SCIENTIFIC PAPER

Zero Leaks With Minimally Invasive Esophagectomy: a Team-Based Approach

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ABSTRACT

Introduction: Minimally invasive surgery has been applied in several ways to esophagectomy. Newer techniques have improved patient outcomes while maintaining oncological principles; however, mortality still exists. Most series have reported mortality rates ranging from 2% to 25%. The aim of this study was to determine the efficacy of minimally invasive esophagectomies (MIE) in a non-university tertiary care center.

Methods: MIE in the form of a combined thoracoscopic and laparoscopic technique was performed cooperatively by 2 surgeons. Records of patients who underwent MIE between September 2005 and August 2008 were retrospectively reviewed.

Results: Thirty-four patients underwent MIE over a 3-year period. There was a male predominance. Mean age at presentation was 62.6 years. Comorbidities were documented in 79% of the patients. Most patients (68%) presented with dysphagia. Two patients had end-stage achalasia, 1 had corrosive esophageal stricture, and 31 had esophageal malignancies. No mortalities were reported. No anastomotic leaks were observed. Eighteen (58%) patients with malignancy received preoperative chemoradiotherapy. Six (33%) patients had a pathological response (CR) on final histopathology. The mean operating time was 294 minutes. The mean blood loss was 302 mL.

Conclusions: Minimally invasive esophagectomy can be performed with results that meet and exceed reported benchmarks. A team-based approach greatly impacts the outcome of the surgery. This surgical technique must be standardized to achieve this outcome.

Key Words: Minimally invasive esophagectomy, Anastomotic leak, Outcomes.

INTRODUCTION

Esophagectomy is a complex procedure involving multiple fields of dissection. It is the treatment of choice for esophageal neoplasms and, sometimes, benign disorders, such as end-stage achalasia and corrosive strictures. Esophagectomy has been associated with high mortality and morbidity rates from the time it was first performed. The esophagectomy techniques (transthoracic, transhiatal, or 3-field approach) and the fields of lymphadenectomies have been an area of debate. However, many studies report equivocal outcomes.[1,2] Minimally invasive surgery has been applied in several ways to esophagectomy: transhiatal, thoracoscopy with laparotomy and cervical anastomosis, thoracotomy with laparoscopy, and lastly thoracoscopy and laparoscopy with cervical or intrathoracic anastomosis. Many centers worldwide have reported on their experiences with esophagectomy using various minimally invasive techniques.[3,4] In recent years, with the availability of improved surgical technology and advances in intensive care, the operative outcome has improved significantly. This has led to an interest in newer techniques that provide improved patient outcomes while maintaining sound oncological principles. The purpose of this report is to describe a novel technique for minimally invasive esophagectomy that has resulted in an excellent outcome in a very ill group of patients. Moreover, the key components of success necessary to improve outcomes in this complex group of patients are examined.

The study was performed to describe (1) a modified technique for performing minimally invasive esophagectomy. In patients with cancer, this technique provides for sound oncologic principles with 3-field dissection; (2) to examine the surgical outcomes after minimally invasive esophagectomy; (3) to discuss the

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components of the process that are required to attain favorable procedure-related outcomes.

Long-term oncologic outcomes were not the object of this study because of the small sample size and the short duration of follow-up.

METHODS

Minimally invasive esophagectomy (MIE) in the form of combined thoracoscopic and laparoscopic esophageal resections performed cooperatively by 2 surgeons (DRJ and JJ) between September 2005 and August 2008 were retrospectively reviewed. The Methodist Dallas Medical Center Institutional Review Board approved the study design. Patient-related data, including age, sex, medical history, presenting symptoms, preoperative weight, and need for preoperative stenting, were collected. Intraoperative data including estimated blood loss, operative time, need for intraoperative blood transfusions, type of reconstruction, and ASA class were collected. Postoperative data including length of hospital stay, need for intensive care unit, need for postoperative blood transfusions, morbidities, and 30-day mortality were evaluated. Histopathologic data including tumor type, margin status, and nodal status were collected. All patients underwent preoperative staging with computerized axial tomography (CAT) scans. Barium swallow and positron emission tomography (PET) scans were obtained when clinically indicated. Endoscopic ultrasound (EUS) was performed in all patients with malignant disease. Patients diagnosed with early stage esophageal cancer (less that T3 lesions with no clinical or EUS noted node positivity) were taken to surgery without preoperative chemotherapy or radiation therapy. Patients with extensive local disease were treated with neoadjuvant chemoradiotherapy. Patients who were to receive preoperative therapy who had significant dysphagia received laparoscopic feeding tube placement and mediport insertion while under the same anesthesia before the commencement of neoadjuvant therapy. This also permitted simultaneous staging for metastasis to the liver and peritoneum. The esophagectomy procedure was performed as outlined below. This was performed 6 weeks to 12 weeks after completion of radiation therapy in those patients who received preoperative treatment. All patients underwent Gastrografin, followed by barium swallow to assess patency of the esophagogastric anastomosis on the sixth postoperative day. The nasogastric tube was removed, and the diet was advanced gradually. Jejunal tube feeding was utilized until the patient could take adequate oral supplementation.

Operative Technique

To adhere to sound oncological principles, it is the feeling of the authors that a 3-field approach is warranted. The authors favor a neck anastomosis. While this approach results in less morbidity if there is a leak, the inherent greater risk exists of injury to the recurrent laryngeal nerve. Wide resection of previously radiated tissue with anastomosis of fresh stomach to esophagus is the authors' preference. Lack of conduit length has not been a concern in the authors' hands. Therefore, the authors have adopted a routine cervical anastomotic technique. Specifically, the technique involves thoracoscopic mobilization of the esophagus in the chest; laparoscopic mobilization of the stomach; minilaparotomy to retrieve the specimen and to perform the pyloroplasty and Kocher maneuver; and open neck incision with passage of the gastric pull-up to the neck from the abdomen and performed as follows.

Thoracoscopic mobilization of the esophagus in the chest

The patient is placed in a left lateral decubitus position and is secured with a beanbag. Single-lung ventilation is achieved by using a double-lumen endotracheal tube, and thoracoscopic trocars are placed as outlined in **Figure 1**. It is critical to place the camera port as inferiorly as possible on the chest wall, while staying above the diaphragm. This allows the working surgeon to work heading cephalad, rather that towards the feet, or backwards. The retractor port should be just inferior to the scapula. The esophagus is detached from its blood supply, and the azygous vein is divided using a stapler with a vascular load. Encircling the esophagus with a Penrose drain will allow easier retraction as the dissection is carried out towards the thoracic inlet. It is difficult, and not necessary, to dissect inferiorly towards the hiatus, as this can be done with ease from the abdomen. A single 32Fr pleural tube is left in place after the thoracic procedure. No epidural catheter is placed. Specifically with regards to the thoracic nodal clearance, local nodes in the paraesophageal, paratracheal, and subcarinal stations are taken. However, the authors do not make any attempt to perform a more extensive nodal dissection.

Laparoscopic mobilization of the stomach

The patient is then placed in leg splitter position, and the operating surgeon stands to the patient's right side,

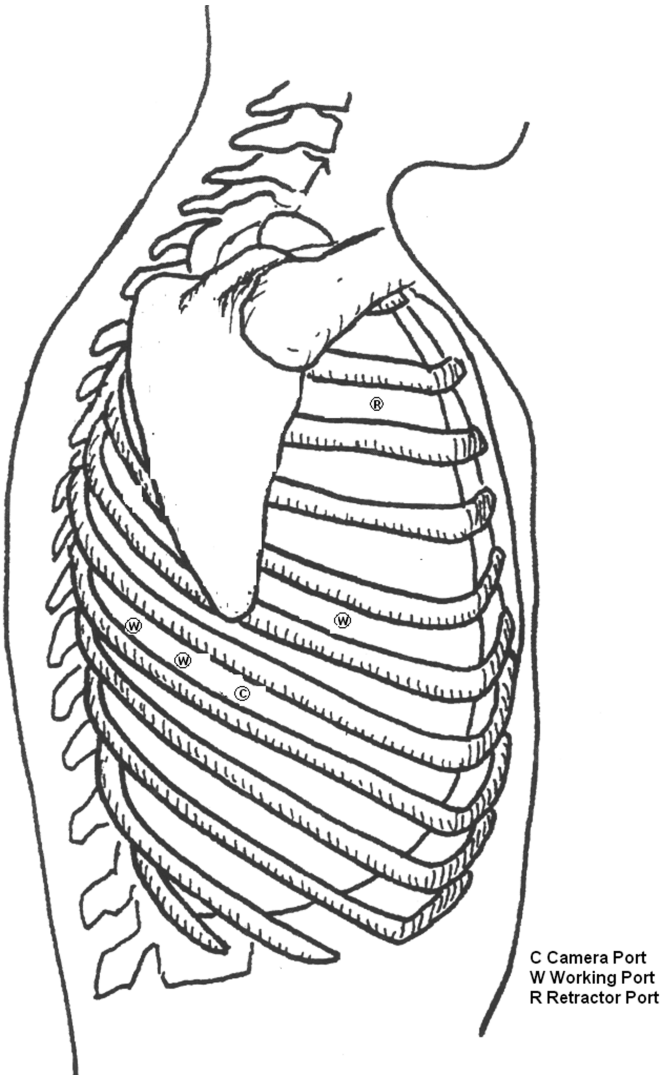

Figure 1. Port placement for thoracoscopic esophageal mobilization.

with the assistant between the legs. Port positions are shown in **Figure 2**. It is important that the retractor port is placed in as far to the patient's right as possible and as directly subcostal as possible. This allows the retractor not to interfere with the work of the operating surgeon. The short gastric vessels are taken using the Harmonic scalpel, the greater curvature is mobilized completely, and the hiatus is then dissected completely. The esophagus can be encircled with a Penrose drain to assist with retraction. The left gastric vascular bundle is taken with a vascular stapler as low as possible to include the celiac nodes. Specific celiac skeletonization is not routinely performed unless clinically concerning nodes are present.

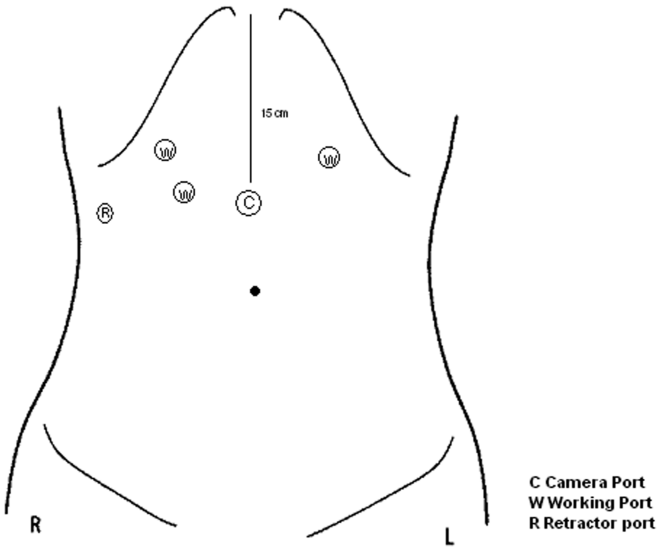

Figure 2. Port placement for laparoscopic component.

Minilaparotomy to retrieve the specimen and to perform the pyloroplasty and Kocher maneuver

At this time, the trocars are removed, and a small incision is made vertically around the camera port. This is carried out so as to permit a hand 3 inches to 4 inches into the abdomen. A Kocher maneuver is performed, and a Heineke-Mikulicz pyloroplasty is performed in a single layer, both under direct visualization. It is important that the Kocher maneuver be generous such that the pylorus reaches the hiatus. This helps to decrease any tension on the conduit and will decrease bile reflux in the future. The authors have not had any issues with conduit length if this technique is adhered to. The authors have found over time that the open pyloroplasty through a minilaparotomy incision has saved time and effort compared with their older technique of a fully minimally invasive approach. The ports have to be adjusted to view the pylorus adequately, and this was found to be cumbersome. Any attachments in the mediastinum can be bluntly dissected with a hand. It is important that the hiatus be manually widened so as not to impinge on the conduit as it ascends into the chest. The use of laparoscopy results in the hiatus being narrowed, and this will impede egress of conduit into the chest and neck resulting in a lack of length.

Open neck incision with passage of the gastric pull-up to the neck from the abdomen

The left neck is then opened, and the esophagus is encircled. It is important to minimize cautery and dissection in the tracheoesophageal groove to decrease the risk of

recurrent laryngeal nerve injury. No specific attempt is made to perform a specific nodal dissection in the neck. The dissection is continued into the posterior mediastinum until the esophagus is completely free. The esophagus is then transected in the neck. A sterile nasogastric tube is attached to the specimen side, and the specimen is retrieved through the abdomen. The stomach is transected by using a stapler with minimal tubularization. The celiac nodes on the lesser curvature should be included in the specimen. The sterile nasogastric tube lying in the posterior mediastinum is attached to the conduit, which is pulled up to the neck. A partially stapled anastomosis is then performed in the neck. The cervical esophagogastric anastomosis is done using the Orringer technique, which is a side to side posterior stapled layer followed by an interrupted anterior hand sewn layer.[5] The neck is explored solely for the purpose of obtaining a cervical esophagogastric anastomosis. A cervical lymphadenectomy is not performed. The procedure is then completed after one drain and a feeding jejunostomy tube are placed in the neck, if this had not already been placed preoperatively.

RESULTS

During the time frame of this study, 34 patients underwent minimally invasive esophagectomy.

Preoperative Factors

Patient demographic data are shown in **Table 1**. There was a male predominance in the study. Mean age at presentation was 62.6 years (SD=14.3, range 20 to 83). Comorbidities were documented in 79% of the study group. The comorbidities were defined as preoperative medical conditions that are known to affect perioperative outcome in patients undergoing surgery, such as ischemic heart disease, COPD, diabetes mellitus, syndrome of inappropriate antidiuretic hormone secretion. The majority of patients had multiple comorbidities. Most patients (68%) presented with dysphagia. All patients underwent a preoperative CAT scan. Two patients were operated on for end-stage achalasia. They had both failed prior Heller myotomy, whereas one patient was operated on for corrosive stricture of the esophagus secondary to lye ingestion. Eighteen (58%) patients with malignancy received preoperative chemoradiotherapy. One patient underwent preoperative esophageal stenting to aid in swallowing.

Operative Factors

Operative-related factors are shown in **Table 2**. The majority of patients (94%) were either ASA class III or IV.

Table 1.
Preoperative Data

Parameter	No. of Patients	%
Total Esophagectomies	34	
Males/Females	21/13	62/38
Presenting Symptoms		
Dysphagia	21	68
Reflux	13	38
Pain	3	9
Vomiting	4	12
GI Bleed	3	9
Anemia	3	9
Asymptomatic	3	9
Odynophagia	2	6
Respiratory Symptoms	3	9
Mean Age (yrs) ± SD* (Range)	62.6 yrs ± 14.3 20–83 years	
Mean Weight ± SD* (Range)	79.8 kg ± 17.1 52–134 kg	
Mean BMI ± SD* (Range)	27 ± 5.93 (19– 40)	
Comorbidities: Diabetes, Ischemic Heart Disease, COPD, etc.	27	79
Previous Major Abdominal Surgery	6	18
Previous Thoracic Surgery	1	3
Esophageal Stenting	1	3
Neoadjuvant Chemoradiotherapy	18	58

*SD = standard deviation; BMI = body mass index.

Mean operating time was 294 minutes (SD=68.3, range 199 to 462). Mean estimated blood loss was 302mL (SD=137, range 100 to 700). Seven (21%) patients received intraoperative blood transfusions, while 4 (12%) received blood in the postoperative period. Three patients (9%) required nonemergent extension one of which was a minithoracotomy due to adhesions around the bronchus. Two patients underwent conversion of the abdominal component with a minilaparotomy incision one each for adequate left gastric clearance and adhesions in the lower thorax and perihiatal area. Both patients who had known esophageal and gastric involvement received neoadjuvant therapy to downstage as much as possible with an anticipation for total gastrectomy. Two patients underwent a

Table 2.
Intraoperative Data

ASA Classification (n)	
ASA I	0
ASA II	2 (6%)
ASA III	18 (53%)
ASA IV	14 (41%)
Mean Estimated Blood Loss (mL) ± SD*	302 mL ± 137
(Range)	(100–700 mL)
Mean Operative Time (min) ± SD*	294 min ± 68.3
(Range)	(199–462 min)
Intraoperative Blood Transfusions	7 (21%)
Extension to Open Celieotomy	
Overall extension	3 (9%)
Extension to minithoracotomy	1 (3%)
Extension to minilaparotomy	2 (6%)

*SD = standard deviation.

colonic transposition with an esophagocolonic anastomosis in the neck. This was done due to a positive stomach margin. The remnant stomach was inadequate to construct the gastric tube for cervical anastomosis. These were performed with a hand-assisted laparoscopic technique.

Postoperative Data

Postoperative data are shown in **Table 3**. No mortalities occurred in the series. The overall morbidity rate was 61%. No anastomotic leaks occurred in any of the patients. Sixty-one percent of the patients who underwent neoadjuvant therapy developed morbidities. Reoperation was necessary in 3 (9%) patients, all for closure for abdominal dehiscence. Amongst the patients who developed wound dehiscence, one had received neoadjuvant therapy and another had undergone an extension to a laparotomy. Delayed gastric emptying was defined as the inability to feed orally or as delayed emptying seen radiologically. Three patients developed an anastomotic stricture; one of these patients underwent dilatation 4 weeks postoperatively, while the others underwent dilatation long after from surgery.

Histopathological Data

The histopathological data are shown in **Table 4**. The most common histopathologic diagnosis was adenocarcinoma. One patient who was diagnosed preoperatively as having Barrett's with high-grade dysplasia had a stage I adenocarcinoma on final histopathology. Eighteen patients received neoadjuvant chemoradiotherapy and subsequently underwent MIE. Of these, 6 (33%) patients had complete response to therapy in that there was no evidence of disease on final histopathology. Two other patients with no residual primary tumor on final histopathology had <1-mm tumor metastasis in the lymph nodes.

Table 3.
Postoperative Data

Parameter	
30 day postoperative mortality (n)	0
Postoperative Blood Tranfusions (n)	4 (12%)
Mean length of stay (days) ± SD	14.6 ± 10.4
Major Morbidity (n)	
Delayed Gastric Emptying	5 (15%)
Cardiac Events	7 (21%)
Aspiration	6 (18%)
Wound Infection	2 (6%)
Wound dehiscence	3 (9%)
Vocal Cord Palsy	2 (6%)
Pneumonia	8 (24%)
Reintubation	4 (12%)
Intestinal Obstruction	1 (3%)
ARDS	1 (3%)
Minor Morbidity	
UTI	5 (15%)
Anastomotic Stricture	3 (9%)
DVT	2 (6%)
Reoperation: Wound Repair (n)	3 (9%)
Non Surgical Reintervention: Esophageal Dilatation (n)	1 (3%)
Ventilatory Support >24 hrs (n)	5 (15%)

*SD = standard deviation; ARDS = acute respiratory distress syndrome; UTI = urinary tract infection; DVT = deep venous thrombosis.

DISCUSSION

Esophagectomy is a challenging surgical technique. Various open techniques depending on the location of the tumor can be performed by general surgeons, surgical oncologists, thoracic surgeons, and foregut surgeons. Each group has a different skill set and bias leading to a heterogeneous method of treating esophageal disease in

Table 4.
Histopathological Data

Diagnosis	No. Pts. (Unless Otherwise Noted)	%
Total Malignant Tumors	31	91
Adenocarcinoma	21	62
Squamous carcinoma	7	20
High-grade dysplasia with Barrett's	3	9
Total Benign Conditions	3	9
End-stage achalasia	2	6
Corrosive stricture	1	3
Final Stage		
Stage 0	3	9
Stage I	8	26
Stage IIA	7	23
Stage IIB	2	6
Stage III	3	9
YP0	8	26
Total Positive Tumor Margins	3	9
Proximal margin positive	2	6
Distal margin positive	1	3
Radial margin positive	1	3
Mean Lymph Nodes Retrieved ± SD (Range)	11 nodes ± 5.44 (1–26)	

the United States. Transthoracic and transhiatal approaches each have their benefits and drawbacks. There has never been a clear oncological advantage to one over the other.[1,2] The major goal of esophageal surgery, however, should be to achieve low mortality and morbidity rates with an equitable oncological survival benefit. This study demonstrates that excellent results can be achieved in high-risk patients undergoing major surgery with a novel minimally invasive technique.

De Paula et al[6] were among the first to report on laparoscopic transhiatal esophagectomies. Law et al[7]described the technique of thoracoscopic esophageal mobilization. Yamamoto et al[8] suggest the feasibility of video-assisted thoracoscopic surgery for thoracic mobilization not only in terms of an improved postoperative outcome but also in terms of equitable 5-year survivals. Subsequently Luketich et al and Nguyen et al have reported on their experiences with total thoracic with laparoscopic thoracic mobilization and resection, suggesting that excellent results can be obtained using minimally invasive techniques and maintaining oncological standards as that in open esophagectomy.[9–11] Most series have reported mortality rates ranging from 2% to 14%.[9,11–14] However, the anastomotic fistula rates in most series remain high.[9,10,14] Importantly, this paper demonstrates no mortalities in a group of patients with significant morbidities and with a zero leak rate. This study demonstrates that the operating time can be limited to 302 minutes in spite of the change in patient positioning and 2 surgeons being involved in the surgery. When comparing the aforementioned parameters with reported series of open esophagectomies, this study demonstrates a comparable operative outcome with no anastomotic fistula rates.

Due to the complexity of the surgery and multiple dissection fields involved in patients often with a poor ASA status, the development of a multidisciplinary team is the critical factor in generating the outcome. Initial assessment of the patient with esophageal disease includes risk stratification of the comorbidities with the input of an excellent pulmonologist and cardiologist. Staging of patients with esophageal malignancies is crucial in delineating who should go on to receive neoadjuvant treatment. Local staging with EUS is crucial to determining who should receive up-front treatment.[15,16] A dedicated gastroenterologist who has EUS skills is essential. Pathologists familiar with cytology are needed to evaluate fine-needle aspirations of the lymph nodes.

Intraoperatively, an anesthesiologist familiar with cardiac anesthesia and single-lung ventilation and the operating team are important. The skill set required of the surgeon will be discussed below. A dedicated scrub technician and circulating nurse are needed to ensure that the flow of the surgery is maintained without unnecessary delays.

Several other points are raised by the data presented in this article:

1) What are the hospital-related factors that suggest that a minimally invasive esophagectomy team can be assembled?

2) What are the surgeon-related factors that allow the surgeon to be able to develop the team?

Mortality and morbidity in complex surgeries are evaluated as key components in assessing a surgeon's, and more importantly, an institution's ability to manage high-risk surgery. Preoperative preparation, especially in patients with multiple comorbidities, needs to be done to

minimize perioperative risk. Selection of appropriate patients for minimally invasive esophagectomy and oncologic management of tumors after minimally invasive esophagectomy requires the expertise of gastroenterologists with EUS skills, medical oncologists, and radiation oncologists. Professionals with these specific skills should be sought when building the team.

The nursing team needs to be carefully selected and trained to be dedicated to patients who undergo minimally invasive surgery. In fact, with careful education and the development of a specific nursing team for both intraoperative and postoperative care, operative times and the intensive care stay can be shortened. The authors have identified a specific nursing supervisor in the operating room to educate and train a set of nurses to take care of patients who undergo minimally invasive surgery. Esophagectomy mandates postoperative intensive care and aggressive postpulmonary care. With minimally invasive esophagectomy, the surgical insult can be reduced so as to reduce the incidence of postoperative thoracic complications. A trained intensive care team lead by the operating surgeon can help achieve the same.

The surgeon factor is a difficult area to evaluate. The surgeon must have a skill set that includes the following:

a) Thoracic surgery

b) Abdominal surgery

c) Minimally invasive surgical techniques (thoracoscopy and laparoscopy)

d) Oncological principles

e) Critical care

The question is, can any one surgeon possess all of these traits? It is the feeling of the authors that a team approach is the best way to give the patient the best chance of success. In fact, the thoracic surgeon might have the best thoracic expertise, but he or she might not have the best ability to mobilize the stomach. The surgical oncologist has the best understanding of the behavior of malignant tumors, but can he or she adequately understand benign disease or minimally invasive techniques? It is with this background that we feel that an organ-specific approach to esophageal disease is important–treating benign disease improves one's ability to treat malignant disease. Given its technical challenges, it has become clear that this operation should be performed by those who have completed a fellowship focusing specifically on esophageal disease. The development of a dedicated upper gastrointestinal surgical fellowship at Methodist Hospital is one example of such a training modality.

CONCLUSION

Minimally invasive esophagectomy can be performed with results that meet and exceed reported benchmarks. The surgical technique needs to be standardized to achieve this outcome.

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