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Perioperative outcomes after transition from conventional to minimally invasive Ivor-Lewis esophagectomy in a specialized center

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Abstract
Background Minimally invasive techniques are now increasingly adopted for the treatment of esophageal cancers. Benefits such as earlier functional recovery and less need for transfusion and intensive care stay should be balanced by a determination to avoid compromise to the oncologic integrity of the procedure, especially in the early phase of transition from open to laparoscopic surgery. This study aimed to compare primary outcomes including oncologic clearance, complications, and functional recovery between open and laparoscopic esophagectomy in a single center.
Methods This prospective study recruited 75 consecutive patients undergoing Ivor-Lewis esophagectomy, all treated by a single surgeon. These patients were divided into three groups. The 24 patients in group A underwent open Ivor-Lewis esophagectomy. The remaining patients underwent laparoscopic Ivor-Lewis esophagectomy in two groups: 25 patients in an early cohort (group B) and 26 patients in a later cohort (group C). All the patients were treated according to the same protocol.
Results The three groups were adequately matched. The findings showed trends toward a reduction in median operative time, with group A requiring 260 min, group B requiring 249 min, and group C requiring 223 min ($p = 0.06$), and a significant reduction in the requirement for perioperative blood transfusion between groups A (65%) and C (27%) ($p = 0.02$). The median lymph node yield was significantly less in group B ($n = 13$) than in group A ($n = 24$) or group C ($n = 22$) ($p = 0.003$). There was no significant difference between the three groups in the length of hospital stay (median stay, 14–16 days) or the requirement for critical care beds (median stay, 3–4 days). The in-hospital mortality rate was zero, and the morbidity rate did not differ between the three groups.
Conclusions This study shows that laparoscopic Ivor-Lewis esophagectomy is associated with a reduced need for blood transfusion, a shorter operative time, and an adequate lymph node harvest. Oncologic principles are not compromised during the transition phase from open to laparoscopic esophagectomy.

Keywords Esophageal · Cancer · GI · Cancer · Ivor-Lewis esophagectomy · Keyhole esophagectomy · Laparoscopic esophagectomy · Minimally invasive esophagectomy

Open esophagectomy carries significant risk of morbidity and even mortality. Recent centralization of esophagogastric cancer services has led to treatment that increasingly complies with national time targets, results in good outcomes, and has a minimal impact on elective benign surgery and intensive care unit (ICU) provision [1]. However, survivors of open esophagectomy face a long path back to a reasonable quality of life, such that patients surviving fewer than 2 years derive little benefit from the procedure [2].

In the future, advances in esophageal surgery hopefully will permit a shorter hospital and intensive therapy unit stay, less pain, and earlier functional recovery. To that end, early reports describing minimally invasive resection of the

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stomach and esophagus have been received with enthusiasm [3]. With increasing adoption of laparoscopic esophageal resection, appraisal of its advantages and oncologic integrity should be emphasized, especially during the early transition from open to minimally invasive surgery in practicing centers.

Patients and methods

Data were collected prospectively over a 3-year period (April, 2004–February, 2007). The study recruited consecutive patients presenting with esophageal disease to a specialized teaching hospital who fulfilled the indication for an Ivor-Lewis esophagectomy. All the patients had surgery performed by a single surgeon. The patients were collated into three nonrandomized groups, with transition to the laparoscopic procedure heralding recruitment to the latter two groups. Group A underwent a conventional open Ivor-Lewis esophagectomy (OILO), whereas groups B and C underwent the laparoscopic abdominal stage of Ivor-Lewis esophagectomy and were subdivided into an early laparoscopic group (group B) and a later laparoscopic group (group C).

Patients with biopsy-proven esophageal cancer (squamous and adenocarcinoma) were referred to the multidisciplinary meeting. They all had the appropriate staging investigations, preoperative assessment, and neoadjuvant chemotherapy according to hospital protocol. All the patients were offered long-term follow-up evaluation.

Operative procedure

Conventional Ivor-Lewis esophagectomy was performed in a standard fashion as described extensively in the surgical literature, and the same principles were applied when minimally invasive surgery was implemented. Specific technical points included gastric mobilization using a Harmonic scalpel (Ethicon Endo-Surgery, OH, USA) and gastric tubularization by ETS stapler (Ethicon Endo-Surgery, OH, USA) without underrunning of gastric staple lines. Pyloroplasties were performed.

Laparoscopic Ivor-Lewis esophagectomy (LILO) starts with the patient in the Lloyd Davies position for the abdominal phase. The operating surgeon stands between the patient's legs. Five or six abdominal ports are established and used in much the same way as for a laparoscopic fundoplication with a Nathanson's liver retractor.

Division of the greater omentum with preservation of the right gastroepiploic arcade is performed by Harmonic scalpel toward the hiatus, with division of the short gastrics along the way. A longitudinal pyloromyotomy breaching the mucosa is stitched transversely in a single-layer continuous fashion with intracorporeal knotting. The stomach then is retracted superiorly, and this plane is dissected toward the left gastric pedicle, with skeletonization of the proximal common hepatic artery to achieve lymph node clearance. The left gastric vein and artery are clipped with two clips placed proximally and one clip placed distally. They are divided separately using the Harmonic scalpel. The lesser omentum is divided up toward the hiatus. Wide hiatal dissection is performed, and the dissection is continued into the mediastinum up to the level of the inferior pulmonary vein if possible.

Gastric tubularization is performed by multiple firings of the GIA linear stapler, starting proximal to the pyloroplasty and directed toward the gastric fundus. Stapling is continued upward to create approximately 80% of the gastric tube, leaving it attached to the specimen to enable retraction through the hiatus during the thoracic phase of the operation. A gastric tube width of approximately 4 to 5 cm is considered satisfactory. Feeding jejunostomy tubes are placed during open surgery, but this practice is changed to triluminal nasojejunal tubes when minimal invasive esophagectomy is performed. Two transhiatal chest drains are placed through the anterior abdominal wall, and the abdominal phase is concluded.

The patient then is placed in the left lateral position. A double-lumen endotracheal tube is always established by the anesthetist at induction to enable single-lung ventilation with positive pressure to begin as soon as the thoracic cavity is entered surgically.

In this study, during the early phase of minimally invasive esophagectomy, a posterolateral thoracotomy was performed. Dissection and reconstruction were carried out solely through the thoracotomy wound. During the latter part of the study, two thoracoscopic ports were established to enable a video-assisted thoracic dissection of the esophagus. One port was placed in the midaxillary line, in the 7th or 8th intercostal space, and the other port was placed higher up in the anterior axillary line. A laparoscope and lung retractor were used through the thoracoscopic ports to offer an enhanced magnified view. Long surgical instruments were used through the thoracotomy to complete the thoracic dissection of the esophagus.

Using this technique, the length of the thoracotomy wound decreased to less than 10 cm. No attempt was made to identify or ligate the thoracic duct. The specimen was pulled upward through the hiatus, disconnected from the gastric tube, and retrieved through the thoracotomy. A hand-sewn continuous esophagogastric anastomosis was established above the divided azygous vein using delayed absorbable suture in a single layer. The transhiatal drains were positioned, and all the wounds were closed.

Patients were electively ventilated postoperatively and placed in a high-dependency setting for the first 24 to 48 h.

Subsequent transfer to the appropriate care setting was dictated by the patient's status. Standard postoperative protocol included initiation of limited oral fluid intake on the first postoperative day, with gradual buildup and the nasojejunal tube left in place. Contrast swallows were not routinely performed unless there was a clinical diagnostic need. Patients' progress was monitored, and they were eventually discharged home when oral intake was adequate for their nutritional needs.

Statistical analysis

For statistical analysis, SPSS software (SPSS, Chicago, IL, USA) was used. Comparison of means was performed by the Mann–Whitney test, with a p value less than 0.050 considered significant.

Results

The 75 patients in this study were divided into three groups, with 24 in group A, 25 in group B, and 26 in group C. The nonrandomized patients in each group were well-matched in terms of median age, presenting symptoms, preoperative histology and tumor node metastasis (TNM) staging (Table 1), and there were no significant differences between the three groups in terms of these factors. The majority of the patients in all three groups presented with dysphagia, and the median tumor length was longer in group A than in group B or C (Table 1). The preoperative American Society of Anesthesiologists (ASA) scores were similar between the groups, and the differences were not significant. There were 2 patients with an ASA score of 1 in each group; 11, 16, and 19 patients with an ASA score of 2 in groups A, B, and C, respectively; and 7, 7, and 4 patients respectively in the three groups with an ASA score of 3. The ASA score had not been recorded for 4 patients in group A and 1 patient in group C.

The blood transfusion requirements were significantly reduced the first 72 h ($p = 0.02$) in group C compared with group B. A significant decrease also was observed in the median length of postoperative ventilation in hours ($p < 0.0001$) in the laparoscopic groups compared with the OILO group (Figs. 1 and 2).

The requirement for subsequent blood transfusion beyond 72 h was not significant. The transfusion rates were 9% for group A, 32% for group B, and 14% for group C. For the patients who required transfusion, the average blood units transfused per patient were respectively 4.5, 5.9, and 4 in groups A, B, and C. The main reason for the above average transfusion needs in group B was that patient who had a long intensive therapy unit stay

Table 1 Patient demographics, presenting symptoms, histology, and tumor node metastasis (TNM) stage

	OILO ($n = 24$) *n* (%)	Early LILO ($n = 25$) *n* (%)	Late LILO ($n = 26$) *n* (%)
Demographics			
Median age (years)	60	64	62
M:F	23:1	19:6	25:1
Preoperative features			
Weight loss	19 (79)	16 (62)	19 (73)
Dysphagia	23 (96)	20 (80)	22 (85)
Neoadjuvant chemotherapy	20 (83)	20 (80)	24 (92)
Average tumor length (cm)	6.5	5	5
Histology			
Adenocarcinoma	21 (88)	18 (72)	21 (81)
Squamous cell carcinoma	3 (12)	6 (24)	4 (15)
Benign	0	1 (4)	1 (4)
Preoperative staging			
T0	0	2	1
T1	1	2	0
T2	1	5	4
T3	18	16	19
T4	3	0	2
N0	8	8	8
N+	16	17	18

OILO open Ivor-Lewis esophagectomy, *LILO* laparoscopic Ivor-Lewis esophagectomy

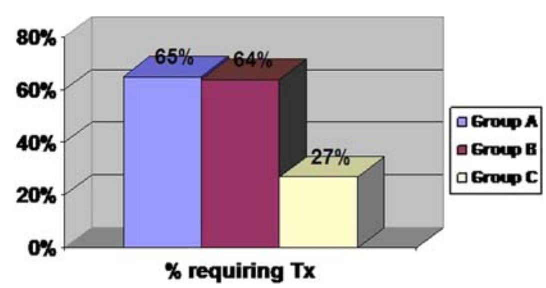

Fig. 1 Percentage of patients requiring postoperative transfusion in the first 72 h

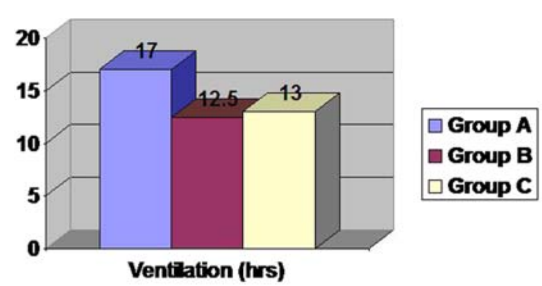

Fig. 2 Median length of postoperative ventilation

experienced acute gastrointestinal bleeding that resolved conservatively, requiring 16 units of blood over time.

The operative time in minutes was similar across the groups (260 min for group A, 249 min for group B, 223 min for group C), with a trend toward a reduction in operation time, although this did not reach statistical significance ($p = 0.06$). The median requirement for critical care was 3 days in group A, 3.5 days in group B, and 4 days in group C, but the differences were nonsignificant. The in-hospital mortality rate was 0% for all the groups. The median length of hospital stay of 14 days in group A, 15 days in group B, and 16 days in group C.

Postoperative histology showed an initial drop in the lymph node yield in group B (Fig. 3), with a significant later increase in group C ($p = 0.003$) compared with group B (Fig. 4). The margins tested positive for the same proportion of patients in each group (8%). The morbidity rates also were similar across the three groups (Table 2). Only one anastomotic leak in three was managed conservatively in group B. All the remaining leaks were treated by reoperation in all the groups. A group B patient who had an acute perioperative bleed required reoperation.

One patient who had a chyle leak also had an anastomotic leak and underwent thoracic duct ligation during the same reoperation. Two other patients who had chyle leaks were treated conservatively and resolved. Gastric tube necrosis occurred for one patient in group A, two patients in group B, and one patient in group C.

Respiratory complications (Table 2) were minor (e.g., atelectasis and pleural effusion) or major (e.g., respiratory failure caused by pneumonia). Pneumonia was experienced by three patients in group A, two patients in group B, and two patients in group C. The length of the follow-up period has remained inadequate to produce any useful survival analysis to date.

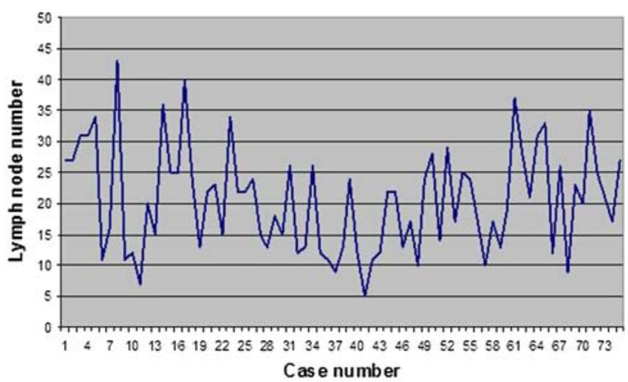

Fig. 3 Lymph node yield by case

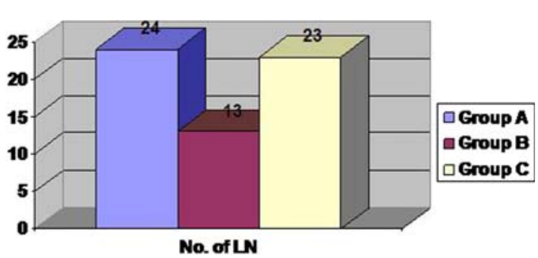

Fig. 4 Median lymph node yield

Discussion

Many surgeons remain skeptical about minimally invasive esophagectomy, perceiving a prolonged learning curve and inadequate oncologic clearance as disadvantages of these procedures. A recent review of 19 minimally invasive esophagectomy studies with 975 patients showed a mean operating time of 281 min [4]. This compares favorably with our study, which had a mean operating time of 223 to 249 min for the laparoscopic groups.

With regard to oncologic integrity, Siewert and Stein [5] reported that extensive lymphadenectomy can improve the prognosis for patients at an early stage of the lymphatic spread. However, for patients with more advanced lymphatic metastases, a two-field lymphadenectomy does not improve the prognosis and can result only in reduced local recurrence [6], whereas a more extensive lymphadenectomy increases the risk and morbidity of the surgical procedure [7]. A mean number of 12 lymph nodes is recognized as sufficient for correct staging of cancer [8]. In this study, a drop in lymph node yield was noted in the

Table 2 Postoperative complication rate and morbidity

	Group A *n* (%)	Group B *n* (%)	Group C *n* (%)	Significance level
Respiratory complications	5 (21)	8 (32)	7 (27)	NS
Cardiovascular complications	3 (13)	2 (8)	4 (15)	NS
Anastomotic leak	2 (8)	3 (12)	1 (4)	NS
Gastric tube necrosis	1	2	1	
Chyle leak	0	1 (4)	2 (8)	NS
Reoperation	1 (4)	3 (12)	1 (4)	NS

NS not significant

early group of laparoscopic procedures (group B), although the median number of lymph nodes remained 13. However, in group C, the median yield increased to reach a number similar to that for open Ivor-Lewis esophagectomy, which probably reflected a leveling out of the learning curve. Again, this compares favorably with other studies. Dresner et al. [9] reported a median recovery of 22 nodes, Palanivelu et al. [10] a mean recovery of 18 lymph nodes, and Nguyen et al. [11] a mean recovery of 10.3 nodes. No lymph node harvest was reported by Luketich et al. [12]. Smithers et al. [13] reported no difference in lymph node retrieval between open and minimally invasive procedures.

One potential benefit of laparoscopic surgery shown by this study was the decrease in initial transfusion requirements for a significant proportion of patients as well as a significant decrease in the median length of postoperative ventilation. Similar results have been reported with minimally invasive esophagectomy for 77 patients, who had a median intraoperative blood loss of 425 ml and a median blood transfusion requirement during the hospital stay of 0 units (range, 0–8 units) [14]. Although postoperative ventilation time was not reported in this study, the median intensive care unit (ICU) length of stay was 6.5 days [14].

In a large study that recruited 222 patients who had undergone minimally invasive esophageal resections, the 30-day hospital mortality rate was 1.4%, and the anastomotic leak rate was 11.7% [12]. In this study, the early laparoscopic leak rates were comparable, at 12%, but decreased to 4% in the latter phase, but this difference was not statistically significant. The in-hospital mortality rate was 0%. Ischemia of the gastric conduit seems to be a greater problem with laparoscopic gastric mobilization than with open surgery (estimated at 3.2% in a recent review) [15]. This has led some authors to advocate gastric preconditioning by ligation of the left gastroepiploic arcade during laparoscopic staging. The benefit of this procedure has yet to be established.

Thus, rough comparisons with recent reports on open surgery suggest that reduced in-hospital mortality, less blood loss, shorter postoperative ventilation time, and a quicker functional recovery may be areas in which minimally invasive surgery might prove superior. This study demonstrated that transition from open to laparoscopic Ivor-Lewis esophagectomy can be achieved safely, with the aforementioned benefits going hand in hand with a satisfactory oncologic outcome.

Disclosure Drs. A. H. Hamouda, M. J. Forshaw, K. Tsigritis, G. E. Jones, A. S. Noorani, A. Rohatgi, and A. J. Botha have no conflicts of interest or financial ties to disclose.

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