Minimally Invasive Esophagectomy

in Esophageal Diseases

Essay
Submitted for partial fulfillment of the master degree in General surgery

By
Zaghloul Abdelatty Elshabasy
M.B., B.CH.

Supervised by
Prof. Dr. Sayed Mohamed Rashad Elsheikh
Professor of General surgery
Faculty of Medicine
Ain Shams University

Dr. Mohamed Mahfouz Mohamed
Lecturer of General Surgery
Faculty of Medicine
Ain Shams University

Ain Shams University

2010
Acknowledgement

First of all, my heartiest thanks to our Lord God, the most kind, most merciful and the most beneficent. I am also deeply so much obliged and can hardly express my hardless and limitless thanks to Prof. Dr. Sayed Mohamed Rashad Elsheikh, Professor of General Surgery, Ain Shams Faculty of Medicine, for his precious remarks, assistance comments, kind encouragement, moral support, continuous advice and sincere assistance for completion of this essay. I heartily and cordially utter all the expressive and impressive words of indebtedness and thankfulness to our honorable Dr. Mohamed Mahfouz Mohamed, Lecturer of General Surgery, Ain Shams Faculty of Medicine, for his patience, valuable guidance cooperative supervision, sincere help and tremendous efforts throughout this work that were the cornerstone in building up of this essay and without his, this work could never have been completed.

Zaghloul Abd elatty

2010
## Contents

<table>
<thead>
<tr>
<th>Subject</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) List of figures</td>
<td></td>
</tr>
<tr>
<td>(II) List of tables</td>
<td></td>
</tr>
<tr>
<td>(III) List of abbreviations</td>
<td></td>
</tr>
<tr>
<td><strong>Chapter (1) Introduction &amp; Aim of the work</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Chapter (2) Anatomy of the esophagus</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Chapter (3) Physiology of the esophagus</strong></td>
<td>43</td>
</tr>
<tr>
<td><strong>Chapter (4) Diagnosis of esophageal Diseases</strong></td>
<td>54</td>
</tr>
<tr>
<td><strong>Chapter (5) Surgical management of esophageal diseases</strong></td>
<td>130</td>
</tr>
<tr>
<td><strong>Chapter (6) Minimally invasive esophagectomy in esophageal diseases</strong></td>
<td>194</td>
</tr>
<tr>
<td><strong>Chapter (7) Summary</strong></td>
<td>231</td>
</tr>
<tr>
<td><strong>Chapter (8) Conclusion</strong></td>
<td>235</td>
</tr>
<tr>
<td><strong>Chapter (9) References</strong></td>
<td>236</td>
</tr>
</tbody>
</table>

**Arabic summary**
(III) List of abbreviations

ACA: Adenocarcinoma
AH: Angle of His
AJCC: American Joint Committee on Cancer
ARDS: Acute respiratory distress syndrome
BE: Barrett’s esophagus
BMI: Body mass index
BS: Barium swallow
CT: Computerized Tomography
EBE: En bloc esophagectomy
EGD: Esophagogastroduodenoscopy
EMR: Endoscopic mucosal resection
ESD: Endoscopic submucosal dissection
EUS: Endoscopic ultrasound
FDG-PET: Fluorodeoxyglucose - positron emission tomography
FIG: Figure
GEJ: Gastroesophageal junction
GERD: Gastroesophageal reflux disease
HGD: High-grade dysplasia,
HRQoL: Health-related quality of life
ICU: Intensive care unit
IEM: Ineffective esophageal motility
LES: Lower esophageal sphincter
LGD: Low-grade dysplasia
MIE: Minimally invasive esophagectomy
MRI: Magnetic resonance imaging
NBI: Narrow band imaging
NPO: Nil per os
PDT: Photodynamic therapy
PFT: Pulmonary function test
PPI: Proton pump inhibitor
RLNs: Recurrent laryngeal nerves
SAP: Symptom association probability
SI: Symptom index
SLNs: Superior laryngeal nerves
TEF: Tracheoesophageal fistula
THE: Transhiatal esophagectomy
TLESRs: Transient LES relaxations
TNM: Tumor, Lymph node, Metastasis
TTE: Transthoracic esophagectomy
UES: Upper esophageal sphincter
VSE: Vagal-sparing esophagectomy
WNM: Wall penetration, Lymph node, Metastasis
(II) List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table (1)</td>
<td>Esophageal motility disorders</td>
<td>69</td>
</tr>
<tr>
<td>Table (2)</td>
<td>Causes of secondary achalasia</td>
<td>72</td>
</tr>
<tr>
<td>Table (3)</td>
<td>TNM Classification for esophageal cancer</td>
<td>108</td>
</tr>
<tr>
<td>Table (4)</td>
<td>TNM Classification for esophageal cancer</td>
<td>109</td>
</tr>
<tr>
<td>Table (5)</td>
<td>Wall Penetration-Node-Metastasis (WNM)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Staging of esophageal carcinoma</td>
<td>110</td>
</tr>
<tr>
<td>Table (6)</td>
<td>Regional lymph nodes in esophageal cancer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cancer</td>
<td>113</td>
</tr>
<tr>
<td>Table (7)</td>
<td>Factors affecting surgical decision making for esophageal cancer</td>
<td>177</td>
</tr>
<tr>
<td>Table (8)</td>
<td>Comparison of esophageal resection Techniques</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>180</td>
</tr>
</tbody>
</table>
## (I) List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure (1)</td>
<td>Development of tracheobronchial diverticulum</td>
<td>6</td>
</tr>
<tr>
<td>Figure (2)</td>
<td>Variations of esophageal atresia and /or tracheoesophageal fistula</td>
<td>11</td>
</tr>
<tr>
<td>Figure (3)</td>
<td>Divisions, terminology, and relationships of the esophagus.</td>
<td>18</td>
</tr>
<tr>
<td>Figure (4)</td>
<td>Layers of the esophagus</td>
<td>19</td>
</tr>
<tr>
<td>Figure (5)</td>
<td>Sling and clasp fibers of the lower esophageal sphincter</td>
<td>27</td>
</tr>
<tr>
<td>Figure (6)</td>
<td>Attachments and structure of the phrenoesophageal membrane</td>
<td>30</td>
</tr>
<tr>
<td>Figure (7)</td>
<td>Arterial supply of the esophagus</td>
<td>34</td>
</tr>
<tr>
<td>Figure (8)</td>
<td>Lymphatic drainage of the esophagus</td>
<td>37</td>
</tr>
<tr>
<td>Figure (9)</td>
<td>Sequence of events during the oropharyngeal phase of swallowing</td>
<td>46</td>
</tr>
<tr>
<td>Figure (10)</td>
<td>Radiogram of hiatal hernia</td>
<td>61</td>
</tr>
</tbody>
</table>
Figure (11) Drawing illustrates the AJCC divisions and clinical divisions of the esophagus

Figure (12) T1 N0 M0 (stage I) SCC of the midesophagus in a 52-year-old man

Figure (13) T4 N1 M0 (stage III) SCC of the midesophagus in a 61-year-old man

Figure (14) Work-up of esophageal cancer

Figure (15) Nissen fundoplication

Figure (16) Nissen fundoplication

Figure (17) Partial anterior fundoplication

Figure (18) Partial posterior fundoplication

Figure (19) Management of caustic injury of the esophagus

Figure (20) Grade of dysplasia and proposed follow-up algorithm for the treatment of Barrett's esophagus

Figure (21) Gastric tube in position after esophagectomy

Figure (22) Laparoscopic mobilization of the stomach
during MIE

Figure (23) After a three-field esophagectomy for a distal esophageal carcinoma

Figure (24) Laparoscopic port position for minimally invasive Ivor Lewis esophagogastrectomy

Figure (25) Laparoscopic construction of the gastric conduit.

Figure (26) Trocar placement for thoracoscopy during minimally invasive Ivor Lewis esophagogastrectomy.

Figure (27) Thoracoscopic resection of the esophagus

Figure (28) Thoracoscopic construction of an intrathoracic anastomosis using a circular stapler

Figure (29) Thoracoscopic construction of an intrathoracic anastomosis using a circular stapler

Figure (30) Chest radiograph with upper gastrointestinal contrast outlining the esophagus
Introduction

Esophageal cancer is the 7th most frequent among solid cancers in the world, epidermoid or squamos cell carcinoma being the most common histological type. Incidence is the highest in the 6th and 7th decades and it is more frequent in males then in females (Malaisrie et al., 2004).

The risk of cancer development in Barrett's esophagus increases further when high-grade dysplasia develops (Falk, 2001).

Chemical or caustic esophageal injury occurs through ingestion of either strong acids (pH < 2) or alkali (pH >12) (Lowell, 2006). Ingestion is most often seen in adults attempting suicide and children who are victims of accidental poisoning (Triadafilopoulos, 2005). The former tend to ingest larger quantities as they are more motivated to swallow the substance whereas children are more likely to spit out the majority of the poison leaving less to insult the esophagus (Mamede and De Mello Filho, 2002).
Esophageal achalasia is a complex motor abnormality of the esophageal body and lower esophageal sphincter, affecting six in 100,000 individuals, and, after gastro esophageal reflux disease, is the second most common functional disorder of the esophagus requiring surgery (Nussbaum et al., 2001).

Esophageal resection may be a life-saving and life enhancing procedure for esophageal cancer, patient with Barrett esophagus with high grade dysplasia, esophageal strictures and end-stage achalasia. The open operative approaches such as those described by Orringer et al., are still the standard of care for esophageal resections in most medical centers. However, the morbidity and mortality associated with these procedures in most medical centers remains significant (Wee and Luketich, 2007).

Traditional open surgical transthoracic and transhiatal esophagectomies are associated with a relatively high morbidity rate of up to 80% and a 5% mortality rate when performed by experienced surgeons. Major complications include pulmonary problems and anastomotic leaks. Other potential problems include intraoperative bleeding, which is more likely to happen
with the transhiatal approach because of the blunt mediastinal dissection, infectious complications and recurrent laryngeal nerve injury (Nguyen et al., 2000).

Since the introduction of laparoscopic fundoplication (Dallemagne et al., 1991), improvements in instrumentation and optics have allowed the development of minimally invasive approaches to esophageal diseases that have been traditionally managed by open operation (Luketich et al., 2000).

Minimally invasive esophagectomy has the potential advantages of being a less traumatic procedure with an easier postoperative recovery and fewer wound and pulmonary complications. In addition, good laparoscopic visualization may facilitate mediastinal dissection and decrease the blood loss associated with open transhiatal dissection (Bottger et al., 2007).
THE AIM OF THE WORK

The aim of this work is to clarify the advantages and disadvantages of the novel technique of the minimally invasive esophagectomy.
Embryology of the esophagus

During the embryonic period of development, cephalocaudal and lateral folding of the embryo occurs. As a result, a portion of the endoderm-lined yolk sac cavity is incorporated into the embryo to form the primitive gut. The primitive gut forms a blind-ending tube consisting of the foregut, the midgut, and the hindgut. The foregut gives rise to the esophagus. It extends from the pharyngeal tube as far caudally as the liver outgrowth (Skandalakis et al., 2004).

The development of the esophagus begins in the 3rd week of gestation, and by 14th week the fetus takes its first swallow. By the end of the 3rd week of development, the primitive foregut develops a ventral diverticulum from which the tracheobronchial tree develops. The tracheoesophageal septum gradually partitions this diverticulum from the dorsal portion of the foregut, resulting in a ventral respiratory primordium and a dorsal esophagus (Fig 1: A, B) (Maish, 2007).

Immediately after this diverticulum forms, the stomach develop further distally by an asymmetrical extension (Skandalakis et al., 2004).
Fig.(1): A,B: Development of tracheobronchial diverticulum from the primitive foregut (4 weeks) (Sadler, 2006). C: Foregut segment in a 4-week-old embryo, showing division into the upper esophageal segment and the primitive lung buds (Blevins, 2005).