ROBOTICS IN THORACIC SURGERY
Advances in Minimally Invasive Surgery

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Surgical Approaches

• **Trans-thoracic**
  – Conventional thoracotomy
  – **Minimal access** (mini-thoracotomy w/ video-assistance)
    » Most commonly performed video assisted technique
  – Video-assisted thoracic surgery (VATS)
  – Robotic VATS
Conventional Open Surgery

- **Standard of Care for early-stage NSCLC**
  - Thoracotomy
  - Anatomical lobectomy
  - Systematic lymphadenectomy

- **Traditional approach**
  - Rib spreading thoracotomy remains most common approach (State Inpatient Database
    - 61% thoracotomy
    - 37.5% VATS
    - 1.3% robotic (Kent et al, Ann Thor Surg 2014)
Introduction

• Traditional approach
  – Improved safety
  – Superior oncological control
  – Associated excessive chest wall trauma
    » Increasing the morbidity and mortality

• Advantages of VATS
  – Length of Stay 4.4 vs 11 days (McKenna, 1999)
  – Reduced post-op pain - equivalent at 2 wks (Nomori, 2000)
  – Improved post-op PFT’s over thoracotomy (Kaseda, 2000)
  – Improved compliance with adjuvant therapy (Patterson, 2007)
  – Cosmetically appealing
Introduction

- Lack of adoption of VATS (Mack, 1997)
  - Multi-factorial
    » Oncological control
    » Limited instrumentation
    » Operative times
    » Insufficient training and experience
Features of the VATS Platform

- VATS - not the “preeminent technology”
  - Counter-intuitive orientation
  - 2-Dimensional imaging
  - Reduced depth perception
  - Limited instrument maneuverability

- Elevate concerns:
  - Maintaining oncological principles
  - Sudden hemorrhage
  - Inability to control hemorrhage
What is Robotic Surgery?
Why use it?
Improvement of mechanical tools?
Leonardo da Vinci

- Advanced the study of human anatomy
- Extremely detailed anatomical drawings
- Comprehensive work of human and comparative anatomy
Leonardo da Vinci
Da Vinci’s Concepts

• Human body is a machine in structure, a chemically based machine
• Intricate movements could be imitated with the use of engineering machine parts such as levers and pulleys
Leonardo’s Robot

- Displayed in Court of Milan 1495
- First human robot
- Capability
  - walk, stand and sit
  - Open and close its mouth
  - Move its head side to side

Modern re-creation of da Vinci robot and inner workings
Concept of telerobotic surgery

- Developed with grants from the United States Department of Defense
- The United States Army
  - Combat surgeons
  - Remote secure location
  - Wounded soldiers on the battlefield
The Development of Telerobotic Surgery

- Stanford Research Institute, IBM, and MIT
  - build a telerobotic system
  - master/slave, software-driven system
  - seven-degrees-of-freedom movement
  - stereoscopic vision system
  - system architecture, redundant sensors, maximum safety
Complete Port Robotic Video-Assisted Lung Surgery
Dylewski, MR. Abstract Presentation, STSA, San Antonio, Tx 2007

OBJECTIVES

• Anatomical dissection
• Trocar access only
• Individual dissection / ligation
  • Vascular structures
  • Bronchial structures
• Complete lymph node dissection
  • Radicality: Limited by VATS platform
• No utility thoracotomy
• Thoracotomy-less specimen removal
  • Confluence of the 10th ICS muscles with the adjacent diaphragm
Trocar placement

Newest Instrumentation

5 mm or 8 mm

8 mm

5 mm or 8 mm

12 mm
Para-Diaphragmatic Specimen Removal and Repair of Diaphragm
Complete Port Access Robotic-Assisted Lobectomy
Robotic-Video-Assisted Thoracoscopic Anatomical Lung Resection (RVATLR)

- Median length of stay (days) 3 (range 1-44)
  - Traditional VATS lobectomy (2003-06): LOS 4 days
- Median length of ICU stay (days) 0 (range 0-15)
- Median blood loss (cc) 75 (range 25-500)
- Median chest tube duration (days) 2 (range 1-15)
- Median operative time (min) 88 (range 30-280)
  - Average operative time 98 min
- Total OR time (min) 175 (range 83-370)
- Median lymph node stations 5 (range 4-8)
Conversion Rates for Lobectomy

**VATS Lobe**

- Review of multiple series 119/1120 cases (10%)
  - Average 10%, Range 0-20%
  - Oncologic reasons (most common)
  - Visibility issues (30%)
  - Bleeding (10/1120, 0.9%, no exsanguinations)

**CPRL3**

- Review of 6 series range (1.5% - 13%)
  - Average 9%
  - Invasion into pulmonary artery (Most common)
  - Attempt at lung sparing operation with central tumors
  - Visibility issues (Uncommon)
  - Bleeding (0.4%-3%)
  - No operative deaths


Cerf, Dylewski, Melfi, Veronesi, Park, et al,
Value of Robotic-Assisted Lobectomy Over Conventional VATS Lobectomy

• Models conventional open surgical technique
  • Teachable to larger caliber of surgeons

• Improved accuracy of dissection
  • Allows precise isolation of vascular structure
    • Reduces likelihood of traction injury - “Arterial Avulsion”
    • Limiting blood loss
    • Reduces post-op bleeding and transfusion rate (1%)

• Meticulous dissection
  • Reduces iatrogenic trauma limiting air leaks (6%)

• Minimal lung retraction
  • Limited manipulation of tumor mass (No touch technique)
  • Reduces likelihood of tumor translocation / capsule disruption
  • May attribute to low rates of SVT (< 3%)
Value of Robotic-Assisted Lobectomy Over Conventional VATS Lobectomy

- Complete dissection of lymph node stations
  - Minimal capsular disruption
- No need for access incision
  - Performed through 4 ports often positioned along a limited rib spaces
  - No need for extension of thoracic incisions to remove lobe
  - Reduced pain and neuralgia
  - Reduces morbidity and mortality
- Wider utilization
  - No need to preselect patients for MIS approach
  - Safe and effective for locally advanced disease
  - Large tumor size
- Reduced port site recurrences
  - McKenna 2006 – 0.6%
Advantages of Robotic System

- Magnification
- 3-dimensional view
- Degrees of freedom in movement of instruments
  - Wristed instruments
  - Not operating with chopsticks
- Decreased chest wall trauma
- Mimic open operation
Criticisms of Robotics

- Cost too much
- Dangerous
- Too hard to teach
- Limited application
- Never have universal appeal

Same criticisms directed at Henry Ford in 1908 with Model T
Criticisms of Robotics

• Cost
  – Higher supply cost for capital, maintenance, disposables
  – Offset by lower utilization of resources
  – Profit margin for hospital is higher on robotic cases
Financial Data for Lobectomy
2005 - 2010

End use of VATS
Direct Cost/Case for Lobectomy
VATS (FY05) vs. CPRL 3 (FY10)

Cases Numbers
VATS – 31
CPRL 3 - 67

<table>
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<tr>
<th>Category</th>
<th>VATS (FY05)</th>
<th>CPRL 3 (FY10)</th>
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<tbody>
<tr>
<td>Salaries</td>
<td>$10,764</td>
<td>$18,114</td>
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<tr>
<td>Supplies</td>
<td>$7,590</td>
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<td>Others</td>
<td>$5,790</td>
<td>$6,243</td>
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<td>Total Costs</td>
<td>$1,561</td>
<td>$1,531</td>
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Criticisms of Robotics

- **Education**
  - VATS requires different skills than open
  - Robot more like open operation, not new procedure, “my own little hands”
  - Double console availability
  - Control of arms – “take back”
Criticisms of Robotics

- Loss of tactile information
  - Haptic feedback
  - Localization tools
    » ENB with blue dye

• Video
Summary

• Conventional total endoscopic video-assisted anatomical lung resection is technically demanding
• Advancements in robotic-assisted platforms have made possible reliable complete port access pulmonary resection
• Robotic-assisted anatomical lung resection is feasible and safe
• Compares favorably to historical series of conventional open and VATS lobectomy
• Robotic-assisted lobectomy is associated with low morbidity, low mortality and short LOS
• Robotic assisted pulmonary resection has wider clinical utility
• Cost savings
• Operative times are favorable to conventional/VATS approaches