Int J Clin Exp Pathol 2017;10(2):1886-1897
www.ijcep.com /ISSN:1936-2625/IJCEP0034951

Original Article

Comparison of survival rate, complications and life quality after different surgical procedures in esophageal cancer

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Received July 4, 2016; Accepted September 8, 2016; Epub February 1, 2017; Published February 15, 2017

Abstract: Background: Compare the survival rate, post-operative complications and long-term life quality in esophageal cancer patients underwent different surgical procedures. Methods: We followed up 401 cases from 433 cases (92.6%) of esophageal cancer patients. According to the surgical procedures, patients were divided into six groups to compare its effects. Results: The 3 and 5-year survival rates were highest in the MIE group and lowest in the SRELTELN group. At 6 months after surgery, the ECOG score was the MIE group < the Sweet group = the CIES group = the Ivor-lewis group = the Mckeown group < the SRELTELN group. The KPS score was the SRELTELN group < the Mckeown group = the CIES group = the Ivor-lewis group = the Sweet group < the MIE group. The MIE group had the lowest intra-operative blood loss and post-operative drainage. The Sweet group had shortest ICU stay. The Mckeown group had highest incidence of post-operative pulmonary atelectasis, pleura thickening adhesion, diarrhea, anastomotic leakage and the highest amount of post-operative drainage than the other three groups. Conclusion: The MIE group has a better survival rate and less intra- and post-operative complications than the other groups, whereas the SRELTELN group has the worst.

Keywords: Esophagus cancer, minimally invasive esophagectomy, survival rate, complications, long-term life quality

Introduction

Esophageal carcinoma is one of the most common upper digestive tract cancers and the 9th malignant disease worldwide. Every year about 300,000 people die from esophageal carcinoma and China is one of the most prevalent areas [1]. One of the reasons is that most patients are at late stages when diagnosed. Surgery is still the first choice for the treatment of esophageal carcinoma patients. The 5-year survival rate can reach up to 90% for early stage patients and more than 50% for the advanced stage patients after surgery treatment. Different surgery procedures may lead to different post-operative complications that affect prognosis. Thus, it is critical to compare the risk factors that could affect the complications in different surgery procedures, and eventually to improve the prognosis.

Currently there are many different surgery procedures for the treatment of esophageal carcinoma. There are 6 major surgery procedures used in our hospital: 1) Sweet method: Since Sweet et al. proposed to remove esophageal carcinoma through left chest for the first time in 1945, this surgery procedure has been widely used in China [2]. 2) Ivor-lewis method: In 1946, Lewis et al. reported to remove esophageal carcinoma via incision at right chest and abdomen, and now this surgery procedure is the most used one in the Western countries [3]. 3) Mckeown method: In 1976, Mckeown et al. reported to achieve satisfied treatment via three resections at neck, chest and abdomen [4]. 4) Minimally invasive esophagectomy (MIE) method: In 1980s, Mocrte et al. first used video-endoscopy [5], which was widely used in thoracic surgery. In 1992, Cuschicri et al. first introduced MIE [6]. 5) Colonic Interposition for

Esophageal Substitution (CIES) method: After the resection of the esophageal carcinoma, organs including stomach, jejunum and colon could be used for reconstruction of the esophagus. Among these organs, when stomach could not be used for the replacement of esophagus, colon replacement is an ideal choice [7], and the other organs are rarely used. 6) Subtotal resection of esophageal through left thoracic and esophagogastroanastomosis in left neck (SRELTELN). This method was introduced to minimize the invasiveness of Sweet method.

Due to the improvement of anesthesia, the widely application of incision and stitch instrument, the enrichment of experience in peri-operation management, the increase of surgery procedures and the improvement of the surgery treatment, the resection rate for esophageal carcinoma was greatly increased, the surgery time was obviously decreased, and the post-operative complications and mortality were further decreased. To achieve the lowest peri-operative and long-term complications, reduce the rate of recurrence and metastasis, increase disease-free survival time and promote the 5-year or 10-year survival rate and life quality in patients after surgery, here we compared different surgery procedures. This is critical for the choosing of treatment strategy, prediction of risk factors and early intervention and eventually increasing the survival rate and post-operative life quality.

Materials and methods

Patient characteristics

Esophageal cancer patients diagnosed between September 2009 and November 2013 underwent incision of esophageal cancer treatment using different surgery procedures by the same team of surgeons at the Department of thoracic surgery at 4th hospital of Hebei Medical University. All cases were examined with stomach endoscopy, the lesion site biopsy and histology examination, routine heart and lung function test, chest and upper abdomen enhanced CT, and electrocardiography. The patients with surgery contradictions, incomplete information and pre-operative radiotherapy and chemotherapy were excluded. Among 433 patients, 401 cases (92.6%) were successfully followed up by phone, mails or outpatient department, and 125 cases were confirmed dead. Survival curves for patients underwent different surgery procedures were drawn by Kaplan-Meier method. The post-operative complications in different surgery procedures were compared. Life quality after surgery was assessed by questionnaire including post-operative appetite, food intake, stomach-esophagus reflex, diarrhea, body weight, Zubrod-ECOG-WHO performance status (PS) score [8] and Karnofsky (KPS) score [9]. The ethics committee at 4th hospital of Hebei Medical University approved this study and written consent has been obtained from all the patients.

Surgery procedures

The 6 different surgery procedures were briefly described as below.

1) Sweet method: A left posterolateral thoracotomy was performed through the fifth or sixth intercostal incision. Sharp and blunt dissection of the esophagus was performed at least 5 cm above lesions. Care was taken to avoid injury to the thoracic duct, the left vagus nerve, and the recurrent laryngeal nerve. Once the esophagus was completely freed, the diaphragm was entered though a 5-to 6-cm radial incision. The stomach was mobilized through the left thoracic cavity, preserving the right gastroepiploic artery and arcades; the left gastric artery and vein were ligated at their origins. If possible, a complete upper abdominal and distal mediastinal lymph node dissection was performed with en bloc resection of the distal esophagus and proximal stomach. Standard preparation of the stomach tube was performed in the left chest through diaphragmatic incision with a mechanical esophagogastric anastomosis above or below the aortic arch.

2) Ivor-lewis method: The stomach was first mobilized through the abdominal incision, preserving the right gastroepiploic artery and arcades; the left gastric artery and vein were ligated at their origins. Then, esophagectomy was performed through the fifth or sixth intercostal incision. The esophagus was resected and the stomach was brought into the right chest through the esophageal hiatus, followed by a mechanical esophagogastric anastomosis.

3) Mckeown method: three resections at neck, chest and abdomen to remove esophageal carcinoma, make tubular stomach and then perform anastomosis of esophagus, stomach and neck.

Table 1. Clinical characteristics in patients

Variable	Variable value n = 401	Variable	Variable value n = 401
Age (years)	61.48±7.95	Male, n (%)	283 (70.57)
Tumor location, n (%)		Tumor invasion depth, n (%)	
1: Upper esophagus	54 (13.47)	T1	82 (20.45)
2: Middle esophagus	241 (60.10)	T2	79 (19.7)
3: Lower esophagus	95 (23.69)	T3	205 (51.12)
4: Invasion from stomach	11 (2.74)	T4	35 (8.73)
Stage, n (%)		Lymph node metastasis, n (%)	
I	76 (18.95)	N0	245 (61.1)
II	178 (44.39)	N1	93 (23.19)
III	138 (34.41)	N2	52 (12.97)
IV and others	9 (2.24)	N3	11 2.74)
Types, n (%)		Surgery procedure, n (%)	
Squamous	367 (91.52)	MIE	41 (10.22)
Adenoma	22 (5.49)	Sweet	269 (67.08)
Mixed	2 (0.50)	Ivor-lewis	47 (11.72)
Small cell cancer	5 (1.25)	Mckeown	26 (6.48)
Sarcomatoid carcinoma	2 (0.50)	CIES	9 (2.24)
Neuroendocrine	2 (0.50)	SRELTELN	9 (2.24)
Lymphoma	1 (0.25)		
Tumor differentiation degree, n (%)			
G1	4 (1.00)		
G2	325 (81.05)		
G3	72 (17.96)		

4) Minimally invasive esophagectomy (MIE) method: free esophagus via thoracic endoscopy, free stomach via abdomen endoscopy, remove esophageal carcinoma, make tubular stomach and then perform anastomosis of esophagus, stomach and neck or free stomach via abdomen endoscopy, thoracic endoscopy assisted small incision to remove esophageal carcinoma and then perform anastomosis of esophagus and stomach in chest.

5) Colonic Interposition for Esophageal Substitution (CIES) method: After the resection of the esophageal carcinoma, colon was used for reconstruction of the esophagus.

6) Subtotal resection of esophageal through left thoracic and esophagogastroanastomosis in left neck (SRELTELN) method. The esophagus was completely freed as the Sweet method. Esophagogastroanastomosis was performed via a 5-to 6-cm radial incision on left neck and the lymph nodes in the neck were cleaned. A drainage tube was placed in the neck and interrupted suture was used on the skin.

Statistical analysis

Data were analyzed with SAS 9.3. Student t test or Wilcoxon Two-Sample Test was used for the comparison of quantitative data between two groups. Kruskal-Wallis test was used for the comparison of multiple groups. X^2 test or Fisher exact test was used for the comparison of frequency data between two or multiple groups. When the outcome is ordered variable, Cochran-Mantel-Haenszel method was used to perform mean score difference analysis. Survival curve was analyzed by Kaplan-Meier method and Log-Rank test was used to test whether the distribution of the survival curves is different. Cox multivariate method was used for regression analysis.

Results

Clinic characteristics for patients

There are 283 cases of male and 118 cases of female patients (**Table 1**). The age at surgery

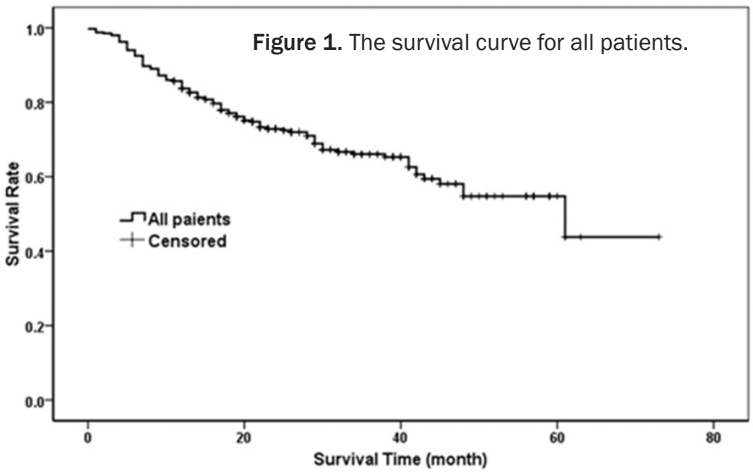

Figure 1. The survival curve for all patients.

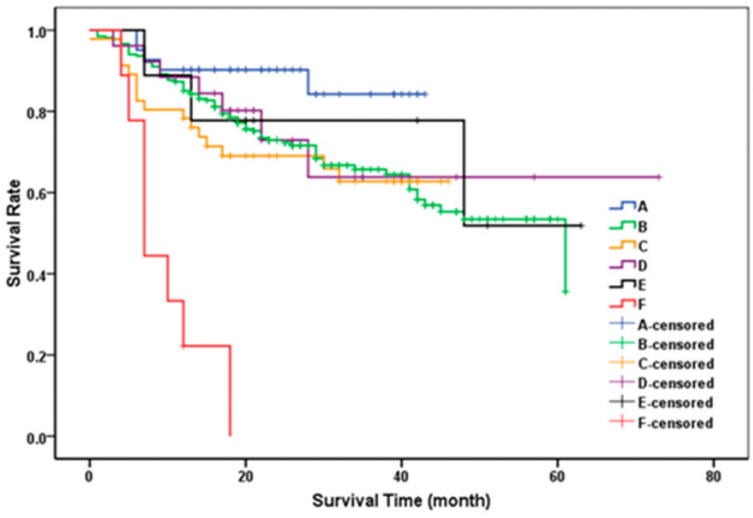

Figure 2. The survival curve for patients underwent different surgery procedures. A. MIE group; B. Sweet group; C. Ivor-lewis group; D. Mckeown group; E. CIES group; F. SRELTELN group.

was 37-83 years old, and the average age was 61.5 years old. The number of patients at age < 60 was 183, and the number at age ≥ 60 was 218. According to UICC TNM stage standards for Esophageal cancer in 2009, 75 cases was at stage I, 178 cases at stage II, 137 cases at stage III and 11 cases at stage IV or other pathologic types. There were 54 cases at upper esophagus, 237 cases at middle esophagus, 90 cases at lower esophagus and 20 cases at other locations including invasion from cardia and gastric body. For surgery procedures, there are 269 cases in Sweet group, 47 cases in Ivor-Lewis group, 9 cases in CIES group, 26 cases in Mckeown group, 41 cases in MIE group and 9 cases in SRELTELN. According to histopathology examination, 367 cases were squamous cancer, 22 cases were adenoma, 2 cases were mixed cancer, one case was lymphoma, two cases were sarcomatoid carcinoma, 5 cases were small cell cancer and 2 cases were neuroendocrine cancer.

Survival rate after different surgery procedures

The overall survival rates for the 401 cases of esophageal cancer patients were 87%, 70%, 59%, 54% and 52% at year 1, 2, 3, 4 and 5, respectively (**Figure 1**). The median survival time was 2244 d. The survival rates for different surgical procedure groups were compared (**Figure 2**; **Table 2**). The 3 and 5-year survival rates were highest in the MIE group and lowest in the SRELTELN group. The 3 and 5-year survival rates in Sweet group and Ivor-lewis group were also significant lower than MIE group. However, the survival distributions in the Mckeown group and the CIES group were not statistically significant different from MIE group. Compared to MIE group, the adjust death risk hazard ratios (HRs) for the SRELTELN group was significant higher (HR = 7.937 [95% CI: Lower, 2.451; higher, 25.696]), whereas HRs in all the other groups were not significantly different (**Table 3**). In addition to surgery procedures, the tumor location, tumor stage and lymph node metastasis status are important factors for death risk. The adjust death risk HRs of post-operative death for cancer occurred at upper esophagus and middle esophagus were significantly higher than those for cancer occurred at lower esophagus and invasion from stomach. The adjust death risk HR for stage III and above but not stage II cancer was significantly higher than stage I. The adjust death risk HR for lymph node metastasis at N2 and N3 but not N1 were significantly higher than N0.

Table 2. Comparison of survival curve for patients receiving different surgery procedures

Variable	*P* value*				
	MIE	Sweet	Ivor-lewis	Mckeown	CIES
Sweet	0.041	-	0.634	0.712	0.694
Ivor-lewis	0.027	0.634	-	0.562	0.465
Mckeown	0.139	0.712	0.562	-	0.998
CIES	0.498	0.694	0.465	0.998	-
SRELTELN	< 0.001	< 0.001	0.001	< 0.001	0.001

*Log-Rank test.

Table 3. Risk factors for post-operative death in patients underwent different surgery procedures

Variable	HR	95% CI of HR		*P**
		Lower	Upper	
Gender				
Male vs. Female	1.178	0.778	1.785	0.439
Age, unit = 1	0.988	0.965	1.012	0.341
Tumor location				
1 vs. 3+4	3.187	1.515	6.706	0.002
2 vs. 3+4	1.750	1.102	2.780	0.018
Types				
Others vs. Adenoma	1.306	0.704	2.420	0.397
Pathology stage				
II vs. I	2.818	0.967	8.214	0.058
III and above vs. I	4.208	1.107	15.992	0.035
Lymph node metastasis				
1 vs. 0	1.407	0.761	2.602	0.277
2+3 vs. 0	2.447	1.167	5.129	0.018
Tumor differentiation degree				
3 vs. 1+2	1.332	0.852	2.081	0.208
Tumor invasion depth				
2 vs. 1	0.482	0.194	1.200	0.117
3 vs. 1	0.656	0.275	1.565	0.342
4 vs. 1	0.760	0.254	2.279	0.625
Surgery procedure				
Sweet vs. MIE	2.159	0.805	5.796	0.126
Ivor-lewis vs. MIE	2.502	0.858	7.297	0.093
Mckeown vs. MIE	0.859	0.258	2.862	0.805
CIES vs. MIE	1.865	0.415	8.390	0.417
SRELTELN vs. MIE	7.937	2.451	25.696	0.001

*COX multivariate proportional hazard regression analysis.

Complications and life quality after different surgery procedures

The hospital stay length was similar among the Sweet group, the Ivor-lewis group and the MIE group, and they were shorter than the Mckeown group, the CIES group and the SRELTELN group (**Table 4**). We also evaluated the ECOG score and KPS score in 401 cases with successful follow-up at 6 months after surgery to compare the difference of physical and functional status for different groups during the recovery phase. The ECOG score was the MIE group < the Sweet group = the CIES group = the Ivor-lewis group = the Mckeown group < the SRELTELN group. The KPS score was the SRELTELN group < the Mckeown group = the CIES group = the Ivor-lewis group = the Sweet group < the MIE group. From the 433 cases of esophageal cancer patients we treated, we selected the four currently more often used surgical procedures (MIE group, Sweet group, Mckeown group and Ivor-lewis group) and analyzed their clinical data in more detail. The data includes intraoperative blood loss, intraoperative and postoperative blood transfusion, whether extubation out of the operating room, postoperative ICU time, postoperative oral food intake time, whether death during hospitalization, postoperative anemia, hypoalbuminemia, pneumonia, electrolyte imbalance, atelectasis, pleural thickening adhesions or thickening, respiratory failure, cardiac function disorders (mainly arrhythmias), chylothorax, empyema, anastomotic fistula, and postoperative chest drainage, the number of groups underwent intraoperative lymph node dissection, the probability for pathological stump positive cases, and the total number of of hospitalization days. Finally, there are a total of 179 cases with complete information (39 cases in MIE group, 98 cases in Sweet group, 29 cases in Mckeown groups, 13 cases in Ivor-lewis group) (**Table 5**). We compared different surgical technique and postoperative complications incidence and got the conclusion that: the intraoperative blood loss, postoperative ICU time, anemia and hypoproteinemia, lung atelectasis, pleural thickening

Table 4. Comparison of the hospitalization time, ECOG and KPS in patients underwent different surgery procedures

Variable	MIE n = 41	Sweet n = 269	Ivor-lewis n = 47	Mckeown n = 26	CIES n = 9	SRELTELN n = 9	*P**
Hospitalization time (d)	20.43±6.68	19.08±5.09	19.23±4.65	25.27±6.59[a,b,c]	25.29±5.28[a,b,c]	26.00±8.39[a,b,c]	< 0.001
ECOG Score	1.51±1.50	2.32±1.92[a]	2.34±1.98[a]	2.46±1.82[a]	2.33±2.18	4.44±1.67[a,b,c,d,e]	0.006
KPS Score	76.58±31.27	59.36±41.75[a]	58.94±43.35	57.30±40.16[a]	58.89±45.67	11.11±33.33[a,b,c,d,e]	0.011

*comparison among 6 groups: a, P < 0.05 compared with MIE group; b, P < 0.05 compared with Sweet group; c, P < 0.05 compared with Ivor-lewis group; d, P < 0.05 compared with Mckeown group; e, P < 0.05 compared with CIES group.

adhesions or thickening, the incidence of anastomotic leakage and postoperative drainage, number of lymph node dissection, the number of days of hospitalization was statistically significant among groups of different surgical methods (P < 0.05). We also found that the MIE group had the lowest intra-operative blood loss and post-operative drainage. The incidence of newly developed post-operative anemia and post-operative hypoproteinaemia in MIE group was less than the Sweet group. The incidence of postoperative arrhythmia and respiratory failure in MIE group was not statistically different from the other groups. The Sweet group had shortest ICU stay. The Mckeown group had highest incidence of post-operative pulmonary atelectasis, pleura thickening adhesion, diarrhea, anastomotic leakage and the highest amount of post-operative drainage than the other three groups.

During the regular 3 months, 6 months, 1 year, 3 years and 5 years follow-up for these 433 cases of esophageal cancer patients, those cases with lost to follow or death were removed from this study group. By the end of the follow up date (2015-1-15), a total of 270 cases with complete information were acquired. The median follow-up time was 30 months (13 months to 63 months). We divided the patients into four groups (MIE group, Sweet group, Ivor-lewis group, others group mainly refers to Mckeown group). By comparison between the groups, we found that appetite of patients from the MIE group, Sweet group and Ivor-lewis group recovered well, and the majority of patients after surgery can be gradually resumed eating solid foods (**Table 6**).

Discussion

In a recent review paper, the authors reported that the overall 5-year survival rate of esophageal adenocarcinoma is about 17%, which is slightly higher than the squamous cell carcinoma. The majority of patients are locally advanced (30%) or advanced (40%) at the time of diagnosis, and the 5-year survival rates were 39% and 4%, respectively. About 60% to 70% of patients failed to receive standard treatment. Multidisciplinary treatment of esophageal cancer was suggested [10]. In the present study we retrospectively analyzed the 433 cases of esophageal cancer who underwent surgical treatment in our department. We plotted the survival curve, and found that the 1, 2, 3, 4, 5-year survival rate was 86%, 73%, 65%, 57%, 53%, respectively. The median survival time was 2244 days. We achieved good results in terms of postoperative survival in esophageal cancer.

With the progress of esophageal cancer diagnosis and treatment, more and more surgical approaches have been developed. The overall trend of esophageal cancer surgery is minimally invasive, completely and popularized, individual and mechanization. With the extensive development of video-assisted thoracoscopic and laparoscopic and continuous improvement, the current full-esophageal endoscopic resection (minimally invasive esophagectomy, MIE) has become a common surgical treatment for esophageal cancer worldwide. A lot of literatures have proved that the surgical trauma of this technology is small, the perioperative mortality and incidence of complications are low, the length of hospital stay are reduced compared with open surgery, and so on. This surgery method is applicable to those elderly patients with poor cardiopulmonary function but no local metastasis. This conclusion has been proven by multiple center randomized controlled trials [11-13]. All of these have provided the evidence that MIE can get short-term benefits. With the extensive development of MIE technology, this technology continues to get recognition [14]. The present study also

Table 5. Comparison of patient status underwent different surgery procedures

Conditions	Surgery procedures				*P*
	MIE n = 39	Sweet n = 98	Ivor-lewis n = 13	Mckeown n = 29	
Operative blood loss, median (IQR)	80 (100, 200)	100 (150, 200)[a]	200 (100, 200)	200 (150, 250)[a,b]	0.001
Perioperative blood infusion, n (%)	2 (5.13)	11 (11.22)	0 (0.00)	7 (24.14)	0.065
Decannulation right after surgery, n (%)	37 (94.87)	95 (96.94)	11 (84.62)	25 (86.21)	0.054
Post-operative ICU, n (%)	9 (23.08)	18 (18.37)	4 (30.77)	13 (44.83)[b]	0.033
Oral food intake time, median (IQR)	7 (6, 8)	6 (6, 7)	6 (6, 6)	7 (6, 10)	0.146
Death during hospitalization, n (%)	0 (0.00)	1 (1.02)	0 (0.00)	0 (0.00)	1.000
Post-operative neo-anemia, n (%)	11 (28.21)	32 (32.65)	10 (76.92)[a,b]	16 (55.17)[a,b]	0.002
Post-operative neo- hypoproteinaemia, n (%)	21 (53.85)	52 (53.06)	9 (69.23)	25 (86.21)[a,b]	0.010
Post-operative pneumonia, n (%)	22 (56.41)	42 (42.86)	7 (53.85)	18 (62.07)	0.221
Post-operative electrolyte imbalance, n (%)	9 (23.08)	8 (8.16)	2 (15.38)	6 (20.69)	0.061
Post-operative pulmonary atelectasis, and, n (%)	5 (12.82)	5 (5.10)	1 (7.69)	7 (24.14)[b]	0.024
Post-operative pleura thickening adhesion, n (%)	5 (12.82)	7 (7.14)	3 (23.08)	10 (34.48)[a,b]	0.002
Post-operative respiratory failure, n (%)	6 (15.38)	17 (17.35)	2 (15.38)	10 (34.48)	0.173
Post-operative complications in heart, n (%)	5 (12.82)	14 (14.29)	1 (7.69)	3 (10.34)	0.984
Post-operative chylothorax, n (%)	1 (2.56)	9 (9.18)	0 (0.00)	1 (3.45)	0.494
Post-operative empyema, n (%)	0 (0.00)	2 (2.04)	0 (0.00)	3 (10.34)	0.098
Post-operative anastomotic leakage, n (%)	6 (15.79)	4 (4.08)[a]	2 (15.38)	7 (24.14)[b]	0.005
Post-operative chest, neck and abdomen drainage, median (IQR)	1460 (915, 1880)	1900 (1260, 2770)[a]	1490 (1128, 2320)	2060 (1540, 2870)[a,b,c]	0.002
Intra-operative lymph node removal, median (IQR)	10 (7, 14)	13 (10, 18)[a]	12 (10, 15)	11 (8, 18)	0.004
Post-operative positive edge by pathology, n (%)	1 (2.56)	2 (2.04)	0 (0.00)	0 (0.00)	1.000
Total hospitalization day, median (IQR)	19 (16, 25)	20 (177, 23)	26 (19, 28)	28 (19, 32)[a,b]	0.003

*comparison among 4 groups: a, P < 0.05 compared with MIE; b, P < 0.05 compared with Sweet group; c, P < 0.05 compared with Ivor-lewis group.

Table 6. Comparison of patient life quality during follow-up

Variable	MIE n = 34	Sweet n = 179	Ivor-lewis n = 31	Others# n = 26	*P*
Body weight change compared with discharge					0.6459
No change	12 (35.29)	69 (38.55)	12 (38.71)	6 (23.08)	
Decrease	10 (29.41)	55 (30.73)	11 (35.48)	11 (42.31)	
Increase	12 (35.29)	55 (30.73)	8 (25.81)	9 (34.62)	
Appetite					0.007
Good	23 (67.65)	131 (73.18)	24 (77.42)	12 (46.15)[a,b,c]	
Fair	10 (29.41)	37 (20.67)	5 (16.13)	8 (30.77)	
Bad	1 (2.94)	11 (6.15)	2 (6.46)	6 (23.08)	
Food intake					0.012
Normal	26 (78.79)	147 (83.52)	27 (87.10)	15 (60.00)[a,b,c]	
Little	6 (18.18)	24 (13.64)	4 (12.90)	7 (28.00)	
Very little	1 (3.03)	5 (2.84)	0 (0.00)	3 (12.00)	
Solid food					0.019
OK	32 (94.12)	164 (91.62)	30 (96.77)	20 (76.92)	
Sometimes not	1 (2.94)	3 (1.68)	0 (0.00)	0 (0.00)	
Often not	1 (2.94)	12 (6.70)	1 (3.23)	6 (23.08)	
Stuck feeling					0.031
No	20 (58.82)	133 (74.72)[a]	25 (80.65)[a]	16 (61.54)[b,c]	
Sometimes yes	8 (23.53)	34 (19.10)	4 (12.90)	5 (19.23)	
Often yes	6 (17.46)	11 (6.18)	2 (6.45)	5 (19.23)	
Full feeling after eating					0.033
No	21 (63.64)	129 (72.07)	20 (64.52)	12 (46.15)[b]	
Sometimes yes	4 (12.12)	32 (17.88)	6 (19.35)	8 (30.77)	
Often yes	6 (18.18)	10 (5.59)	2 (6.45)	2 (7.69)	
Always yes	2 (6.06)	8 (4.47)	3 (9.68)	4 (15.38)	
Pain when eating					< 0.001
No	32 (94.12)	168 (94.38)	29 (70.73)[a,b]	24 (92.31)[c]	
Yes	2 (5.88)	10 (5.62)	12 (29.27)	2 (7.70)	
Thirsty					0.122
No	24 (72.73)	151 (85.31)	25 (80.65)	21 (80.77)	
A little	4 (12.12)	19 (10.73)	5 (16.13)	2 (7.69)	
Obvious	5 (15.15)	7 (3.95)	1 (3.23)	3 (11.54)	
Sour regurgitation and heartburn					0.2264
No	16 (47.06)	107 (60.11)	20 (64.52)	15 (57.69)	
Sometimes	13 (38.24)	59 (33.15)	10 (32.26)	8 (30.77)	
Often	5 (4.71)	12 (6.74)	1 (3.23)	1 (11.54)	
Diarrhea					0.933
No	25 (73.53)	118 (65.92)	20 (64.52)	18 (69.23)	
Sometimes	4 (11.76)	45 (25.14)	8 (25.81)	5 (19.23)	
Always	7 (14.70)	15 (8.94)	3 (9.68)	3 (11.54)	
Fatigue					0.156
No	22 (66.67)	127 (71.75)	18 (58.06)	16 (61.54)	
Sometimes	8 (24.24)	35 (19.77)	9 (29.03)	3 (11.54)	
Often	3 (9.09)	15 (8.47)	4 (12.90)	7 (26.93)	

a, $P < 0.05$ Compared with MIE group; b, $P < 0.05$ compared with Sweet group; c, $P < 0.05$ compared with Ivor-lewis group; #including Mckeown group, CIES group and SRELTELN group.

proved that the 3, 5-year survival rates in MIE group were higher than the other five groups, and the survival distributions were not statistically significant between MIE group and Mckeown group. This shows that the minimally invasive esophageal cancer treatment in our hospital has reached the open degree level.

There is also a prospective non-randomized study compared the postoperative recovery among MIE, laparoscopic-assisted esophagectomy (LAE) and open surgery (OE). The results showed that MIE group had better recovery after surgery than the other two groups. Though the daily activities and fatigue level in both MIE and LAE group were gradually restored to the basic level within six months, OE group had worse postoperative recovery compared with the previous two groups within six months [12]. To compare the physical state recovery of patients after surgery in our study, we used ECOG score and KPS score, and also obtained similar results. And in follow-up study, the appetite of patients from MIE group, Sweet group and Ivor-lewis group recovered well, and the majority of patients after surgery can be gradually resumed eating solid foods.

The extensive development of MIE is also accompanied by increased incidence of some complications. It has been reported that arrhythmia, pneumonia, anastomotic leakage and other complications are prone to occur after MIE surgery [15], whereas esophageal anastomotic leakage is an important reason for postoperative mortality and increased length of hospital stay [16]. A review by the Benjamin et al. showed that compared to open esophagectomy, the incidence of postoperative diaphragmatic hernia is higher in MIE [17]. We found that the incidence of postoperative arrhythmias, anastomotic leakage, and pneumonia in our MIE GROUP is also very high. They are 12.82%, 15.79% and 56.41%, respectively. The way for how to reduce the incidence of these complications in MIE surgery remains challenging.

The elevated complication rate of esophageal cancer is accompanied by more and more thoroughness. Where in lymph node dissection is an important component. Because the breadth, complexity and diversity of esophageal cancer lymph node metastasis, and with the recent raised controversial concepts such as lymph node ratio (lymph node metastasis degree) [18]", "lymph node micrometastases (MM)" [19, 20], and "sentinel lymph node (SLN)" [21], more and more thoracic surgeons believe in the importance of a standardized, thorough cleaning of the lymph nodes. Lymph node dissection from the traditional two-field dissection (lower mediastinal and abdominal) gradually develop to expanded two-field dissection (mediastinal expanded upward supreme cervicothoracic junction), and later extended to the neck, chest and abdomen three-field lymphadenectomy. With the continuous improvement and experience accumulation for the three-field lymph node dissection technology, a large number of reports demonstrated that esophageal three-field lymph node dissection can reduce the probability of local recurrence and improve 5-year survival compared to the traditional two-field lymphadenectomy. Also, the incidence of complications caused by operation can be controlled in certain degree, thus the three-field lymph node dissection has become increasingly feasible surgical approach [22-30]. According to Nishimaki et al., the overall 5-year survival in patients with esophageal cancer after three-field lymph node cleaning up is as high as 68% [31]. Later, two similar concepts based on three-field were proposed: the Total Mesoesophageal Dissection (TMD) [32] and En-bloc resection of esophageal cancer [33]. They advocate removing adjacent tissue (including vascular and thoracic vascular catheter, bilateral mediastinal pleura, adipose tissue, etc.) when performing radical resection of esophageal cancer. With advance of the surgical approach and enlarged lymph node dissection, the rate of complications is also increasing. The questions about how to balance the pros and cons, and how to improve surgical techniques to minimize the occurrence of these complications are still challenges.

To this end, the current most popular topic is about Robot-Assisted minimally invasive esophagectomy (RAMIE). This technology has greatly increased the mediastinal visualization, and can complete a more meticulous dissection from the diaphragm to the separation between the pleura [34]. Surgical Robot can achieve unprecedented precision control on a surgical instrument during minimally invasive surgery, thus this can maximally ensure the safety of esophageal cancer patients, and mini-

mize the complications [35]. However, due to long operation time, high starting point for wide applications, high cost, slow development and other reasons, it is still uncertain about how much the patients could benefit from robotic surgery. This technology is still in its infancy and it is not extensively used in China.

Based on the fact that esophageal squamous cell carcinoma is the main type of esophageal cancer in China, they mainly occur in the lower section of the esophagus and they are more common in relatively underdeveloped rural areas than urban [36], and the medical technology and equipment among different areas are quite various, the surgical treatment for esophageal cancer is currently still dominated by Sweet method in China. Because China has high incidence of esophageal cancer, and the surgeons continue to improve their operation skills and anastomosis techniques, the Sweet surgical treatment with security, effectiveness and applicability still has a certain advantage in China [37]. A study compared Sweet method and Ivor-Lewis method, and suggested that both methods have high safety and low operative mortality [38, 39].

This study is designed to retrospectively study the esophageal cancer patients in our hospital, compare and actively improve surgical techniques, balance the advantages and disadvantages of the operation for esophageal cancer in our department. However, due to limited sample size in this single-center retrospective study, after grouping, the number of cases in each group of samples for each level is not equal, and the sample size is even small in certain groups. The selection of surgical approach is dependent on the pre-operative cardiopulmonary functional status, pre-operative tumor evaluation, the preference of participating surgeon and the level of medical technology in the operating unit. For example, we prefer Ivor-lewis and Sweet surgical procedure for the lower esophageal cancer in our hospital, and MIE for early stage patients. In addition, in our study, the hospital stay is relatively long, because we included the 4-5 days required for patients' admission to hospital, the body checkup and other aspects of the preoperative preparation. Moreover, most patients received postoperative radiotherapy, chemotherapy, combined radiotherapy and chemotherapy, immunotherapy, anti-cancer traditional Chinese medicine treatment. Some patients with advanced disease have also received neo-adjuvant radiotherapy and chemotherapy and other treatment. These factors may affect the results of surgical treatment produced, thus affecting the distribution of the survival curve. Lastly, there is a certain learning curve since we started radical resection of esophageal cancer by using MIE in our hospital. Therefore, the results of this study still need to be confirmed by the evidence-based medicine.

Acknowledgements

This study was supported by the Key Support Project of Medical Sciences in Hebei Province (20150356).

Disclosure of conflict of interest

None.

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