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Short-term Outcomes of Minimally Invasive McKeown Procedure Versus Open Ivor-Lewis Procedure for Lower and Middle Esophageal Cancer

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Abstract: ***Objective:*** ***To compare the short-term efficacy of treating lower and middle esophageal cancer by thoracolaparoscopic minimally invasive McKeown radical esophagectomy with open Ivor-Lewis esophagectomy.*** ***Methods:*** ***Fifty-four patients with middle and lower esophageal cancer admitted to the Department of Thoracic Surgery and Department of Surgical Oncology of our hospital from January 2013 to December 2017 were reviewed, and were divided into 16 cases in the observation group, which underwent thoracolaparoscopic minimally invasive McKeown esophageal cancer radical operation, and 38 cases in the control group, which underwent open thoracic Ivor-Lewis esophageal cancer radical operation, according to different surgical methods. The perioperative indicators, postoperative complications, and quality of life scores of the two groups were compared.*** ***Results:*** ***Intraoperative bleeding, postoperative chest drainage, extubation time, venting time, and hospitalization time of the observation group were lower than those of the control group (P<0.05); and the number of cleared lymph nodes of the observation group was more than that of the control group (P<0.05). Comparing the VAS pain scores of the two groups on the 1st, 2nd and 3rd days of postoperative activity, the VAS score of the observation group was lower than that of the control group (P<0.05). Comparison of leukocyte count and C-reactive protein on the 1st and 7th postoperative days between the two groups, the observation group was lower than the control group (P<0.05). There were differences in the observation group in the occurrence of reflux gastritis, lung infection, anastomotic fistula, abnormal skin sensation and hoarseness compared with the control group (P<0.05). Comparing the quality of life scores of the two groups at 1 month after surgery, there was a difference between the observation group in somatic, role, emotional, and general function scores were better than the control group (P<0.05), while there was no statistical significance in cognitive and social function scores (P>0.05).*** ***Conclusion:*** ***Minimally invasive McKeown's procedure and open Ivor-Lewis's procedure can both be used as surgical procedures for the treatment of lower and middle esophageal cancer, Ivor-Lewis's procedure has a lower incidence of anastomotic fistula and laryngeal recurrent nerve paralysis, and is highly traumatizing; minimally invasive McKeown's procedure clears a larger number of lymph nodes, has a positive efficacy, is less traumatizing, has a quicker recovery, and has better short-term results.***

Keywords: Minimally invasive McKeown procedure, Open Ivor-Lewis procedure, Esophageal cancer, Short-term outcome.

1. Introduction

Esophageal cancer is one of the most common gastrointestinal tumors, and China, as the world's first country with the highest incidence of esophageal cancer, has more than 50% of the world's total number of new cases and deaths of esophageal cancer every year, which is a serious threat to the lives and health of the residents [1]. Surgery is the most important treatment for esophageal cancer. Surgery is the first choice of treatment for esophageal cancer, including traditional open-heart surgery (left open-heart surgery - Sweet surgery, right open-heart surgery - Lewis surgery), minimally invasive surgery including trans-esophageal surgery, and minimally invasive surgery including trans-esophageal surgery - Sweet surgery [2]. Minimally invasive procedures include transesophageal resection through the esophageal hiatus, minimally invasive Ivor-Lewis procedure, and minimally invasive McKeown procedure. Due to the complexity of radical esophageal cancer surgery, there has been a great deal of controversy over the choice of the optimal surgical procedure [3]. The choice of the best operation has been controversial because of the complexity of radical esophageal cancer. The open Ivor-Lewis procedure is characterized by large incision, high trauma, high bleeding, good removal of enlarged lymph nodes visible to the naked eye in the operative field, and incomplete removal of lymph nodes adjacent to the recurrent laryngeal nerve; however, the incidence of anastomotic fistula and recurrent laryngeal nerve paralysis after surgery is low. Minimally invasive McKeown's procedure is able to enlarge the local field of view under thoracolaparoscopy, clearly expose the esophagus and surrounding tissues and structures, and remove a larger number of lymph nodes, including paralaryngeal lymph nodes and cervical lymph nodes, which reduces the postoperative recurrence and improves the survival rate, and it has become the most commonly used surgical procedure, which has the advantages of less trauma, fewer postoperative complications, quicker recovery, and higher quality of life [4]. Based on this, the short-term efficacy of minimally invasive McKeown's procedure versus open Ivor-Lewis procedure for the treatment of lower and middle esophageal cancer was investigated, and minimally invasive radical esophageal cancer surgery can replace open thoracic surgery with satisfactory clinical results, which are reported as follows.

2. Information and Methodology

2.1 General information Review 54 cases of middle and lower esophageal cancer patients admitted from January 2013 to December 2017 in our hospital. Based on the different surgical methods, they were divided into 16 cases in the observation group and 38 cases in the control group. The observation group used thoracolaparoscopic minimally invasive McKeown radical esophageal cancer surgery, with

11 cases of men and 5 cases of women, with an average age of (56.14±8.79) years; 9 cases of tumors were located in the middle segment and 7 cases in the lower segment. In the control group, open Ivor-Lewis radical esophageal cancer surgery was performed in 26 cases of men and 12 cases of women, with an average age of (56.21±8.81) years old; there were 24 cases of tumors located in the middle segment and 14 cases of tumors located in the lower segment. There was no difference in the comparison of gender, age and tumor location between the two groups (P>0.05), and they were comparable. Inclusion criteria: 1) Confirmed diagnosis of middle and lower esophageal cancer by gastroscopic biopsy; 2) PET-CT, enhanced CT scan showed no local invasion of the tumor and no distant metastasis; 3) KPS score ≥60; 4) No preoperative radiotherapy; 5) Evaluation of cardiopulmonary function to tolerate surgery; 6) Signed informed consent by the patient and family. Exclusion criteria: 1) Patients with distant tumor metastasis; 2) Previous history of right thoracic surgery; 3) Pre-operative radiotherapy; 4) Abnormal coagulation function; 5) Diseases of the mental system; 6) Cardio-cerebral, hepatic and renal dysfunction or excessive obesity; 7) TNM stage > III; 8) accompanied by serious infections or hematologic diseases.

2.2 Methodology

2.2.1 Observation group Perform thoracolaparoscopic minimally invasive McKeown radical esophageal cancer surgery:Take the left lateral position after successful single-lumen tracheal intubation anesthesia, disinfect and spread the towel. Chest stage: the observation hole was located at the 8th intercostal space of the right mid-axillary line, the operation hole was located at the 4th intercostal space of the right anterior axillary line and the 6th intercostal space of the right anterior axillary line, and the operator and assistants stood on the left side of the patient; an artificial pneumothorax was established with a pressure of 8 mmHg; the lower and middle esophagus was freed to the esophageal hiatus, the arch of the chiasm was dissected, and the upper end of the esophagus was freed to the entrance of the thorax and the lymph nodes such as those next to the left main trachea and those next to the infratrachiasmatic process and the inferior pulmonary ligament were cleared; the right reentry throat was obtrusively The lymph nodes next to the right recurrent laryngeal nerve are cleared bluntly and sharply, the left tracheoesophageal groove is fully exposed, and the lymph nodes next to the left recurrent laryngeal nerve are cleared free. 2) Abdomen and neck stage: change the position to supine position, shoulder pads, head tilted to the right to reveal the left neck, disinfect and spread the towel. Artificial pneumoperitoneum was established with a pressure of 12 mmHg, the observation hole was located below the umbilicus, and the operation hole and auxiliary hole were located 2 cm above the umbilicus at the right midclavicular line, under the right and left rib margins, and under the xiphoid process; the stomach was freed from the lesser curvature of the stomach and the greater curvature of the stomach, and the esophageal hiatus was connected to the thoracic cavity, and it was down to the pylorus. The left sternocleidomastoid muscle was incised obliquely in front of the left sternocleidomastoid muscle for about 4 cm, and the cervical esophagus was cut off by freeing the cervical esophagus and clearing the cervical laryngeal recurrent nerve paragangliomatous lymph nodes. Extend the subxiphoid foramen to take the median incision of the upper abdomen about 5cm, take the thoracic esophagus and stomach out through the upper abdominal incision, stretch the stomach and spread the stomach, make the tube stomach from the second branch of the right gastric blood vessel along the gastric curvature to the fundus of the stomach with a straight line cutting suture device with a width of about 4cm, resect the whole esophagus and cardia, take the tube stomach through the esophageal slit hole to the neck along the esophageal bed and perform the gastroesophageal mechanical end-side anastomosis, and leave it in the gastrointestinal decompression. A fistula was placed in the jejunum 30 cm from the flexor ligament and was introduced and fixed from the left subcostal incision.

2.2.2 Control group: open thoracic Ivor-Lewis esophageal cancer surgery: double-lumen endotracheal intubation, take the flat position after successful anesthesia, and routinely disinfect and spread the towel. 1) Abdominal stage: take the epigastric median incision about 10cm long into the abdomen, the freeing of the stomach and the production of tube stomach, jejunostomy is the same as minimally invasive McKeown esophageal cancer radical surgery. The position was changed to left lateral lying position, and an incision of about 20 cm was made in the 5th intercostal space to enter the thoracic cavity, dissect the lower pulmonary ligament, free the esophagus upward and downward, dissect the singular vein, place the anastomotic mushroom head with purse-string suture method, and then cut off the esophagus; sweep the lymph nodes next to the left main trachea and under the rondulet, and next to the lower pulmonary ligament, etc.; pull the tube stomach to the thoracic cavity, and then dissect it in the reserved part of the fundus of the stomach to resect the esophagus. The body of the anastomosis apparatus was passed out at the highest point of the gastric fundus, and the esophagogastric anastomosis was performed at the right pleural roof, and the anastomosis was reinforced and suspended.

2.3 Observation Indicators

2.3.1 Perioperative indexes: observe and record perioperative indexes such as the number of cleared lymph nodes, intraoperative bleeding, postoperative chest drainage, chest tube removal time, venting time and postoperative hospitalization time.

2.3.2 Postoperative pain: the assessment was done by visual analog scoring method, and the patients' VAS score values were recorded at the 1st, 2nd and 3rd postoperative activities.

2.3.3 Indicators of inflammatory response: venous blood was drawn and sent for testing of leukocyte count and C-reactive protein on the 1st and 7th postoperative days.

2.3.4 Complications: observe the occurrence of reflux gastritis, lung infection, pulmonary atelectasis, anastomotic fistula, anastomotic stenosis, skin sensory abnormalities, hoarseness and so on in the postoperative period, and compare the complication rate.

2.3.5 Quality of life status: the European Organization for Research and Treatment of Cancer's quality of life rating scale

was used at 1 month after surgery. The special scale for assessing quality of life in malignant tumors was investigated, including somatic, role, cognitive, emotional, social and comprehensive functioning, and the higher the score, the better the quality of life [6].

2.4 Statistical Methods

The statistical data were analyzed by SPSS 19.0 statistical software, and the measurement data were expressed as (x±s), and the comparison between the two groups was performed by the independent samples t-test; the count data were expressed as the number of cases n (%), and the comparison between the two groups was performed by the $\chi 2$ test. $P<0.05$ was used to indicate that the difference was statistically significant.

3. Results

3.1 Comparison of Intraoperative and Postoperative Perioperative Indicators

Intraoperative bleeding, postoperative chest drainage, extubation time, exhaustion time, and hospitalization time of the observation group were lower than those of the control group ($P<0.05$); the number of cleared lymph nodes in the observation group was more than that of the control group ($P<0.05$); and there was a difference in the comparison of perioperative indexes ($P<0.05$), as shown in Table 1.

Table 1: Comparison of intraoperative and postoperative perioperative indicators (x±s)

groups	n	Lymphatic cleansing Knots (nos.)	Intraoperative bleeding Volume (ml)	postoperative chest compressions Volume (ml)	intubation (d)	exhaust (d)	Length of hospitalization (d)
Observation Group	16	20.9±3.6	120.4±35.8	575.2±214.7	5.7±1.6	2.5±1.2	13.8±2.4
control subjects	38	16.7±2.7	168.1±55.6	715.6±233.5	7.4±2.0	3.4±1.6	15.6±3.1
t-value		4.7172	3.1576	2.0641	3.0129	2.0192	2.0717
P-value		0.0000	0.0026	0.0440	0.0040	0.0486	0.0433

3.2 Comparison of VAS Pain Scores at Postoperative Activities

Comparison of VAS pain scores on days 1, 2 and 3 at the time of postoperative activities between the two groups showed that the VAS scores of the observation group were lower than those of the control group, and there was a difference ($P<0.05$), as shown in Table 2.

Table 2: Comparison of VAS pain scores at postoperative activities (x±s)

groups	Postoperative day 1	Postoperative day 2	Postoperative day 3
Observation group (16 cases)	3.9±1.8	4.2±1.6	3.2±1.5
Control group (38 cases)	5.7±1.3	5.1±1.4	4.7±1.2
t-value	4.1316	2.0677	3.8906
P-value	0.0001	0.0437	0.0003

3.3 Comparison of Postoperative Inflammatory Response Indicators

Comparison of leukocyte count and C-reactive protein on the 1st and 7th postoperative days between the two groups, the observation group was lower than the control group, which was statistically significant ($P<0.05$), see Table 3.

Table 3: Comparison of postoperative white blood cell count and C-reactive protein (x±s)

groups	White blood cell count (x109/L)		C-reactive protein D-(mg/L)	
	Postoperative day 1	Postoperative day 7	Postoperative day 1	Postoperative day 7
Observation Group	14.25±0.80	8.34±0.52	78.44±19.65	17.06±4.77
control subjects	14.68±0.59	8.85±0.74	96.13±31.82	20.64±5.94
t-value	2.1945	2.5025	2.0581	2.1346
P-value	0.0327	0.0155	0.0446	0.0375

3.4 Comparison of Postoperative Complication Rates

The observation group developed reflux gastritis, lung infection, anastomotic fistula, abnormal skin sensation, and hoarseness with statistical significance ($P<0.05$) compared with the control group, see Table 4.

Table 4: Comparison of postoperative complications [n (%)

groups	reflux gastritis	lung infection	pulmonary hypotension	anastomotic fistula	anastomotic stenosis	Skin sensory abnormalities	hoarse
Observation Group	1 (6.25)	1 (6.25)	0 (0.0)	2 (12.5)	1 (6.25)	0 (0.0)	2 (12.5)
control subjects	0 (0.0)	6 (15.79)	1 (2.63)	1 (2.63)	1 (2.63)	4 (10.53)	1 (2.63)
χ^2 value	6.4516	1.4608	2.6650	6.9656	1.5443	11.1152	6.9656
P-value	0.0111	0.0312	0.1026	0.0083	0.2140	0.0009	0.0083

3.5 Comparison of Quality of Life Status

Comparison of quality of life scores at 1 month postoperatively, the observation group was better than the control group in terms of somatic, role, emotional, and general functioning scores, and there was a difference ($P<0.05$), whereas there was no difference in cognitive and social functioning scores ($P>0.05$), as shown in Table 5.

Table 5: Comparison of quality of life status scores at 1 month postoperatively (x±s)

Quality of life indicators	Observation Group	control subjects	t-value	P-value
body function	93.1±4.7	86.1±8.4	3.1227	0.0029
Role Functions	89.7±10.2	80.7±11.6	2.6930	0.0095
emotional function	78.4±11.6	71.1±9.3	2.4451	0.0179
cognitive function	92.5±9.8	91.7±10.2	0.2661	0.7912
social function	77.2±15.5	78.0±12.6	0.1988	0.8432
integrated function	69.1±14.8	60.7±11.7	2.2242	0.0305

4. Discussion

Esophageal cancer has a high incidence and mortality rate in China, and it is most common in middle-aged and old-aged men over 40 years old, and most of the patients belong to the middle and late stages when they are found [5]. The incidence of squamous cell carcinoma of the middle and lower esophagus is the highest, accounting for 95.6% of the malignant tumors of the esophagus [6]. It accounts for 95.6% of the malignant tumors of the esophagus. Currently, surgical resection is the preferred treatment for esophageal cancer, supplemented by comprehensive treatment of radiotherapy and chemotherapy. Traditional open-heart surgery is characterized by large incision, heavy bleeding and trauma; postoperative chest pain and sensory abnormalities are obvious, which seriously affects the quality of postoperative life. Data show that [7]: Minimally invasive radical esophagectomy for esophageal cancer has the advantages of less trauma, fewer postoperative complications, faster recovery and higher quality of life, and it can obtain the same curative effect as open surgery, and it can effectively reduce the complication rate because of the small stress reaction of the body after surgery.

At present, radical resection plus lymph node dissection is the mainstay of esophageal cancer, and the scope of lymph node dissection is still controversial due to the anatomical and physiological peculiarities of the esophagus. As the lymphatic drainage of esophagus is non-segmental, lymph node metastasis is relatively extensive and can occur in 3 regions of cervical, thoracic and abdominal regions; the rate of lymph node jumping metastasis in early stage of esophageal cancer is 60% [8]. According to the 8th edition of the American Cancer Consortium (AJCC) TNM staging of esophageal cancer, the N staging is all based on the number of lymph node metastasis [9]. In the latest international expert consensus of 2021, surgical lymph node dissection up to 20 or more lymph nodes is recommended [10] In the latest international expert consensus in 2021, surgical lymph node dissection of more than 20 lymph nodes was recommended [11, 12]. reported that systematic lymph node dissection can really benefit the survival of esophageal cancer patients, and the lymph nodes next to the recurrent laryngeal nerve are more common sites of lymphatic metastasis in esophageal cancer, so the dissection of lymph nodes in this area can reduce postoperative recurrence and improve the survival rate [13]. The clearance of this lymph node can reduce postoperative recurrence and improve the survival rate. Minimally invasive McKeown esophagectomy is advantageous for paraglottic nerve lymph node clearance. The open Ivor-Lewis procedure has better results in removing the enlarged lymph nodes visible to the naked eye in the operative field, but it is difficult to completely remove the lymph nodes in the upper mediastinum and neck [14]. The minimally invasive McKeown procedure has been shown to be effective in removing enlarged lymph nodes visible to the naked eye in the field. The minimally invasive McKeown procedure can enlarge the local field of view, clearly expose the esophagus and surrounding tissues, and avoid damage to the recurrent laryngeal nerve and thoracic duct [15]. The minimally invasive McKeown procedure is effective in removing the upper mediastinal and cervical lymph nodes. This study shows that minimally invasive McKeown esophagectomy can be applied to treat lower and middle esophageal cancer, which has the characteristics of small incision, light pain, small trauma, etc. The field of operation is clearer, especially the lymph nodes next to the recurrent laryngeal nerves can be removed with intuitive visual field, precise removal, avoiding the injury of recurrent laryngeal nerves, and reducing the complication.

In terms of postoperative complications, this study found that the low incidence of anastomotic fistula in the Ivor-Lewis procedure was considered to be related to the fact that the anastomosis was in the thoracic cavity and the anastomotic tension was low and the blood supply provided was good, whereas, in the McKeown procedure the length of tubular gastric raise during cervical anastomosis was long, and the anastomosis was prone to anastomotic fistula because of the high tension in the anastomosis and the poor blood supply provided. Injury to the recurrent laryngeal nerve during minimally invasive McKeown esophagectomy and postoperative hoarseness were considered to be related to the stimulation of the recurrent laryngeal nerve by pulling and compression during intraoperative lymph node clearance, thermal injury with energy instruments, and postoperative tissue edema or localized hematoma compression. The author used blunt and sharp separation when clearing the lymph nodes next to the recurrent laryngeal nerve during surgery, avoided the use of energy instruments, and carefully hemostatized the hemorrhage to reduce the damage to the recurrent laryngeal nerve. In this study, the perioperative period was characterized by the application of the rapid rehabilitation surgical concept of integrating Chinese and Western medicine [16]. In addition to the conventional western surgical treatment, the application of traditional Chinese medicine and appropriate operation techniques of Chinese medicine (foot bath, acupoints, moxibustion, acupuncture, intermediate frequency, etc.) can promote human blood circulation, increase gastrointestinal peristalsis, improve appetite and sleep, regulate the endocrine system, and enhance the function of human organs; achieve the improvement of patients' postoperative body function, sleep and anxiety, reduce postoperative complications, and accelerate the rapid recovery of postoperative organ function, which will be the best way to improve patients' postoperative function. It will become the inevitable trend of future surgical development.

Open Ivor-Lewis radical esophagectomy removes the diseased tissue of the esophagus, destroying the integrity of the chest wall and seriously damaging the respiratory and circulatory functions; the procedure is highly traumatic to the body, and the excessive extrusion of the lung tissues during the operation results in damage to alveoli, which triggers activation of the inflammatory cells and releases a large amount of inflammatory factors, and aggravates the postoperative stress and inflammatory reactions [17]. Minimally invasive McKeown esophagectomy is performed through small incisions in the chest and abdominal walls, thus avoiding the need to cut off long muscle tissues in the chest and abdominal walls and open up the ribs, and reducing the damage to the intercostal nerves and the neighboring tissues and organs in the chest and abdominal cavities, which significantly reduces the postoperative pain and postoperative traumatic stress. This study showed that the white blood cell

count and C-reactive protein in the observation group were lower than those in the control group on the 1st and 7th postoperative days, and the difference was statistically significant (P<0.05). Minimally invasive McKeown esophagectomy significantly reduced pain and inflammatory reaction, which facilitated the patients' postoperative coughing and sputum removal and reduced the occurrence of systemic inflammatory reaction syndrome, and lowered the incidence of postoperative traumatic stress, hypoxemia and pulmonary insufficiency. Therefore, minimally invasive McKeown surgery is a delicate operation, with less pulling and squeezing of lung tissues, and less exudation of inflammatory cells and mediators from lung tissues; open Ivor-Lewis surgery cuts off the latissimus dorsi muscle, serratus anterior, part of the erector spinae muscle, and opens up the ribs, which severely affects the patient's respiratory function, and causes severe pain, refusal to cough and sputum in the postoperative period, and inability of the respiratory inflammatory secretion to be discharged efficiently, which obstructs airway , and pulmonary atelectasis and lung infection appeared, which is in line with Rong Yu [18] et al. study. Another study found that [19, 20] Minimally invasive McKeown radical esophageal cancer surgery is less destructive to the integrity of the patient's thorax, and the postoperative wound pain is significantly reduced. This study found that when comparing the two groups' postoperative VAS pain scores on the 1st, 2nd and 3rd days of postoperative activity, the observation group's VAS score was significantly lower than that of the control group (P<0.05), which is conducive to the patients' coughing and expectoration in the postoperative period, and it is able to give full play to the advantages of minimally invasive surgery to promote the rapid recovery in the postoperative period, and the therapeutic effect is remarkable. and the therapeutic effect is remarkable.

In conclusion, both minimally invasive McKeown's procedure and open Ivor-Lewis procedure can be used as the treatment of lower and middle esophageal cancer, and the Ivor-Lewis procedure has a lower incidence of anastomotic fistula and laryngeal nerve paralysis; minimally invasive McKeown's procedure has a higher number of lymph nodes cleared, and has certain therapeutic efficacy, feasibility, and high safety.

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