Lung Cancer: From Prevention & Screening to Robotic Lung Preserving Surgery

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A Lethal Disease!

- 1.6 Millions death per year worldwide
- 170 k death in US per year
22% of All Cancer Deaths are related to Tobacco Abuse
Smoking and Lung Cancer

Product that, when used as intended, Kills
Tobacco Smoking: Cause of various Cancers and chronic Conditions

<table>
<thead>
<tr>
<th>Smoking Cancers</th>
<th>Chronic Diseases</th>
<th>Secondhand Smoke Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oropharynx</td>
<td>Stroke</td>
<td>Children</td>
</tr>
<tr>
<td>Larynx</td>
<td>Blindness, cataracts</td>
<td>Respiratory symptoms, impaired lung function</td>
</tr>
<tr>
<td>Esophagus</td>
<td>Periodontitis</td>
<td>Adults</td>
</tr>
<tr>
<td>Trachea, bronchus, and lung</td>
<td>Aortic aneurysm</td>
<td></td>
</tr>
<tr>
<td>Acute myeloid leukemia</td>
<td>Coronary heart disease</td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td>Pneumonia</td>
<td>Middle ear disease</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Atherosclerotic peripheral vascular disease</td>
<td>Lung cancer</td>
</tr>
<tr>
<td>Kidney and ureter</td>
<td>Chronic obstructive pulmonary disease, asthma, and other respiratory effects</td>
<td>Sudden infant death syndrome</td>
</tr>
<tr>
<td>Cervix</td>
<td>Hip fractures</td>
<td>Nasal irritation</td>
</tr>
<tr>
<td>Bladder</td>
<td>Reproductive effects in women (including reduced fertility)</td>
<td>Lung cancer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coronary heart disease</td>
</tr>
</tbody>
</table>

Reproductive effects in women: low birth weight.
Tobacco Smoking: Historical Background

- Native Americans used for ceremonial purposes
- Columbus brought it to Europe
- Philip Morris: London early 1800s
- James B Duke of North Carolina late 1800s
“In UK, the 1962 report of the Royal College of Physicians concluded that smoking was a cause of lung cancer and bronchitis, and a contributing factor for coronary artery disease.”
“In US, 1964 landmark report of the Advisory Committee to the Surgeon General concluded that smoking was a cause of lung cancer in men and of chronic bronchitis”
Tobacco Smoke Leading to Cancer

- Burning of Tobacco along with the various additives and paper, at a very high temperature.
- Produces 7000 compounds
- Well known Toxins:
  - Benzene (a leukemogen)
  - Formaldehyde
  - Benzopyrene
  - Carbon monoxide
  - Cyanide
  - Acrolein
  - Polonium
Lung Cancer Related Deaths in US Males
Lung Cancer Related Deaths in US Females
WHAT HAPPENS WHEN A SMOKER QUITS
A 15 YEAR TIMELINE

20 MINUTES
HR & BP drops To Normal

12 HOURS
The Level of CO Drops to normal

1-9 WEEKS
Cough and Bronchitis improves

2 WEEKS
Circulation and lung function improves

1 YEAR
RISK of CAD decreases to Half

5 YEARS
Risk of H & N, esophageal, bladder ca decreases

10 YEARS
Risk of dying from lung cancer decreases to half

15 YEARS
Risk of heart diseases decrease to level of non smoker
This is definitely the last pack I’ll ever smoke!
20-Year Lag Time Between Smoking and Lung Cancer

Cigarettes Smoked Per Person Per Year

Cigarette Consumption (men)

Lung Cancer (men)

Lung Cancer Deaths (Per 100,000 People)

1900 1920 1940 1960 1980 Year
Lung Cancer Screening
National Lung Screening Trial

National Cancer Institute

Denise R. Aberle, MD
Cancer Imaging Program, DCTD | NCI
David Geffen School of Medicine at UCLA
National PI, ACRIN-NLST

Christine D. Berg, MD
Chief, Early Detection Research Group
Division of Cancer Prevention | NCI
Project Officer, LSS-NLST
Prospective, randomized trial comparing low-dose helical CT screening to chest x-ray screening with the endpoint of lung cancer specific mortality in high risk participants

- Ages 55 – 74
- 30 pack year smoking history
- If former smoker have quit within 15 years
33 participating sites
### Results of Interim Analysis of Primary Endpoint
**Reported on Oct. 20, 2010**

<table>
<thead>
<tr>
<th>Arm</th>
<th>Person years (py)</th>
<th>Lung cancer deaths</th>
<th>Lung cancer mortality per 100,000 py</th>
<th>Reduction in lung cancer mortality</th>
<th>Value of test statistic</th>
<th>Efficacy boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>144,097</td>
<td>354</td>
<td>245.7</td>
<td><strong>20.3</strong></td>
<td>-3.21</td>
<td>-2.02</td>
</tr>
<tr>
<td>CXR</td>
<td>143,363</td>
<td>442</td>
<td>308.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deficit of lung cancer deaths in CT arm exceeds that expected by chance, even allowing for multiple looks at the data.
## Results of Analysis of All-cause Mortality (Secondary Endpoint) Reported on Oct. 20, 2010

<table>
<thead>
<tr>
<th>Arm</th>
<th>Person years (py)</th>
<th>Deaths</th>
<th>All-cause mortality per 100,000 py</th>
<th>Reduction in all-cause mortality (%)</th>
<th>Value of test statistic</th>
<th>Value for significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>167,389</td>
<td>1870</td>
<td>1117.2</td>
<td>6.9</td>
<td>-2.27</td>
<td>-1.96</td>
</tr>
<tr>
<td>CXR</td>
<td>166,328</td>
<td>1996</td>
<td>1200.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deficit of deaths in CT arm exceeds that expected by chance.
Kaplan-Meier Curves for Lung Cancer Mortality
Kaplan-Meier Curves for All-Cause Mortality

Years from Randomization
Survival Distribution Function

Table 11.5.6a
Kaplan-Meier Curves for Lung Cancer Case Survival
(Lung Cancer Cause of Death)

![Graph showing Kaplan-Meier Curves for Lung Cancer Case Survival](image)

- **Years from Diagnosis**
- **Survival Distribution Function**

Legend:
- Solid line: Spiral CT
- Dashed line: X-Ray
Nelson Trial
WCLC 2018

- Population-based, Randomized controlled trial
- 50-74 years age, high risk group
- CT scans at baseline, 1, 3 and 5.5 years after randomization
- 10 year follow up
- 26% reduction in the lung cancer related deaths
- 69 percent of screen-detected lung cancers were detected at Stage I.
- Curative surgical resection was three times more prevalent in study group
Low Dose CT shows a lung nodule. What to do Know?
Lung Nodule on LDCT

- **suspicious**
  - **YES**
    - CTPET SCAN
      - **YES**
        - Distant Metastasis
          - **YES**
            - Biopsy
              - **YES**
                - Mediastinal Adenopathy
                  - **YES**
                    - EBUS
                      - **positive**
                        - Induction Chemo and Radiation Therapy
                      - **negative**
                        - Robotic Segmentectomy Or Lobectomy
                - **NO**
                  - EBUS
                    - **positive**
                      - Induction Chemo and Radiation Therapy
                    - **negative**
                      - Robotic Segmentectomy Or Lobectomy
          - **NO**
            - Repeat CT in 3-12 months
    - **NO**
      - Repeat CT in 3-12 months

- **NO**
  - Repeat CT in 3-12 months
Ground Glass Opacity (GGO)

- Pure GGO
- GGO with Solid Component
- Carcinoma in situ
- Minimally Invasive carcinoma
NSCLC Staging

PET/CT

- Excellent sensitivity
- Limited PPV
- False positives common
- Better than CT or PET alone in detecting LN involvement or mets
CT Guided Biopsy
ENB PROCESS

CT Scan: DICOM CD

PLANNING: Prepare for the procedure and learn the patient’s anatomy

PROCEDURE: Navigate, biopsy, and plan for treatment
Pre-Operative Procedure Planning

Choose Your Target (destination)
EBUS/Mediastinoscopy
Robotic Lung Preserving Resection: Robotic Segmentectomy
Background - Segmentectomy

- Churchill et al. (1939) – Anatomic segmentectomy for bronchiectasis
  
  "The bronchopulmonary segment may replace the lobe as the surgical unit of the lung"

- Jensik, Faber et al. (1973) – Anatomic segmentectomy for lung cancer
- Lung Cancer Study Group (1995) – threefold increase in recurrence rate for sublobar resection (17.2% vs. 6.4%), 2.4-fold increase after segmental resection
- Yoshikawa et al. (2002) – Extended segmentectomy – 82% 5-year survival for tumors less than 2 cm
- Okada et al. (2005) – Equivalent 5 yr disease-free survival (≤ 2 cm) – 96.7 vs. 92.4%
- Schuchert, Landreneau, Abbas. (2007) – Equivalent recurrence-free and overall survival for pathologic Stage I NSCLC.
## Lobectomy vs Sublobar Resection

### 5 Year Cancer Specific Survival “Stage I”

<table>
<thead>
<tr>
<th>TUMOR SIZE</th>
<th>Segmental Resection</th>
<th>Lobectomy</th>
<th>Wedge Resection</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mm or less</td>
<td>96.7</td>
<td>92.4</td>
<td>85.7</td>
</tr>
<tr>
<td>20-30 mm</td>
<td>84.6</td>
<td>87.4</td>
<td>39.4</td>
</tr>
<tr>
<td>More than 30 mm</td>
<td>62.9</td>
<td>81.3</td>
<td>0</td>
</tr>
</tbody>
</table>

WVU Experience of Robotic vs VATS Anatomical Pulmonary Segmentectomy
## Clinical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>VATS (22 pts)</th>
<th>Robotic (38 pts)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>71.3 ± 10.2</td>
<td>68.6 ± 10.1</td>
<td>0.367</td>
</tr>
<tr>
<td>Female</td>
<td>14 (64%)</td>
<td>16 (57%)</td>
<td>0.642</td>
</tr>
<tr>
<td>BMI</td>
<td>27.1 ± 4.7</td>
<td>27.3 ± 7.0</td>
<td>0.904</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4 (18%)</td>
<td>2 (7%)</td>
<td>0.385</td>
</tr>
<tr>
<td>Hypertension</td>
<td>17 (77%)</td>
<td>18 (64%)</td>
<td>0.320</td>
</tr>
<tr>
<td>CHF</td>
<td>2 (9%)</td>
<td>0</td>
<td>0.189</td>
</tr>
<tr>
<td>CAD</td>
<td>5 (23%)</td>
<td>3 (11%)</td>
<td>0.277</td>
</tr>
<tr>
<td>PVD</td>
<td>1 (5%)</td>
<td>3 (11%)</td>
<td>0.621</td>
</tr>
<tr>
<td>COPD</td>
<td>10 (46%)</td>
<td>15 (54%)</td>
<td>0.569</td>
</tr>
<tr>
<td>FEV1%Pred</td>
<td>81.9 ± 25.8</td>
<td>81.4 ± 17.3</td>
<td>0.939</td>
</tr>
<tr>
<td>Creatinine</td>
<td>0.8 ± 0.2</td>
<td>0.8 ± 0.2</td>
<td>0.932</td>
</tr>
<tr>
<td>Outcome</td>
<td>VATS</td>
<td>Robotic</td>
<td>P value</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>LOS, days (IQR)</td>
<td>4 [2–5]</td>
<td>2 [2–4]</td>
<td>0.089</td>
</tr>
<tr>
<td>Complications</td>
<td>8 (36%)</td>
<td>4 (14%)</td>
<td>0.070</td>
</tr>
<tr>
<td>Chest tube air leak</td>
<td>4 (18%)</td>
<td>2 (7%)</td>
<td>0.385</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Conversion</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>2 (9%)</td>
<td>0</td>
<td>0.189</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>2 (9%)</td>
<td>0</td>
<td>0.189</td>
</tr>
<tr>
<td>ARDS</td>
<td>1 (5%)</td>
<td>0</td>
<td>0.440</td>
</tr>
<tr>
<td>Neuro central event</td>
<td>1 (5%)</td>
<td>1 (4%)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Unexpected ICU</td>
<td>1 (5%)</td>
<td>1 (4%)</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Readmit &lt;30 days</td>
<td>1 (5%)</td>
<td>0</td>
<td>0.440</td>
</tr>
<tr>
<td>Mortality &lt;30 days</td>
<td>1 (5%)</td>
<td>0</td>
<td>0.440</td>
</tr>
</tbody>
</table>
## Robot Si vs Xi vs VATS: Cost Analysis

<table>
<thead>
<tr>
<th>Item</th>
<th>Robot Using Manual Staplers</th>
<th>Robot Using Robotic Xi Staplers</th>
<th>VATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stapler handle</td>
<td>$350 x 1 = $350</td>
<td>$350 x 1 = $350</td>
<td>$350 x 1 = $350</td>
</tr>
<tr>
<td>Vascular load</td>
<td>$150 x 2 = $300</td>
<td>$630</td>
<td>$150 x 2 = $300</td>
</tr>
<tr>
<td>Bronchus - green/blue load</td>
<td>$150 x 1 = $150</td>
<td>$315</td>
<td>$150 x 1 = $150</td>
</tr>
<tr>
<td>Parenchyma - green load x 3</td>
<td>$150 x 3 = $450</td>
<td>$945</td>
<td>$150 x 3 = $450</td>
</tr>
<tr>
<td>Robotic instrument/ports (forceps, bipolar, tip up grasper)</td>
<td>$600</td>
<td>$600</td>
<td>$600</td>
</tr>
<tr>
<td>Total</td>
<td>$1,850 + $350*</td>
<td>$2,498</td>
<td>$1,250 + $350*</td>
</tr>
<tr>
<td>Cost of hospital stay ($900 per day step down status)</td>
<td>$1,800 (2 days)</td>
<td>$1,800 (2 days)</td>
<td>$3,600 (4 days)</td>
</tr>
<tr>
<td>FINAL COST</td>
<td>$3,300</td>
<td>$4,298</td>
<td>$4,500</td>
</tr>
</tbody>
</table>
Potential Cost Offsets
Clinical Measures - Segmentectomy

Cost: $7,812 (per conversion)

Estimated Cost Savings Per Procedure:
- $4,520 vs. Open
- $3,190 vs. Lap/VATs

Estimated Total Cost Savings:
- $171,760 vs. Open
- $121,220 vs. Lap/VATs

Length of Stay (days):
- OPEN (N=5,913): 8.1
- LAP/VATS (N=4,612): 2.6
- DAV INCI (N=38): 7.3, 5.3, 2.6

Conversions (percentage):
- OPEN (N=5,913): 8.1%
- LAP/VATS (N=4,612): 2.6%

OR Room Time (min.):
- OPEN (N=5,913): 176 min.
- LAP/VATS (N=4,612): 180, 150 min.

Cost: $900 (per bed day)
RUL Posterior segmentectomy
Using Xi stapler
RUL S1 apical segment with abnormal vein
Xi Stapler
Thank you