New Advance in Thoracic Surgical Technique for Lung Cancer
The Robotic Approach

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Conventional Thoracotomy

**Pros**
- Optimum exposure
- Safe access

**Cons**
- Muscle division (usually)
- Rib spreading
- Impaired pulmonary function
- Increase morbidity (compared to VATS)
Thoracotomy
Video-Assisted Thoracoscopic Surgery (VATS)

- Valid alternative to thoracotomy
  - Uncomplicated benign and malignant disease
  - Safe and feasible for early-stage non-small cell lung cancer
  - Comparable to open procedures
  - VATS lobectomy not widely adopted (utilized in 20%)
Video-Assisted Thoracoscopic Lung Resection (VATS)
VATS Lung Resection

3-5 inch incision
Technical Limitations of VATS

- Counter-intuitive orientation
- 2-dimensional imaging
- Reduced depth perception
- Limited instrument maneuverability
  - Concerns for safety of vascular dissection
- LN dissection can be difficult
VATS Lobectomy

- Relative Contraindications
  - Tumor size > 5 cm
  - Anticipated sleeve resection
  - Hilar lymphadenopathy
  - Chest wall or mediastinal involvement
  - Neoadjuvant XRT or chemotherapy
  - Prior chest surgery
VATS Lobectomy

- McKenna – Ann Thorac Surg 2006
  - 1100 pts between ‘92-’04
  - Mean LOS 4.8 days
  - 16% complication rate
    » Prolonged air leak, Afib, PNA, MI
  - 9 deaths (0.8%)
  - 4% transfusion rate
  - 2.5 % converted to thoracotomy
Open Lobectomy

<table>
<thead>
<tr>
<th>ACOSOG Z0030 - 2006</th>
<th>STS database ‘99-’06 Boffa</th>
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<tbody>
<tr>
<td>766 pts with early stage NSCLC</td>
<td>6042 pts with early stage NSCLC</td>
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<tr>
<td>Complication rate of 37%</td>
<td>Complication rate of 32%</td>
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<tr>
<td>» Prolonged air leak 8%</td>
<td>» Prolonged air leak 8%</td>
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<tr>
<td>» Arrhythmia 15%</td>
<td>» Arrhythmia 11%</td>
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<tr>
<td>» PNA 6%</td>
<td>» PNA 4%</td>
</tr>
<tr>
<td>» LOS 6 days</td>
<td>» LOS 5 days</td>
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<tr>
<td>Mortality 1%</td>
<td>Mortality 2%</td>
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VATS vs Open Lobectomy

  - Review 39 studies – 3114 VATS vs 3256 open
  - Overall complication rate – 16% vs 31%
    » LOS – 8 vs 13 days
    » CT duration – 4 vs 6 days
    » Prolonged air leak, PNA, Afib were lower with VATS
  - Improved survival rates with VATS
    » Absolute survival advantage - 5% at 1 yr to 17% at 4 yrs
      – ? Less immunosuppressive
VATS vs Open Lobectomy

- Paul – J Thorac Cardiovasc Surg 2010
  - STS database – 1281 VATS vs 5042 open
  - Complications
    » Arrhythmia 7% vs 11%
    » Reintubation 1.4% vs 3.1%
    » Transfusion 2.4% vs 4.7%
    » LOS 4 vs 6 days
    » CT duration 3 vs 4 days
    » No difference in mortality
Biologic Perspective

- Several studies have demonstrated reduced inflammatory response with VATS
  - Less reduction in CD4 and natural killer cells
    - Could partially explain why perioperative outcomes are better
    - ? Lead to long term survival advantage
VATS vs Open Lobectomy

- Oncologic Perspective
  - Sugi - World J Surg 2000
    » 100 pts Stage IA NSCLC – 52 open 48 VATS
      - No difference in 3 and 5 yr survival
  - Yan – J Clin Oncol 2009
    » 5 yr survival slightly improved with VATS
      - 82% vs 79%
  - Suggests VATS at least oncologically equivalent to open lobectomy
Negative Perceptions of VATS Lobectomy

- No large prospective, randomized trials
  - CALGB trial 140501 VATS vs. Open lobectomy cancelled due to inadequate funding
- Limited utility
  - T1 lesions (< 3.0 cm) - 13% patients (Mountain, 2000)
  - Peripheral based lesions / questionable in T2, N1 (Forlian, 2001)
- Limited lymph node dissection
- Non-anatomical lobar resection
  - May compromise margin of resection
  - Simultaneous stapling - High rate of bilobectomy (Gharagozloo 2003)
- Limited data on 5 year survival for malignancy
- Mindset of the surgeon with the technique
Techniques of VATS Lobectomy

- Large series
  - Majority of VATS lobectomy w/ utility thoracotomy
    - Median length of utility incision 5 – 7 cm
    - Median operative time: Open 228 min vs VATS 204 min (Whitson, 2007)

- Totally endoscopic VATS lobectomy
  - “Closed” (Ishikawa, Surg. Endosc, 07)
  - “Complete” (Shiraishi J Thorac Cardiovasc Surg, 06)

- Limitations:
  - Incomplete fissures
  - Risk imposed by dissection of fragile pulmonary vessels
  - Difficulties encountered during lymph node dissection
Paradigm Shift to Totally Endoscopic Lobectomy with Robotic Assistance
Why Better Than VATS?

- Technical perspective
  - Better visualization
    - HD 3D vs 2D vision
    - Surgeon controls camera
  - Improved dexterity
    - Endowrist with full range of motion

- ? Better outcomes
  - Paucity of data at this point
  - At least equivalent
Robotic Video-Assisted Thoracoscopic Lung Surgery

- Anatomical dissection
- Trocar access only
- Individual dissection / ligation
  - Vascular structures
  - Bronchial structures
- Complete lymph node dissection
- No utility thoracotomy
- Lung removal performed beneath rib cage tip of 11th rib
Operating Room Layout
Trocar placement
Docking #3 Arm
Primary Dissection Arm
Parallel to spine
Docking #2 Arm
Retracting Arm

Neutral position

Abduction
Adduction
Instruments for Pulmonary Resection
Introduction of Instruments
Trans-Diaphragmatic Specimen Removal and Repair of Diaphragm
Robotic Video Assisted Thoracoscopic Lung Resection
Cao et al, Annals CT Surgery 5/2012

- **Meta-analysis of 12 institutions**
  - Mortality – 0-3.8%
  - Morbidity – 10-39%
    - Prolonged air leak – 4-13%
    - Tachyarrhythmias – 3-19%
    - Pneumonia – 1-5%
    - Conversion to thoracotomy – 0-19%
  - LOS – 2-11 days
  - OR time – 130-238 min
11/2002-5/2010 325 pts at 3 institutions for early stage NSCLC

- Morbidity – 25%
  - SVT – 11% most common
- Conversion to thoracotomy – 8%
- Mortality – 0.3%
- LOS – 5 days
- 5 yr survival – 80%
  - Stage 1 – 88%, stage 2 – 49%, stage 3 – 43%
- Data c/w prior results for thoracotony and VATS
Robotic-Video-Assisted Thoracoscopic Lung Resection

- **Cost comparison** (Park, Ann CT Surg 5/2012)
  - Thoracotomy > RVATS > VATS
  - Thoracotomy $4000 more than RVATS
  - RVATS $4000 more than VATS
    - Main reason RVATS and VATS cheaper due to shorter LOS
    - ? RVATS worth the inc expense
      - Inc surgical volume – market driven
      - Better platform with 3-d visualization and better dexterity
Robotic-Video-Assisted Thoracoscopic Lung Resection
Mark Dylewski, M.D.  South Miami Hospital Center for Robotic Surgery

- 206 cases underwent robotic-video-assisted thoracoscopic anatomical lung resection from January 2007 – September 2010
- 110 female / 96 males
- Ages range from 20 – 92 years of age
- Median age of 68 years
- Median Tumor size 2 cm (0.7-8.5 cm)
Robotic-Video-Assisted Thoracoscopic Lung Resection (RVATS)

Type of Lobectomy
- RUL
- RML
- RLL
- LUL
- LLL
- Sleeve
- Lobe w/ EBR

Type of resection
- Segment
- Bilobectomy
- Lobectomy
- Pneumonectomy

EBR- enbloc resection
Stage of Lung Cancer and Tumor Type (n=150)

- Stage IIA: Adenocarcinoma (38), Squamous cell (19), Carcinoid (13)
- Stage IIB: Adenocarcinoma (9), Squamous cell (8), Carcinoid (2)
- Stage II: Adenocarcinoma (9), Squamous cell (2), Carcinoid (7)
- Stage IIIA: Adenocarcinoma (7), Squamous cell (7), Carcinoid (3), Others (5)
- Stage IV: Adenocarcinoma (1), Squamous cell (1), Others (1)
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) 0.5 (range 0-15)
- Median blood loss (cc) 72 (range 25-500)
- Median chest tube duration (days) 1.5 (range 1-15)
- Median operative time (min) 90 (range 30-280)
- Total OR time (min) 175 (range 83-370)
- Median lymph node stations 5 (range 4-8)
Operative Time

Estimated learning curve: 37 cases
COMPLICATIONS

Fatal error...
Perioperative Complications

Death
Pneumothorax
Reop Bleeding
Stroke
Conversion/difficulty
Conversion bleeding
Splenectomy/bleeding
Air leak > 6 days
Mural Thrombus
Effusion
Arrhythmia
Post-op bleeding
Myocardial infarction
Pneumonia
Wound infection

n = 49 (23.7%)

EBR- en bloc resection

Common Terminology Criteria for Adverse Events and Common Toxicity Criteria – Grade 2-3
Robotic-Video-Assisted Thoracoscopic Lung Resection

- Complications:
  - 60-day Mortality (3/206) 1.4% / Morbidity (49/206) 24%
  - Pneumonia / Aspiration in 8 (3.9%) patients
  - Recurrent effusion / Thoracentesis in 12 (5.8%) patients
  - Prolonged air leak greater than 6 days in 13 (6.3%) patients
  - Post-op myocardial infarction or CVA in 2 (0.97%) patients
  - Hemorrhage 3 (1.4%) patient
    - Splenectomy / Blood transfusion / Atrial fibrillation / Mural thrombus / pneumonia (1)
    - Hemothorax requiring reoperation (1) and post op transfusion 2 Units (1)
  - Supraventricular Arrhythmia 6 (2.9%)
  - Splenectomy 1 (0.5%)
  - Conversion to conventional VATS or thoracotomy 4 (1.9%)
Value of Robotic-Assisted Lobectomy Over Conventional VATS Lobectomy

- Models conventional surgical techniques
- Improved accuracy of dissection
  - Allows precise isolation of vascular structure
  - Meticulous dissection
    » Reduces iatrogenic trauma limiting air leaks (6.3%)
    » Limiting blood loss
      » Reduces post-op bleeding and transfusion rate (1.6%)
      » McKenna, 07- transfusion rate – 4.1%
  - Limited manipulation of lung and tumor mass (No touch technique)
    » Reduces likelihood of tumor translocation
    » May attribute to low rates of SVT (2.9%)
    » VATS lobectomy: Rate SVT (McKenna, 07 –2.9%, Duke University, 02 – 3.7%)
  - Allows complete dissection of lymph node stations
Value of RVATS Over Conventional VATS Lobectomy

- **No need for access incision**
  - Performed through 4 ports often positioned along a single rib space
  - No need for extension of thoracic incisions to remove lobe
  - Reduced pain and neuralgia
  - Reduces morbidity and mortality

- **Wider utilization**
  - Locally advanced disease
  - Large tumor size

- **Reduced port site recurrences**
  - McKenna 2006 – 0.6%
Summary

- Conventional total endoscopic video-assisted anatomical lung resection is technically demanding
- Advancements in robotic-assisted platforms have made possible reliable total endoscopic video-assisted 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
- No additional OR personnel required
- Total OR and Operative times are favorable to VATS approach