Disclosure Slide

• Consultant for Mallincrodt and Quark Pharmaceuticals
Robotic Thoracic Surgery

• Yesterday and Today
• Tomorrow
• How do we get to tomorrow?
Robotic Thoracic Surgery Yesterday

OBJECTIVE:
Recently, robots have been introduced into surgical procedures in an attempt to facilitate surgical performance. The purpose of this study was to develop a technique to perform thoracoscopic lung resection using a telemanipulation system.

METHODS:
We have used a robotic system to perform thoracoscopic surgery in 12 cases: five lobectomies, three tumor enucleations, three excisions and one bulla stitching completed with fibrin glue for spontaneous pneumothorax. The operations were performed using the Intuitive Microsurgical system (Da Vinci System) through three ports and a fourth space 'service entrance' incision, in the major lung resection.

Robotic Thoracic Surgery Yesterday

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

FIGURE 2. Median operative times (skin incision to skin closure) for completed completely portal robotic lobectomy with 4 robotic arms (CPRL) with time in sequential order.

J Thorac Cardiovasc Surg 2011;142:740-6
Nationwide Assessment of Robotic Lobectomy for Non-Small Cell Lung Cancer

Fig 1. Use of open, video-assisted thoracic surgery (VATS), and robotic lobectomy (2010 to 2012). *Significant increase in robotic lobectomy from 3.0% to 9.1% between 2010 and 2012 (p < 0.001).
Nationwide Assessment of Robotic Lobectomy for Non-Small Cell Lung Cancer

Table 2. Number of Hospitals Performing at Least One Robotic Lobectomy Over Time

<table>
<thead>
<tr>
<th>Variable</th>
<th>2010 (n = 1,215)</th>
<th>2011 (n = 1,215)</th>
<th>2012 (n = 1,215)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitals, No. (%)</td>
<td>153 (12.6)</td>
<td>203 (16.7)</td>
<td>255 (21.0)</td>
</tr>
<tr>
<td>Volume of robotic cases, median (IQR)</td>
<td>2 (1–4)</td>
<td>3 (1–7)</td>
<td>4 (1–9)</td>
</tr>
</tbody>
</table>

IQR = interquartile range.
# Nationwide Assessment of Robotic Lobectomy for Non-Small Cell Lung Cancer

## Table 4. Comparison of Outcomes in Unmatched Open, Video-Assisted Thoracic Surgery, and Robotic Lobectomy Patients

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Open</th>
<th>VATS</th>
<th>Robotic</th>
<th>p Value&lt;sup&gt;a&lt;/sup&gt;</th>
<th>p Value&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital LOS, mean (SD), d</td>
<td>7.4 (6.7)</td>
<td>6.0 (6.3)</td>
<td>6.1 (5.5)</td>
<td>&lt;0.001</td>
<td>0.025</td>
</tr>
<tr>
<td>Prolonged LOS, No. (%)</td>
<td>3,467/43,405 (8.0)</td>
<td>600/12,604 (4.8)</td>
<td>210/3,570 (5.9)</td>
<td>&lt;0.001</td>
<td>0.007</td>
</tr>
<tr>
<td>Lymph nodes examined, mean (SD), No.</td>
<td>9.6 (7.4)</td>
<td>10.8 (8.6)</td>
<td>9.9 (7.3)</td>
<td>0.003</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≥12 lymph nodes examined, No. (%)</td>
<td>12,582/42,601 (29.5)</td>
<td>4,199/11,877 (35.4)</td>
<td>1,096/3,423 (32.0)</td>
<td>0.002</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Positive surgical margin, No. (%)</td>
<td>2,333/45,527 (5.1)</td>
<td>500/12,990 (3.8)</td>
<td>125/3,689 (3.4)</td>
<td>&lt;0.001</td>
<td>0.194</td>
</tr>
<tr>
<td>30-day unplanned readmission, No. (%)</td>
<td>2,011/45,342 (4.4)</td>
<td>651/12,969 (5.0)</td>
<td>150/3,680 (4.1)</td>
<td>0.308</td>
<td>0.018</td>
</tr>
<tr>
<td>30-day mortality, No. (%)</td>
<td>1,070/43,791 (2.4)</td>
<td>189/12,432 (1.5)</td>
<td>58/3,429 (1.7)</td>
<td>0.006</td>
<td>0.474</td>
</tr>
<tr>
<td>90-day mortality, No. (%)</td>
<td>2,013/42,334 (4.8)</td>
<td>349/11,943 (2.9)</td>
<td>97/3,238 (3.0)</td>
<td>&lt;0.001</td>
<td>0.826</td>
</tr>
</tbody>
</table>

*<sup>a</sup> Obtained using ANOVA<sup>1</sup> for continuous variables and a chi-square test for categorical variables.

*<sup>b</sup> Corrected for baseline differences using a linear regression model.
Robotic Thoracic Surgery: Today

dV adoption in Lobectomy
Premier 2009-2016E

[Graph depicting adoption rates of different surgical methods]

Courtesy of Intuitive
E V O L U T I O N  O F  M I S  T E C H N O L O G Y

1999
- da Vinci®
  - Eliminates lap compromises
  - Simple instruments

2006
- da Vinci® Si™
  - 3D HD Vision (720p)
  - Cross-quadrant access
  - Streamlined set-up

2009
- da Vinci® Si™
  - Dual Console option
  - Enhanced HD Vision (1080i)
  - Upgradable architecture

2014
- da Vinci® Xi™
  - Multi-quadrant access
  - Crystal clear 3D HD vision
  - Platform for future technologies

- FIREFLY™ (EXPECTED MID 2014)
- XI SKILLS SIMULATOR™ (AVAILABLE NOW)
- INTEGRATED ENERGY (AVAILABLE NOW)
- VESSEL SEALER (AVAILABLE NOW)
- STAPLER (EXPECTED MID 2014)
- FUTURE INNOVATION SINGLE PORT SURGERY

ADVANCED INSTRUMENTATION
- SINGLE-SITE™
- SKILLS® SIMULATOR™
- ADVANCED INSTRUMENTATION
da Vinci X Surgical System

Lower-cost, robotic-assisted surgical option for hospitals, surgeons

Q2 2017 510(k) clearance and CE Mark authorization

- Optimized for focused-quadrant surgery for procedures, including prostatectomy, hernia repair, and benign hysterectomy
- Incorporates da Vinci Xi endoscope technology, instruments, and accessories
- Provides access to latest vessel sealing and stapling technology
- Upgrade pathway to da Vinci Xi and SP
da Vinci Single Port (SP)

Less Invasive Approaches to the Body

da Vinci SP

Not yet FDA cleared in the US.
Robotic Bronchoscopy

Less Invasive Approaches to the Body

Flexible catheter based system: Fosun Pharma JV

Distance 164.8mm

Not yet FDA cleared in the US.
Click on a feature icon
TransEnterix
TransEnterix

EYE-SENSING CAMERA CONTROL
TransEnterix

SECURITY OF HAPTIC FORCE FEEDBACK
VERB Surgical
Medtronic accelerates investment in robotic surgery firm Mazor

Device maker is exclusive distributor for Mazor's robotics spine systems.

By Joe Carlson Star Tribune | SEPTEMBER 1, 2017 — 8:56PM

Medtronic is now selling robotic surgical systems.
Robotic Thoracic Surgery: How do we get to tomorrow?

• Training
• Starting a program
• Quality and credentialing
Robotic Thoracic Surgery: Training
Robotic Thoracic Surgery: Training
Robotic Thoracic Surgery: Training

Navigating the Pathway to Robotic Competency in General Thoracic Surgery

Christopher W. Seder, MD, Stephen D. Cassivi, MD, and Dennis A. Wigle, MD, PhD


**FIGURE 1.** Triphasic pathway for development of robotic competency. Lab indicates laboratory.
ROBOTIC TRAINING NETWORK

This network is led by a multidisciplinary team of surgeons who are also Fellows in the American College of Surgeons (FACS) and the American Congress of Obstetricians and Gynecology (FACOG).

LEARN MORE >>

FUNDAMENTALS OF ROBOTIC SURGERY

ISE wants to recognize and support the efforts of the Fundamentals of Robotic Surgery (FRS), a multi-specialty, proficiency-based curriculum to help surgeons safely and efficiently perform robotic-assisted surgery.

LEARN MORE >>

ROBOTIC REGISTRY

The new era of information science has resulted in immediate availability, analysis and sharing of real world data (RWD) that is available at the time of the occurrence – at the pace of innovation and change.

LEARN MORE >>
Welcome to the Robotic Training Network

Please sign in below to access the online curriculum
Fundamentals of Robotic Surgery (FRS)

- Develop a validated multi-specialty, technical skills competency based curriculum for surgeons to safely and efficiently perform basic robotic-assisted surgery.
- Proficiency-based progression model
Starting a Robotic Program in General Thoracic Surgery: Why, How, and Lessons Learned

Robert J. Cerfolio, MD, Ayesha S. Bryant, MD, and Douglas J. Minnich, MD

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of Robot Cases</th>
<th>Number of Total Cases</th>
<th>Percent of Total Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb-09</td>
<td>1</td>
<td>87</td>
<td>1%</td>
</tr>
<tr>
<td>Mar-09</td>
<td>1</td>
<td>90</td>
<td>1%</td>
</tr>
<tr>
<td>Apr-09</td>
<td>0</td>
<td>84</td>
<td>0%</td>
</tr>
<tr>
<td>May-09</td>
<td>0</td>
<td>68</td>
<td>0%</td>
</tr>
<tr>
<td>Jun-09</td>
<td>3</td>
<td>111</td>
<td>3%</td>
</tr>
<tr>
<td>Jul-09</td>
<td>5</td>
<td>87</td>
<td>6%</td>
</tr>
<tr>
<td>Aug-09</td>
<td>8</td>
<td>91</td>
<td>9%</td>
</tr>
<tr>
<td>Sep-09</td>
<td>4</td>
<td>79</td>
<td>5%</td>
</tr>
<tr>
<td>Oct-09</td>
<td>2</td>
<td>82</td>
<td>4%</td>
</tr>
<tr>
<td>Nov-09</td>
<td>2</td>
<td>57</td>
<td>3%</td>
</tr>
<tr>
<td>Dec-09</td>
<td>4</td>
<td>62</td>
<td>6%</td>
</tr>
<tr>
<td>Jan-10</td>
<td>12</td>
<td>68</td>
<td>11%</td>
</tr>
<tr>
<td>Feb-10</td>
<td>11</td>
<td>105</td>
<td>13%</td>
</tr>
<tr>
<td>Mar-10</td>
<td>11</td>
<td>82</td>
<td>12%</td>
</tr>
<tr>
<td>Apr-10</td>
<td>10</td>
<td>96</td>
<td>13%</td>
</tr>
<tr>
<td>May-10</td>
<td>13</td>
<td>81</td>
<td>14%</td>
</tr>
<tr>
<td>Jun-10</td>
<td>18</td>
<td>90</td>
<td>14%</td>
</tr>
<tr>
<td>Jul-10</td>
<td>18</td>
<td>63</td>
<td>27%</td>
</tr>
<tr>
<td>Aug-10</td>
<td>19</td>
<td>75</td>
<td>24%</td>
</tr>
<tr>
<td>Sep-10</td>
<td>20</td>
<td>79</td>
<td>24%</td>
</tr>
</tbody>
</table>

Fig 2. Number of robotic operations performed per month by one surgeon and as a growing percentage of his practice.

## Starting a Robotic Program in General Thoracic Surgery: Why, How, and Lessons Learned

Robert J. Cerfolio, MD, Ayesha S. Bryant, MD, and Douglas J. Minnich, MD

### Table 5. Lessons Learned: Common Problems and Modifications and Solutions

<table>
<thead>
<tr>
<th>Problem</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robotic arms hitting</td>
<td>Make each port at least 8- to 9-cm apart, use arm 3 for the posterior port, dock using camera sweet spot</td>
</tr>
<tr>
<td>Cannot take down inferior pulmonary ligament without repositioning camera</td>
<td>Place robotic camera port no higher than the 8th intercostal space</td>
</tr>
<tr>
<td>Exposures is difficult, reliant on bedside assistant (via 15-mm port) who is different each case</td>
<td>Use robotic arm 3 as the posterior port and use it to retract the lung using a 5-mm bowel grasper</td>
</tr>
<tr>
<td>Stapling the fissure is more difficult than open</td>
<td>Ensure surgeon’s view on console is set to “wide,” pull camera back into trocar for more panoramic view</td>
</tr>
<tr>
<td>Small bleeding prevents visualization and suction removes CO₂ and decreases visibility</td>
<td>Remove blood using rolled-up sponges—activate sucker only when submerged under blood, use fenestrated bipolar instrument for hemostasis</td>
</tr>
<tr>
<td>One surgeon operates while the other watches</td>
<td>The attending surgeon can assist and proctor the resident using robotic arm 3, while the resident uses arms 1 and 2 to dissect, if duel consoles are available</td>
</tr>
<tr>
<td>Vessels stapling is performed by the assistant and is dangerous</td>
<td>Test the ideal port to introduce the vascular stapler, using the straight robotic arms as a guide—use a vessel loop to guide stapler placement—awaiting robotic stapler</td>
</tr>
<tr>
<td>Costs are high</td>
<td>Minimize costs by using reusable metal instead of plastic ports, only 3 to 4 robotic instruments are needed per operation, clip small PA branches instead of using a stapler</td>
</tr>
</tbody>
</table>

Robotic Thoracic Surgery: Quality and Credentialing

Robotically Assisted vs Laparoscopic Hysterectomy Among Women With Benign Gynecologic Disease

Jason D. Wright, MD
Cande V. Ananth, PhD, MPH
Sharyn N. Lewin, MD
William M. Burke, MD
Yu-Shiang Lu, MS
Alfred I. Neugut, MD, PhD
Thomas J. Herzog, MD
Dawn L. Hershman, MD

Importance Although robotically assisted hysterectomy for benign gynecologic conditions has been reported, little is known about the incorporation of the procedure into practice, its complication profile, or its costs compared with other routes of hysterectomy.

Objectives To analyze the uptake of robotically assisted hysterectomy, to determine the association between use of robotic surgery and rates of abdominal and laparoscopic hysterectomy, and to compare the in-house complications of robotically assisted hysterectomy vs abdominal and laparoscopic procedures.


JAMA. 2013;309(7):689-698
Robotic Thoracic Surgery: Quality and Credentialing

Comparative Effectiveness Research on Robotic Surgery

Joel S. Weissman, PhD
Michael Zinner, MD

The study by Wright et al leaves some important unanswered questions. Robotic surgery may have a shorter learning curve than laparoscopic surgery, making it an...
ROBOTIC REGISTRY CONSENSUS CONFERENCE
September 22-23, 2016

Florida Hospital Nicholson Center
Celebration, Florida

Summary Report
Crowdsourcing Robotic Surgical Skills: C-SATS

What is C-SATS?

How it Works

C-SATS is an online service for skills improvement via inter-operative video review.

How it Works

1. Performance Capture
2. Objective Reviews
3. Continuous Improvement

STEP 1
STEP 2
STEP 3
Surgical Skill and Complication Rates after Bariatric Surgery

John D. Birkmeyer, M.D., Jonathan F. Finks, M.D., Amanda O'Reilly, R.N., M.S., Mary Oerline, M.S., Arthur M. Carlin, M.D., Andre R. Nunn, M.D., Justin Dirmick, M.D., M.P.H., Mousumi Banerjee, Ph.D., and Nancy J.O. Birkmeyer, Ph.D., for the Michigan Bariatric Surgery Collaborative

- 20 Bariatric Surgeons
- Single Gastric Bypass Video
- Review by 10 Peers
- Various Surgical Skills Domains

**Better Score = Better Outcomes**

New Engl J Med 2013;369; 1434-1442
Figure 2. Risk-Adjusted Complication Rates with Laparoscopic Gastric Bypass, According to Quartile of Surgical Skill.
Crowdsourcing: a valid alternative to expert evaluation of robotic surgery skills

Michael R. Polin, MD; Nazema Y. Siddiqui, MD, MHSc; Bryan A. Comstock, MS; Helai Hesham, MD; Casey Brown, DO; Thomas S. Lendvay, MD; Martin A. Martino, MD
C-SATS Example:

Overall Case Score

20.0/25

Our heatmap shows you at a glance where most comments are. Watch the relevant portions of the video and view related comments.

Neurovascular Bundle Dissection

The Neurovascular Bundle Dissection step of your case scored 19.5

<table>
<thead>
<tr>
<th>Depth Perception</th>
<th>Bimanual Dexterity</th>
<th>Efficiency</th>
<th>Force Sensitivity</th>
<th>Robotic Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8</td>
<td>4.2</td>
<td>3.9</td>
<td>3.5</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Overall In preparation for an effective and efficient NVB dissection I find that a complete and extensive dissection posterior to prostate and anterior to rectum sets up for a cleaner dissection. Isolation of the prostatic pedicles is easier so that often only 3 clips are required on each side. the retraction of the gland is good in this case giving a nice view of the NVB. I also thought that the surgeon was calm when bleeding occurred and was able to avoid the use of electrocautery.

Force Sensitivity Very rough on the right side and along the right posterolateral dissection. This contributed to the planes not coming off well.
Example of Single Surgeon Performance

Surgical Performance Score

Average Score: 20.4

OCT Overall Results:
- Score: 23.5
- Percentile: 90%

Depth Perception

Opportunity Skill: Bimanual Dexterity

How this video compares

About this graph
Operative Events

• Single lumen ETT
• VV ECMO 4-4.5 L
  – Venous drainage
    • 19 fr arterial cannula RIJ to SVC/RA junction
    • 21 fr multistage venous cannula LFV to IVC
  – ”Arterial” return
    • 21 fr single stage venous cannula RFV to RA
• Right posterolateral thoracotomy
Conclusions

• Robotic technologies have progressed over the last 15 years
• The future continues to look bright for the use of robotics in Cardiothoracic Surgery
• Training, credentialing, and evidence of cost-effectiveness remain areas for improvement