Original Article

Modified McKeown *vs.* traditional McKeown minimally invasive esophagectomy in improving short-term efficacy and the quality of life of esophageal cancers: a retrospective comparative cohort study

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Background: Traditional McKeown minimally invasive esophagectomy (MIE-McKeown) with resection of the thoracic and abdominal branches of vagus nerve, the azygos vein and the bronchial artery, is notorious for high complications incidence and sharply decreased quality of life (QoL) postoperatively in esophageal cancer (EC). Recently, reports of preservation of azygos vein arch or the vagus nerve have shown the advantages of decreasing postoperative complication incidence. However, the modified MIE-McKeown with preservation of azygos vein arch, vagus nerve and the bronchial artery has never been investigated in EC. In the present study, we aimed to compare the short-term efficacy and postoperative QoL between modified MIE-McKeown and traditional MIE-McKeown.

Methods: A total of 218 eligible patients with esophageal squamous cell carcinoma (ESCC) who met our inclusion criteria between October 2018 and January 2022 in our center were retrospectively enrolled and divided into modified MIE-McKeown group (N=48) and the control group with traditional MIE-McKeown (N=170) according to their surgical procedure. We compared the perioperative parameters (e.g., operation time and postoperative complications) between the two groups. The core quality of life questionnaire (QLQ-C30) (version 3.0) and the EC-specific QoL assessment form (QLQ-OES18) were used to evaluate the QoL in the 2 groups at 1 and 3 months after operation.

Results: There were no significant differences in baseline characteristics between modified MIE-McKeown group and the control group. Compared with the control group, the modified MIE-McKeown group had significantly lower postoperative drainage volume (551.46±249.45 *vs.* 812.96±405.82; P<0.001) and a lower incidence of thoracic stomach syndrome (TSS; P=0.001). The bleeding loss in the modified MIE-McKeown group was lower than that in the control group (56.88±20.44 *vs.* 83.18±97.93; P=0.066), but not significantly. There were no significant differences observed in postoperative complications and other perioperative parameters between the two groups. The results of QLQ-C30 and QLQ-OES18 questionnaire revealed that the modified MIE-McKeown group was associated with better physical function, better global health status and milder symptoms of gastroesophageal reflux and cough.

Conclusions: The modified MIE-McKeown is a safe and efficient procedure and has the potential to improve postoperative health status of patients with EC.

Keywords: McKeown minimally invasive esophagectomy (MIE-McKeown); esophageal cancer (EC); QLQ-C30; QLQ-OES18; quality of life (QoL)

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Introduction

Esophageal cancer (EC) has a poor prognosis and is the seventh most common cancer and sixth most common cause of death worldwide. Its prevalence and mortality are particularly high in East Asia, especially in China (1), with nearly half of the world's EC cases occurring in China. More than 90% of the EC cases in China are esophageal squamous cell carcinoma (ESCC), which has a 5-year survival rate of lower than 20% (2). In addition to its poor prognosis, ESCC also dramatically reduces the quality of life (QoL) and imposes a severe socioeconomic burden. At present, the mainstay of treatment for EC includes resection of the tumor and complete regional lymph node dissection. McKeown minimally invasive esophagectomy (MIE-McKeown) is an important surgical procedure in EC treatment. As a safe and feasible surgical technique, it enables the complete removal of the EC and thorough lymph node dissection (3,4). Since lymph node metastasis of EC can occur in the early stage, conventional radical surgery for EC requires the transection of the thoracic and abdominal branches of the vagus nerve, and in some cases, the azygos vein and the bronchial artery will also be transected. However, evidence has shown that transection of the vagus nerve may lead to postoperative chronic diarrhea, dumping syndrome, and gastroparesis, which in turn can negatively affect the prognosis and sharply reduce QoL (5). Even although preoperative chemoradiotherapy has been reported to prolong survival of patients with EC (6), there is an urge need to adjust the surgical procedure in order to improve postoperative QoL. Another study has revealed that transecting the azygos arch during surgery for locally advanced EC can further increase the complete resection rate (7). Nevertheless, a previously published report has shown that intraoperative preservation of the vagus nerve, preservation of the azygos vein arch, and thoracoscopic and laparoscopic resection of EC can improve the postoperative QoL (8). However, studies have also shown that preserving the azygos arch and its surrounding tissues can reduce both the surgical extent and trauma without a corresponding increase of the local recurrence, thus providing the same long-term clinical effectiveness (8,9). In addition, preserving the azygos arch is an effective and minimally-invasive way to reduce thoracic stomach syndrome (TSS) and improve postoperative QoL (10). The bronchial arteries supply the bronchi and the tissue of the lungs. They can effectively improve the recovery of bronchial blood supply after thoracic surgery and contribute to promoting expectoration and alleviating lung infection (11,12). It has also been proposed that preservation of the vagus nerve is an ideal procedure for some patients with early-stage EC (13), and vagal-sparing esophagectomy preserves the gastric functions including storage, secretion, and motility. Preservation of any functional tissue during esophagectomy is a challenge technique, but there is no study that evaluate the safety and efficacy of modified MIE-McKeown with preservation of the azygos arch, bronchial artery, and vagus nerve trunk at the same time during the operation. Therefore, in this present study, we aimed to evaluate the safety and efficacy of modified MIE-McKeown and to compare the modified and the traditional MIE-McKeown in terms of improving postoperative QoL in our single center. We present the following article in accordance with the STROBE reporting checklist (available at https://jgo.amegroups.com/article/view/10.21037/jgo-22-712/rc).

Methods

Patients

Between October 2018 and January 2022, all the ESCC patients treated with MIE-McKeown who had not receive any preoperative treatment were retrospectively reviewed in our center. The inclusion criteria were as the following: (I) males or females aged 18–80 years; (II) treatment-naive patients with squamous cell carcinoma of the thoracic esophagus confirmed by gastroscopy and gastric biopsy; (III) patients with cT1-3N0M0 thoracic esophageal malignancy not at the level of the azygos arch, as confirmed by ultrasound gastroscope, contrast-enhanced computed tomography (CT) of the chest and upper abdomen, and a multidisciplinary team approach; (IV) those with uncontrolled chronic disease and/or serious comorbidities; (V) those with good cardiopulmonary function and able to tolerate general anesthesia; and (VI) those able to be followed up on time according to the treatment protocol

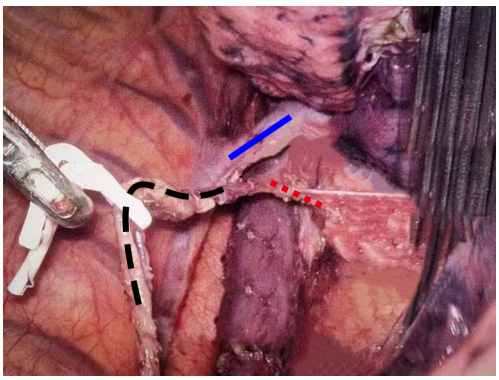

Figure 1 Thoracic operation with preservation of the azygos arch (blue solid line), vagus nerve trunk (black dotted line), and bronchial arteries (red dotted line).

and complete telephone surveys. All patients were followed up in the outpatient clinic every 3 months for the first 2 years after the surgery, every 6 months for the next 3 years, and annually thereafter. All enrolled patients were divided into two groups: the modified MIE-McKeown group with preservation of the vagus nerve trunk, azygos vein arch, and bronchial artery at the same time during esophagectomy and the control group with resection of the above tissues. All the MIE-McKeown were performed by the same surgeon (Prof. Wanli Lin). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the medical ethics committee of Gaozhou People's Hospital (No. GYLLPJ-2022015). Informed consent was taken from all the patients.

Main steps of the modified MIE-McKeown

Thoracic operation

General anesthesia was performed by single-lumen endotracheal intubation. The patient lay in the left lateral position. After the establishment of artificial pneumothorax, 4-port video-assisted thoracoscopic surgery (VATS) was performed. First, the possible invasion of EC, regional lymph node involvement, and surrounding tissues were explored. If the thoracic vagus nerve trunk and azygos vein had not been invaded by the tumor, the azygos arch, bronchial arteries, and vagus nerve trunk were preserved. The tubular stomach was embedded under the esophageal bed and azygos arch to complete the modified McKeown-MIE. After the right vagus nerve trunk and right recurrent laryngeal nerve (RLN) in the superior mediastinum were thoroughly exposed, lymph node station 4R and adjacent adipose tissue were dissected, and the upper thoracic esophagus and station 8 lymph nodes were mobilized. The mediastinal pleura in the middle and lower thoracic esophagus was divided longitudinally under the azygos arch. The venous arch and the right bronchial artery below the arch were carefully protected. The right lung tissue was pushed aside, and the esophageal bed was fully preserved. After the esophagus was mobilized alongside the hilum, the right vagus nerve trunk was fully exposed and then suspended with a rubber strap (*Figure 1*) for anatomical marking and separation. Meanwhile, the pulmonary branch of the vagus nerve from the level of the carina to the level of the inferior pulmonary vein toward the hilum was preserved. In the region between the esophagus and the aorta and under the azygos arch, the left vagus nerve trunk was exposed along the top of the left main bronchus and then also suspended with a rubber strap. The bilateral vagus nerve trunks were mobilized to the esophageal hiatus, the vagus nerve trunk was preserved, and the small branches were transected. With the left RLN carefully protected, the lymph node tissues near the RLN were dissected. After thoracic hemostasis was completely stopped, the bilateral rubber straps were suspended on the diaphragm. Meanwhile, stations 2L, 4L, 7, 8M, 8Lo, 9R, and 15 were dissected.

Abdominal operation

The patient was turned into a supine position. After the establishment of artificial pneumoperitoneum, a 5-port laparoscopic operation was performed. The stomach body was lifted, and the ligaments around the stomach (e.g., gastrosplenic ligament, gastrocolonal ligament, and gastropancreatic ligament) were divided bluntly or sharply. The right gastric artery was severed by high-intensity focused ultrasound (HIFU), and the left gastric artery was double-clamped with vascular clips after the amputation. The greater curvature of the stomach was thoroughly mobilized until the pyloric tissue, with the right gastroepiploic artery being carefully protected. Following this, 2 marked rubber straps on the chest were pulled down to lift the anterior trunk of the vagus nerve, which was gradually separated downward to reveal the hepatic branch of the vagus nerve, which was then thoroughly separated and protected (*Figure 2*). The stomach was lifted upward to reveal the celiac branch of the vagus nerve (*Figure 2*), which was carefully protected. Lymph node stations 16, 17, 18, 19, and 20 in the upper abdomen were removed. A 5-cm incision was made in the left neck, through which the esophagus was pulled out and severed at a distance of more

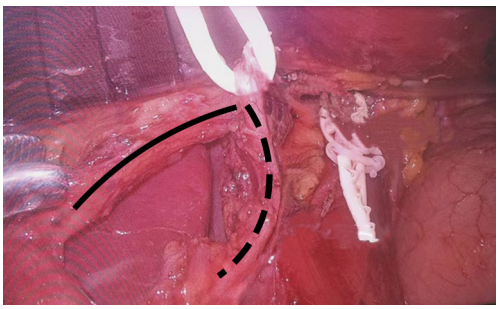

Figure 2 Abdominal operation with preservation of the hepatic branch (solid line) and celiac branche (dotted line) of the vagus nerve.

than 5 cm from the tumor. The two stumps were sutured and connected to the gastric tube. Another 5-cm incision was made in the upper abdomen to extract gastric tissue and EC. The gastric tissue was closed with a cutter/stapler to create a tubular stomach, and the gastric stump was sutured with continuous sutures. The fundus and the lower gastric tube were sutured and connected, and the tubular stomach was pulled to the neck with the help of the gastric tube through the esophageal bed and under the azygos arch.

Neck operation

After adequate lubrication was applied, the tubular stomach was pulled upward to the left neck through use of the gastric tube. A suitable circular cutter/stapler was used for anastomosis according to the size of the esophageal stump.

Main measurements

Data including age, gender, preoperative albumin level, tumor differentiation, tumor location, and postoperative pathological data were collected. Perioperative indicators included surgical bleeding, operation time, lymph node dissection, postoperative intensive care unit (ICU) stay (hours), postoperative drainage, postoperative hospital stay, postoperative anastomotic leak, RLN injury, postoperative lung infection, postoperative swallowing dysfunction, postoperative anastomotic stenosis, and postoperative TSS.

The core quality of life questionnaire (QLQ-C30) (version 3.0) (14) and the EC-specific QoL assessment form (QLQ-OES18) questionnaires (Chinese edition) (15) were used to evaluate the QoL of patients in the modified MIE-McKeown group and the control group at 1 and 3 months after surgery. The surveys were performed mainly by telephone interviews and by questionnaire-based surveys in outpatient and inpatient departments. The QLQ-C30 (version 3.0) is composed of 30 questions (14) in 5 functional scales (physical, role, cognitive, emotional, and social), 9 symptom scales (e.g., fatigue, pain, and nausea/vomiting), and a global health status/QoL scale. The scores are converted into a 100-point scoring system (0–100), in which a higher score in the functional scales and global health status scale indicated a better QoL and a higher score in the symptom scale indicated a lower QoL. QLQ-OES18 is an EC-specific QoL assessment tool composed of 18 questions (15). It incorporates 10 items, including dysphagia, eating, reflux, EC-related pain, trouble swallowing saliva, choking when swallowing, dry mouth, trouble with tasting, trouble with coughing, and trouble with talking. A higher swallowing function score indicated a higher QoL, while a higher score in any other symptom indicated a lower QoL.

Statistical analysis

Continuous variables, described as mean and standard deviation (SD), were compared using *t*-test. Categorical variables, described as frequencies and percentages, were compared with chi-square test. All P values were reported as two-sided, and $P<0.05$ were considered statistically significant. All statistical analyses were performed by IBM SPSS version 22.0 (SPSS Inc., Chicago, IL, USA).

Results

General clinical data of the 2 groups

Totally, 48 patients received modified MIE-McKeown and 170 patients received traditional MIE-McKeown (the control group) were enrolled in the present study. As shown in *Table 1*, the average age of the modified group and the control group was 65.35 and 65.64, most of the patients were pathologically staged as T3 [modified group: 24 (50%); control group: 107 (62.9%)] and as N0 [modified group: 40 (83.3%); control group: 135 (79.4%)]. The modified MIE-McKeown group (n=48) and the control group (n=170) showed no significant difference in terms of age, gender, preoperative serum albumin level, tumor differentiation, T stage, lymph node metastasis, tumor location, or tumor length (all P values >0.05; *Table 1*).

Perioperative indicators

The operation time (308.67±57.77 *vs.* 305.46±61.43 min; P=0.747) and the number of lymph nodes dissected

Table 1 General clinical data of the modified MIE-McKeown group and control group

General clinicopathologic features	Modified MIE-McKeown group	Control group	P value
n	48	170	
Gender (n)			
Male	28	88	0.421
Female	20	82	
Age (years) (mean ± SD)	65.35±5.52	65.64±8.42	0.827
Serum albumin (g/L) (mean ± SD)	39.7±3.90	39.4±4.00	0.73
Tumor differentiation (n)			
G_1	5	18	0.625
G_2	30	117	
G_3	13	35	
T stage (n)			
T_1	10	22	0.222
T_2	14	41	
T_3	24	107	
Lymph node metastasis (n)			
No	40	135	0.547
Yes	8	35	
Tumor location (n)			
Upper thoracic esophagus	5	24	0.801
Middle thoracic esophagus	38	129	
Lower thoracic esophagus	5	17	
Tumor length (cm) (mean ± SD)	3.23±1.73	3.14±1.27	0.679

MIE-McKeown, McKeown minimally invasive esophagectomy; SD, standard deviation.

(31.29±12.03 *vs.* 28.65±9.26; P=0.105) were not significantly different (*Table 2*). There was less intraoperative blood loss less in the modified MIE-McKeown group (56.88±20.44 *vs.* 83.18±97.93 mL; P=0.066), but this difference was not statistically significant (*Table 2*).

Postoperative indicators

The postoperative ICU stay (19.6±6.52 *vs.* 23.37±22.72 hours; P=0.257) was not significantly different. The postoperative hospital stay (12.67±2.86 *vs.* 14.47±9.27 days; P=0.186) was shorter in the modified MIE-McKeown group, but the difference was not statistically significant. Postoperative anastomotic leak occurred in 2 cases (4.2%) in the modified MIE-McKeown group and 8 cases (4.7%) in the control group. RLN injury occurred in 5 cases (10.4%) in the modified MIE-McKeown group and 8 cases (4.7%) in the control group. Differences in pulmonary infection, dysphagia, postoperative anastomotic stenosis, and other postoperative complications were not statistically significant. Compared with the control group, the modified MIE-McKeown group had a significantly lower postoperative drainage volume (551.4±249.45 *vs.* 812.96±405.82 mL; P<0.001). One month after the surgery, chest CT showed that the dilatation of the chest and stomach was more obvious in the control group than in the modified MIE-McKeown group (*Figure 3*). The incidence of TSS was significantly lower in the modified MIE-McKeown group (n=4, 8.3%) than in the control group (n=57, 33.5%; P=0.001; *Table 2*).

Table 2 Comparisons of perioperative indicators between the modified MIE-McKeown group and the control group

Perioperative indicators	Modified MIE-McKeown group (n=48)	Control group (n=170)	P value
Intraoperative blood loss (mL) (mean ± SD)	56.88±20.44	83.18±97.93	0.066
Operative time (min) (mean ± SD)	308.67±57.77	305.46±61.43	0.747
Number of lymph nodes dissected (mean ± SD)	31.29±12.03	28.65±9.26	0.105
Postoperative ICU stay (hours) (mean ± SD)	19.6±6.52	23.37±22.72	0.257
Volume of postoperative pleural drainage (mL) (mean ± SD)	551.4±249.45	812.96±405.82	<0.001
Postoperative hospital stay (days) (mean ± SD)	12.67±2.86	14.47±9.27	0.186
Postoperative anastomotic leak, n (%)	2 (4.2)	8 (4.7)	1
Recurrent laryngeal nerve injury, n (%)	5 (10.4)	8 (4.7)	0.14
Pulmonary infection, n (%)	5 (10.4)	15 (8.8)	0.736
Dysphagia, n (%)	5 (10.4)	14 (8.2)	0.636
Postoperative anastomotic stricture, n (%)	3 (6.3)	19 (11.2)	0.466
Postoperative thoracic stomach syndrome, n (%)	4 (8.3)	57 (33.5)	0.001

ICU, intensive care unit; MIE, minimally invasive esophagectomy.

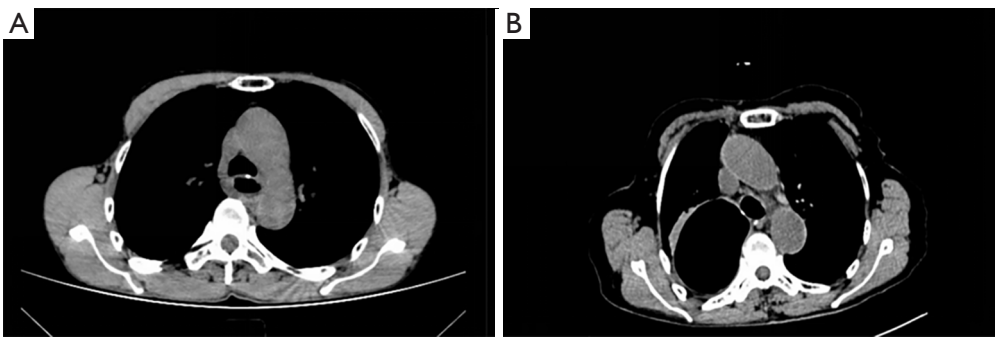

Figure 3 CT findings in the 2 groups (A: the modified MIE-McKeown group; B: the control group). Thoracic stomach syndrome was present in the control group. CT, computed tomography; MIE, minimally invasive esophagectomy.

QoL 1 and 3 months after operation

We used the tumor QoL assessment form, QLQ-C30, and the EC-specific QoL assessment form, QLQ-OES18, to compare the scores of each dimension in the first month and the third month after the operation. All 48 patients in the modified MIE-McKeown group received the postoperative QoL questionnaire-based surveys, and 165 patients in the control group (170 cases in total) received the surveys. The scores of all scales in the third postoperative month were superior to those in the first postoperative month in both groups.

As shown by the QLQ-C30 results, the scores of the physical functioning in the first and third postoperative months were significantly higher in the modified MIE-McKeown group than in the control group (first postoperative month: 71.39±11.17 *vs.* 64.73±16.41, P=0.009; third postoperative month: 78.33±12.72 *vs.* 73.29±15.99, P=0.046; *Table 3*). The scores of the global health status in the first and third postoperative months also showed significant differences between these 2 groups (first postoperative month: 70.83±7.88 *vs.* 64.14±12.93; P<0.001; third postoperative month: 80.21±9.04 *vs.* 70.71±12.33, P<0.001; *Table 3*). In the symptom scales, the scores of diarrhea were lower in the modified MIE-McKeown group than in the control group (first postoperative month: 25.69±19.74 *vs.* 36.97±22.4, P=0.002; third postoperative month: 15.97±16.83

Table 3 QLQ-C30 scores at the first and third postoperative months in the modified MIE-McKeown group and the control group

Dimension	1st postoperative month			3rd postoperative month		
	Modified MIE-McKeown group	Control group	P value	Modified MIE-McKeown group	Control group	P value
Physical functioning	71.39±11.17	64.73±16.41	0.009	78.33±12.72	73.29±15.99	0.046
Role functioning	69.44±22.10	66.16±21.65	0.375	74.31±14.16	73.43±21.06	0.788
Emotional functioning	79.86±10.71	76.97±11.92	0.132	85.07±7.28	82.58±10.96	0.140
Cognitive functioning	80.90±12.86	82.63±14.3	0.453	84.03±11.38	84.85±13.63	0.704
Social functioning	85.70±15.8	81.11±15.35	0.116	87.85±12.74	83.94±12.33	0.056
Global health status	70.83±7.88	64.14±12.93	0.001	80.21±9.04	70.71±12.33	0.001
Fatigue	22.45±15.12	25.12±13.88	0.253	17.13±12.75	19.46±14.59	0.318
Nausea and vomiting	27.43±11.14	23.3±15.45	0.068	18.75±14.84	18.28±13.43	0.836
Pain	33.68±18.35	34.55±15.79	0.748	15.63±12.59	17.07±12.88	0.492
Dyspnea	17.36±16.83	21.21±23.6	0.293	11.81±16.11	15.35±18.22	0.225
Sleeping disturbances	33.33±25.73	35.96±24.96	0.525	20.83±21.33	22.83±19.41	0.541
Appetite loss	25±18.83	27.7±23.16	0.571	13.89±17.97	17.58±17.09	0.195
Constipation	14.58±19.33	12.32±20.57	0.498	11.81±17.52	10.91±16.53	0.745
Diarrhea	25.69±19.74	36.97±22.4	0.002	15.97±16.83	24.65±23.54	0.018
Economic difficulty	36.11±21.56	38.59±22.38	0.497	32.64±22.27	37.17±24.53	0.252

Numbers are in mean ± SD. MIE, minimally invasive esophagectomy; QLQ-C30, Core Quality of Life questionnaire.

vs. 24.65±23.54, P=0.018; *Table 3*). No other function and symptom scores showed significant difference.

For the QLQ-OES18, the scores of reflux were significantly lower in the modified MIE-McKeown group than in the control group (first postoperative month: 34.03±20.03 *vs.* 51.82±17.85, P=0.001; third postoperative month: 21.53±12.38 *vs.* 31.01±16.55, P=0.001; *Table 4*). In addition, the modified MIE-McKeown group had significantly lower cough scores (first postoperative month: 20.83±26.3 *vs.* 37.98±19.44, P=0.001; third postoperative month: 14.58±19.33 *vs.* 25.45±22.36, P=0.003; *Table 4*).

Discussion

Need for protection of esophageal function during minimally invasive surgery for EC

The incidence of EC has dramatically increased in China. As a common malignant tumor with poor prognosis, EC has a high mortality rate and can lead to a serious decline in QoL. Surgery remains the treatment of choice for most early and mid-stage EC. Conventional open surgery is associated with high rates of postoperative complications and mortality, but endoscopic minimally invasive surgery avoids thoracotomy and laparotomy and thus reduces perioperative complications while maintaining the therapeutic effectiveness and quality of traditional surgeries (13). Among the minimally invasive methods, McKeown-MIE is currently the most widely used procedure for EC in China. It enables the resection of the thoracic esophagus, application of the tubular stomach, and anastomosis between the tubular stomach and the esophagus in the neck. Additionally, 2 or more–field lymph node dissection facilitates the tumor resection and may improve long-term survival (16). Despite the continuous advances in surgical techniques, perioperative complications and postoperative QoL decline are still unavoidable (17). For example, patients may experience RLN and thoracic duct injuries during the operation, anastomotic leak and pulmonary infection after the operation, and symptoms such as TSS, acid reflux, belching, and diarrhea that occur after discharge from hospital. Our increased understanding of minimally invasive surgery for EC has called for better protection of organs and tissues during surgery and

Table 4 QLQ-OES18 scores at the first and third postoperative months in the modified MIE-McKeown group and the control group

Symptom	1st postoperative month			3rd postoperative month		
	Modified MIE-McKeown group	Control group	P value	Modified MIE-McKeown group	Control group	P value
Dysphagia	73.38±11.17	76.16±7.88	0.053	86.34±16.25	82.63±15.29	0.145
Eating	18.92±10.70	22.07±16.71	0.219	15.97±9.39	19.24±11.44	0.072
Reflux	34.03±20.03	51.82±17.85	0.001	21.53±12.38	31.01±16.55	0.001
Esophageal cancer–related pain	24.31±12.05	24.71±16.66	0.875	19.21±12.71	21.68±16.68	0.344
Trouble swallowing saliva	9.72±15.31	12.73±16.24	0.255	6.25±13.15	10.30±15.88	0.108
Choking when swallowing	18.75±16.71	23.43±20.24	0.145	13.19±19.13	15.56±18.23	0.436
Dry mouth	26.39±20.58	27.27±22.47	0.807	16.67±18.19	21.41±22.38	0.180
Trouble with tasting	12.50±18.99	14.75±17.01	0.434	11.81±17.52	12.32±16.14	0.848
Cough	20.83±26.30	37.98±19.44	0.001	14.58±19.33	25.45±22.36	0.003
Trouble with talking	14.58±21.64	17.78±18.23	0.308	12.5±17.70	16.36±17.89	0.188

Numbers are in mean ± SD. MIE, minimally invasive esophagectomy; QLQ-OES18, esophageal cancer–specific quality of life questionnaire.

improvement of postoperative QoL (18).

Considerations of the vagus nerve, azygos arch, and bronchial artery in minimally invasive surgery for EC

Traditional radical surgery for EC typically involves amputation of the vagus nerve and transection of the azygos arch and the bronchial artery. A previous study has shown that this may lead to postoperative chronic diarrhea, dumping syndrome (19), chronic cough, and TSS, which can have deleterious effects on the QoL of patients. Vagus nerve–sparing esophagectomy may preserve the secretion, motility, and storage functions of the stomach. For patients with Barrett esophagus with high-grade dysplasia or those with EC confined to the lamina propria, the nutrition status and bowel regulation function may be kept normal after vagus–sparing esophagectomy, with no subsequent weight loss. Jiang *et al.* (20) found that pericardial azygos portal disconnection could reduce postoperative abdominal distension, diarrhea, and malabsorption. In addition, Zhang *et al.* (21) reported that the disconnection of the pulmonary branch of the vagus nerve had little effect on the postoperative lung function of patients with EC and could improve the lung function those patients with airway hyperresponsiveness. Wang *et al.* (22) demonstrated that preservation of the vagus nerve during EC surgery could potentially improve the postoperative QoL. Similarly, we found that preservation of the vagus nerve improved the global health of patients after operation, especially in the areas of postoperative chronic diarrhea and chronic cough.

The bronchial artery can provide more oxygen to the ischemic pulmonary tissues (23), thus improving lung function and alleviating pulmonary infection. However, in our study, the postoperative pulmonary infection markers were not significantly different between the 2 groups, which warrants further investigation in studies with larger samples. However, a significant difference was found in the postoperative chronic cough symptom scores between the 2 groups. Whether this was caused by the sparing of the bronchial artery or vagus nerve needs to be further explored.

The question as to whether or not the azygos arch should be severed during EC surgery remains controversial. Some authors believe that lymph nodes around the azygos arch can be easily involved, and therefore the azygos arch and its surrounding tissues should be routinely resected (24). Others have demonstrated that preserving the azygos arch has advantages in reducing intraoperative bleeding and shortening ICU stay (25). Our present study also showed that azygos vein preservation has the potential to reduce intraoperative bleeding. Notably, if the tumor is preoperatively judged to be located at the level of the azygos arch or if there are metastatic lymph nodes, the azygos arch should be divided. Some authors also suggest that the preservation of azygos arch is conducive to the formation of bundle-like structures and thus helps to reduce postoperative dilatation of the tubular stomach (8). Our

findings also indicate that preservation of the azygos arch can be advantageous in reducing TSS.

Advantages of the modified McKeown-MIE

Our study retrospectively compared the clinical data of patients who had undergone McKeown-MIE with preservation of the vagus nerve, azygos arch, and bronchial arteries (the modified McKeown-MIE group) to those patients who underwent McKeown-MIE with these same tissues being transected (the control group). It was found that the modified procedure reduced postoperative pleural drainage volume, lowered the incidence of TSS, and improved postoperative QoL. Although both vagus nerve–sparing minimally invasive surgery for EC and tazygos arch–sparing surgery for EC have previously been investigated, our study is the first to report the preservation of multiple tissues during McKeown-MIE with reference to short-term QoL data. Based on our findings, we support a new procedure that can reduce postoperative complications and improve postoperative QoL in patients with EC.

Despite these promising findings, some limitations to our study should be mentioned. First, the retrospective design we employed might have introduced selection bias, with there being fewer patients in the modified McKeown-MIE group than in the control group. Second, we lacked the lack of long-term survival data for patients with EC in whom the vagus nerve, azygos arch, and the bronchial artery were preserved. Thus, determining whether a difference in long-term survival between these 2 groups can be expected requires long-term follow-up and tracking. Ultimately, randomized controlled prospective clinical studies should be conducted to confirm any advantages this modified procedure may confer.

Conclusions

The modified MIE-McKeown procedure that preserves the vagus nerve trunk, azygos arch, and bronchial artery is safe and effective and probably does not increase the difficulty of esophagectomy or the incidence of postoperative complications. In addition to lessening postoperative pleural drainage and preventing postoperative TSS, it has the potential to improve postoperative physical function, reduce postoperative symptoms and improve the short-term quality of life of patients with EC. However, due to certain limitations of our study, further randomized designed studies with large scale are needed to confirm these results.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was approved by the medical ethics committee of Gaozhou People's Hospital (No. GYLLPJ-2022015) and was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Informed consent was taken from all the patients.

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