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Minimally invasive esophagectomy for cancer: laparoscopic transhiatal procedure or thoracoscopy in prone position followed by laparoscopy?

G. Dapri · J. Himpens · G. B. Cadière

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Abstract
Background Minimally invasive esophagectomy is rapidly emerging as a suitable surgical alternative to the open technique. This retrospective comparative study aimed to compare two minimally invasive techniques for esophagectomy: transhiatal laparoscopy with intrathoracic or cervical anastomosis (group A) and right thoracoscopy in prone position followed by laparoscopy and left cervicotomy (group B) performed by the same surgeon (G.B.C.). The operative time, perioperative blood loss, intensive care and total hospital stays, peri- and postoperative morbidity, in-hospital mortality, number of lymph nodes dissected, and survival were the outcome measures.
Methods Between April 1999 and August 2005, 24 patients (group A) and 15 patients (group B) underwent minimally invasive esophagectomy for cancer in the authors' department. Their median age was 61 years in group A and 61 years in group B. Preoperatively, the endoscopic location of the tumor was in the upper third in 2 cases (1 vs 1), the middle third in 11 cases (7 vs 4), and the lower third in 26 cases (16 vs 10). Two patients in each group received neoadjuvant chemo- and radiotherapy. One patient (group A) and two patients (group B) received only neoadjuvant chemotherapy, and three patients (group A) received only neoadjuvant radiotherapy.
Results The median operative time was 300 min (range, 240–420 min) in group A and 377 min (range, 240–540 min) in group B (nonsignificant difference [NS]). The median perioperative bleeding was 325 ml (range, 100–800 ml) in group A and 700 ml (range, 100–2,400 ml) in group B (NS). The perioperative complications included one splenectomy in each group and one conversion to thoracotomy in group B. The postoperative medical complications totaled three in group A and six in group B. The postoperative surgical complications included one hemoperitoneum, one pneumothorax, five anastomotic leaks, and two recurrent laryngeal nerve paralyses in group A and two tracheal necroses, four anastomotic leaks, one colic fistula, and three recurrent laryngeal nerve paralyses in group B. The median intensive care unit (ICU) stay was 5 days (range, 2–70 days) for group A and 5 days (range, 1–180 days) for group B (NS). The median hospital stay was 12 days (range, 7–98 days) for group A and 14 days (range, 7–480 days) for group B ($p = 0.05$). The early mortality rate was 0%. All the specimens were free of disease. The median number of mediastinal/periesophageal lymph nodes was 3 (range, 1–10) for group A and 4 (range, 2–13) for group B (NS), and the median number of celiac/perigastric lymph nodes was 11 (range, 2–31) for group A and 10 (range, 3–22) for group B (NS). After a median follow-up period of 42.4 months (range, 2–84 months) for group A and 19.1 months (range, 1.5–34 months) for group B, 12 patients in group A died after a median period of 22 months (range, 2–55 months), and 7 patients in group B died after a median time of 15 months (range, 1.5–23 months).
Conclusions This retrospective comparative study showed that minimally invasive esophagectomy performed by thoracoscopy in the prone position is comparable with laparoscopic transhiatal esophagectomy in terms of the significant postoperative and survival outcomes.

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Keywords Esophageal cancer · Laparoscopy · Prone position · Thoracoscopy · Transhiatal esophagectomy

Esophagectomy is a considerable surgical undertaking, not only because of the need for a combined abdominal and thoracic approach, but also because patients with esophageal cancer frequently are elderly, debilitated, and malnourished, and often have chronic obstructive pulmonary disease [1]. Traditional procedures are characterized by considerable morbidity and mortality. Experienced centers have reported morbidity and mortality rates in the range of 6% to 7% [2]. The mortality rate is variable and reported to be about 8% in high-volume centers and 23% in low-volume centers [3].

Over the past decade, minimally invasive thoracic and laparoscopic approaches have emerged as effective alternatives to open techniques of esophagectomy without compromise to pathologic or oncologic outcomes [4]. Several minimally invasive approaches for esophagectomy have been described: thoracoscopy in prone position [5–7], thoracolaparoscopy [4, 8, 9], thoracoscopically assisted technique [10, 11], videomediastinoscopic technique [12], endoscopic Ivor-Lewis technique [13–15], laparoscopic transhiatal technique [16–18], laparoscopic esophagogastrectomy [19–20], and laparoscopically assisted transhiatal technique [21]. The choice between these approaches is, to a degree, one of personal preference.

This retrospective comparative study aimed to compare two minimally invasive techniques for esophagectomy: transhiatal laparoscopy with intrathoracic or cervical anastomosis (group A) and right thoracoscopy in prone position followed by laparoscopy and left cervicotomy (group B) performed by the same surgeon (G.B.C.). The operative time, perioperative blood loss, Intensive Care Unit (ICU) and total hospital stays, peri- and postoperative morbidity, in-hospital mortality, number of lymph nodes dissected, and survival were the outcome measures.

Patients and methods

Between April 1999 and August 2005, 24 patients (17 men and 7 women) in group A and 15 patients (12 men and 3 women) in group B underwent minimally invasive esophagectomy for cancer in our department (nonsignificant difference [NS]). The median age was 61 years (range, 44–73 years) in group A and 61 years (range, 37–86 years) in group B (NS). No patients in either group had undergone a thoracic procedure, but 12 patients in group A and 3 patients in group B had undergone previous abdominal surgery (Table 1). The American Society of Anesthesiology (ASA) classification appeared to be 1 for 3 patients in group A and 4 patients in group B, 2 for 11 patients in group A and 6 patients in group B, and 3 for 10 patients in group A and 5 patients in group B (NS).

The preoperative assessment for all the patients consisted of a barium swallow, esophagogastroduodenoscopy with biopsy, transluminal endoscopic ultrasonography, and chest and abdominal computed tomography (CT) scan. The tumor was located in the upper third of the esophagus in 2 cases (1 vs 1), the middle third in 11 cases (7 vs 4), and the lower third in 26 cases (16 vs 10).

The histology of the biopsy samples showed adenocarcinoma for 11 patients in group A and 7 patients in group B, and squamous cell carcinoma for 13 patients in group A and 8 patients in group B. The preoperative T stage, as determined by endoscopic ultrasonography, was 0 in 2 cases (0/24 vs 2/15), I in 8 cases (5/24 vs 3/15), IIa in 12 cases (7/24 vs 5/15), IIb in 6 cases (4/24 vs 2/15), III in 9 cases (6/24 vs 3/15), and IV in 2 cases (2/24 vs 0/15).

Two patients in each group received neoadjuvant chemo- and radiotherapy. One patient in group A and two patients in group B received only neoadjuvant chemotherapy, and three patients in group A received only neoadjuvant radiotherapy (Table 1).

All the patients were admitted to the ICU in the postoperative period, and postoperative analgesia was provided by patient-controlled analgesia. Nasogastric tubes were not used for postoperative gastric decompression in any of the

Table 1 Patient and tumor demographics

	Group A (n = 24)	Group B (n = 15)
Sex (M/F)	17/7	12/3
Median age (years)	61	61
Previous abdominal surgery	12	3
Previous thoracic surgery	0	0
ASA: 1	3	4
2	11	6
3	10	5
Tumor site		
Upper third	1	1
Middle third	7	4
Lower third	16	10
Biopsy Adenocarcinoma	11	7
Aquamous cell carcinoma	13	8
Preoperative Radio- + chemotherapy	2	2
Chemotherapy	1	2
Radiotherapy	3	0

ASA, American Society of Anesthesiology

patients. A barium swallow was performed in all cases before a liquid diet was begun.

The study measures include operative time, perioperative blood loss, ICU and total hospital stays, peri- and postoperative morbidity, in-hospital mortality, number of lymph nodes dissected, and survival.

Pathologic staging after surgery was performed according to International Union Against Cancer (UICC) tumor node metastasis (TNM) classification [22]. A multidisciplinary follow-up protocol involving regular outpatient clinic visits with the oncologists, surgeons, and gastroenterologists was established. Statistical analysis was performed, and a p value less than 0.05 was considered significant.

Surgical technique

Transhiatal laparoscopy (group A)

The patient is positioned supine with the legs apart and the head turned toward the right in hyperextension. The patient is draped so as to allow trocar placement in the abdomen as well as an incision along the left sternocleidomastoid muscle in the neck. The surgeon stands between the patient's legs, the cameraman to the patient's right, the other assistant to his left, and the scrub nurse beside the patient's left leg. Five trocars are used: a 10-mm trocar 2 cm above the umbilicus, a 5-mm trocar on the midclavicular line under the left costal margin, a 12-mm trocar halfway between the first two trocars, a 12-mm trocar in the right midclavicular line under the right costal margin, and a 10-mm trocar under the xyphoid process.

The dissection of the lesser omentum starts to the left of the right gastric artery and follows the latter toward the hepatic hilus, moving then to the left side of the liver until it reaches the right crus. Next, the dissection of the anterior sheet of the esophagogastric and the phrenogastric ligament is performed. In the dissection of the right pillar, it is important to reach a good opening of the hiatus and to remain at a distance from the tumor. The right pillar is dissected up to the edge of the aorta. The dissection of the gastrocolic ligament and thus the opening of the lesser sac is carried out just lateral to the gastroepiploic artery and vein. The lesser sac is subsequently opened in the direction of the spleen, with care taken to preserve the gastroepiploic vessels. Dissection of the gastrosplenic ligament reaching the previous section of the phrenogastric ligament ends this phase of the procedure.

Subsequently, dissection of the lesser sac is resumed in the direction of the gastroduodenal artery. The greater omentum then is separated from the mesocolon up to the colic angle. Kocher's maneuver is performed. Vision for the superior limit of the pancreatic tail, the celiac trunk, and the hepatic pedicule is enhanced by the use of a 30° angled scope and by pulling the gastric antrum down to the left of the patient. The peritoneal sheet that joins the tail of the pancreas is dissected with the coagulating hook. All lymphoglandular tissue from this point toward the right is sampled, with preservation of the right gastric artery and the hepatic pedicule.

Skeletonization of the portal vein and hepatic pedicule is performed using the coagulating hook. The assistant pulls the perivascular fatty and lymphoglandular tissue to the left of the patient. A careful dissection of the common hepatic artery going upstream reaches the celiac trunk. The left gastric vessels are isolated and divided between clips (Fig. 1). Dissection of all lymphoglandular tissue is completed along the abdominal aorta until the diaphragmatic pillars are reached. A complete mobilization of the stomach has thus been performed. The tubulization is outlined by superficial scoring of the stomach.

The tubulization is performed by several applications of linear stapler blue load (ETS, Ethicon, Endosurgery,

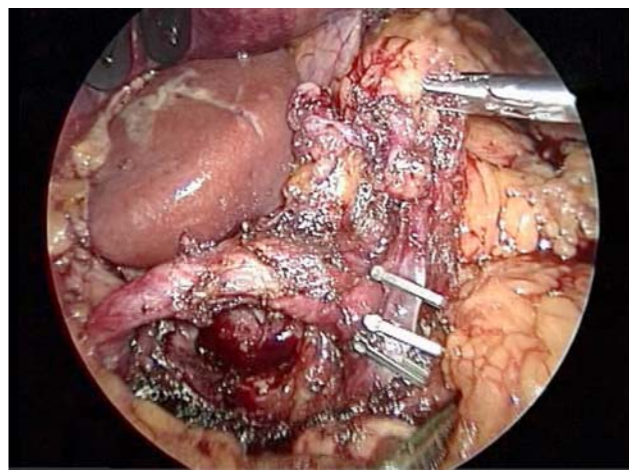

Fig. 1 Section between clips of the left gastric artery and vein

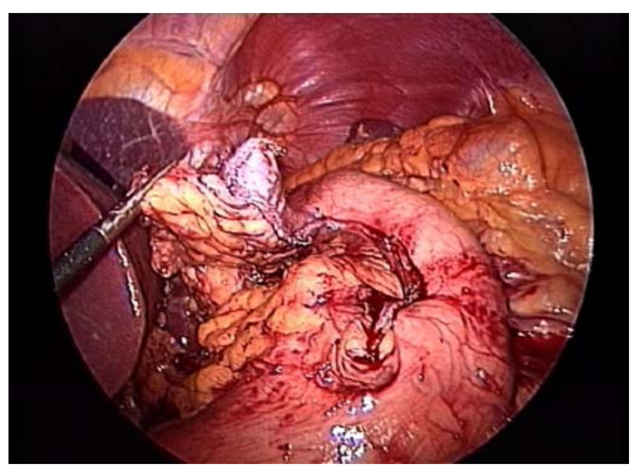

Fig. 2 Gastric tube

Cincinnati, OH) (Fig. 2). The initial firing of the stapler begins at the level of the crow's foot, perpendicular to the lesser curvature. Other firings are placed parallel to the greater curvature. The section is kept incomplete and ends approximately 4 cm distal to the summit of the fundus. The stapler line is reinforced by separate 2/0 silk stitches. A vertical phrenotomy is performed at the summit of the crural pillars. The limits of the mediastinal dissection are as follows: anteriorly (the pericardium and the left inferior pulmonary vein), on the left side (the left pleura), on the right side (the right pleura), and posteriorly (the aorta). In cases of cancer of the cardia, both mediastinal pleura are resected. A careful dissection is achieved using the ultrasonic scissors (Ultracison, Ethicon Endosurgery Inc.). The final anterior limit is 2 cm above the inferior pulmonary vein, and the posterior limit is the passage between the aortic arch and the descending aorta.

If a transhiatal intrathoracic esophagogastric anastomosis is performed (4 patients in group A), the esophagus is partially sectioned by scissors, and the anvil of a 25-mm circular stapler (Proximate ILS; Ethicon Endosurgery Inc.) is introduced into the lumen (Fig. 3). The esophagus then is completely sectioned (Fig. 4), and a 2/0 silk purse-string stitch is performed using the Endostitch device (Tyco Healthcare, New Haven, CT). The stomach is transected 4 cm distal to the summit of the fundus using two or more blue linear staples.

The circular stapler is introduced into the abdomen by the 12-mm left trocar and inserted into the gastric tube. The spike appears on the anterosuperior wall of the stomach, and the mechanical anastomosis is performed. The gastrotomy is closed by a 2/0 silk running suture. The specimen is retrieved (in a plastic bag) after the 12-mm left trocar has been enlarged. A drain is left in the hiatus, and the trocar openings are closed in layers.

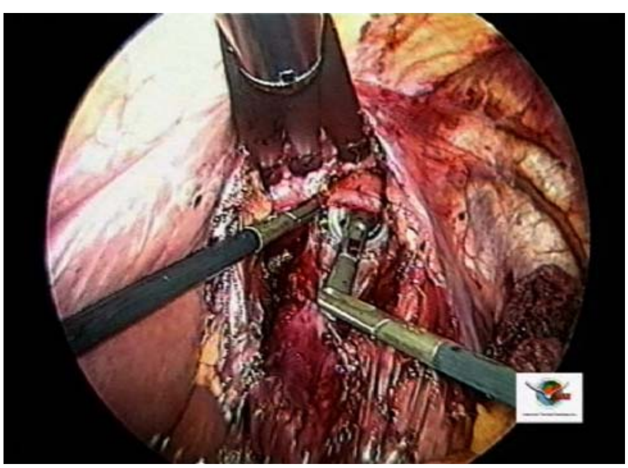

Fig. 3 Totally mechanical transhiatal anastomosis: introduction of the anvil into the distal esophagus

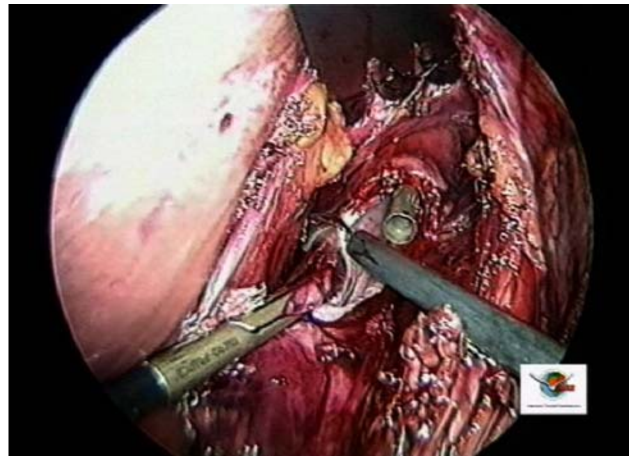

Fig. 4 Totally mechanical transhiatal anastomosis: section of the distal esophagus

If a cervical esophagogastric anastomosis is performed (20 patients in group A), the patient remains in the gynecologic position, and the pneumoperitoneum is deflated. An incision is performed lateral to the left sternocleidomastoid muscle. The omohyoid muscle is identified and sectioned. The retraction of the left thyroid lobe is accomplished with the help of the assistant's finger to avoid the risks of recurrent nerve damage. The cleavage planes are easily found because they have already been started by the pneumomediastinum. The esophagus is mobilized at its left posterior side until the surgeon can insert one hand into the posterior upper mediastinum, reaching the cervicomediastinal space. The anterior face of the esophagus is separated by the tracheal membrane until the previous intrathoracic dissection is reached. Lifting of the esophagus containing the tumoral mass (protected by a plastic bag) is achieved under laparoscopic control.

A totally mechanical side-to-side esophagogastric anastomosis is performed using three blue firings of the same linear stapler used for the gastric tube. The first firing is performed by inserting the linear stapler into the proximal esophagus and distal stomach. The other two staplings close the edges of the first one and permit isolation of the surgical specimen. The procedure ends with placement of drains in the neck and the abdominal hiatus. Cervicotomy and trocar openings are closed in layers.

Right thoracoscopy in prone position followed by laparoscopy and cervicotomy (group B)

The patient is placed in prone position after induction of general anesthesia and insertion of a double-lumen endotracheal tube. The right arm is placed in front of and beside the head to obtain an open angle between the scapula and

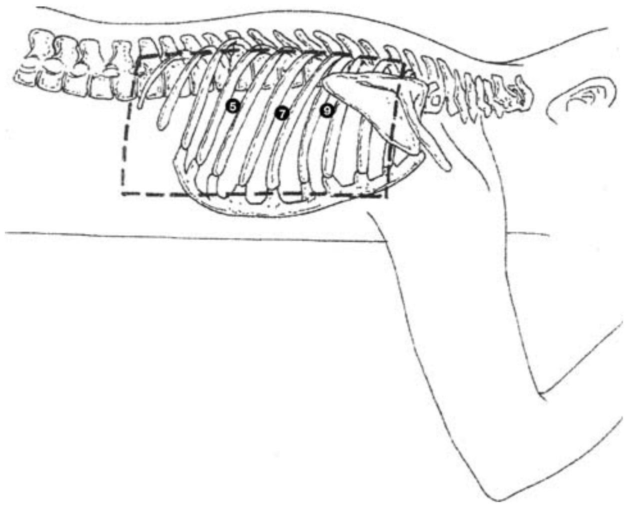

Fig. 5 Trocars position during right thoracoscopic esophagectomy in prone position

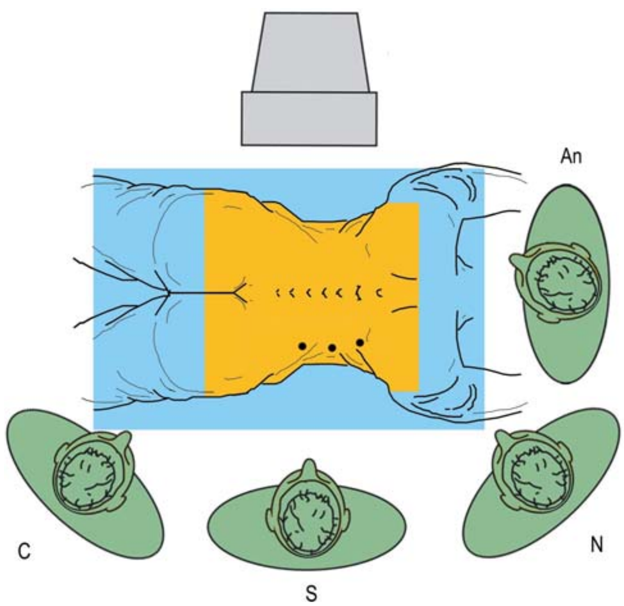

Fig. 6 Team position during right thoracoscopic esophagectomy in prone position. C, cameraman; S, surgeon; N, scrub nurse; An, anesthesiologist

spine (Fig. 5). The surgeon stands at the right side of the patient, the cameraman to his left, and scrub nurse to his right (Fig. 6). Three trocars are needed: a 10-mm trocar for the 30° angled optical system in the seventh intercostal space, a 5-mm trocar in the ninth intercostal space for the grasping forceps, and a 5-mm trocar in the fifth intercostal space for the coagulating hook, needleholder, clip applicator, and scissors.

To achieve a good exposure, a transitory pneumothorax using carbon dioxide (CO_2) (6–8 mmHg) is performed, with the lung maintained in the partially deflated state. Due

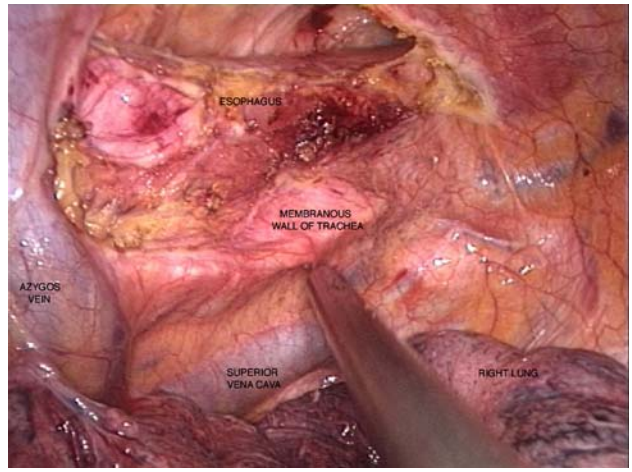

Fig. 7 Thoracoscopic esophageal dissection in prone position

to gravity, the cardiopulmonary window drops back, and the space of the dissection is directly opened. The mediastinal pleura overlying the esophagus is incised, and the esophagus is circumferentially mobilized along the trachea and the descending aorta (Fig. 7), reaching the right diaphragmatic pillar.

All fatty tissue is separated from the pericardium and descending aorta. The arch of the azygos vein is isolated, ligated by 2/0 silk stitches and clips, and divided (Fig. 8). The paraesophageal, paratracheal, subcarinal, bilateral tracheobronchial, and right peripulmonary artery and vein lymph nodes are dissected so as to achieve an en bloc surgical specimen (Fig. 9). A 28-Fr chest tube is inserted in the 11th intercostal space in the anterior axillary line at the end of this step, and the trocar scars are closed.

The patient is now placed in supine position with the legs separated. Laparoscopy is performed as described

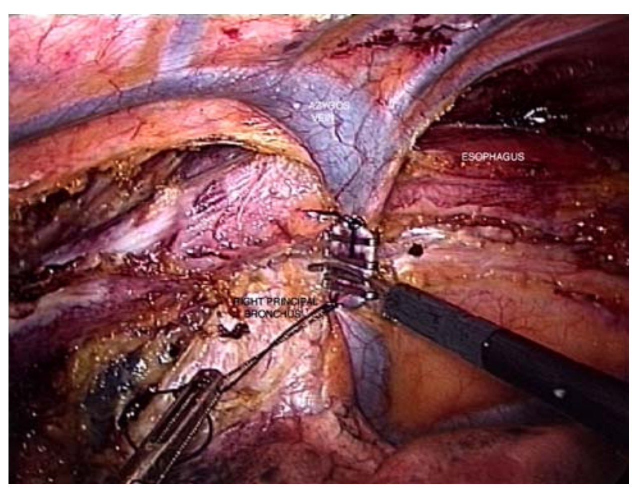

Fig. 8 Azygos vein section

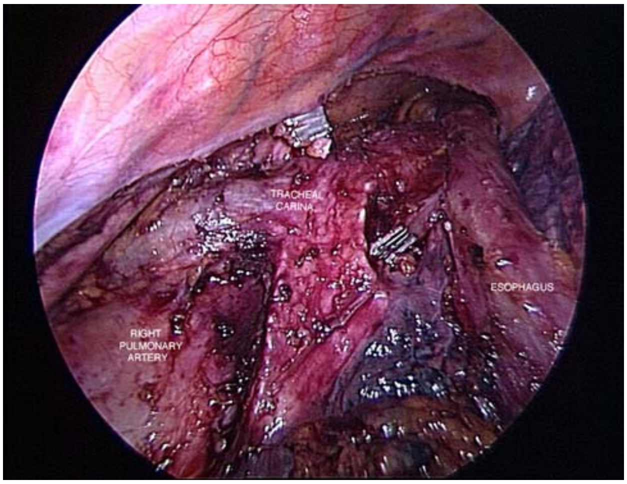

Fig. 9 Final view of thoracoscopic lymphadenectomy

earlier until the vertical phrenotomy, in which the thoracic dissection performed in prone position is reached. The procedure continues with left cervicotomy (as described earlier) and ends with placement of drains in the neck and the abdominal hiatus. The cervicotomy and trocar openings are closed in layers.

Results

The median operative time was 300 min (range, 240–420 min) for group A and 377 min (range, 240–540 min) for group B (NS). The thoracoscopic step in group B required 75 min (range, 60–90 min). The median perioperative blood loss was 325 ml (range, 100–800 ml) in group A and 700 ml (range, 100–2,400 ml) in group B (NS) (Table 2). In group A, 20 patients underwent a cervical esophagogastric anastomosis and 4 patients had a transhiatal intrathoracic anastomosis.

The median ICU stay was 5 days (range, 2–70 days) for group A and 5 days (range, 1–180 days) for group B (NS). The median hospital stay was 12 days (range, 7–98 days) for group A and 14 days (range, 7–480 days) for group B ($p = 0.05$). The perioperative and early mortality rate was 0% (Table 2).

Table 2 Perioperative and postoperative data[a]

	Group A (n = 24)	Group B (n = 15)	p Value
Operative time (min)	300 (240–420)	377 (240–540)	0.75
Perioperative bleeding (ml)	325 (100–800)	700 (100–2400)	0.07
ICU stay (days)	5 (2–70)	5 (1–180)	0.25
Total hospital stay (days)	12 (7–98)	14 (7–480)	0.05

ICU, intensive care unit

[a] Values are median (range)

Table 3 Early postoperative medical and surgical complications

		Group A (n = 24)	Group B (n = 15)
Medical	Pulmonary embolism	1	—
	Pneumoniae	1	1
	Respiratory failure	—	1
	Cardiac arrhythmia	1	—
	Deep venous thrombosis	—	1
Surgical	Hemoperitoneum	1	—
	Pneumothorax	1	—
	Tracheal necrosis	—	2
	Anastomotic leak	5	4
	Colic fistula	—	1
	Recurrent laryngeal. nerve paralyses	2	3

Perioperative complications were experienced by one patient in group A (1 splenectomy due to technical problems) and three patients in group B (1 splenectomy due to technical problems; 1 transverse colon perforation, during greater curvature mobilization; and 1 conversion to right thoracotomy, for uncontrolled bleeding from a superior esophageal artery).

Details of the postoperative medical and surgical complications are given in Table 3. The anastomotic leaks were treated conservatively, with success for all patients. One of the patients with tracheal necrosis was treated conservatively but died of hemoptysis 6 months after surgery. The other case of tracheal necrosis was managed surgically with repair of the gastrotracheal fistula, and the patient made a good recovery.

In terms of late complications, anastomotic stenosis occurred for seven patients in group A and four patients in group B. All these cases were treated using endoscopic dilation. Two patients in group B experienced a hiatal hernia, which was repaired surgically.

All specimen margins were free of disease. The median number of mediastinal/periesophageal lymph nodes was 3 (range, 1–10) in group A and 4 (range, 2–13) in group B (NS), and the median number of celiac/perigastric lymph nodes was 11 (range, 2–31) in group A and 10 (range, 3–

Table 4 Postoperative tumor node metastasis (TNM) results

		pTis	pT1	pT2	pT3	pT4
Group A	N0	/	5	4	3	/
	N1	/	1	6	4	1
Group B	N0	2	3	2	3	/
	N1	/	/	2	3	/

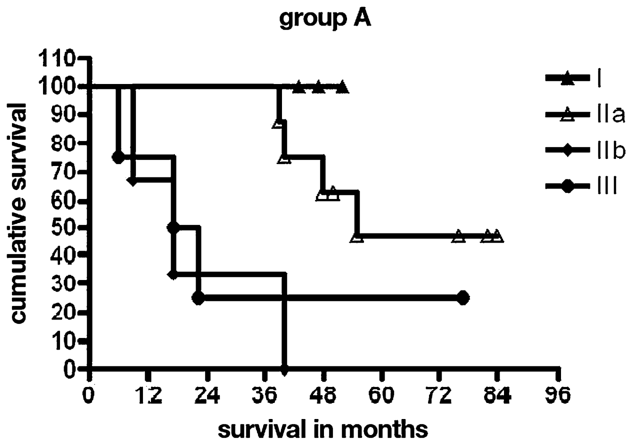

Fig. 10 Group A (transhiatal laparoscopy) Kaplan-Meier survival curve

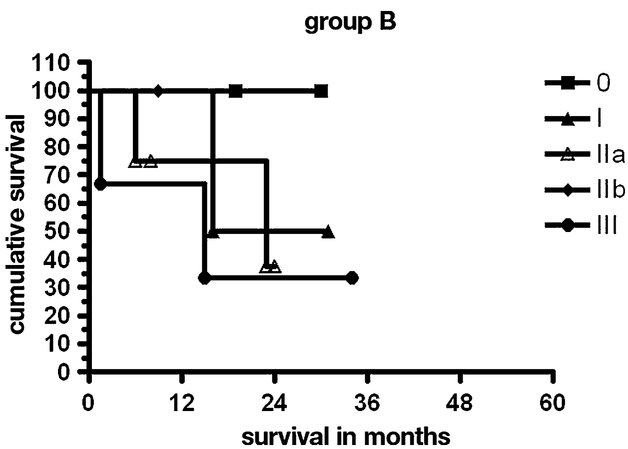

Fig. 11 Group B (right thoracoscopy in prone position followed by laparoscopy and cervicotomy) Kaplan-Meier survival curve

22) in group B (NS). The final pTNM stage is shown in Table 4.

The survival curve for the two groups is shown in Figs. 10 and 11. The median follow-up period was 42.4 months (range, 2–84 months) for group A and 19.1 months (range, 1.5–34 months) for group B. In group A, 12 patients died after a median period of 22 months (range, 2–55 months), and 7 patients in group B died after a median period of 15 months (range, 1.5–23 months). Based on an overall survival rate of 50% for group A and 46.6% for group B, the disease-free survival rate was 66.6% for group A and 100% for group B.

Discussion

The transhiatal laparoscopic approach followed by cervical anastomosis was first described by DePaula et al. [16], who also reported the advantages of the minimally invasive access in addition to the benefit of ability to manage a less serious anastomotic fistula secondary to a cervical anastomosis. Later, Swanstrom and Hansen [17] focused attention on the lymphadenectomy during the laparoscopic approach. They believed that because of a positive-pressure mediastinal insufflation, a fairly wide resection of the paraesophageal mediastinal tissues is possible. This approach appears to be less invasive than a thoracoscopy in lateral or prone position, but the laparoscopic approach has some technical disadvantages such as difficulty mobilizing the middle third of the esophagus because of the limited working space in the mediastinum, the short length of laparoscopic instruments, the difficulty performing a mediastinal nodal dissection, the exposure of the operative field, and ergonomics [23].

To diminish the extent of upper esophageal blunt dissection and the risk of bleeding and perforation, many consider the thoracoscopic approach to be a superior alternative. Thoracoscopic dissection and esophageal mobilization was first described by Cuschieri et al. [5]. This procedure is based on the principle that gravity will enable the cardiopulmonary block to fall anteriorly, aiding in dissection of the esophagus off the spine. Because the surgeon is in front of the esophagus, the ergonomics of the procedure are satisfactory, and it is possible to perform the procedure using only three trocars without the need of a fourth trocar for lung retraction. Moreover, although a double-lumen tube is inserted, the procedure does not require single-lung ventilation. Exposure is further facilitated by the use of CO_2 pneumothorax, which in addition to maintaining an adequate operative field, aids extraction of coagulation smoke by continuous insufflation.

In our department, we started to perform esophagectomy by minimally invasive surgery using the transhiatal approach. In 2002, we introduced thoracoscopy using the prone position technique. The choice between the two techniques is based on the location and stage of the disease as well as the patient's condition.

In our series, the operative time appeared to be longer in group B than in group A (NS). This difference probably is related to the changes in the patient's position during the three steps of the procedure in group B. After the orotracheal intubation, the patient was turned from a supine to a prone position and then again to a supine position at the end of the thoracoscopic step. Considering the complexity of the three steps of the procedure described, it is difficult to define a learning curve or to estimate how much the operative time will decrease with experience. We do not perform a feeding jejunostomy and pyloroplasty, and this is reported to save operating time [17]. As stated earlier, the choice to perform these procedures depends on the preference and experience of the surgeon [24].

It is commonly believed that because of the direct and accurate visualization offered by thoracoscopy, the incidence of preoperative bleeding is lower than with transhiatal dissection. However, this was not evident in our series, probably due to one case of bleeding from a superior esophageal artery, for which conversion to a thoracotomy was required to control the hemorrhage. A possible disadvantage of the prone technique is that in case of an emergency such as this, precious time could be lost in changing the position of the patient. Bleeding and aortic injury during thoracoscopic dissection have been already described [11, 25].

The ICU stay in our series appeared to be longer than observed in the literature (Table 5). This may be related to the fact that some patients required postoperative ventilation in the ICU. The median hospital stay in this study appeared to be longer as well (Table 5), confirming the report of Rizk et al. [26], in which the technical complications may have been associated with the increased length of stay.

In the literature, any difference between thoracoscopy and transhiatal laparoscopy appears in terms of respiratory complications [27]. In contrast to classic thoracotomy [28, 29], the incidence of postoperative pulmonary infection after thoracoscopy is reduced, and in our series it appeared to be similar to that for the transhiatal approach. Palanivelu et al. [6], for a series of 130 right thoracoscopies in prone position, described that intermittent ventilation of the right lung opened up a substantial percentage of the alveoli, which might help in the prevention of postoperative atelectasis and successive pneumoniae. In the prone position, the functional residual capacity is higher than in the supine position, and hypoxia and hypercarbia are avoided by reducing the extent of pulmonary dysfunction and atelectasis postoperatively. Oxygen saturation is maintained well within normal limits throughout the operation [6, 27]. In contrast to the literature, there were no cases of tracheal [30, 31] or bronchial [32] laceration, but two cases of tracheal necrosis in group B. This complication probably is related to a technical error in dissection of the esophagus off the trachea with the coagulating hook, resulting in devascularization.

As seen in open series, the rates of anastomotic leak, stricture, and injury to the recurrent laryngeal nerve are relatively frequent when dissection to the neck is performed [29, 33]. In the current series, it is evident that this complication occurred only in the group that had a cervical anastomosis. In contrast to Santos et al. [34], we believe

Table 5 Literature reports on transhiatal laparoscopic esophagectomy and thoracoscopic esophagectomy and laparoscopy in prone and lateral position

First author (year)	Type of surgery	n	Operative time (min)	Blood loss (ml)	ICU Stay (days)
DePaula et al. (1995)	TLE	12	256[a]	NA	NA
Swanstrom (1997)	TLE	9	410[a]	290[a]	1[b]
Avital et al. (2005)	TLE	22	380[a]	220[a]	NA
Current study	TLE	24	300[b]	325[b]	5[b]
Nguyen et al. (2000)	TLP/LE	46	350[a]	279[a]	2[b]
Luketich et al. (2003)	TLP/LE	222	NA	NA	1[b]
Palanivelu et al. (2006)	TPP/LE	130	220[a]	180[a]	1[b]
Smithers et al. (2007)	TPP/LE	23	420[b]	500[b]	1[b]
Current study	TPP/LE	15	420[b]	700[b]	5[b]

Total hospital stay (days)	Mortality (%)	Conversion (%)	Anastomotic Leak (%)	Lymph nodes (n)
7.6[a]	0	0	8.3	NA
6.4[a]	0	0	0	6[a]
8[b]	4.5	4.5	4.5	14.3[a]
12[b]	0	0	20.8	T = 3, A = 11[b]
8[b]	4.3	2.2	4.3	10.3[a]
7[b]	1.4	7.2	11.7	NA
8[b]	1.5	0	2.3	18[a]
11[b]	0	NA	4	T = 8, A = 10[b]
14[b]	0	6.6	26.6	T = 4, A = 10[b]

ICU, intensive care unit; TLE, transhiatal laparoscopic esophagectomy; NA, not available; TPP/LE, thoracoscopic prone position + laparoscopic esophagectomy; TLP/LE, thoracoscopic lateral position + laparoscopic esophagectomy; T, from the thorax; A, from the abdomen

[a] Mean

[b] Median

that this complication probably is related to the technique of esophagogastrostomy, which is total mechanical stapled anastomosis. When a cervical anastomosis is performed, drains are left, respectively, in the neck and the hiatus to achieve a controlled leak of contents traveling down the gastric tube [8]. It also is evident that all the cases of anastomotic leaks resulted in late postoperative dysphagia, which was managed by endoscopic dilation.

In our series, a temporary recurrent laryngeal nerve paralysis appeared in both groups, probably due to the dissection of the upper esophagus during left cervicotomy [27, 35]. Fortunately, this is a temporary complication, which resolves in 2 to 14 months [16, 17]. In our series, symptom resolution occurred by 6 months.

Most reports focus on the value of extended lymphadenectomy in both the mediastinum and the superior abdominal compartment (two-field lymphadenectomy). Some surgeons think that adding bilateral cervical lymphadenectomy (three-field lymphadenectomy) also is essential [36, 37]. However, extending the lymphadenectomy to the cervical region remains debatable because of the technical difficulties and associated morbidity [38]. We usually perform the two-field lymphadenectomy, and our study shows no statistically significant difference in the numbers of lymph nodes retrieved. Although the difference may not be evident in our series, we assumed that thoracoscopy in prone position could be superior to transhiatal approach in terms of lymph node dissection because we believe that the paraesophageal, paratracheal, subcarinal, and bilateral tracheobronchial nodes along the right peripulmonary artery and veins can be resected with greater accuracy and precision due to the enhanced visualization [39].

The survival rate after minimally invasive esophagectomy is similar to that for patients who have undergone surgery by the open approach [10]. From our study on the final stage of the specimen analyzed, no statistical differences can be shown for stages I, IIb, and III. Our results at 2 years are similar to that reported in the literature [4, 6, 8, 23, 40].

In conclusion, this retrospective comparative study shows that minimally invasive esophagectomy performed by thoracoscopy in the prone position is comparable with transhiatal esophagectomy in terms of the significant postoperative and survival outcomes.

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