Comparison of Minimally Invasive Esophagectomy
With Transthoracic and Transhiatal Esophagectomy

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Hypothesis: Minimally invasive esophagectomy can be performed as safely as conventional esophagectomy and has distinct perioperative outcome advantages.


Setting: University medical center.

Patients: Eighteen consecutive patients underwent combined thoracoscopic and laparoscopic esophagectomy from October 9, 1998, through January 19, 2000. These patients were compared with 16 patients who underwent transthoracic esophagectomy and 20 patients who underwent blunt transhiatal esophagectomy from June 1, 1993, through August 5, 1998.

Main Outcome Measures: Operative time, amount of blood loss, number of operative transfusions, length of intensive care and hospital stays, complications, and mortality.

Results: Patients who had minimally invasive esophagectomy had shorter operative times, less blood loss, fewer transfusions, and shortened intensive care unit and hospital courses than patients who underwent transthoracic or blunt transhiatal esophagectomy. There was no significant difference in the incidence of anastomotic leak or respiratory complications among the 3 groups.

Conclusion: Minimally invasive esophagectomy is safe and provides clinical advantages compared with transthoracic and blunt transhiatal esophagectomy.

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ESOPHAGECTOMY FOR benign or malignant disease is associated with high morbidity and mortality.1 Although the best approach to esophagectomy remains controversial, the 2 most frequently performed operations are transthoracic (TT) and blunt transhiatal esophagectomy (THE).2-3 The transthoracic approach allows the surgeon to perform a wide mediastinal lymphadenectomy and provide adequate hemostasis that cannot be ensured by THE. However, THE avoids a thoracotomy and therefore reduces associated pulmonary complications.

With the recent advances in laparoscopic surgery, it is possible to apply minimally invasive surgical techniques to esophagectomy. The initial minimally invasive surgical procedure dealt mainly with thoracoscopic esophagectomy combined with a standard upper midline laparotomy and cervical anastomosis.4-7 Subsequently, several authors have demonstrated the feasibility and safety of minimally invasive total esophagectomy (laparoscopic transhiatal technique or combined thoracoscopic and laparoscopic approach).8-11 However, there has been no study comparing patients treated with minimally invasive esophagectomy with those treated with conventional esophagectomy. Herein, we compared 18 consecutive patients who underwent minimally invasive esophagectomy with those who had TT and THE.

RESULTS

There were no significant differences among the 3 groups in terms of age, history of abdominal surgery, American Society of Anesthesiology classification, and indications for surgery (Table 1). The 3 groups were not matched for sex; there were slightly more women in the TM/LE group. Nine (64%) of 14 patients with esophageal cancer in the TM/LE group, 8 (44%) of 18 patients in the THE group, and 1 (7%) of 15 patients in the TT group un-
PATIENTS AND METHODS

PATIENTS

From October 9, 1998, through January 19, 2000, 25 patients were evaluated for esophagectomy at the University of California, Davis, Medical Center, Sacramento. Eighteen patients (72%) underwent combined thoracoscopic and laparoscopic esophagectomy (TM/LE), and 7 patients with esophageal cancer were treated nonoperatively for locally advanced unresectable disease or documented distant metastasis. During this period, conventional esophagectomy (TT or THE) was not performed on any patient at our institution.

Data on patients undergoing TM/LE were prospectively collected on a computerized form: age, sex, operative time, estimated blood loss, number of patients needing intraoperative blood transfusion, length of intensive care unit (ICU) and hospital stays, mortality, and postoperative complications. If a patient was readmitted to the ICU, the duration of stay was recorded and added to the total ICU stay. Hospital stay was calculated from the date of surgery to the date of discharge. The same form was used to collect information from a retrospective chart review of all patients who underwent TT or THE from June 1, 1993, through August 5, 1998. During that period, 16 patients underwent TT and 20 patients underwent THE. Nineteen patients were excluded from the review for the following reasons: emergency esophagectomy (8 patients), subtotal gastrectomy and primary colonic interposition (5 patients), and combined pharyngolaryngectomy with esophagectomy (6 patients). Patients who underwent TM/LE were compared using the criteria listed above with those who underwent TT or THE. Because of the short follow-up time in the TM/LE group, survival data were not analyzed.

OPERATIVE TECHNIQUES

Combined Thoracoscopic and Laparoscopic Esophagectomy

The TM/LE technique has been described previously.12 In short, the procedure was conducted in 3 stages. In the first stage, thoracoscopic dissection was done with the patient in the left lateral decubitus position. Four thoracic trocars were introduced in the right chest. Carbon dioxide insufflation was not used during thoracoscopic. The mediastinal pleura overlying the esophagus was divided to expose the intrathoracic esophagus. The azygos vein was divided, and a Penrose drain was placed around the esophagus to facilitate esophageal retraction. The esophagus was circumferentially mobilized from the esophageal hiatus up to the thoracic inlet. Paraesophageal lymph nodes were dissected and removed or mobilized en bloc with the resected specimen. A 28F chest tube was inserted through the camera port for postoperative chest drainage.

In the second stage, the patient was placed in the supine position. Five abdominal ports were placed on the anterior abdominal wall. The entire greater curvature of the stomach was mobilized, preserving the right gastroepiploic vessels. The left gastric vessel was isolated and divided with an endoscopic stapler (US Surgical Corp, Norwalk, Conn). Laparoscopic pyloroplasty was performed with interrupted sutures. The gastric conduit was created by stapling the stomach, starting on the lesser curvature and ending at the angle of His. The gastric conduit was sutured to the mobilized esophagus for tunneling to the neck. A feeding jejunostomy was placed laparoscopically in the proximal jejunum. In the third stage, a horizontal neck incision was made 1 finger breadth above the suprasternal notch. The cervical esophagus was mobilized until the dissection plane achieved in the right chest was encountered. The entire esophageal specimen with the attached gastric conduit was delivered through the cervical incision. An esophagogastic anastomosis was created with a circular end-to-end anastomotic stapler (Premium Plus CEEA 25; US Surgical Corp) placed through a small gastrostomy in the gastric conduit.

Blunt Transhiatal Esophagectomy

The stomach was used as the esophageal substitute in 19 (95%) of 20 patients. The colon was used in 1 patient who was found intraoperatively to have ischemia of the gastric conduit. The gastric conduit or colon interposition was placed in the original esophageal bed in all 20 patients.

Transthoracic Esophagectomy

A right thoracotomy was performed in 11 of 16 patients. Five patients had a left thoracotomy. A hand-sewn intrathoracic anastomosis was performed on 15 of 16 patients. One patient had a cervical anastomosis.

POSTOPERATIVE CARE

All patients were transferred to the ICU. In the TM/LE group, postoperative analgesia was provided by patient-controlled analgesia; in the TT and THE groups, by epidural catheter. A barium contrast study was routinely performed on postoperative day 3 or 4 in the TM/LE group unless the patient was still in the ICU; the contrast study was done on postoperative day 7 in the TT and THE groups. Chest tubes were removed and clear liquid diet started when the contrast study demonstrated no leaks. Supplemental jejunal feeding was administered routinely for 1 to 2 weeks after operation in the TM/LE group.

STATISTICAL ANALYSIS

Data were reported as mean±SD. Demographics and indications for surgery were compared by means of 1-way analysis of variance or the Fisher exact test. Comparison of operative results between surgical groups was performed by means of a Kruskal-Wallis test, followed by a pairwise Mann-Whitney test. Complication rates were compared between groups by means of the χ2 test for independence. Statistical analysis was performed using standardized biomedical software (Statview; SAS Institute Inc, Cary, NC). Differences were considered significant at P<.05.

OPERATIVE DATA

The perioperative outcomes for all groups are listed in Table 2. The operating time and operative blood loss...
were significantly less in the TM/LE group than in the TT and THE groups (P<.001). There were no intraoperative complications in either the thoracoscopic or laparoscopic portion of the TM/LE procedure that required conversion to thoracotomy or laparotomy. There also were no intraoperative complications in the TT group, but intraoperative complications occurred in 4 (20%) of 20 patients in the THE group, ie, a tracheal tear (1 patient), an incidental splenectomy (2 patients), and a torn azygos vein (1 patient). Intraoperative transsections were required in 3 patients (17%) in the TM/LE group, 8 patients (50%) in the TT group, and 15 patients (75%) in the THE group. The TM/LE patients had a shorter ICU stay than the TT (P = .03) or THE (P = .04) patients. The length of hospital stay was 50% shorter in the TM/LE group than in the TT (P = .004) and the THE (P = .001) groups. The mean number of lymph nodes removed by TM/LE was similar to the number removed during the TT and THE operations. All surgical margins were free of tumor in the TM/LE group. One of 16 patients in the TT group had a positive margin for Barrett’s metaplasia, and 1 of 20 patients in the THE group had a positive margin for carcinoma.

**MORBIDITY AND MORTALITY**

Postoperative complications are shown in Table 3. Two anastomotic leaks occurred in the TM/LE group. One of these leaks was treated with cervical drainage; the other was an anastomotic leak with concomitant tracheal disruption and required a thoracotomy for mediastinal drainage and primary repair of the trachea. Two anastomotic leaks occurred in the TT group and were managed by performing a second thoracotomy. In the THE group, 2 anastomotic leaks were managed by means of local cervical drainage. There was no significant difference in the incidence of respiratory complications (eg, pneumonia, respiratory failure, and pulmonary embolism) among the 3 groups (3 patients [17%] in the TM/LE group, 3 [19%] in the TT group, and 4 [20%] in the THE group). One patient in the TM/LE group developed a tracheal-gastric fistula 7 weeks after esophagectomy that required operative repair. Hoarseness occurred in 4 (20%) of 20 patients in the THE group but did not occur in the TT or TM/LE groups. The 30-day mortality was zero in all 3 groups. One in-hospital death (5%) due to multiple-organ failure occurred in the THE group on day 70.

**SHORT-TERM FOLLOW-UP**

The mean follow-up period for the 18 patients undergoing TM/LE was 6.3 months (range, 2-14 months). At the time of this report, none of the patients with esophageal cancer had developed recurrent local or metastatic disease and there had been no tumor recurrence at the thoracoscopic or laparoscopic cannula sites. One patient developed a tracheal-gastric fistula and died of broncho-pneumonia 6 months after undergoing TM/LE.

**COMMENT**

Morbidity and mortality after conventional esophagectomy are well recognized. The translusional technique (THE) was popularized by Orringer to avoid a major thora-
and Hansen were the first to report on a total laparotomoy was still required, which can contribute to postoperative pain and pulmonary complications.

To our knowledge, De Paula et al and Swanstrom and Hansen were the first to report on a total laparoscopic transthoracic esophagectomy operation similar to the THE technique. Subsequently, Luketich and colleagues reported on the TM/LE operation, which consisted of a thoracoscopic esophageal mobilization procedure as described by Law et al and laparoscopic gastric mobilization with a cervical anastomosis as described by De Paula et al and Swanstrom and Hansen. Although total minimally invasive esophagectomy had been shown to be feasible, controversy still existed concerning its clinical benefits.

In our study, TM/LE, compared with TT and THE, required less operative time and resulted in less operative blood loss and reduced ICU and hospital stays. The mean operative blood loss in the TM/LE group was 297 mL, which is less than reports of blood loss after standard esophagectomy (526-840 mL for THE and 608-1051 mL for TT). Only 17% of the patients in the TM/LE group required intraoperative blood transfusion compared with 50% in the TT and 75% in the THE groups. Another major advantage of TM/LE was the shortened hospital stay (mean, 11.3 days; median, 5 days) compared with that of the TT (mean, 23.0 days) and THE (mean, 22.3 days) groups. The length of hospital stay after TT and THE in our institution was comparable to the mean hospital stay of 22 days reported by Patti et al for patients who underwent esophagectomy at 5 major centers in California. Other published series have reported a mean hospital stay of 16 to 23 days for THE and 15 to 27 days for TT. The postoperative complication rate after TM/LE was comparable to that of the TT and THE groups. There was no significant difference in the incidence of postoperative anastomotic leaks or respiratory complications among the 3 groups, although hoarseness occurred only in the THE group. A tracheal-gastric fistula occurred in 1 patient 7 weeks after TM/LE. This patient had respiratory failure requiring prolonged intubation; it was difficult, therefore, to discern if the fistula was related to the operative procedure or was secondary to the prolonged intubation.

As our study was a retrospective review, it has the inherent bias of a nonrandomized study. Because the operative procedures were performed during 2 different intervals, bias in the length of ICU stay or surgeon willingness to discharge patients early may have been introduced in the conventional esophagectomy group. Despite this limitation, a valid conclusion can be made from our results that TM/LE is a safe and acceptable alternative to conventional esophagectomy for selected patients.

The main advantage of the TM/LE approach is the use of thoracoscopy for mobilization of the intrathoracic esophagus. Thoracoscopy allows better visualization for nodal clearance, a controlled dissection of the esophagus to avoid injury of mediastinal structures, and a decrease in operative blood loss. Although we did not encounter any major intraoperative emergencies during thoracoscopic dissection, several investigators have reported major complications such as bleeding, aortic injury, and tracheal laceration. In addition, a cervical anastomosis was performed in TM/LE (as in the THE approach) that reduces the risk of mediastinitis in case of an anastomotic leak. The disadvantage of the TM/LE approach is the need for costly laparoscopic equipment and specialized instrumentation. The TM/LE approach is also technically demanding and requires advanced laparoscopic skills such as complex laparoscopic surgical dissection, use of a laparoscopic stapling technique, and extensive use of intracorporeal suturing. The TM/LE approach should not be used for patients with a history of right thoracotomy, T4 disease, or a previous major esophageal operation.

As with other laparoscopic operations for cancer, concern has been raised about port-site cancer recurrence, adequacy of surgical margins, and an adequate number of lymph node resections. The margins of resection of all patients in our study who underwent TM/LE were free of tumor or Barrett’s metaplasia. We used intraoperative endoscopy to identify the proximal and distal extent of tumor involvement before surgical resection; endoscopy helps to identify patients with tumor involvement of the gastroesophageal junction and a more extensive resection of the gastric cardia can be performed. The mean number of lymph nodes retrieved in the TM/LE group was similar to the number retrieved in the TT and THE procedures. Oncologic principles were followed during the TM/LE surgical dissection and direct manipulation of the tumor mass was minimized. Thoracic trocars were used at all chest port sites to prevent direct contact of the dissecting instrument with the chest wall. We removed the resected specimen through the cervical incision instead of through an abdominal incision, as one mechanism for port-site cancer recurrence is direct contact of the tumor at the limited extraction site. In our short follow-up, there has been no port-site metastasis observed after TM/LE.

Based on our preliminary experience, minimally invasive esophagectomy appears to be as safe as conventional esophagectomy. Applications of thoracoscopy and laparoscopy to esophagectomy eliminate the thoracotomy and laparotomy incisions and therefore further reduce operative trauma and enhance postoperative recovery. Minimally invasive esophagectomy can also be applied as a palliative measure for unresectable disease when other endoscopic modalities have failed.
Long-term survival data after TM/LE are not yet available. Prospective clinical investigations with longer follow-up in tertiary centers will be required to answer additional questions, such as the impact of TM/LE on cancer recurrence and the length of survival in patients undergoing TM/LE for carcinoma. We emphasize that TM/LE is an advanced minimally invasive operation requiring knowledge of advanced laparoscopic and thoracoscopic techniques and experience in conventional esophageal surgery. We caution that this technique should be undertaken only in centers with vast experience in esophageal surgery and by surgeons with advanced laparoscopic and thoracoscopic skills.

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15. Goldmire M, Maddern G, Le Prise E, Meunier B, Campion JP, Law S. Thoracoabdominal esophagectomy on thoracoscopic mobilization and subsequently discovered disseminated disease during laparoscopy? In our experience with laparoscopic transhiatal esophagectomy, 18% were found to be nonresectable based on discovery of unsuspected carcinomatosis or distant metastases.

What was the method of patient selection for the open transhiatal esophagectomies and standard Ivor Lewis procedures and for the decision to give neoadjuvant chemoradiation? Specifically, was this protocol driven or based on different surgeons’

DISCUSSION

Lee Swanstrom, MD, Portland, Ore: I think the video was spectacular. I would love to have it in our library; it is really a nice effort. The treatment of esophageal cancer has been a paradigm of frustration. There has been little success in improving surgical cures and, really, the only advance in surgical treatment has been that we kill fewer patients today with the surgery! The only actual headway against the disease has been made with nonsurgical treatments such as endoscopic palliation and chemoradiation. Current treatment of esophageal cancer, a highly deadly and largely incurable disease, should be directed with the primary goal of maximum improvement in the quality of the rest of the patient’s life. This is not to say that surgeons shouldn’t make every reasonable effort to achieve a cure; that is obvious. It must be recognized, however, that cure as a goal will fail as much as 85% of the time. And, therefore, studies such as this one, which look critically at ways to lessen the invasiveness of surgical treatment, deserve close attention.

Endoscopic esophagectomy is an especially interesting treatment option. At least theoretically, it offers the advantage of radical surgical resection (still the best chance for a cure), with the lessened physiologic insult and resulting prolonged recovery that we have come to appreciate with many laparoscopic procedures. On the other hand, many surgeons remain justifiably concerned about the possible dangers represented by laparoscopic resections of treatment of cancer: missed lesions, inadequate staging, compromised margins, and possible tumor dissemination. Dr Nguyen and his associates present a well-constructed look at their technique of thoracoscopic and laparoscopic total esophagectomy and present their series in the context of the University of California, Davis, esophagectomy experience during the 1990s. As the authors point out, this is a retrospective comparison of different techniques performed by different surgeons. This represents an obvious weakness in this report, which the authors are well aware of. Still, this is an important review, as it comes from a single institution and represents the modern era of surgical care of esophageal cancer patients. Questions I have are:

1. Patient selection: In general what are your indications and contraindications for esophagectomy? What do you tell the endoscopic patients regarding the status of this approach?

Have you ever encountered the situation where you have performed the thoracoscopic mobilization and subsequently discovered disseminated disease during laparoscopy? In our experience with laparoscopic transhiatal esophagectomy, 18% were found to be nonresectable based on discovery of unsuspected carcinomatosis or distant metastases.
preferences? Do you think the neoadjuvant therapy had an impact on the outcomes?

2. As you know, we have been performing esophagectomy using a totally laparoscopic approach. What do you perceive as the relative advantages and disadvantages of the “Pittsburgh” method vs a laparoscopic approach?

3. Assuming that we are not compromising curative methodology or exposing the patient to high operative risk, the most important potential patient advantage to this procedure is a more rapid recovery. Dr Nguyen has documented a reduced ICU time and hospital stay. We have also found this to be true, although our overall hospital stay has only been slightly decreased from the open [procedure]. Could this be influenced by the time frame of the study? That is, does managed care play a role in your series? For us, the biggest in-hospital advantage has been the ability of more than half of our patients to not require any ICU admission, and 83% are extubated in the OR [operating room]. Is this a difference between the endoscopic techniques or are your patients admitted on a protocol basis? How many are extubated in the OR? Finally, the most gratifying aspect of minimally invasive esophagectomy has been the truly dramatic decrease in the posthospital recovery period. Have the authors noticed the same phenomenon?

When you see a 3-minute video clip of a very, very difficult procedure, it makes it look easy, but this is a surgical tour de force, and I think the authors have shown their skill.

Dr Goodnight: Let me emphasize that the work you heard presented is that of Dr Nguyen and that of a specialized team. My contributions are many of the transhiatal cases, which do not match the statistics of Dr Orringer. Nonetheless, I have been very excited to be involved in the work. I had the privilege of doing the first one with Dr Nguyen when he came, and I knew the exact moment when I had looked into the future. The case was very exciting; the patient went home in 5 days, and I said, yes, I think we are onto something new.

I appreciate Dr Swanstrom’s comments very much. He asked about patient selection. I will reiterate quickly the indications for the laparoscopic/thoracoscopic esophagectomy were stricture in 11%, Barrett in 11%, and carcinoma in 78%. The exclusion criteria were a history of a right thoracotomy, T4 disease, or morbid obesity (someone in the order of 250 to 300 pounds [112.5-135.0 kg], a BMI [body mass index] of >35 kg/m²). We consider the procedure investigational. We have made other changes, which bear on Dr Swanstrom’s later comments. Essentially, we have 1 team doing these procedures, which clearly will reduce morbidity and reduce length of stay. And, obviously, we are very much on the learning curve. Once again, Dr Orringer set the standard when he said you probably need to do 50 cases—plus a year to reach the very lowest morbidity. Well, obviously, very few do that. We are working on it, but we have a ways to go.

Have we encountered a situation where, after the thoracoscopic procedure, we opened the abdomen and found cancer spread? No, Dr Nguyen does a staging laparoscopic procedure first, puts in a feeding tube, and stages the liver with ultrasound. No one has turned down the procedure. The patient selection, as far as the transhiatal procedure or transthoracic, was surgeon preference of the 4 surgeons doing them over that period of time that he presented.

Sixty percent of the current group have received neoadjuvant therapy. It is simply too soon to tell whether this has any impact on outcome.

Dr Swanstrom has been a pioneer of essentially a laparoscopic transhiatal procedure. His questions are quite appropriate. What are the advantages of adding a thoracoscopic procedure? Our perceptions are that (1) it gives a controlled dissection of the mediastinum; (2) we think it gives better visualization for management of lesions of the upper and middle third of the esophagus; and (3) there is a potential for better lymph node dissection, and it may reduce blood loss. The obvious disadvantage is that you have to do a thoracoscopic procedure, then turn the patient over and go ahead with the laparoscopic approach.

Dr Swanstrom then asks—and it’s sort of the same question I posed to Dr Morton—what good is all of this? What I might say is that the video does not do justice to the optics. I had felt that I had gotten good at the anatomy of this operation by the transhiatal approach. I was blown away with what I could see as a rank amateur by this thoracoscopic and laparoscopic approach. So it offers an excellent visualization of the tissues.

The main message here is what are the median stays of these patients? Once again, it was 2 days in the ICU and 5 days in the hospital. There are outliers. Esophagectomy is a significant procedure. Obviously, our statistics will get steadily better as we gain experience with the procedure. I might add that all of the patients are indeed extubated in the operating room. I think what we will see over the first part of this century is a variety of ways to measure the stress of operating on patients. One gets a strong clinical impression, if you do this procedure, that it is indeed less stressful on the patient than the open procedure. Measuring that, quantifying that, I think, remains to be done.

ARCHIVES OF INTERNAL MEDICINE

Overweight, Obesity, and Health Risk

More than half of adult Americans are overweight or obese, and public health recommendations call for weight loss in those who are overweight with associated medical conditions or who are obese. However, some controversy exists in the lay press and in the medical literature about the health risks of obesity. We review briefly the large body of evidence indicating that higher levels of body weight and body fat are associated with an increased risk for the development of numerous adverse health consequences. Efforts to prevent further weight gain in adults at risk for overweight and obesity are essential. For those whose present or future health is at risk because of their obesity and who are motivated to make lifestyle changes, a recommendation for weight loss is appropriate. (2000;160:898-904)

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