LEARNING CURVE OF
ROBOTIC LOBECTOMY FOR LUNG CANCER

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AATS-EACTS
ROBOTIC CARDIOTHORACIC
SURGERY SYMPOSIUM
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For new surgical procedures, the concern is that a patient may have an adverse outcome because of the inexperience of the surgeon. The dilemma is that the only way to gain experience is to perform multiple procedures.

**Definition:** Number of cases require to gain knowledge, improve skills and achieve technical competence in performing a surgical procedure.

**Learning curves for cancer surgery:**
1) surgical proficiency: operation time and conversion
2) surgical safety: rate of peri-operative complications
3) oncological outcomes: local recurrence and adequate lymph nodes dissection

LEARNING CURVE IN DIFFERENT ENDOSCOPIC PROCEDURES

Laparoscopic cholecystectomy: 13
Videothoracoscopic thymectomy: 60
VATS esophagectomy: 34
Laparoscopic colorectal surgery: 30-70
VATS lobectomy: 30-50

VALIDATED METHODS TO ACCESSING LEARNING CURVE

OBJECTIVE STRUCTURED ASSESSMENT OF SURGICAL SKILLS – OSATS
- Respect for tissue
- Time and motion
- Instrument handling
- Suture handling
- Flow of operation – use of assistants
- Knowledge of procedure
- Overall performance
- Quality of final product

MOTION ANALYSIS (COMPUTERISED APPLICATION PROGRAMMING INTERFACE - API)
- Path length
- Distance traveled
- Time taken to completion

In one report the mean time to perform some drills was significantly less using the robot compared with laparoscopy. As the technical difficulty of the drill increased, the difference in mean time increased in favour of the robot (1).

Two papers evaluated the impact of stereoscopic vision on learning curve. All the tasks were performed quicker using 3D vision and with fewer number of errors compared to 2D vision (2, 3).

Two studies assessed dominant versus non-dominant hand skills. They concluded that while with conventional laparoscopy, the dominant hand performed significantly better than the non-dominant hand, using the robot created equivalence between the dominant and non-dominant hand (4, 5).

VATS LOBECTOMY

- Introduction of the minimally invasive approach marks one of the great advances in surgery and the advantages of VATS lobectomy are well accepted.
- Shortcomings:
  - limited visual information
  - limited freedom of movement
  - poor ergonomics
- Challenge for surgeons and danger for patients
- Significant learning curve to develop and maintain advanced skills

The majority of advanced thoracoscopic cases are performed by a small number of surgeons.
Robotic System

**Advantages:** natural movements of the surgeon’s hands are translated into precise instrument movements inside the patient with tremor filtration. Three dimensional view offers a visual magnification even better than that available in open surgery.

Robotic system has made advanced thoracoscopic surgery **accessible** to surgeons who do not have advanced videoendoscopic training.

**Disadvantages**
- Greater expense (OR resource)
- Skilled technical staff
- Elimination of tactile feedback
- Limited options for trocars placement
DIAGNOSTIC REVOLUTION FOR LUNG CANCER

- Screening programs > more than 80% stage I and II
- Imaging Technology: Pet scan, CAD system and volumetry
- Modern medicine: from the “maximum tolerable treatment” to the “minimum effective treatment”
LOW INVASIVE TREATMENTS

Non surgical treatments

- Stereotactic RT
- Thermoablation
  (second primary or multifocal lesions)

Limited resections/no lymph node resection

VATS and robotic approach
ROBOTIC LOBECTOMIES

Acceptable learning curve?

Adequate oncological radicality?
METHODS: 54 patients

- Stage I-II disease
- FEV 1 >65%
- Age < 75 y
- No prior treatment for lung cancer
- Preop complete staging
- Informed consent

Operating time was defined as time from first incision to time of closure, and also included times for VATS wedge resection and frozen section examination.
**CASE CONTROL STUDY**

- Propensity score matching
- Clinical characteristics of lung cancer patients who underwent robotic lobectomy and matched lung cancer controls who underwent open lobectomy

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Robotic lobectomy</th>
<th>Open Lobectomy</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>38</td>
<td>34</td>
<td>0.41</td>
</tr>
<tr>
<td>Women</td>
<td>16</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;55</td>
<td>8</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>55-59</td>
<td>12</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>19</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>65+</td>
<td>15</td>
<td>16</td>
<td>0.54†</td>
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<tr>
<td><strong>FEV1% predicted</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (standard deviation)</td>
<td>95 (19)</td>
<td>95 (20)</td>
<td>0.91‡</td>
</tr>
<tr>
<td>Median (range)</td>
<td>95 (49-141)</td>
<td>90 (66-169)</td>
<td>0.48§</td>
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<tr>
<td><strong>Lobe</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>20</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Upper</td>
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<td>31</td>
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<tr>
<td><strong>Clinical tumor stage</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>cT1</td>
<td>45</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>cT2</td>
<td>9</td>
<td>6</td>
<td>0.40</td>
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<tr>
<td><strong>Clinical lymph node status</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>cN0</td>
<td>51</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>cN1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>cN2*</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>cN3*</td>
<td>0</td>
<td>1</td>
<td>0.80†</td>
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<tr>
<td><strong>ASA score</strong></td>
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<tr>
<td>1</td>
<td>11</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>37</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>10</td>
<td>0.41†</td>
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<tr>
<td><strong>BMI</strong></td>
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<td>Less than 18.5</td>
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<td>18.5-25</td>
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<td>25-30</td>
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<td>30 or more</td>
<td>5</td>
<td>7</td>
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<tr>
<td><strong>Cardiac comorbidity</strong></td>
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<tr>
<td>No</td>
<td>48</td>
<td>46</td>
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<td>6</td>
<td>8</td>
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<td><strong>Smoking status</strong></td>
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<td>Never smoke</td>
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<tr>
<td>Ex-smoker</td>
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<tr>
<td>Current smoker</td>
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<td>35</td>
<td>0.98</td>
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SURGICAL TECHNIQUE

- Four-arms robotic system
- Lateral position
- Robot at the head posteriorly
- Four incisions including a small utility thoracotomy
- No rib spreading
- 30 degree camera in VII space mid axillary line
SURGICAL TECHNIQUE

Isolation of RUL pulmonary artery

Isolation of RUL bronchus

Right mediastinal lymph node dissection
The median time of robotic intervention for completed operations decreased by 43 minutes between the first and the last two series of interventions (p=0.01)
ROBOTIC LOBECTOMY
Mean duration: 220 min
This time includes robotic set up and frozen section
Plateau reached after the first 15 cases

VATS LOBECTOMY
Mean duration: 206 minutes
Plateau reached after 50 cases

HS Lee
AATS 2009
## LEARNING CURVE - SAFETY - RADICALITY

<table>
<thead>
<tr>
<th></th>
<th>ROBOT (54)</th>
<th>OPEN (54)</th>
<th>p value</th>
<th>p value</th>
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<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>I vs II+III</td>
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<tr>
<td>Complications</td>
<td>33%</td>
<td>22%</td>
<td>6%</td>
<td>19%</td>
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<tr>
<td>Operative time</td>
<td>260</td>
<td>213</td>
<td>235</td>
<td>154</td>
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<tr>
<td>Postop days</td>
<td>6 days</td>
<td>5 days</td>
<td>4 days</td>
<td>6 days</td>
</tr>
<tr>
<td>Median N° LN</td>
<td>15</td>
<td>17</td>
<td>17</td>
<td>18</td>
</tr>
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</table>

1) Complications, postoperative days and operative time declines across the 3 robotic tertiles
2) Operative time was higher for robotic procedures
3) Postoperative stay was lower after robotic than open procedures
4) Complications and N° lymph nodes removed were comparable in open and robotic lobectomies
## CAUSES OF CONVERSION

<table>
<thead>
<tr>
<th>Cause</th>
<th>Count</th>
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<td>Absent fissure</td>
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<tr>
<td>Emphysema</td>
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<td>Oncological reason</td>
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<tr>
<td>Anatomical reason</td>
<td>1</td>
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<tr>
<td>Intraop bleeding</td>
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</table>

In case VATS exploration showed diffuse pleural adhesions we didn’t start robotic procedures.
Modern medicine and diffusion of screening programs require less invasive treatment for early stage lung cancers.

Robotic systems have made thoracoscopic surgery accessible to surgeons who do not have advanced videoendoscopic training.

Data from the literature suggest that robotic lobectomy increases the learning curve.

The learning curve for robotic lobectomy includes less than 18 cases for surgeons with no experience in vats lobectomies.

Robotic lobectomy is safe and represents an adequate oncological procedure.

Most disadvantages of the robotics will be overcome when technological advances improve instrumentation and extended use of robotics reduces costs.
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