Session V: Minimally Invasive Esophageal Surgery

Minimally Invasive Esophagectomy

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Overview

- Background information
- Definition of a Minimally Invasive esophagectomy
- Evolution of technique
- Esophagectomy: Results of MIE

Most dramatic in white Males

Risk Factors: GERD, Obesity, Barrett’s

Esophageal Adenocarcinoma

Melanoma

Lung Cancer

Prostate Cancer

Breast Cancer

Colorectal Cancer

Trends in esophageal adenocarcinoma incidence and mortality

Surgical Resection
Mortality from Esophagectomy in the U.S.

• National Medicare data base assessed outcomes from a variety of surgical procedures
• Esophagectomy mortality ranged from 8.1% at high-volume hospital to as high as 23% at low-volume hospitals (NEJM 2002)
• Published series from experienced centers lower this to less than 5%, significant morbidity
• Less invasive approaches may help Surgeons to lower morbidity
Why consider a less-invasive surgical approach for esophageal cancer?

- Improve the surgical standard of care
  - Decrease morbidity
  - Shorten hospital stay
  - More rapid return to daily activities

- However, we must not:
  - Take ill-advised technical short cuts leading to an increase in complications (leaks, conduit damage, omitting important technical steps)
  - Compromise oncologic principles of surgical resection
  - Lose sight of cost considerations

- Increase in early stage referrals from Barrett’s surveillance, seeking low-morbidity options
Early on Minimally Invasive Esophagectomy Lacked a Consistent Minimally Invasive Approach, What is a Minimally Invasive Esophagectomy?

- Right VATS, laparotomy and neck incision
- Laparotomy for gastric mobilization, thoracoscopic esophagectomy and intrathoracic anastomosis
- Laparoscopic gastric mobilization, thoracotomy with intrathoracic anastomosis
- Thoracoscopic esophagectomy, laparoscopic hand-assisted
- Totally laparoscopic mobilization, esophagectomy with neck anastomosis (Transhiatal)
- No advantages noted at that time, but clearly no consistent approach had emerged

Our Approaches: totally laparoscopic/thoracoscopic

- **Thoracoscopic esophagectomy, laparoscopic gastric mobilization and cervical anastomosis (McKeown)**
- **Laparoscopic gastric mobilization, thoracoscopy with intrathoracic anastomosis (Ivor Lewis)**

Law and Wong: Lancet Oncology 2002
Operative Approaches
Initial Experience

• Laparoscopic transhiatal esophagectomy with cervical anastomosis (n=9)
• Laparoscopic mobilization with right thoracotomy (n=8)
• Laparoscopic and thoracoscopic esophagectomy (n=59)
• Four conversions to open
  • All secondary to adhesions
• No emergent conversions
Operative Data

- Median operative time: 7.5 hours (4-13.6)
- Median ICU stay: 1.0 days (range 0-60)
- Median hospital stay: 7 days (range 4-73)
- Median number of lymph nodes dissected: 16 (10-51)
- 77 with negative surgical margins (3 with positive microscopic adventitial margins)
- Average blood loss: 240 cc
Major Complications (24%)

**Luketich Series**
- Mortality: zero in first 77, 0
- Anastomotic leaks (n=7, 9%)
- Hypopharyngeal perforation (1)
- Tracheal tear post-op day 6 (1)
- ARDS (2)
- Permanent recurrent laryngeal nerve injury (n=2, 2.6%)
- Chylothorax (n=3, 3.9%)
- Pyloric leak (1)
- Pyloric stenosis requiring laparoscopic pyloroplasty (3)
- Partial necrosis of gastric tube (3)

**Orringer Series**
- 4%
- 13%
- <1%
- <1%
- Not stated
Long-Term Results: Local Recurrence Rates After MIE in Pittsburgh

- 70 patients with esophageal cancer with documented N disease by lap staging
- Three cycles of chemotherapy followed by MIE with 2-filed lymph node dissection
- Oncologic outcomes:
  - 5-year survival 35%
  - At a median follow-up of over 40 months, local recurrence only in less than 5%
  - Distant recurrence, primarily lung, liver, lung in 60%
- Lerut: 5% local recurrence rate after en bloc resection

## Comparison of Thoracoscopic/Laparoscopic Esophagectomy with Open: Nguyen, et al

<table>
<thead>
<tr>
<th></th>
<th>TM/LE (n = 18)</th>
<th>TT (n = 16)</th>
<th>THE (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time, min</td>
<td>364 ± 73†</td>
<td>437 ± 65</td>
<td>391 ± 144</td>
</tr>
<tr>
<td>Blood loss, mL</td>
<td>297 ± 233†</td>
<td>1046 ± 792</td>
<td>1142 ± 785</td>
</tr>
<tr>
<td>Intraoperative transfusion, U</td>
<td>0.3 ± 0.7†</td>
<td>1.8 ± 2.2</td>
<td>2.9 ± 3.1</td>
</tr>
<tr>
<td>ICU stay, d</td>
<td>6.1 ± 11.3†</td>
<td>9.9 ± 16.3</td>
<td>11.1 ± 15.7</td>
</tr>
<tr>
<td>Hospital stay, d</td>
<td>11.3 ± 14.2†</td>
<td>23.0 ± 22.3</td>
<td>22.3 ± 16.1</td>
</tr>
<tr>
<td>No. of nodes removed</td>
<td>10.8 ± 8.4</td>
<td>6.3 ± 6.0</td>
<td>6.9 ± 5.4</td>
</tr>
</tbody>
</table>

*Data are given as mean ± SD. TM/LE indicates combined thoracoscopic and laparoscopic esophagectomy; TT, transthoracic esophagectomy; THE, blunt transhiatal esophagectomy; and ICU, intensive care unit.

†P < .05, compared with TT and THE groups, by Mann-Whitney tests.
Technique: Laparoscopic-Transhiatal versus thoracoscopic/laparoscopic

- **Lap-THE:**
  - **PRO:**
  - No repositioning pt
  - No single lung ventilation
  - **CON:**
  - small working space
  - Limited access to thoracic nodes
  - Gastric tip ischemia
  - RLN injury

- **Lap/VATS:**
  - **PRO:**
  - better exposure /dissection of mediastinum
  - Better esophageal margins
  - ? Survival/local recurrence benefit
  - **CON:**
  - repositioning required
  - double lumen tube required
  - Delayed abdominal assessment
  - Gastric tip ischemia
  - Gastric margins
  - RLN injury

- **MIE Ivor Lewis:**
  - **PRO:**
  - pros of lap/vats
  - No pharyngeal/RLN issues
  - Less gastric tip ischemia
  - Larger diameter anastomosis, less strictures
  - Better gastric margins
  - **CON:**
  - Esophageal margins (SCC, or high Barrett’s
  - Technical challenge of VATS anastomosis

N=15, initial approach

N=>500

N=>700 current approach
Methods: Initial Series (n=222)

• Initial selection included only T-1 tumors and high-grade dysplasia
• As experience was gained, T2 (n=71) and T3N1 (n=81) included
• Selection: resectable tumor by EUS and CT scanning, laparoscopic staging if questionable
• Prospective data base of standard outcomes
• Two quality of life (QOL) instruments
  – SF-36
  – Heartburn-related QOL

Patient Population

- 222 patients (186 males, 36 females)
  - Totally laparoscopic with neck anastomosis (n=14)
  - VATS esophageal mobilization, laparoscopic gastric tube, neck anastomosis (McKeown n=208)

- Updated results on first 1000 MIEs presented
- Average age 66 years (39-89)
- 51% received preoperative chemo and/or radiotherapy

Pathology
- Barrett’s high-grade dysplasia (35)
- Stage I (31)
- Stage II (71)
- Stage III (81)
- Stage IV (4)

Quality of Life Results

• SF-36 Global QOL
  – Physical Component Score: 44 post-op, no significant difference compared to pre-op values or age-matched norms
  – Mental Component score: 51 post-op, no significant difference compared to pre-op values or age-matched norms

• Heartburn-Related QOL
  – Post-op score 4.6 consistent with normal population score
  – Only 4% of patients had a post-op score in the severe reflux range (>15)
Laparoscopic Port Placement

Self-retaining liver retractor

4 5-mm ports
one 10-mm port
Laparoscopic Steps: Gastric Tubularization, Celiac node dissection, stapling of left gastric vessels

GE junction tumor
Mobilization of Stomach

- Handle the stomach gently
- Division of the omentum and omental branches of the gastroepiploic artery
- Avoid injury to the gastroepiploic arcade
- Avoid injury to the greater curvature of the stomach while dividing the short gastriacs
Creation of the gastric tube

- Construct narrow tube, 3-4 cm
- Begin 3-4 cm above pylorus
- Run staple line parallel to the line of the short gastrics
- Keep stomach on slight “stretch” while applying stapler
- Minimize trauma to the actual new conduit, “no touch” technique
Other Steps

• Needle Catheter Jejunostomy (our standard)
• Pyloroplasty (our standard, but may not be necessary with narrow gastric tube)
• Celiac LN dissection (our standard)
Laparoscopic Steps: Gastric Tubularization, Celiac node dissection, stapling of left gastric vessels

GE junction tumor

Endo-GIA II (4.8 mm load)
Tack Gastric Tube to Mobilized GE-Junction Tumor For Neck Retrieval
Completed Reconstruction With Cervical Anastomosis

- Open crura
- Tack gastric tube to hiatus
Ivor Lewis: VATS Portion of Operation

- Standard LN dissection
- Open phrenoesophageal ligament and retrieve specimen and deliver gastric tube into chest
- Transect esophagus
- Remove specimen
- Insert anvil and perform intrathoracic EEA anastomosis (preferably 28 mm, or 25 EEA)
Typical Location of Surgeon and Assistant Instruments During VATS part of Ivor Lewis or McKeown Approaches
VATS Ivor- Lewis Anastomosis (Video)
Ivor Lewis Approach

- Less gastric tube needed, better margins for cardia involvement, less ischemia
- Avoid neck dissection and potential recurrent laryngeal nerve injury
- Less aspiration
- Downside: intrathoracic leak can be more difficult to manage, no third field of LN dissection
- Technique, Learning curve to the VATS intrathoracic anastomosis
Laparoscopic Ports 3 Weeks Post-op
Thoracoscopic Ports 3-Weeks Post-op
Updated Series U Pittsburgh
American Surgical Association 2011 (n=1011)
Approaches

- McKeown 3 incision Minimally invasive esophagectomy with neck anastomosis (n=481; 48%)
- Ivor-Lewis Minimally invasive esophagectomy with chest anastomosis (n=530; 52%)

Patient Population

• 1011 patients (80% men, 20% women)
• Average age 64 years (39-89)
• 31% received preoperative chemo and/or radiotherapy
• Malignant Disease 95%
• Pathology
  • Barrett’s high-grade dysplasia 95 (13%)
  • Stage I 135 (18%)
  • Stage II 239 (31%)
  • Stage III 241 (32%)
  • Stage IV 48 (6%)

Objectives of Current study

• **Primary Objective:** To evaluate operative outcomes following minimally invasive esophagectomy in 1000 consecutive patients.

• **Secondary Objective:** To compare the outcomes of our two primary surgical approaches:
  – Vats, laparoscopy, neck anastomosis (McKeown MIE)
  – Laparoscopy, VATS, chest anastomosis (Ivor-Lewis MIE)
Study Design

- **Inclusion criteria**
  - Elective MIE for any indication (n= 1011)
  - Time: 1996 to 2011

- **Exclusion Criteria**
  - Non-elective MIE (n=22)
  - Open or hybrid esophagectomy

- Stratified based on approach, location of anastomosis
  - 3 incision McKeown MIE = 481; Ivor- Lewis MIE-Chest = 530
- Demographics, preoperative variables, operative details and adverse outcomes compared
- Survival assessed
Preoperative Patient Demographics

- MIE-Neck (n=481; 48%)
- MIE-Chest (n=530; 52%)
- No differences in preoperative patient characteristics between MIE-Neck and MIE-Chest

<table>
<thead>
<tr>
<th></th>
<th>n=1011</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (median, IQR)</td>
<td>64 (56, 72)</td>
<td>0.45</td>
</tr>
<tr>
<td>Male Sex</td>
<td>80%</td>
<td>0.21</td>
</tr>
<tr>
<td>Caucasian Race (n, %)</td>
<td>97%</td>
<td>0.502</td>
</tr>
<tr>
<td>BMI (kg/m²; median, IQR)</td>
<td>28 (25, 32)</td>
<td>0.144</td>
</tr>
<tr>
<td>BMI less than 30</td>
<td>63%</td>
<td></td>
</tr>
<tr>
<td>BMI 30 or greater</td>
<td>37%</td>
<td></td>
</tr>
</tbody>
</table>

### Indication for Operation and Co morbid Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>n=980</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Malignant Disease (%)</strong></td>
<td>95%</td>
<td>0.13</td>
</tr>
<tr>
<td><strong>Use of induction therapy</strong></td>
<td>31%</td>
<td>0.668</td>
</tr>
<tr>
<td><strong>Co morbid Conditions (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted CCI &gt;3</td>
<td>49%</td>
<td>0.69</td>
</tr>
<tr>
<td>COPD/Emphysema</td>
<td>12%</td>
<td>0.054</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>23%</td>
<td>0.99</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>19%</td>
<td>0.95</td>
</tr>
<tr>
<td>GERD</td>
<td>71%</td>
<td>0.76</td>
</tr>
<tr>
<td>Chronic Renal Insufficiency (baseline Cr&gt;2 or HD)</td>
<td>3%</td>
<td>0.88</td>
</tr>
<tr>
<td>Prior gastric or esophageal surgery</td>
<td>11%</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Operative Data

• Median operative time:
  – Overall 6.7 hours
  – Non-resident case: 4 hours
• Conversion to Open: 4%
• Median ICU stay: 2.0 days
• Median hospital stay: 8 days
• Median number of lymph nodes dissected 21
• 98% with negative surgical margins
<table>
<thead>
<tr>
<th>Pathologic Results</th>
<th>MIE-Neck</th>
<th>MIE-Chest</th>
<th>Total</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal/distal margins negative</td>
<td>98%</td>
<td>98%</td>
<td>98%</td>
<td>0.62</td>
</tr>
<tr>
<td>Median Number of LN examined</td>
<td>19</td>
<td>23</td>
<td>21</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adenocarcinoma Tumor Type</td>
<td>68%</td>
<td>83%</td>
<td>76%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nodal metastasis at esophagectomy</td>
<td>39%</td>
<td>49%</td>
<td>44%</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Pathology

Perioperative Outcomes
Mortality

• Mortality (30 day) for all patients (n=1011): 1.68 %

• Ivor-Lewis MIE: 0.9 %

## Major Complications-1
### Technique-related

<table>
<thead>
<tr>
<th>Condition</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>17 (1.68)</td>
</tr>
<tr>
<td>Anastomotic leak –overall</td>
<td>5%</td>
</tr>
<tr>
<td>Leak requiring surgery</td>
<td></td>
</tr>
<tr>
<td>Gastric tip necrosis</td>
<td>2%</td>
</tr>
<tr>
<td>Empyema</td>
<td>6%</td>
</tr>
<tr>
<td>Vocal cord paresis/ palsy</td>
<td>4%</td>
</tr>
</tbody>
</table>

Orringer Series
First 1,000 cases
- Mortality: 4%
- Anastomotic leak: 5%
- Gastric tip necrosis: 2%
- Empyema: 6%
- Vocal cord paresis/ palsy: 4%
## Morbidity: Comparison

<table>
<thead>
<tr>
<th></th>
<th>MIE-Neck</th>
<th>MIE-Chest</th>
<th>Total</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=481 (48)</td>
<td>n=530 (52)</td>
<td>n=1011</td>
<td></td>
</tr>
<tr>
<td><strong>Operative Mortality (30 day)</strong></td>
<td>12 (2.5)</td>
<td>5 (0.9)</td>
<td>17 (1.68)</td>
<td>0.126</td>
</tr>
<tr>
<td>Vocal Cord Paresis/Paralysis</td>
<td>8%</td>
<td>1%</td>
<td>4%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Empyema</td>
<td>6%</td>
<td>5%</td>
<td>6%</td>
<td>0.431</td>
</tr>
<tr>
<td>ARDS</td>
<td>4%</td>
<td>2%</td>
<td>3%</td>
<td>0.026</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>0.809</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>4%</td>
<td>2%</td>
<td>3%</td>
<td>0.033</td>
</tr>
<tr>
<td>Anastomotic leak requiring surgery</td>
<td>5%</td>
<td>4%</td>
<td>5%</td>
<td>0.439</td>
</tr>
<tr>
<td>Gastric tube necrosis</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
<td>0.140</td>
</tr>
</tbody>
</table>

Results of a Phase II Multicenter Study of Minimally Invasive Esophagectomy
Eastern Cooperative Oncology Group
Study E2202

J. Luketich et al
Ann Surgery 2015
Minimally Invasive Esophagectomy

Results of a Prospective Phase II Multicenter Trial—the Eastern Cooperative Oncology Group (E2202) Study

James D. Luketich, MD,* Arjun Pennathur, MD,* Yoko Franchetti, PhD,† Paul J. Catalano, PhD,‡
Scott Swanson, MD,§ David J. Sugarbaker, MD,§ Alberto De Hoyos, MD,¶ Michael A. Maddaus, MD,||
Ninh T. Nguyen, MD,** Al B. Benson, MD,¶ and Hiran C. Fernando, MD††
Prospective phase II trial of Minimally Invasive Esophagectomy

Total of 110 patients enrolled from 17 institutions in the United States (ECOG, CALGB, ACOSOG).

Protocol Surgery (MIE) was performed in 95 patients

Overall 30-day mortality rate 2%

Stage specific survival was similar to open series

ECOG 2202 Trial: Summary

- First Prospective phase II trial of Minimally Invasive Esophagectomy in the world
- Total of 110 patients enrolled from 17 institutions in the United States (ECOG, CALGB, ACOSOG).
- MIE was performed in 95 patients
- Overall 30-day mortality rate 2%
- Stage specific survival was similar to open series
- Locoregional recurrence only occurred in 6.9% of patients

*Luketich JD et al; Ann Surg 2015*
ECOG 2202: Surgery - Details

- Protocol Surgery (MIE) was performed in 95 out of 104 patients eligible for primary analysis.
- Duration of Thoracic and Abdomen Components – 330 Minutes (median).
- Anastomotic Technique:
  - Stapled – 90.3%
  - Hand Sewn – 9.7%
- Pyloric Drainage Procedure: 74%
- Feeding Jejunostomy Tube: 97%
- Lymphadenectomy:
  - Median Number of lymph nodes removed – 19
- Resection Status:
  - R0 resection with negative margins – 99 (96.1%)

Luketich JD et al; Ann Surg 2015
Results: Peri-Operative Outcomes

- Median length of ICU Stay – 2 Days
- Median Hospital LOS: 9 days
- Operative Mortality in eligible patients who underwent MIE – 2%

Major Grade 3 or higher adverse events:

- Pneumonitis 3.8%
- Anastomotic leak: 8.6%
- ARDS: 5.7%
- Atrial Fibrillation 2.9%

Luketich JD et al; Ann Surg 2015
ECOG 2202 Results: Discharge Status

• Most patients (n=92; 92%) were living at home after discharge

• Only 8 (8%) required admission or readmission to a care facility during follow-up.

• It is not known whether admission was related to the protocol therapy, the diagnosis of esophageal cancer, or for other reasons

Luketich JD et al; Ann Surg 2015
ECOG 2202 Results: Survival

- Mean follow-up of 35.8 months
- Estimated 3-year **overall survival** for the entire cohort was 58.4% (95% Confidence interval 48-68%).
- Stage specific survival was comparable to open series

*Luketich JD et al; Ann Surg 2015*
ECOG 2202 Results: Overall survival after MIE

Luketich JD et al; Ann Surg 2015
Results: Recurrence

- During follow-up, recurrence occurred in 28.4% of patients.
- Locoregional recurrence only occurred in 7 of the 102 patients (6.9%)
- Distant recurrence in 21 (20.6%)

_Luketich JD et al; Ann Surg 2015_
Conclusions

• Our minimally invasive experience includes a 2-field lymph node dissection and is associated with a low mortality rate for Ivor-Lewis (0.9%), acceptable morbidity, short hospital stay (8 days) and preserved QOL (compares favorably to open surgery)
  – Survival, stage for stage no different from open surgery results

• We recommend aggressive staging (EUS/PET) followed by laparoscopic/thoracoscopic Ivor Lewis esophagectomy with two-field lymph node dissection for distal esophageal cancers Stage I and II
  – Stage III consider neoadjuvant therapy vs. resect and adjuvant

• Prospective, controlled trial of minimally invasive esophagectomy to assess outcomes in a multi-institutional setting (Eastern Cooperative Oncology Group 2202) results encouraging
Thank You