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ORIGINAL ARTICLE

Impact of unplanned events on early postoperative results of minimally invasive esophagectomy

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Abstract

Background: Minimally invasive esophagectomy (MIE) is increasingly performed worldwide. Unplanned events during thoracoscopy or laparoscopy can jeopardize the procedure, sometimes necessitating conversion to open surgery. The aim of this study was to evaluate the impact of unplanned events on early postoperative outcomes after MIE.

Method: A consecutive group of 303 patients who underwent MIE between January 2011 and December 2015 were reviewed. The patients were allocated to two groups comprising those with (G-UPE, 85 patients) and without unplanned events (G-Regular, 218 patients). Unplanned events, defined as events that clearly changed or prolonged the procedure included intraoperative bleeding, chest and/or peritoneal adhesions, tumor invasion (sT4a + T4b), non-radical resection (R2 resection), and conversion for any reason. Differences in postoperative complications between the groups were analyzed.

Results: The most common unplanned events were pleural and/or peritoneal adhesions (28/89, 31.5%), followed by intraoperative discovery of tumor invasion (sT4a + T4b, 25/89, 28.1%). There were significant differences in the incidence of respiratory (57.6% vs. 8.3%) and nervous system complications (10.6% vs. 2.7%), postoperative infection (32.9% vs. 5.0%), and chylothorax (8.2% vs. 0.9%) between the G-UPE and G-Regular groups, respectively ($P < 0.05$). The most common reasons for conversion to open procedures were pleural and/or peritoneal adhesions (9/38, 23.8%) and intraoperative bleeding (7/38, 18.4%). The main reasons for R2 resection were tumor invasion of the trachea or bronchus (7/21, 33.2%) and of the aorta (5/21, 23.8%).

Conclusion: Unplanned events during MIE increase the incidence of postoperative complications. Improved clinical staging and more careful surgery minimize unplanned events.

Introduction

Esophageal cancer is biologically and clinically aggressive and prognosis is generally poor.[1] Surgery is the mainstay of treatment for resectable esophageal cancer.[2] Over the past decade, minimally invasive esophagectomy (MIE) has gradually become more widely performed.[3]

Minimally invasive esophagectomy, which involves the cervical, thoracic, and abdominal regions, requires considerable expertise.[4] Surgeons with relatively little experience of performing MIE will inevitably encounter unplanned events during the procedure, including intraoperative bleeding, chest and/or peritoneal adhesion, and tumor invasion (sT4a + T4b), which could not have been anticipated preoperatively.

Such unexpected events are defined as unplanned events and may affect patients' early postoperative recovery. No previous reports have addressed this issue; therefore, we decided to evaluate the impact of unplanned events on early postoperative outcomes after MIE by retrospectively analyzing relevant data on 303 consecutive patients.

Methods

Patients

This is a retrospective analysis of 303 consecutive patients who underwent MIE at the Department of Thoracic Surgery, Shanghai Chest Hospital from January 2011 to December 2015. The same group of doctors performed all operations. The patients provided written consent for the operative procedures, and the Ethics Committee of Shanghai Chest Hospital approved the study.

Preoperative workup

Preoperative workup items included esophagoscopy, esophageal ultrasonography, neck ultrasound, chest and abdominal enhanced computed tomography (CT), head CT, and bone scan. We do not include a positron emission tomography (PET)-CT scan in the preoperative workup because medical insurance does not cover the expense in China. We perform bronchoscopy when the tumor is located in the upper thoracic area.

Table 1 Relevant clinical and pathological data according to study group

Variable	G-UPE (n = 85) (%)	G-Regular (n = 218) (%)	P
Gender			0.236
Male	74 (87.1)	178 (81.7)	
Female	11 (12.9)	40 (18.3)	
Age at operation (years)	61.5 ± 10.2	62.0 ± 8.4	0.312
HBP/DM	8 (9.4)	28 (12.8)	0.431
Neoadjuvant therapy	9 (10.6)	24 (11.0)	0.916
Tumor location			0.609
Cervical	0 (0.0)	5 (2.3)	
Upper	10 (11.8)	21 (9.6)	
Mid	45 (52.9)	104 (47.7)	
Lower	30 (35.3)	88 (40.4)	
Differentiation			0.828
G1 + G2	37 (43.5)	104 (47.7)	
G3	48 (56.5)	114 (52.3)	
Pathological T stage			0.445
pTis	0 (0.0)	1 (0.5)	
pT1	18 (21.2)	55 (25.2)	
pT2	21 (24.7)	62 (28.5)	
pT3	21 (24.7)	57 (26.1)	
pT4	25 (29.4)	43 (19.7)	
Pathological N stage			0.622
pN0	41 (48.2)	107 (49.1)	
pN1	18 (21.2)	54 (24.8)	
pN2	14 (16.5)	37 (16.9)	
pN3	12 (14.1)	20 (9.2)	

HBP/DM, high blood pressure/diabetes mellitus.

Operative procedure

All patients underwent the following procedure: subtotal esophagectomy was performed via cervical, right thoracic, and abdominal approaches, followed by cervical anastomosis. Thoracic and abdominal two-field lymphadenectomy was then performed according to the lymph node stations advised by the Japan Esophageal Society.[5] Lymph node stations include the left and right recurrent laryngeal nerves, upper esophageal, mid esophageal, carina, left and right bronchus, lower esophageal, left and right cardiac, left gastric artery, and lesser curvature.

Definition of unplanned events

Unplanned events were defined as events that occurred intraoperatively, such as bleeding, chest and/or peritoneal adhesions, serious tumor invasion (sT4a + T4b), and R2 resection, that could not be anticipated preoperatively. The patients were allocated to the two groups: patients with (G-UPE, n = 85) and without unplanned events (G-Regular, n = 218).

Relevant clinical and pathological data according to study group are shown in Table 1 and the frequency of unplanned intraoperative events in Table 2.

Impact of unplanned events on postoperative complications in patients undergoing minimally invasive esophagectomy (MIE)

Differences in the incidence of postoperative complications between the groups were compared. The reasons for conversion to open surgery, intraoperative bleeding, and R2 resection were also analyzed according to the presence or absence of unplanned events.

Statistical analysis

Measurement data are expressed as mean ± standard deviation. Data on patient characteristics and outcomes were

Table 2 Frequency of unplanned events

Unplanned events	n	(%)
Chest and/or peritoneal adhesion	28	31.5
sT4a + T4b	20 + 5	28.2
R2 resection	18	20.2
Intraoperative bleeding	14	15.7
Thoracic puncture device into the abdominal cavity	1	1.1
Airway injury	1	1.1
Avulsion of gastric tube	1	1.1
Right gastroepiploic artery injury	1	1.1

Table 3 Comparison of postoperative complications according to study group

Variable	G-UPE (n = 85) (%)	G-Regular (n = 218) (%)	P
Respiratory system	49 (57.6)	18 (8.3)	<0.001
Respiratory failure	13 (15.3)	9 (4.1)	
Pulmonary infection	12 (14.1)	4 (1.6)	
Tracheal re-intubation	8 (9.4)	2 (0.9)	
Left pneumothorax	8 (9.4)	3 (1.4)	
Atelectasis	3 (3.5)	0 (0.0)	
Asthma	2 (2.4)	0 (0.0)	
Airway injury (fistula)	2 (2.4)	0 (0.0)	
Rupture of chest tube	1 (1.2)	0 (0.0)	
Digestive system	34 (40.0)	41 (18.8)	0.059
Leakage	23 (27.1)	37 (14.9)	
Diaphragmatic hernia	3 (3.5)	0 (0.0)	
Intestinal obstruction	2 (2.4)	1 (0.5)	
Esophagotracheal fistula	4 (4.7)	1 (0.5)	
Gastric necrosis	1 (1.2)	1 (0.5)	
Non healing of jejunostomy	1 (1.2)	1 (0.5)	
Nervous system	9 (10.6)	6 (2.7)	0.044
Delirium	7 (8.2)	5 (2.3)	
Cerebrovascular accident	2 (2.4)	1 (0.5)	
Infection	28 (32.9)	11 (5.0)	< 0.001
Neck incision	12 (14.1)	1 (0.5)	
Thoracic cavity	6 (7.1)	5 (2.3)	
Mediastinal infection	7 (8.2)	4 (1.6)	
Abdominal infection	0 (0.0)	1 (0.5)	
Septic shock	2 (2.4)	0 (0.0)	
Purulent pericarditis	1 (1.2)	0 (0.0)	
Re-operation	11 (12.9)	9 (3.6)	0.062
Re-entry ICU	5 (5.9)	9 (3.6)	0.991
Mortality	2 (2.4)	4 (1.6)	0.896
Recurrent laryngeal nerve paralysis	16 (18.8)	18 (8.3)	0.141
Arrhythmia	12 (14.1)	21 (9.6)	0.949
Chylothorax	7 (8.2)	2 (0.9)	0.008
Intra-abdominal hernia	0 (0.0)	1 (0.5)	0.454

ICU, intensive care unit.

analyzed using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). χ^2 or Fisher's exact tests were used to evaluate differences between the groups. Differences were considered statistically significant when $P < 0.05$.

Table 4 Reasons for conversion to open surgery

Causes	n (%)
Pleural or (and) peritoneal adhesion	9 (23.8)
Intraoperative bleeding	7 (18.4)
Invasion of bronchus	7 (18.4)
Invasion of left recurrent laryngeal nerve	5 (13.2)
Tumor invasion of aorta	5 (13.2)
Tumor diameter greater than 5 cm	2 (5.2)
Tumor invasion of left lung	2 (5.2)
Re-anastomosis of right gastroepiploic artery	1 (2.6)

Table 5 Sites of intraoperative bleeding

Sites	n (%)
Spleen	5 (35.7)
Azygos vein	3 (17.6)
Short gastric vessels	2 (14.3)
Left inferior phrenic arteries	1 (7.1)
Inferior vena cava	1 (7.1)
Right innominate vein	1 (7.1)
Internal mammary artery	1 (7.1)

Results

Comparison of postoperative complications between the study groups

The esophageal cancers were resected in combined thoracoscopic and laparoscopic procedures in 228 patients and in combined thoracoscopic and laparotomy procedures in 75 patients. The incidences of postoperative respiratory (57.6% vs. 8.3%) and nervous system complications (10.6% vs. 2.7%), postoperative infection (32.9% vs. 5.0%), and chylothorax (8.2% vs. 0.9%) were significantly higher in the G-UPE than in the G-Regular group ($P < 0.05$) (Table 3).

Analysis of reasons for conversion to open surgery

The most common reasons for conversion to open surgery were pleural and/or peritoneal adhesions (23.8%) and intraoperative bleeding (18.4%) that could not easily be controlled, followed by serious invasion of the bronchus (18.4%) and the left recurrent laryngeal nerve by lymph node metastases (13.2%) (Table 4).

Analysis of sites of intraoperative bleeding during MIE

The most common site of intraoperative bleeding during MIE was the spleen (35.7%) (Table 5).

Analysis of reasons for R2 resection

The most common reasons for R2 resection were tumor invasion of the bronchus (33.2%), followed by tumor invasion of the aorta (23.8%) and invasion of the left recurrent laryngeal nerve by metastatic lymph nodes (23.8%) (Table 6).

Frequency of intraoperative unplanned events during MIE according to number of MIEs performed by the surgical team

The learning curve shown in Figure 1 indicates that the initial high incidence of unplanned intraoperative events

Table 6 Reasons for R2 resection

R2 resection	*n* (%)
Tumor invasion of bronchus	7 (33.2)
Tumor invasion of aorta	5 (23.8)
Invasion of left recurrent laryngeal nerve by metastatic lymph nodes	5 (23.8)
Tumor invasion of the left atrium	1 (4.8)
Tumor invasion of right subclavian artery	1 (4.8)
Lymph node invasion of celiac trunk artery	1 (4.8)
Lymph node invasion of left gastric artery	1 (4.8)

decreased significantly with increasing experience with the procedure. In the initial 50 cases of MIE, unplanned events occurred in 54% of cases, but after 250 patients had undergone MIE, the unplanned events encountered decreased to 5.7%.

Discussion

Thoracoscopic esophagectomy was first performed in 1992 in the United Kingdom by Cuschieri *et al.*[6] Subsequently some studies have reported that MIE can result in serious postoperative complications requiring reoperation because of the longer operation duration required for MIE.[7,8] In recent years, MIE has gradually been more frequently performed in clinics. Several single-center studies have demonstrated perioperative benefits, including fewer postoperative complications, lower perioperative mortality, and shorter intensive care unit stay for minimally invasive approaches compared to open surgery.[9,10] In a phase III randomized controlled clinical trial in the Netherlands, the incidence of respiratory complications after MIE was significantly lower than in conventional open thoracotomy.[11] Other studies have shown that the oncologic efficacy of MIE is not inferior to open surgery and may actually be a better method because of the significantly greater number of lymph nodes resected.[12]

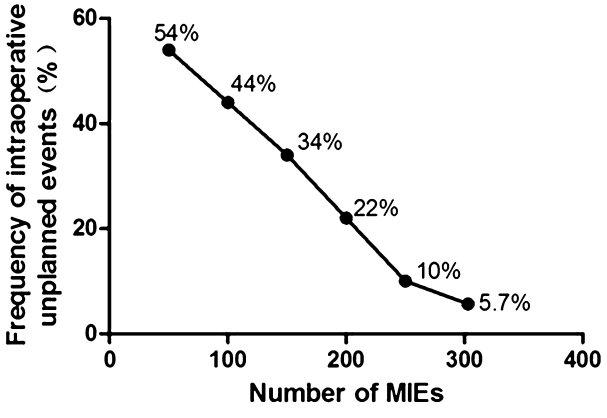

Figure 1 Incidence of unplanned events according to the experience of the surgical team. MIE, minimally invasive esophagectomy.

Moreover, overall and disease-free survival rates after MIE are at least equivalent or superior to open procedures.[13,14] However, few studies have investigated unplanned events during MIE, thus the impact of such events on early postoperative outcomes are unknown.

We allocated the 303 patients in this study to G-UPE and G-Regular groups according to the presence or absence of unplanned events during MIE and found an overall rate of unplanned events of 28.1% (85/303). The incidence of postoperative respiratory and nervous system complications was significantly higher in the G-UPE than the G-Regular group. The most common complication was respiratory failure, followed by pulmonary infection. Postoperative infection and chylothorax also occurred significantly more frequently in the G-UPE than in the G-Regular group. We concluded that unplanned events during MIE have an adverse impact on early postoperative recovery.

The most common unplanned event was chest and/or peritoneal adhesions, followed (in order) by serious tumor invasion (sT4a + T4b), R2 resection, intraoperative bleeding, puncture of the thoracic device into the abdominal cavity, airway injury, avulsion of the gastric tube, and right gastric artery injury. Of these, chest and/or peritoneal adhesions are factors beyond the surgeon's control, whereas the remaining unplanned events could and should be minimized by adequate experience and care on the part of the surgeon. Therefore, with ongoing accumulation of experience in performing MIE, the rate of unplanned events can be expected to decrease. Our data show that when the surgical team first began to perform MIE there was a high incidence of intraoperative unplanned events. The incidence of unplanned events subsequently decreased significantly in parallel with increasing experience in performing this procedure. The greater their experience of performing MIE, the greater the ability the surgeons acquired to prevent unplanned events, such as intraoperative bleeding and airway injury.

The data on conversion to open surgery clearly show that the main reason for conversion to thoracotomy or laparotomy is serious tumor invasion (sT4a + T4b) identified intraoperatively, such as serious tumor invasion of the trachea, bronchus, and aorta that could not be resected in a thoracoscopic procedure. Unsurprisingly, this is also the major reason for R2 resection. In addition, in some patients, R2 resection was attributable to invasion by lymph node metastases of the left recurrent laryngeal nerve or celiac trunk artery that could not be completely resected. Therefore, accurate preoperative clinical staging is essential to ensure successful MIE, especially when aiming for radical resection of the tumor.

Preoperative staging of esophageal carcinoma is performed to evaluate the location and extent of tumors, the

degree of tumor invasion of adjacent tissues and organs, whether lymph nodes are involved, and whether there are distant metastases. According to our data, the incidence of unplanned events and R2 resection is higher in patients with upper thoracic esophageal cancer and/or in whom the left and/or right recurrent laryngeal nerve are seriously invaded. Therefore, in patients with upper thoracic esophageal carcinoma, especially when the tumor is located at the cervical and thoracic junction, we recommend precise evaluation of tumor invasion and lymph node metastasis by selective bronchoscopy, esophageal ultrasonography, endobronchial ultrasonography, and PET in addition to routine esophagoscopy and an esophagogram. Patients with abnormally large lymph nodes adjacent to the recurrent laryngeal nerve, left gastric artery, or celiac trunk artery should undergo comprehensive assessment by enhanced CT, magnetic resonance imaging, and PET. Such thorough evaluation of the possibility of completely resecting metastatic lymph nodes would decrease the rate of R2 resection. Patients with locally advanced esophageal cancer reportedly should receive preoperative induction therapy. MIE could be considered for such patients with tumor remission after neoadjuvant chemotherapy or neoadjuvant chemoradiotherapy.[15,16]

In conclusion, unplanned events increase the incidence of postoperative complications after MIE. With increasing experience in performing MIE, the incidence of unplanned events decreases and, consequently, the incidence of complications also decreases. Accurate clinical tumor node metastasis staging before surgery can reduce the incidence of postoperative complications after MIE.

Disclosure

No authors report any conflict of interest.

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