12-Clinical Investigation

Preservation of the vagus nerves in subtotal esophagectomy without thoracotomy[1]

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Abstract

Purpose: To evaluate the outcome of transhiatal esophagectomy without thoracotomy and with preservation of the vagal trunks for the treatment of advanced megaesophagus.
Methods: Between March 2006 and September 2017, it was performed 136 transhiatal esophagectomies without thoracotomy by laparoscopy, with preservation of the vagus nerves. All patients were evaluated pre and postoperatively for respiratory and nutritional aspects Post operatively, some surgical aspects were evaluated like radiology and endoscopy of the digestive tract.
Results: Follow-up for 7 months to 12 years by clinical, radiologic, endoscopic and pH monitoring revealed satisfactory and encouraging outcomes of the procedure.
Conclusion: The laparoscopic transhiatal esophagectomy is a feasible and safe technique with good postoperative outcomes.
Key words: Laparoscopy. Esophagectomy. Vagus Nerve.

■ Introduction

The aim of surgical treatment of any condition is to relieve and/or abolish symptoms and to prevent progression of the disease with the lowest complication and mortality rates possible. Subtotal esophagectomy without thoracotomy has been proposed as the best surgical approach to the treatment of advanced megaesophagus.

Radiologically, advanced megaesophagus is characterized by elongation of the esophagus and axis deviation in relation to the spine (dolichol-megaesophagus). From a functional point of view, advanced megaesophagus is defined when manometry reveals a contraction wave amplitude of the esophagus less than 20 mmHg, regardless of esophageal diameter[1]. In the advanced forms, the esophagus becomes an inert pouch, which almost always exhibits stasis. Consequent chronic dysplastic and/or neoplastic alterations in the esophageal wall are observed at a rate that is up to 140 times higher than that seen in the general population[2]. The persistence of stasis causes bacterial proliferation and changes in the intraluminal flora of the esophagus[3], which is aggravated in the presence of bronchoaspiration. The production of weak acids changes the esophageal pH and increases the prevalence of HPV[4], a virus that has been associated with a higher incidence of malignant neoplasms at other sites of the organism[5-7].

Historically, Câmara Lopes and Ferreira Santos used subtotal esophagectomy by cervicotomy, right thoracotomy and laparotomy as surgical approaches to the treatment of advanced megaesophagus[8]. Eugênio Bueno and Pinotti[9,10] proposed resection of the esophagus by laparotomy and cervicotomy. De Paula[11] and Crema[12] proposed subtotal esophagectomy using a laparoscopic and transmediastinal approach for preparation of the stomach and dissection of the abdominal and thoracic esophagus, and left cervicotomy for removal of the specimen and esophagogastric anastomosis, a widely used technique for the treatment of advanced megaesophagus in referral centers.

The truncal vagotomy performed during esophagectomy leads to high rates of chronic diarrhea, Dumping syndrome, gastric emptying problems, weight loss, and cholelithiasis. A decrease in the inflammatory response resulting from inflammatory sepsis has also been described. The use of the laparoscopic approach and preservation of the vagal trunks have substantially improved the outcomes of esophagectomy during the early and late postoperative period, maintaining gastric emptying and pancreatic and gastric secretion close to preoperative values. Indications for subtotal esophagectomy with preservation of the vagal trunks include high-grade dysplastic lesions, intramucosal carcinoma, Barret's esophagus with high-grade dysplasia, and advanced or relapsed megaesophagus.

The objective of this study was to evaluate the outcome of transhiatal esophagectomy without thoracotomy and with preservation of the vagal trunks for the treatment of advanced megaesophagus.

■ Methods

The patients received information about the surgical procedure performed and the study protocol was approved by the Ethics Committee on Research Involving Humans of the Universidade Federal do Triângulo Mineiro.

Between March 2006 and September 2017, we performed 136 transhiatal esophagectomies without thoracotomy by laparoscopy, with preservation of the vagus nerves. Of these, 123 (90.45%) patients had chagasic megaesophagus and 13 (9.55%) had idiopathic megaesophagus. The mean age was 59.3 (17-79) years and 81 (59.55%) patients were male.

Before surgery, all patients were submitted to *Trypanosoma cruzi* serology, esophageal contrast examination, upper endoscopy, electromanometry, 24-hour pH monitoring, and gallbladder ultrasonography. Pre- and postoperative nutritional and physiotherapeutic assessments were performed on all patients. The following data were obtained: anthropometric (weight, height, arm muscle circumference, skinfold, and creatinine/height index), biochemical (total proteins, albumin, and transferrin), immunological (total lymphocytes and tuberculin purified protein derivative), and physiotherapeutic. All patients were submitted to ambulatory preoperative preparation for 7 to 21 days, which consisted of respiratory physiotherapy and enteral nutrition support (1.5g protein/kg/day) through a nasoenteral tube placed into the stomach.

Preoperative preparation

Clinical evaluation, especially cardiological, pulmonary and nutritional assessment, should be performed routinely since patients with megaesophagus usually exhibit comorbidities and are malnourished at the time of treatment. The evaluation of gastric emptying time by Tc99 scintigraphy and with barium contrast introduced through the tube placed into the stomach is important to rule out an association with megastomach, which is observed at our service in 8% of patients with chagasic megaesophagus.

Abdominal ultrasonography is also useful for the diagnosis of cholelithiasis, which is associated with chagasic megaesophagus in 14 to 26% of cases[13,14]. In a study conducted at our service, cholelithiasis was associated with chagasic megaesophagus in 28.5% of the patients[15].

On the day before surgery, a thick Fouchet or Levin oroesophageal catheter is passed and the esophagus is cleaned mechanically with 0.9% saline.

Surgical technique

The position of the patient is the same as that used for laparoscopic esophagocardiomyotomy. The patient is placed in the lithotomy position, with the legs extended, separated and adequately supported on a leg holder. The surgeon stands between the legs and the assistants on the left side of the patient (camera and presentation). The monitor, if only one, is positioned at the headrest to the right of the operating table.

Five ports are used: a) a 10-mm trocar placed above the umbilical scar, approximately 15 cm from the xiphoid appendix (30-degree optics); b) a 10-mm trocar placed in the left subcostal region at the midclavicular line (right hand of the surgeon); c) a 5-mm trocar placed in the right subcostal region at the midclavicular line (left hand of the surgeon); d) a 5-mm trocar placed in the midline subxiphoid position (assistant separating the left lobe of the liver), and e) a 5-mm trocar placed to the left of the scar (assistant pushing the junction and esophagus), with a 5-mm trocar being sufficient. When associated with cholelithiasis, the fifth port can be placed to the right, facilitating presentation of the gallbladder at the time of cholecystectomy.

At a pneumoperitoneum of 12 mmHg, the procedure is initiated by opening the phrenoesophageal membrane and greater omentum, providing access to the right branch of the right pillar of the diaphragm. From this point onwards, the periesophageal tissue is released around the terminal esophagus, isolating the esophagus by dissection of the gastroesophageal junction and repairing the abdominal esophagus with a Penrose drain. The anterior and posterior vagal trunks are identified and isolated. Dissection of the vagal trunks until the gastroesophageal junction is important when choosing vagus nerve

preservation during esophageal resection (Figures 1 and 2). At this stage, dissection is continued under direct vision of the esophageal body, identifying the pleura, pericardium, azygos vein and vagal trunks throughout the thoracic extension. Hemostasis is performed by monopolar cauterization and/or clipping of the greater esophageal branches, but an ultrasonic scalpel is the preferred method and is frequently used. It is important that the surgical plane is close to the esophagus to avoid injury to the pleura and mediastinal structures. For better access to the mediastinum during dissection of the thoracic esophagus, we perform a midline transection of the diaphragm and place the operating table in the Trendelenburg position, as used in the abdominal cervical approach during open surgery.

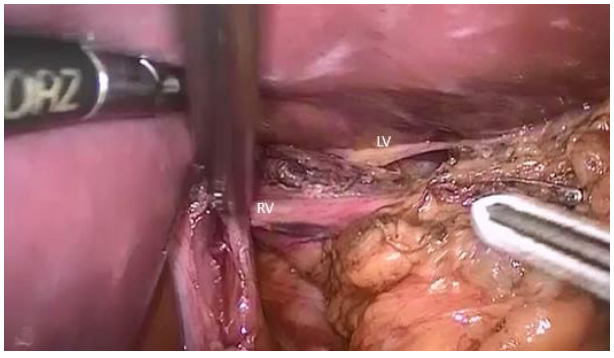

Figure 1 - Completely dissected esophageal segment. Details of the right and left vagal trunks. **RV**: right vagal trunk; **LV**: left vagal trunk.

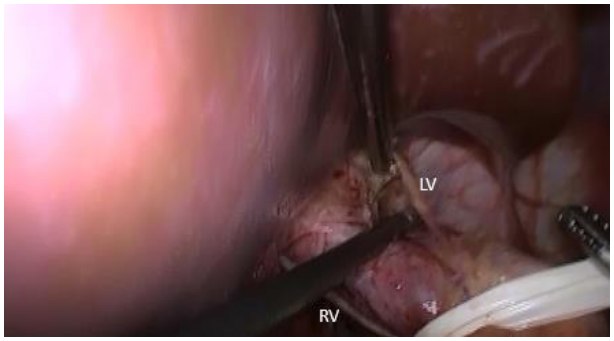

Figure 2 - Completely dissected esophageal segment. Details of the right and left vagal trunks. **RV**: right vagal trunk; **LV**: left vagal trunk.

After dissection of the abdominal and thoracic esophagus is completed, the stomach is prepared with release of the greater curvature. Mono- or bipolar electrocautery or, preferentially, a harmonic scalpel is used for sectioning of the short vessels and of the gastrocolic omentum. Double clipping is used for ligation of the gastroepiploic artery and vein and of the left gastric artery and vein, preserving the arcade of the greater and lesser curvature.

We do not perform pyloroplasty during surgical treatment of advanced megaesophagus in the case of chagasic or idiopathic esophagopathy. Once preparation of the stomach is complete, dissection of the cervical esophagus is performed by left cervicotomy. By gently pushing the surgical specimen, the esophagus and proximal part of the stomach in the cervical region are exteriorized and the gastroesophageal junction is cut with a linear cutting stapler with a green load. During cervical traction of the previously dissected esophagus, the passage of the esophagus and stomach through the mediastinum must be monitored under direct vision with the optic placed in the inferior mediastinum.

An esophagogastric anastomosis is performed with manual continuous polypropylene monofilament suture in a single plane. A nasoenteral tube is placed into the duodenum, when possible, or into the gastric antrum for enteral feeding as described for preoperative preparation, 24 hours after the surgical procedure. We do no use cervical or abdominal drainage.

It should be noted that dissection of the anterior and posterior vagal trunks should be performed before dissection of the esophagus and preparation of the stomach to avoid inadvertent sectioning of the vagal trunks during the cervical time. The absence of pyloroplasty in patients with megaesophagus who do not have megastomach prevents the reflux of duodenal content to the stomach, which is

now positioned in the posterior mediastinum, a region of negative pressure. Another important factor is that the esophagogastric anastomosis remains in the cervical region, which is characterized by positive pressure, thus preventing the reflux of gastric fluid into the esophagus and consequent esophagitis. The latter may occur when the anastomosis is in an intrathoracic position.

The use of the whole stomach as a plasty organ is justified by the better vascularization of the gastric fundus since it avoids interruption of the submucosal vascular network of the gastric body and fundus, maintaining the vascular communication with the arcade of the lesser and greater curvature. Thus, maintenance of the gastric innervation is also facilitated.

■ Results

The mean duration of surgery was 120 minutes (90-150) and improvement was observed in all parameters analyzed. Only five patients (8.34%) required ventilation support after surgery and three received blood transfusion during or after surgery. Early complications were observed in 19 patients (13.97%). There were nine cases (6.61%) of hemopneumothorax that required a peri- or postoperative chest drain. Early gastric stasis (3 months) was observed in three cases (2.2%), a cervical fistula in five (3.67%), which resolved clinically by exclusive enteral nutrition and cervical drainage through removal of the cervical incisions, and dysphonia in eight (5.88%). Late complications occurred in 10 cases (7.35%). Five patients (3.67%) had dysphonia that improved only after 3 months. Dysphagia due to anastomotic stricture was observed in four cases (2.94%), three of them requiring endoscopic dilatation and one submitted to plasty of the anastomosis.

When gastric emptying was compared with the historical series in which the vagus nerve was not preserved, we found early gastric emptying problems in three (2.2%) of the 136 cases with vagus nerve preservation and in eight (8.42%) of the 95 cases without preservation, with this difference being statistically significant. Late gastric stasis was not observed in any case of the group with vagus nerve preservation and in four cases (4.21%) without preservation.

Two patients (1.47%) died, one patient with a pacemaker due to cardiac arrhythmia on postoperative day 12 and one due to mediastinitis on postoperative day 28.

Histopathological examination of the surgical specimen and polymerase chain reaction (PCR) for *T. cruzi* confirmed chagasic esophagopathy in 123 cases (90.45%) and idiopathic disease in 13 (9.55%). Cases with associated neoplasms diagnosed before surgery or in the surgical specimen were excluded from this series.

Contrast examination of the esophageal stump, stomach and duodenum was performed 10 days, 3 months and one year after surgery and revealed the presence of the esophagogastric anastomosis in the cervical region, good passage of the contrast through the anastomosis, and good gastric emptying. Endoscopy performed 3 months and one year after surgical treatment detected 20 cases (14.7%) of mild esophagitis in the esophageal stump, although manometry showed that the anastomosis was situated in a high-pressure region and 24-hour pH monitoring with the sensor placed 2 cm above the esophagogastric anastomosis did not detect acid reflux in any patient.

Follow-up for 7 months to 12 years by clinical, radiologic, endoscopic and pH monitoring revealed satisfactory and encouraging outcomes of the procedure.

■ Discussion

The choice of the most appropriate technique for the treatment of megaesophagus

is based on the stage of esophagopathy. In the non-advanced stage, cardiomyotomy combined with a partial antireflux valve has been found to be the best surgical option.

In the advanced stage of esophagopathy, contrast examination reveals an esophageal diameter of 10 cm and/or tortuosity of the esophagus with axis deviation (dolichol-esophagus)[16,17].

From a functional point of view, megaesophagus is characterized manometrically by a contraction wave amplitude of the body of less than 20 mmHg. Previous studies have shown peristaltic waves less than 20 mmHg in all patients with radiologically advanced megaesophagus[1], while 38.4% of patients with radiologically non-advanced megaesophagus have low-amplitude waves. These patients were therefore classified as functionally advanced megaesophagus.

Surgical treatment of this form of the disease (non-advanced stage) using any technique targeting the gastroesophageal junction has shown unsatisfactory results[18]; therefore, subtotal esophagectomy with removal of this inert pouch filled with stasis fluid rich in enterobacteria[3] and with important mucosal alterations (stasis esophagitis, dysplasia, and/or neoplasm) is indicated[19].

The advent of the laparoscopic approach has led to a reduction in pulmonary dysfunction and consequently in postoperative complications, which had reached rates of 30%[10] with the open technique, rates higher than that found in the present series (13.97%). Mortality was 1.47% in this study. In a meta-analysis of 17 articles involving 1.422 patients submitted to esophagectomy, Aiolfi *et al.*[20] found a mortality rate of 2.6%. A similar mortality rate (2.69%) has been reported by Molena *et al.*[21] in 963 subtotal esophagectomies for benign disorders in the United States.

Herbella *et al.*[22] described anatomically the presence of two vagal trunks in 83.4%; these trunks were separated in 26.7% and communications between them were detected in 56.7%. One or two bifurcated trunks occurred in only 13.3% of cases.

In the present study, esophagogastric anastomotic fistulas were observed in five cases (3.67%). Similar rates have been reported by Oninger *et al.*[23] (4%) and much lower rates by Tank *et al.*[24] (13.3%) and Devaney *et al.*[25] (10%).

The use of the whole stomach as a plasty organ facilitates preservation of the vagal trunks and innervation of the stomach. Peyre and Demeester[26] used a gastric tube and proposed preservation of the vagal trunks and innervation of the antrum and pylorus, which resulted in a reduction of postoperative morbidity and mortality. Preservation of the vagal trunks has been shown to favor the maintenance of gastric emptying during the early and late postoperative period. In the present study, only three (2.2%) of the 136 cases with vagus nerve preservation exhibited early gastric emptying problems and none of the patients had late problems. Among the 95 cases submitted to surgery without vagus nerve preservation, eight (8.42%) had early gastric emptying problems and four (4.21%) had late problems. Similar results have been reported by Banki *et al.*[27].

An increase in the incidence of transient dysphonia has been described for the laparoscopic transhiatal approach (25%-66.6%)[19]. An increase of dysphonia in the laparoscopic transhiatal technique was also detected at our service. This increase compared to the cervicoabdominal approach (4.8%) is probably due to local manipulation of the cervical region where the esophagus is sectioned and removal of the surgical specimen, which usually has a large volume. A reduction of dysphonia in the last 30 cases (6.67%) was noted when compared to the beginning of the series (23.3%).

In the absence of stenosis of the esophagogastric anastomosis, subtotal

esophagectomy completely abolishes dysphagia. By taking care of maintaining the esophagogastric anastomosis in the cervical region, an area of positive pressure, the intensity of gastroesophageal reflux and consequently moderate and severe esophagitis of the esophageal stump are reduced, especially in cases in which the pylorus is preserved and duodenogastric reflux is lower.

The secretion of pancreatic peptide was studied in 46 cases and confirmed functional preservation of the vagus nerves. This fact was also observed by Banki *et al.*[27] who detected an increase in pancreatic peptide 30 minutes after stimulation in patients submitted to subtotal esophagectomy with preservation of the vagus nerves[28].

According to Mormando *et al.*[29], vagus nerve preservation is a good option to improve the quality of life of patients submitted to esophagectomy for the treatment of benign disorders.

■ Conclusion

Laparoscopic transhiatal esophagectomy is a feasible and safe technique with excellent postoperative outcomes.

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