



The original Ivor Lewis two stage esophagectomy revisited in the era of minimally invasive surgery

A. Hawasli*, L. Camero, T. Williams, G. Ambrosi, M. Sahly, D. Demos, S. Harrington

St. John Hospital & Medical Center, 22101 Moross Rd, Detroit, MI, 48236, USA

ARTICLE INFO

Article history:

Received 24 July 2018

Received in revised form

26 November 2018

Accepted 28 November 2018

ABSTRACT

Background: Esophagectomy has high cardiac and pulmonary complication rates that can reach 43% and 58% respectively. The original Ivor Lewis esophagectomy was a two-stage procedure. We revisited this procedure using a hybrid minimally-invasive approach.

Methods: Thirty-five consecutive patients with esophageal cancer were operated on over an eight-year period. The first stage used laparoscopic mobilization of the stomach, while the second stage used open thoracotomy. Six patients were aborted due to unresectable disease.

Results: Twenty-nine patients were studied. The mean operative times for stage-one and stage-two were 108 ± 18 and 226 ± 63 min respectively. All patients were extubated in the operating room. One (3.4%) patients had cardiac complication and one (3.4%) patient had pulmonary complication.

Conclusion: Metachronous hybrid two-stage esophagectomy was associated with a low rate of cardio-pulmonary complications. It may be considered as an alternative to the one-stage esophagectomy, especially in low-volume centers, to decrease these high-risk cardio-pulmonary complications.

© 2018 Elsevier Inc. All rights reserved.

Introduction

The current open Ivor Lewis one stage esophagectomy (OIE) is a complex and high-risk procedure. Operative and anesthesia times for the procedure can extend to more than 7 h.¹ The original Ivor Lewis esophagectomy, published in 1944, was a two-stage esophagectomy with a two week interval between the two stages.² Nine months later, Norman Tanner published his one-stage esophagectomy.³ Recent research by Scholes et al. suggests that anesthesia duration is among the largest risk factors for developing post-operative pulmonary complications, with patients sedated for more than 3 h having been found to be more than 4 times more likely to develop these complications.⁴ Canet et al., showed that thoracic surgery is the second highest predictor of postoperative pulmonary complications (39.6%) followed by abdominal surgery (7.2%).⁵ In that context, it is not surprising that studies of traditional OIE have found high rates of post-operative pulmonary and cardiac complications of 58% and 43% respectively.^{1,6}

Several investigators have reported on attempts to reduce these high complication rates by using minimally invasive techniques.

While their specific approaches to Minimally Invasive Esophagectomy (MIE) have varied, they shared the broad strategy of performing the abdominal part laparoscopically while keeping the chest portion as either an open thoracotomy or thoracoscopic approach under the same session.^{1,6–8} Bailey et al., showed a decrease in cardiac complications to 8% and pulmonary complication to 38% using laparoscopy/thoracotomy approach.⁶ Noble et al., however, showed no change in cardiac complication rate of 14% or pulmonary complication rate of 35% when using laparoscopic/thoracoscopic approach.⁷ On the other hand, Sihag et al. showed a reduction in cardiac complications to 13% and pulmonary complications to 3% by using a laparoscopic/thoracoscopic approach with aggressive extubation of the patients in the operating room.¹ In using thoracoscopy instead of thoracotomy, Tapias et al. found a significant learning curve in mastering the thoracoscopic portion with surgeon's optimal performance being achieved after 35 to 40 cases.⁸

In view of the above findings of the continued high cardio-pulmonary complications in spite of using minimally invasive approaches, our intention was to evaluate the possibility of decreasing these complications. We planned to do this by separating the two stages of a lengthy operation into two independent procedures on different dates similar to the original Ivor Lewis approach with less interval between the two stages and utilizing the laparoscopic

* Corresponding author.

E-mail address: eastsidesurgical@aol.com (A. Hawasli).

approach for the first stage. We kept the second stage as an open thoracotomy in order to maintain a quality cancer operation and to avoid the long learning curve of the thoracoscopic approach especially in our low volume hospital.

Materials & methods

Forty patients with esophageal cancer were operated on from September 2010 to January 2018 at a single community teaching hospital with an average of 5 cases per year. Five patients that were operated on by different surgical teams were excluded. Thirty-five consecutive patients were operated on using the two-stage esophagectomy by the same surgical team. Six patients were aborted due to un-resectable or metastatic disease. Five (14%) patients were aborted after the laparoscopic stage and one (3%) patient after the thoracoscopic stage. These six (17%) patients were excluded from further analysis. The remaining twenty-nine (83%) patients completed the second stage esophagectomy and formed our cohort.

Stage-one esophagectomy was performed by laparoscopic mobilization of the stomach with pyloromyotomy. Ten patients (34.5%) had a feeding jejunostomy placed. Nine of them were placed during the laparoscopic stage, while one patient had a feeding tube placed before neoadjuvant. Open right trans-thoracic esophagectomy, as the second stage procedure, was performed within two days. Post-operative outcomes were measured including length of each operation, number of lymph nodes removed, epidural catheter use following stage-two, length of Intensive Care Unit (ICU) stay, post-operative ventilation, hospital length of stay (LOS), reoperation, complications, and thirty-day morbidity and mortality. Institutional Review Board (IRB) approval was obtained. Results were reported as simple mean \pm Standard Deviation.

Surgical technique and hospital course

Our approach to this procedure utilized two different surgical services to assure the best results. All our patients were operated on by two surgeons using two-stage metachronous hybrid minimally invasive approach (Laparoscopy/Thoracotomy). Stage-one, the laparoscopic mobilization of the stomach, was performed by a laparoscopic general foregut surgeon. This stage was performed using four trocars with five puncture holes. The stomach was mobilized with preservation of the right gastric and right gastro-epiploic arteries. The hiatus was opened enough to allow the stomach to be pulled up into the chest. A laparoscopic pylo-romyotomy with omental patch was performed. The left gastric artery was transected at its origin using a trisapler vascular load (Covidien, Mansfield, MA). A laparoscopic feeding jejunostomy was placed initially and abandoned later due to a complication. The patient was then extubated in the operating room and was sent to the regular surgical floor on clear liquid diet.

Within 2 days the second stage esophagectomy using a right posterior-lateral thoracotomy was performed by a cardio-thoracic surgeon. The esophagus was mobilized and the lymph nodes were completely dissected. Care was taken to avoid injury to the thoracic duct. The Azygos vein was divided. The stomach was then pulled up into the chest. The general surgeon was then called back where he joined the operation. The esophagus was then transected. An esophago-gastric anastomosis was performed using a circular stapler 4.8 mm (Covidien, Mansfield, MA). The esophageal donut was sent to pathology to assure clearance of the margin. The stomach was transected below the left gastric artery and the lymph nodes with distance from tumor edge using a TA-90 stapler (Covidien, Mansfield, MA). The patient was then extubated in the

operative suite, sent to the recovery room, and then to the intensive care unit. After 24 h of observation, the patient was transferred to the surgical floor. An upper gastro-intestinal study was performed on the third post-operative day looking for leaks from the anastomosis or the cut edge of the stomach. If no leak was present, a clear liquid diet was started. The chest tube was removed when the drainage was decreased with no evidence of any leak after initiating the clear liquid diet. The diet was advanced and the patient was discharged when tolerating soft diet.

Results

Twenty-nine consecutive patients (26 males and 3 females) completed the two-stage esophagectomy. The mean age was 62 ± 9 years. The mean operative time for stage-one was 108 ± 18 min. There were no intra-operative blood transfusions or conversions from laparoscopy to laparotomy for complications.

The second stage thoracotomy was performed within 1–2 days. The mean operative time was 226 ± 63 min. The mean number of lymph nodes removed was 12 ± 7 nodes. All patients were extubated post-operatively at the conclusion of each stage in the operating room. Epidural catheters were placed before the thoracotomy in 24 (82.8%) patients. The mean ICU stay after the second stage was 1.8 ± 1.7 days. The mean total hospital LOS, including the first stage, was 12 ± 5 days excluding two (6.9%) patients who died; one after a stroke and one from consequences of esophageal anastomotic leak. Cardio-pulmonary complications occurred in two patients. One (3.4%) patient had atrial fibrillation and one (3.4%) patient had pneumonia. Eight (27.6%) patients had non-cardiopulmonary complications. These complications are summarized in [Table 1](#).

Discussion

Outcomes post esophagectomy at our low-volume institution compared favorably with those reported in studies of OIE and MIE procedures conducted at major academic centers. For example, Bailey et al. from Oxford University Regional Esophagogastric Cancer Referral Center in the United Kingdom (UK) in a report on 73 patients over 2.5 years found that their MIE procedure reduced their cardiac complication rate from 25% to 8% and pulmonary complications from 58% to 38% in comparison to their open approach.⁵ Conversely, Noble et al. in a report on 106 patients over 6 years period from the University Hospital of Southampton UK found that complication rates did not differ substantially between MIE and OIE procedures (13% vs. 14% respectively for cardiac

Table 1
Complications.

Complications	# (%)
Cardio-pulmonary:	2 (6.9%)
Atrial Fibrillation	1 (3.4%)
Pneumonia	1 (3.4%)
Non-cardio-pulmonary:	8 (27.6%)
Jejunostomy leak	1 (3.4%)
Anastomotic leak	1 (3.4%)
Chyle leak	2 (6.9%)
Gastroparesis	2 (6.9%)
Wound infection	1 (3.4%)
Stroke	1 (3.4%)
Reoperation	2 (6.9%)
for jejunostomy leak	1 (3.4%)
for Chyle leak	1 (3.4%)
Death:	2 (6.9%)
from anastomosis leak	1 (3.4%)
from stroke	1 (3.4%)

complications and 32% vs. 35% respectively for pulmonary complications).⁶ Sihag et al. in a report on 114 patients over 3 year period from Massachusetts General Hospital found a reduction in the cardiac complication rate from 22% in the OIE to 13% in the MIE while the pulmonary complication rate dropped from 43% in the OIE to 3% in the MIE group.¹

A recent multicenter study by Van Workum et al. from the Netherlands of 787 patients comparing total minimally invasive Ivor Lewis (TMIE) (laparoscopy/thoracoscopy, chest anastomosis) to total minimally invasive McKeown esophagectomy (laparoscopy/thoracoscopy, neck anastomosis), showed overall better results with TMIE.⁸ In spite of that, the TMIE overall complication rate after score-matched analysis of the two groups was still high at 55.7%. The cardiac complication rate was also high at 19.5%, with atrial fibrillation of 16.7%, myocardial infarction 5.7% and asystole 6.2%. Their pulmonary complication rate was 31.9% and pneumonia 19.0%. Their median operative time was 411 min. There was no difference in the LOS between the two groups which was 11 vs. 12 days.

One important difference between our approach and that used in some other centers was that all of our patients were extubated in the operative room. Our pulmonary complications were the same (3.4%) as those of Sihag et al. of 3% where they also aggressively extubated their patients in the operating room. However, our cardiac complications rate of 3.4% was lower than their cardiac complication rate of 13% in their MIE group, which could be attributed to the longer operative time of the single stage approach. Our hybrid procedure can be best compared to that of Bailey et al. since both studies used the laparoscopy for the first stage and the open thoracotomy as the second procedure with the difference being in the metachronous approach of the second stage that we adapted. In Bailey et al. study all patients were ventilated overnight. Their rate of pulmonary complications was considerably higher than our pulmonary complication rate.⁶ Ventilation status was not reported by Noble et al.⁷ (Table 2).

Our ability to decrease cardio-pulmonary complications can be attributed, in part, to the metachronous two-stages with reasonably short operative time for each stage. This strategy was designed to decrease the detrimental effect of the prolonged anesthetic on the heart and lungs, along with early extubation immediately post-operatively, and the use of epidural catheter for pain control.¹²

Our combined average operative time for the two separate stages of 334 (108 + 226) minutes is comparable to those reported by the above authors for either the OIE or MIE approaches ranging from 300 to 366 min with a high operative time that can reach 441 min.^{1,6}

We abandoned placement of feeding jejunotomy after one adverse event in which the tube was pulled out accidentally,

resulting in peritonitis on the day of discharge requiring re-operation. Although placement of a feeding jejunotomy is a common practice during esophagectomy, we noticed that we hardly used it post-operatively. Thus, in our opinion, the risk of placing feeding jejunotomy was not justified, and therefore we did not place it in the next 18 (62%) patients. None of these patients required any parenteral feeding. All patients were able to tolerate their oral intake.

Our waiting period between the two stages of 1–2 days is shorter than the two weeks that was reported by Ivor Lewis, and the 4–14 days reported by other studies involving two-stage procedures to achieve ischemic conditioning of the stomach.^{10,11} In spite of that, however, we did not see any adverse effect from this short period separating the two stages. In addition, our data showed our mean total hospital LOS (including the 1–2 days between the stages) of 12 days is comparable to the other reported means of hospital LOS after OIE or MIE which ranged between 7 and 18 days.^{6–9}

An indirect logistical advantage of the metachronous two-stage approach is the better utilization of the operating room and the thoracic surgeon's time. Each stage is boarded with a reasonable short operative time, 2 h for stage one and 4 h for stage two. This is in contrast to the single stage esophagectomy which is usually boarded with the traditional 6–8 h block. Therefore, in the event of aborting the case after the first stage due to metastatic disease, neither the operating room schedule nor the thoracic surgeon are greatly impacted. In addition, the inherited value of the minimally effect of laparoscopy on recovery time allows patients to start or resume their adjuvant treatment of their metastatic disease rather than waiting for recovery from a laparotomy incision. This occurred in five (14%) of our cases.

Limitations of our study include the relatively small size cohort (due to our low volume of cases seen at our community teaching hospital), and the lack of a comparison group using traditional OIE procedures. Although the results reported here are promising, more research is needed before any definitive recommendation can be justified.

Conclusion

Our experience demonstrates the potential benefits of our hybrid laparoscopy/thoracotomy metachronous two-stage esophagectomy as an alternative to the one-stage esophagectomy either open or by minimally invasive approaches, especially in a low-volume institutions. A dedicated team geared toward this approach is very important to achieve good results. Further research is needed to explore the benefits of this approach in a larger sample, and with a methodology that allows for direct

Table 2
Comparison.

Volume	Noble (7) 18 pt/yr		Sihag (1) 38 pt/yr		Bailey (6) 29 pt/yr		Hawasli/Camero 5 pt/yr
Approach and = pt	Lomy/ Tomy = 53	Lscopy/ Tscopy = 53	Lomy/ Tomy = 76	Lscopy/ Tscopy = 38	Lomy/ Tomy = 31	Hybrid Lscopy/ Tomy = 39	hybrid Two-Stage Lscopy/ Tomy = 29
Pulmonary	32%	35%	43%	3%	58%	38%	3.4%
Cardiac	13%	14%	22%	13%	25%	8%	3.4%
Leak	4%	9%	5%	0%			3.4%
OR time	240 min	300 min	366 min	361 min	343 min	360 min	108 + 226 = 334 min
LOS	12 days	12 days	9 days	7 days	18 days	14 days	11.6 + 4.5 days
Mortality	2%	2%	2.60%	0%	6%	5%	3.40%
Conversion		8%				5%	0%

Lscopy: Laparoscopy, Lomy: Laparotomy, Tscopy: Thoracoscopy, Tomy: Thoracotomy.
OR: Operating LOS: Length of stay pt: Patients yr: year.

comparison of patient's outcomes with other single stage open and minimally invasive approaches.

Conflicts of interest

No conflict of interest by any of the authors.

References

1. Sihag S, Wright CD, Wain JC, et al. Comparison of perioperative outcomes following open versus minimally invasive Ivor Lewis oesophagectomy at a single, high-volume centre. *Eur J Cardio Thorac Surg*. 2012;42(3):430–437. <https://doi.org/10.1093/ejcts/ezs031>.
2. Lewis I. The surgical treatment of carcinoma of the oesophagus with special reference to a new operation for growths of the middle third. *Br J Surg*. 1946;34(133):18–31. <https://doi.org/10.1002/bjs.18003413304>.
3. Tanner NC. The present position of carcinoma of the oesophagus. *Postgrad Med J*. 1947;23(257):109–139.
4. Scholes R, Browning L, Sztendur E, et al. Duration of anaesthesia, type of surgery, respiratory co-morbidity, predicted VO₂max and smoking after upper abdominal surgery: an observational study. *Aust J Physiother*. 2009;55:191–197.
5. Canet J, Gallart L, Gomar C, on behalf of the ARISCAT Group. Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiology*. 2010;113:1338–1350.
6. Bailey L, Khan O, Willows E, et al. Open and laparoscopically assisted oesophagectomy: a prospective comparative study†. *Eur J Cardio Thorac Surg*. 2013;43(2):268–273. <https://doi.org/10.1093/ejcts/ezs314>.
7. Noble F, Kelly JJ, Bailey IS, et al. South coast cancer collaboration – oesophago-gastric (SC3-OG). A prospective comparison of totally minimally invasive versus open Ivor Lewis esophagectomy. *Dis Esophagus*. 2013;26(3):263–271. <https://doi.org/10.1111/j.1442-2050.2012.01356.x>.
8. Tapias LF, Morse CR. Minimally invasive Ivor Lewis esophagectomy: description of a learning curve. *J Am Coll Surg*. 2014;218(6):1130–1140. <https://doi.org/10.1016/j.jamcollsurg.2014.02.014>.
9. van Workum F, Slaman AE, van Berge Henegouwen MI, et al. Propensity score-matched analysis comparing minimally invasive Ivor Lewis versus minimally invasive Ivor Lewis esophagectomy. *Ann Surg*. 2018 Aug 10. <https://doi.org/10.1097/SLA.0000000000002982> [Epub ahead of print].
10. Yetasook AK, Leung D, Howington JA, et al. Laparoscopic ischemic conditioning of the stomach prior to esophagectomy. *Dis Esophagus*. 2013;26(5):479–486. <https://doi.org/10.1111/j.1442-2050.2012.01374.x>.
11. Hölscher AH, Schneider PM, Gutschow C, et al. Laparoscopic ischemic conditioning of the stomach for esophageal replacement. *Ann Surg*. 2007;245(2):241–246. <https://doi.org/10.1097/01.sla.0000245847.40779.10>.
12. Chandrashekar MV, Irving M, Wayman J, et al. Immediate extubation and epidural analgesia allow safe management in a high-dependency unit after two-stage oesophagectomy. Results of eight years of experience in a specialized upper gastrointestinal unit in a district general hospital. *Br J Anaesth*. 2003;90(4):474–479. <https://doi.org/10.1093/bja/aeg091>.