



Lessons Learned from the First 60 Minimally Invasive Esophagectomy in Prone Position

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Abstract

Background: Since the initial description of laparoscopic fundoplication in 1991 for the treatment of gastroesophageal reflux disease, different minimally invasive procedures have been developed until nowadays, when esophagectomy is performed using combined thoracoscopy and laparoscopy.

Objective: The aim of our study is to analyse the intraoperative complications of minimally invasive esophagectomy in prone position.

Material and methods: Between November 2011 and April 2020, 60 patients underwent minimally invasive esophagectomy in prone position in the Hospital Interzonal General de Agudos General San Martín and private practice of La Plata city.

Results: During the abdominal stage one patient presented coronary vessel injury and other with short vessel injury. The complications occurring in the thoracic stage included lung injury, azygos arch injury, thoracic duct section, laryngeal recurrent nerve lesion, main stem bronchus injury and pericardium lesion, during lymph node resection. Most of these complications occurred in the first 30 patients, while in the remaining 30 cases only two complications ($p = 0.4$)

Conclusion: Minimally invasive esophagectomy in prone position is a feasible and safe procedure that can cause serious intraoperative complications due to its complexity. Although the results of our series did not show statistically significant differences, the number of complications during surgeries performed by the same team showed an important reduction associated with better training.

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Keywords: Minimally invasive esophagectomy; Prone position; Complications.



Introduction

Surgical resection is regarded as the only curative option for resectable oesophageal cancer; however, it has been commonly associated with significant morbidity and mortality. Since the initial description of laparoscopic fundoplication in 1991 for the treatment of gastroesophageal reflux disease, different minimally invasive procedures have been developed for the management of esophageal diseases. In this way, thoracoscopic staging was incorporated to avoid unnecessary thoracotomy in advanced tumors; later, video-assisted thoracoscopic procedures were developed until nowadays, when esophagectomy is performed using combined thoracoscopy and laparoscopy [1,2].

Minimally Invasive Esophagectomy (MIE) in Prone Position (PP) is a procedure during which the patient is placed in a prone position during the thoracoscopic approach. The first experiences were published by Cuschieri et al. in 1994 who described this approach to access the posterior mediastinum and the esophagus for mobilization and resection. The largest experience reported with MIE in PP was described by Palanivelu et al. in 2006. This publication provides a detailed description of the procedure and reports surprising results of low morbidity and mortality. This was the starting point for many surgeons to use this approach in candidates for esophagectomy [4,5].

The aim of our study is to analyse the intraoperative complications of MIE in PP during the first 60 procedures.

Methods

Between November 2011 and May 2020, 60 patients underwent MIE in PP in the Hospital Interzonal General de Agudos General San Martin and private practice of La Plata. The characteristics of the patients and the type of esophageal disease are described in Table 1.

All the procedures were performed by the same surgical team integrated by an experienced thoracic surgeon. The training process was previously carried out in pigs in the Minimally Invasive Surgery Laboratory of the Faculty of Medicine of the National University of La Plata (UNLP).

Thoracic stage: The patient is positioned in prone position, with both arms extended. Two devices are used to provide support on the upper chest and pelvis for an adequate excursion of the diaphragm and ventilation. Three ports are introduced: A 10 mm port at the level of the tip of the scapula, a 5 mm trocar at the level of the 4th or 5th intercostal space, approximately 7 cm from the spine, and a 10 mm port for the left hand at the ninth intercostal space, 7 cm from the spine. Sometimes we use one more trocar to perform lymphadenectomy of the suprascapular space in cases of squamous carcinomas. Once the camera has been introduced, the thoracic vertebrae are visualized; the mediastinal pleura is opened, the azygos arch is cut, followed by total mobilization of the esophagus and resection of the subcarinal lymph nodes. We used selective intubation in the first 20 cases and then changed to normal intubation with 8 mm Hg carbon dioxide insufflation. We also changed the sequence of the procedure. The first step is the transection of the inferior pulmonary ligament. Then the mediastinum is opened immediately below the aorta with the aim of performing a complete mesoesophagus resection. Therefore, the esophagus is dissected and pushed upwards behind the pericardium and alongside the inferior pulmonary vein up to the right main stem bronchus. The entire periesophageal lymph nodes are excised en bloc with

the specimen. The arch of the azygos vein is sectioned; the esophagus is dissected with the subcarinal lymph nodes and is continued to the borders of the trachea in case of squamous cell carcinoma.

Abdominal stage: the patient is repositioned to the supine position. The surgeon takes place in between the legs, the first assistant on the right side of the patient, the second assistant on the left side of the patient. The procedure starts with the opening of the greater omentum and continues along the greater curvature, preserving the right gastro-epiploic vessels that will provide irrigation to the gastropasty. Lymph nodes from the celiac trunk are then dissected. After skeletonization of the stomach, the cervical esophagus is dissected and the specimen is removed through a mini supraumbilical midline laparotomy. At this level, the gastric conduit is constructed using mechanical stapler (hybrid technique). Then, the gastric conduit is pulled up through the mediastinum and an anastomosis is performed with the cervical esophagus (McKeown procedure) When a subtotal esophagectomy with anastomosis in the mediastinum is performed according to the Ivor-Lewis technique, the procedure begins in the abdomen, the gastropasty is made completely through laparoscopy.

Our digital file and videos were used for data collection, and we performed a bibliographic search in Pubmed, Embase and Cochrane Library. The statistical analysis was performed using Fisher's exact test. P values less than 0.05 were considered statistically significant.

Results

The procedure was successfully in most cases. One patient with a history of pneumonia with pleural effusion was converted during the thoracic stage because the posterior mediastinum could not be accessed due to pleural and pulmonary adhesions. Another patient was converted during the abdominal stage due to multiple adhesions secondary to previous surgeries. Intraoperative complications are summarized in Table 2.

The two cases of lung injury were minor complications. Azygos arch injury was due to inappropriate manipulation of the vascular endostapler that was resolved using clips. The thoracic duct was inadvertently dissected, producing chylothorax with poor response to medical treatment. The patient required reoperation five days with clip insertion via thoracoscopy. The recurrent laryngeal nerve injury was an unfortunate complication that produced permanent dysphonia in a 27-year-old female patient with a good oncological prognosis due to a stage T2 N0 carcinoma. Finally, the harmonic scalpel produced thermal damage of the left main stem bronchus during resection of the subcarinal lymph nodes. Although it was a dramatic event, it could be solved by using a hermetically sealed 4-0 monofilament suture. This situation prolonged the patient's stay at the intensive care unit, but, fortunately, no major inconveniences developed. Injury of the coronary and short vessels during resection of the abdominal lymph nodes was rapidly solved using clips and there was no need for conversion. Most of these complications occurred in the first 30 patients (group 1) while six intraoperative complications, while only three complication occurred in the remaining 30 cases (group 2), lung injury produced by a trocar in a patient with pleuropulmonary adhesions and a small and a pericardial perforation that has not required any treatment. The third complication has been the case of haemorrhage due to injury to the short vessels during abdominal stage; Table 3.

When comparing patients who received neoadjuvant therapy with those who underwent surgery directly, only three patients in the neoadjuvant therapy group presented versus six patients with complications in the other group ($p = 0.7$). There were no mortality consequences for any of the complications mentioned and these complications were not associated with mortality in our series.

Table 1: Characteristics of the patients and the type of esophageal disease.

Characteristics	Data (%)
Age Mean	59.0 ± 9,9
Sex Male Female	41 (68) 19 (32)
Pathology Adenocarcinoma Squamous carcinoma Megaoesophagus	40 (67) 19 (32) 1 (1)
Neoadjuvant	26 (44)
Surgery Thoracic and abdominal approach (Ivor -Lewis) Thoracic, abdominal, and cervical approach (Mckeown)	6 (10) 54 (90)

Table 2: Intraoperative complications.

Complications	Data (%)
Abdominal stage Injury of coronary vessels Injury short vessels	1 (1.6) 1 (1.6)
Thoracic stage First step Right lung injury Esophageal mobilization Injury of azygos arch Injury of thoracic duct Pericardium injury Lymphadenectomy Injury of the right recurrent laryngeal nerve Injury of the left main stem bronchus	2 (3.3) 1 (1.6) 1 (1.6) 1 (1.6) 1 (1.6) 1 (1.6) 1 (1.6) 1 (1.6)
Total	9 (15)

Table 3: Groups comparison.

Complications	Group 1	Group 2	P value *
Injury of coronary vessels Injury short vessels	1	1	
Right lung injury Injury of azygos arch Injury of thoracic duct Pericardium injury Injury of the right recurrent laryngeal nerve Injury of the left main stem bronchus	1 1 1 1 1 1	1 1	0,4
Total	6	3	

*non-significant ($p = 0.4$).

Discussion

There is enough evidence supporting the use of MIE due to less pulmonary complications while maintaining equal oncological long-term outcomes of open surgery [12-15].

Prone position for the minimally invasive procedure has been proposed as an alternative to the lateral approach due to decreased pulmonary morbidity, better surgeon ergonomics and operative exposure, and higher lymph node yield due to better exposure of the sub-carinal space. The most important disadvantage is the difficulty generated by this position in case a rapid conversion is needed [16-18].

As already mentioned, the advantages of MIE in the PP are remarkable. However, the procedure related complications may be serious; therefore, all possible care must be taken to avoid or at least minimize them. These complications can occur at the beginning of the thoracic stage, and include injury of the lungs, pleura or diaphragm, mainly in patients with previous surgeries or infections with pleural effusion. Esophageal mobilization may cause vascular injury of esophageal vessels, azygos vein, aorta, pericardium and left pulmonary vein which is hidden behind the esophagus. Complete or partial section of the thoracic duct has also been described, which is not detected during surgery, resulting in chylothorax and even serious malnutrition and fluid and electrolyte disorders. Airway injury, mainly in the carina or main stem bronchus, and recurrent laryngeal nerve injury may occur during lymph node resection, particularly in patients with extended lymph node resection due to squamous cell carcinoma. During the thoracic stage, meticulous care must be taken during dissection and when using thermal devices to minimize the incidence of complications; if possible, devices with reduced thermal spread should be used. The abdominal stage is not exempt from the usual complications of laparoscopic surgery. The main complications of esophagectomy are associated with right gastroepiploic artery injury during gastric mobilization, a situation that could compromise gastroplasty vascularization, and injury of the celiac trunk and branches during lymph node resection [18-20].

The learning curve of MIE in PP shows differences in the different publications. In our series, the number of complications decreased after 30 procedures; however, this reduction was not statistically significant. This could be due to the small sample size. For some authors, the learning curve to reach a plateau ranges between 15 and 20 cases, while other authors who worked with systematized cumulative measurement systems reported more than 35 or 40 cases [8,20-23].

Conclusion

In conclusion, MIE in PP is a feasible and safe procedure, but it can cause serious intraoperative complications due to its complexity. Although with the results of our series they cannot be relevant conclusions, the number of complications during surgeries performed by the same team showed a reduction associated with better training.

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