tube duration (d)</td>
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<td>Median length of stay (d)</td>
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<tr>
<td>Postoperative complications (n = 9, 26%)</td>
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<tr>
<td>Supraventricular arrhythmia</td>
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<tr>
<td>Hemorrhage</td>
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<tr>
<td>Myocardial infarction</td>
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<td>Prolonged air leak</td>
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Robotic Lobectomy for Non-small Cell Lung Cancer (NSCLC): Long-term Oncologic Results

Park et al, Presented at the 2011 AATS

- 325 patients at 3 institutions
  - 310 clinical stage I
- Median operative time of 206 minutes (110-383)
- Median length of stay of 5 days
- 25% with complications (21.5% minor, 3.7% major), 1 peri-operative mortality
- Long-term outcomes consistent with VATS and thoracotomy series
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 prospectively compared results of completely portal robotic 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 30%; P = .005), lower mortality (0% vs 3.1%; P = .11), improved mental quality of life (5 vs 10; 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)

| Table 2. Comparison of the outcomes of the 106 patients who underwent completely portal robotic lobectomy with 4 robotic arms compared with 318 patients (matched controls) who underwent open lobectomy with rib- and nerve-sparing thoracotomy |
|------------------|-----------------|-----------------|-----------------|-----------------|
|                  | Robotic operation (N = 106) | Rib- and nerve-sparing thoracotomy (N = 318) | P value         |
| Estimated blood loss (mL, median ± SD) | 30 ± 26 | 90 ± 22 | .03 |
| Operative time (h, median ± SD)       | 2.2 ± 1.0 | 1.5 ± 0.8 | <.001 |
| No. of mediastinal (N2) lymph node stations removed (median) | 5 | 5 | >.999 |
| No. of mediastinal (N2) lymph nodes removed (median) | 12 | 11 | .906 |
| No. of N1 lymph node stations removed (median) | 3 | 3 | >.999 |
| No. of N1 lymph node removed (median) | 5 | 4 | .89 |
| Chest tube duration (d, median and range) | 1.5 (1-6) | 3.0 (1-6) | .001 |
| Hospital stay (d, median and range) | 2.0 (1-7) | 4.0 (1-6) | .01 |
| Morbidity (no.) | 28 (27%) | 120 (38%) | .05 |
| Operative mortality (no.) | 0 | 11 (3%) | .11 |
| Verbal pain score 3 wk postoperatively (median and range) | 2.5 (0-7) | 4.4 (0-8) | .04 |
Nationwide Assessment of Robotic Lobectomy for Non-Small Cell Lung Cancer

Ravi Rajaram, MD, MSc, Sanjay Mohanty, MD, MS, David J. Bentrem, MD, Emily S. Pavey, MA, David D. Odell, MD, MMSc, Ankit Bharat, MD, Karl Y. Bilimoria, MD, MS, and Malcolm M. DeCamp, MD

62,206 Lobectomies in the NCDB (2010-12)
45,527 open
12,990 VATS
3,689 robotic

Ann Thorac Surg 2017;103:1092–100

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SI Robot
Patient and Robot Setup

- Lung isolation with double lumen endotracheal tube
- Patient in lateral decubitus position
- Place ports
- Position robot arms
  - Attain “sweet spot” to maximize range of motion
  - Align camera arm
- Roll in cart and dock robot
  - 1st camera and then other arms
Lobectomy Port Placement

- Several methods of port placement can be utilized
- Camera port placed in the 8th-9th intercostal space in the posterior axillary line
  - In general, instrument ports (#s 1 & 2) must be a hands-breadth away from the camera port
    - One robot port placed one hands-breadth anteriorly in the 5th-6th intercostal space
    - Second robot port placed one hands-breadth posteriorly and superiorly in approximately the seventh intercostal space
- Can setup the 4th arm (robot arm #3) to perform retraction
- 12 step port placed between the anterior incision and the camera in the 8th-10th intercostal space
  - Bag placed through this port to retrieve the specimen at the end of the case
System Position
Left Lower Lobectomy
Another Stapler Passing Method
XI Robot

- Docking from the Side
- More stapler options:
  - No vascular staplers or 30mm staplers for the SI
  - Bedside assistant has somewhat less active role.
- Less arm collisions than SI
  - XI instruments are longer (2 inches) and thinner than Si instruments
  - XI allows maneuvering and dropping of the patient clearance joints
  - Can move from the inferior pulmonary ligament to the apex
- XI allows port hopping for the scope since all ports are 8 mm ports with no dedicated camera arm.
- The consoles are pretty much unchanged between the Si and Xi, other than the software.
  - On the Xi, the surgeon can now change their own cautery settings rather than relying on the circulator to change them.
XI Robotic Lobectomy Port Placement

- Place camera port (size 8) in the 7th intercostal space at the anterior axillary line.
- Place another size 8 port as posteriorly as possible in the 7th or 8th space.
- Place another port in between these two. Needs to be a size 12 port if plan to staple from here.
- Place another port more anteriorly in the 7th space. Needs to be a size 12 port if plan to staple from here.
- A 12 step port more inferiorly, usually in the 10th intercostal space.
XI Robotic Middle Lobectomy
Robotic Advantages Over VATS

- **3D/HD visualization & 10x magnification**
  - Surgeon drives camera

- **Better instrumentation: endo-wrist technology**
  - More degrees hand movement – more precise dissection
  - Easier (?) better) lymph node dissection

- **Less pain?, Shorter hospital stay?**

- **More ergometric (surgeon is seated)**

- **More proficient self assistance**
  - 2 free hands to do procedure
  - An additional robot arm can be used to retract

- **Easier to demonstrate/teach?**
Disadvantages

- The robot is a limited and expensive resource
  - Initial capital investment
  - Annual maintenance costs
  - Disposable materials (instruments and drapes)
- Less versatile than VATS
  - How to handle unexpected findings, other lesions
- Technology eliminates both tremor and tactile feedback
- Robotic instruments generally not specifically designed for thoracic surgery
  - Only 1 robot company
- Although surgeon is more independent in terms of dissection, assistants remain very important
  - Provide lung retraction and suction when necessary
  - Placement of staplers
    - Ideally, assistants are familiar with conventional VATS lobectomy techniques and can control bleeding
Robotic-Assisted, Video-Assisted Thoracoscopic and Open Lobectomy: Propensity-Matched Analysis of Recent Premier Data

23,779 Elective Lobectomies 2011-2015
2,994 Robotic
9,360 VATS
11,425 Open

<table>
<thead>
<tr>
<th></th>
<th>Robotic (n=2951)</th>
<th>VATS (n=2951)</th>
<th>p-value</th>
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<tr>
<td>OR Time</td>
<td>275 minutes</td>
<td>247 minutes</td>
<td>&lt;0.0001</td>
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<tr>
<td>Conversion</td>
<td>6.3%</td>
<td>13.1%</td>
<td>&lt;0.0001</td>
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<tr>
<td>Morbidity</td>
<td>34.1%</td>
<td>37.6%</td>
<td>0.006</td>
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<tr>
<td>Length of Stay</td>
<td>5 days</td>
<td>6 days</td>
<td>0.006</td>
</tr>
<tr>
<td>30-Day Mortality</td>
<td>1.2%</td>
<td>1.4%</td>
<td>0.6</td>
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Long-term Survival Based on the Surgical Approach to Lobectomy For Clinical Stage I Nonsmall Cell Lung Cancer

Comparison of Robotic, Video-assisted Thoracic Surgery, and Thoracotomy Lobectomy

470 patients 2002-2012
- 172 Robotic
- 141 VATS
- 157 Open

Lymph Node Stations
- 5 Robotic
- 4 Open
- 3 VATS

Length of Stay
- 4 Robotic
- 4 VATS
- 5 Open
Use and Outcomes of Minimally Invasive Lobectomy for Stage I Non-Small Cell Lung Cancer in the National Cancer Data Base

30,040 lobectomies 2010-2012
   7,824 VATS
   2,025 Robotic

Robotic and VATS outcomes
   Similar:
      Nodal upstaging
      30-day mortality
      2-year survival
   Similar benefits compared to open
   Shorter length of stay (5 vs 6 days)
Summary

A robotic approach is an excellent way to perform a minimally invasive lobectomy.

Short-term benefits over an open approach.

Probably equivalent benefits to a VATS approach.

- Likely easier for traditionally open surgeons to transition to a robotic approach than a VATS approach.
- More important for a robotic approach to have a consistent bed-side and peri-operative team.