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Original Article

Efficacy of thoracoscopy combined with laparoscopy and esophagectomy and analysis of the risk factors for postoperative infection

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Abstract: Objective: To explore the efficacy of thoracoscopy combined with laparoscopy (TCL) and esophagectomy in patients with esophageal carcinoma (EC) and analyze the risk factors for postoperative infection. Methods: A total of 122 patients with EC admitted to our hospital were randomly divided into the study group (SG) and the control group (CG), with 61 patients in each group. Patients in the SG were treated with TCL, while patients in the CG were treated with traditional radical surgery for EC. The operation time, intraoperative blood loss, swallowing function, length of stay (LOS), number of lymph node dissections, postoperative infection rate, and quality of life in the first month after treatment were recorded and compared between the two groups. A logistic regression model was used to analyze the risk factors for postoperative infection. Results: The operation time, intraoperative blood loss, LOS, and postoperative infection rate of the SG were significantly lower than those of the CG (all $P<0.05$). However, the number of lymph node dissections, swallowing function, and quality of life of patients in the SG were significantly higher than those in the CG, with statistically significant differences (all $P<0.05$). Postoperative hypoproteinemia, diabetes mellitus, and surgical mode were independent risk factors for postoperative infection in patients with EC ($P<0.05$). Conclusion: Compared with traditional radical surgery for EC, TCL and resection can effectively reduce trauma, improve the lymph node dissection rate, promote postoperative recovery, and reduce postoperative infection, which is worthy of clinical application and promotion. Hypoproteinemia, diabetes mellitus, and surgical procedures are independent risk factors for postoperative infection in patients with EC. However, with improved medical technologies, the attention to and understanding of these high-risk factors can effectively improve postoperative infection in EC patients.

Keywords: Thoracoscopy combined with laparoscopy, resection of esophageal carcinoma, postoperative infection, risk factor

Introduction

Esophageal carcinoma (EC) is a common malignant tumor of the digestive tract. In recent years, with changes in the social environment and living habits, its incidence rate has been rising, posing a serious threat to human health and life [1, 2]. However, the specific mechanism and causes of the disease have not been fully understood yet, and the treatment is still based on a combination of surgery and chemoradiotherapy [3]. At present, the most common surgical methods for patients with EC include thoracotomy plus resection of EC and gastric or jejunostomy, but the 5-year survival rate is still low [4, 5]. The thorax is cut open in traditional thoracotomy, which damages the patient's respiratory muscles and causes respiratory complications [6]. Therefore, for patients with EC, treatment with better lymph node dissection and less trauma to the chest is of great clinical significance.

In recent years, with the development of science and medical technology, endoscopic techniques have been developed [7]. Due to its minimally invasive nature and rapid postoperative recovery, endoscopic surgery has achieved good results in many diseases. Studies have shown that removal of EC with endoscopic surgery is safe [2, 8]. As early as the beginning of the 21st century, there was a study on the application of thoracoscopy combined with laparoscopy (TCL) in the resection of EC [9]. At the same time, postoperative infection of patients with EC has always been an important factor affecting the surgical outcome and postoperative recovery of patients. A previous study showed that the use of laparoscopy in EC surgery can significantly reduce the postoperative infection rate [10].

However, TCL has high requirements for the equipment and technical skill of operators [11], and there are relatively few studies on the efficacy of TCL in patients with EC and its impact on postoperative infection. Therefore, the effects of TCL on patients who underwent resection for EC and the risk factors for postoperative infection were analyzed in this study to support the application of TCL in EC surgery and provide guidance for the prevention of postoperative infection.

Materials and methods

General information

A total of 122 patients with EC from 2018 to 2020 were prospectively analyzed, including 69 men and 53 women with an average age of 62.41±7.43 years. Among them, there were 72 patients at pathological stage I, and 50 patients at stage II. The patients were randomly divided into the study group (SG) and the control group (CG), with 61 patients in each group. Patients in the SG were treated with TCL, and those in the CG were treated with traditional radical surgery.

Inclusion criteria: (1) Patients diagnosed with EC by pathological diagnosis and met the surgical criteria; (2) Patients with pathological stages I-IIb; and (3) Patients aged 45-75 years.

Exclusion criteria: (1) Patients with malignant tumors other than EC; (2) Patients with severe hepatorenal dysfunction or surgical contraindications; (3) Patients who underwent chemoradiotherapy before surgery; (4) Patients with lymph node metastasis, communication impairment or cognitive dysfunction; and (5) Patients who could not cooperate with the study.

All patients and their families agreed to participate in the experiment by signing the informed consent form. This study was approved by the ethics committee of Zaozhuang Municipal Hospital (NCT02465328).

Surgical methods

The patients in the CG underwent traditional radical surgery for EC. The procedures are as follows: After general anesthesia, an incision of approximately 17 cm in length was made in the patient's 5th intercostal space. The esophagus was dissociated, and lymph node dissection was performed after determining the condition of the thoracic cavity. After the dissection, a 14-cm-long incision was cut in the middle of the abdomen of the patient, the stomach was dissociated, and the abdominal lymph nodes were dissected. Finally, an incision of approximately 5 cm in length was made at the sternum, and the esophagus was moved to the aortic arch, followed by lymph node dissection. After the dissection, the cervical esophagus segment and the bottom of the stomach were anastomosed and sutured.

Patients in the SG underwent surgery using the TCL. The procedures are as follows: the patient was anesthetized with a single lumen endotracheal intubation, and the lung was ventilated. Thoracoscopic surgery was then performed. The patient was placed in the left lateral position, and an observation hole was established at a position of 20° on the left side of the patient. The main operating hole was established at the junction of the 4th intercostal space and the midaxillary line, and an auxiliary operating hole was established at the 7th and 9th intercostal spaces. Then, the trophoblastic vessels of the esophagus were cut off with an ultrasonic knife, and the lymph nodes were dissected. The stomach and esophagus were anastomosed after dissection.

Measurement outcomes

(1) The operation time and intraoperative blood loss in the two groups were recorded and compared. (2) The length of stay (LOS) and lymph node dissections in both groups were recorded and compared. (3) The swallowing function evaluation scale (Standardized Swallowing Assessment, SSA) [12] was used to evaluate and compare the swallowing function of the two groups before and after treatment. The evalua-

Table 1. Comparison of the general information

Project	Research group (n=61)	Control group (n=61)	t/X^2	P
Gender			0.033	0.855
Male	35 (57.38)	34 (55.74)		
Female	26 (42.62)	27 (44.26)		
Age			0.033	0.856
≥.8	32 (52.46)	33 (54.10)		
<62	29 (47.54)	28 (45.90)		
BMI			0.033	0.856
≥.8	31 (50.82)	32 (52.46)		
<23	30 (49.18)	29 (47.54)		
Pathological staging			0.136	0.713
I stage	35 (57.38)	37 (60.66)		
II stage	26 (42.62)	24 (39.34)		
Tumor diameter			0.212	0.892
≥4 cm	22	19		
<4 cm	39	42		
Coagulation function				
APTT (s)	27.92±2.61	28.02±2.55	0.214	0.831
PT (s)	12.13±1.05	12.11±0.98	0.109	0.914
FIB (g/L)	3.11±0.16	3.09±0.13	0.758	0.450
TT (s)	14.51±1.27	14.45±1.24	0.264	0.792
History of smoking			0.037	0.848
Yes	41 (36.61)	40 (35.71)		
No	20 (63.39)	21 (64.29)		
Renal function index (μmol/L)				
creatinine	61.35±4.26	62.07±4.22	0.938	0.350
Urea	5.33±0.52	5.41±0.61	0.780	0.437
Uric acid	322.65±12.31	323.73±13.09	0.469	0.640

tion of swallowing function was divided into three parts: (i) the clinical examination, including consciousness, control of the head and torso, breathing, lip closure, soft palate, throat function, gag reflex, and autonomous cough, with a total score of 8-23 points; (ii) patients swallowed 5 mL of water 3 times, and the laryngeal movement, repeated swallowing, wheezing during swallowing, laryngeal function after swallowing, *etc*. were observed, with a total score of 5-11 points; (iii) if none of the above-mentioned abnormalities was observed, the patient swallowed 60 mL of water, and the time required for swallowing, presence of cough, *etc*. was observed, with a total score of 5-12 points. The lowest total score of this scale is 18 points, and the highest score is 46 points. A higher score represents a better swallowing function. (4) The postoperative infection rates of the two groups of patients were recorded and compared, including infections (incision infection, pulmonary infection, or surgical site infection). (5) The Quality of Life Questionnaire-Lung Cancer was used to record and compare the quality of life of the two groups of patients after treatment [13]. The scale includes five domains: role function, emotional function, physical function, cognitive function, and social function. A higher score represents a better quality of life. (6) The risk factors for postoperative infection in patients were analyzed using logistic regression.

Statistical analysis

Statistical analysis was performed using SPSS 18.0 (IBM; Armonk, New York, United States). The count data were compared using the *Chi*-square test, and the measurement data were expressed as the mean ± standard deviation (mean ± SD). The two groups were compared using the *t*-test, and the paired *t*-test was used before and after treatment. Logistic regression models were used for the multivariate analyses. Statistical significance was set at $P<0.05$.

Results

General information

There were no significant differences in terms of gender, age, tumor size, body mass index, ratio of lymph node metastasis, and pathological stage between the two groups (all $P>0.05$) (**Table 1**).

Comparison of operation time and intraoperative blood loss between the two groups

In the SG, the operation time was 279.42±64.85 min, and the intraoperative blood loss

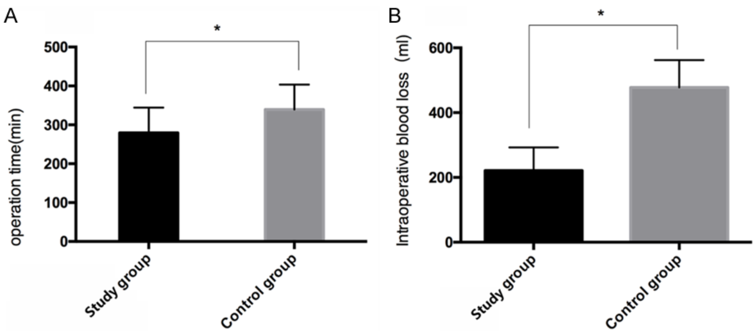

Figure 1. Comparison of operative time and intraoperative blood loss between the two groups of patients. A. The operation time of SG was shorter than that of CG. B. The intraoperative blood loss of SG was lower than that of CG. Note: * indicates $P<0.05$.

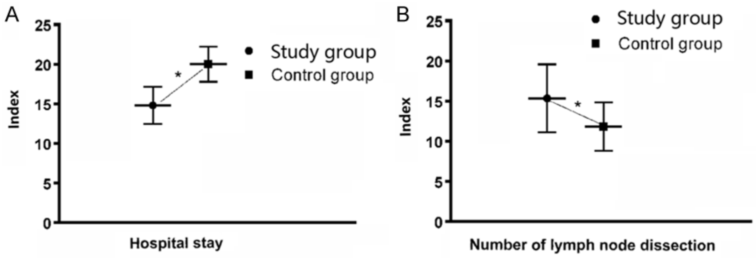

Figure 2. Comparison of LOS and lymph node dissection between the two groups of patients. The LOS of SG was shorter than that of CG (A), and the number of lymph node dissection was greater than that of CG (B) ($P<0.05$). Note: * indicates $P<0.05$.

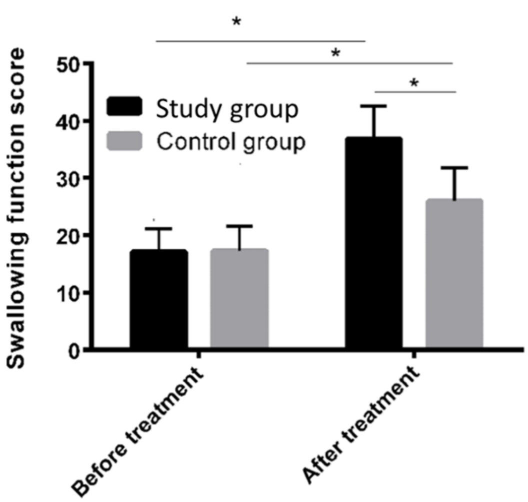

Figure 3. Comparison of swallowing function before and after treatment between the two groups of patients. There was no difference in swallowing function between the two groups before treatment ($P>0.05$). The swallowing function of the two groups was significantly improved after treatment, and the swallowing function of SG was better than that of CG ($P<0.05$). Note: * indicates $P<0.05$.

was 221.33±71.6 mL. In the CG, the operation time was 338.91±64.33 min, and the intraoperative blood loss was 477.55±84.52 mL. The operation time was shorter and intraoperative blood loss was lower in the SG than that in the CG (both $P<0.05$) (**Figure 1**).

Comparison of LOS and lymph node dissection between the two groups of patients

In the SG, the LOS was 14.82±2.33 days, and the number of lymph node dissections was 15.36±4.24. In the CG, the LOS was 20.03±2.21 days, and the number of lymph node dissections was 11.86±3.01. The LOS in the SG was shorter than that in the CG, while the number of lymph node dissections in the SG was greater than that in the CG (t=0.782, $P=0.031$) (**Figure 2**).

Comparison of swallowing function before and after treatment between the two groups

The swallow function scores of the SG before and after treatment were 17.13±4.02 and 36.81±5.73, respectively, while those in the CG were 17.31±4.26 and 26.02±5.69, respectively. There was no difference in the swallowing function between the two groups before treatment ($P>0.05$). After treatment, both groups showed improved swallowing function, and SG improved more significantly than CG ($P=0.015$) (**Figure 3**).

Comparison of postoperative infection rates between the two groups

There were 3 cases of incision infection, 2 cases of pulmonary infection, and 1 case of surgical site infection, with a postoperative infection rate of 9.84% in SG. In the CG, the cases of the corresponding infections were 6, 6, and 5, respectively, with a postoperative infection rate of 27.87%. The postoperative

Table 2. Comparison of postoperative infection rates between the two groups of patients [n (%)]

Infection	Research group (n=61)	Control group (n=61)	t/X^2	*P*
Incision infection	3 (4.92)	6 (9.84)	1.080	0.299
Lung infection	2 (3.28)	6 (9.84)	2.130	0.144
Surgical site infection	1 (1.63)	5 (8.20)	3.652	0.056
Total infection rate	6 (9.84)	17 (27.87)	6.483	0.011

Table 3. Comparison of quality of life between the two groups of patients after 2 courses of treatment

Project	Research group (n=61)	Control group (n=61)	*t*	*P*
Role function	61.56±2.01	50.34±2.12	30.00	<0.001
Emotional function	61.71±2.12	49.80±2.03	31.69	<0.001
Physical function	60.88±2.07	51.36±2.11	25.15	<0.001
Cognitive function	63.57±2.91	50.22±2.76	26.00	<0.001
Social function	60.16±2.05	51.41±2.35	21.91	<0.001

infection rate in the SG was lower than that in the CG ($P<0.05$) (**Table 2**).

Comparison of quality of life between the two groups one month after treatment

The functional, emotional, physical, cognitive, and social function scores of the SG were 61.56±2.01, 61.71±2.12, 60.88±2.07, 63.57±2.91, and 60.16±2.05, respectively, while they were 50.34±2.12, 49.80±2.03, 51.36±2.11, 50.22±2.76, and 51.41±2.35, respectively, in the CG. The quality of life in SG was higher than that of the CG ($P<0.05$) (**Table 3**).

Single-factor analysis of postoperative infection

Patients were divided into the infected group (23 patients) and the non-infected group (99 patients) according to the occurrence of postoperative infection. The univariate comparison showed differences between the groups in terms of age, postoperative hypoproteinemia, presence of diabetes, surgical procedure, and tumor location ($P<0.05$) (**Table 4**).

Multivariate analysis of postoperative infection

The factors with statistical differences in the univariate analysis were included in the multivariate analysis, and **Table 5** shows the assignment. The results showed that age was not an independent risk factor for postoperative infection in patients, but postoperative hypoproteinemia (odds ratio [OR]: 3.968, 95% confidence interval [CI]: 1.341-9.885), combination with diabetes (OR: 0.489, 95% CI: 1.452-11.557), and surgical approach (OR: 6.709, 95% CI: 1.519-13.752) were independent risk factors for postoperative infection in patients with EC (**Table 6**).

Discussion

As a common malignant tumor of the digestive tract, EC has a very complex pathogenesis, and its cause is related to many factors, such as lifestyle, body, and mold [14]. Surgery is the most direct and effective treatment for patients with EC. Traditionally, thoracotomy has been used in clinical practice for the radical resection of ECs. Although it has a good curative effect, there are still some shortcomings, such as large incision and great trauma to patients. This results in poorer tolerance and slower recovery in older patients [15, 16]. In recent years, with the development of minimally invasive techniques, thoracoscopy and laparoscopy have been widely used and achieved good results in the treatment of various diseases [17]. A study [18] has shown that TCL is the least traumatic surgical procedure for patients with EC, but with high requirements for technical operation, resulting in limited current clinical promotion. In addition, as long as surgery is performed, it is difficult to avoid postoperative infection. Therefore, in addition to exploring the efficacy of TCL in patients with EC, this study also investigated the risk factors for postoperative infection.

In our study, patients in the SG had shorter LOS, more lymph node dissection, and more improved swallowing function than those in the CG ($P<0.05$). This suggests that TCL can effectively reduce the trauma of patients during surgery, improve the efficiency of lymph node dissection, and promote the recovery of postoperative swallowing function. TCL has been reported as an alternative treatment for EC radical surgery [19]. It has been found that TCL can further reduce the postoperative pain and LOS

Table 4. Univariate analysis of postoperative infection in patients with esophageal carcinoma

Factor	Infected group (n=23)	Non-infected group (n=99)	X^2	*P*
Gender			1.465	0.997
Male	13 (56.52)	56 (56.57)		
Female	10 (43.48)	43 (43.43)		
Age			4.848	0.028
≥.0	17 (73.91)	48 (48.48)		
<62	6 (26.09)	51 (52.52)		
BMI			0.003	0.955
≥.9	12 (52.17)	51 (51.52)		
<23	11 (47.83)	48 (48.48)		
Pathological staging			0.040	0.841
I stage	14 (60.87)	58 (58.59)		
II stage	9 (39.13)	41 (41.41)		
History of chest and abdomen surgery			0.000	0.990
Yes	7 (30.43)	30 (30.30)		
No	16 (69.57)	69 (69.70)		
Postoperative low protein disease			6.664	0.010
Yes	18 (78.26)	48 (48.48)		
No	5 (21.74)	51 (51.52)		
Diabetes			6.048	0.014
Yes	17 (73.91)	45 (45.45)		
No	6 (26.09)	54 (54.55)		
Surgical approach			6.483	0.011
Traditional radical surgery	17 (73.91)	44 (44.44)		
Thoracoscopic combined with laparoscopy	6 (26.09)	55 (55.56)		
Tumor site			1.623	0.203
Upper thoracic	15 (65.22)	50 (50.51)		
Middle thoracic	8 (34.78)	49 (49.49)		

Table 5. Assignment table

Factor	Assignment
Age	≥esig, <62 =0
Postoperative hypoproteinemia	yes =1, no =0
Combined with diabetes	yes =1, no =0
Surgical approach	Traditional radical surgery =1, Thoracoscopic combined with laparoscopy =0

Table 6. Multivariate analysis of postoperative infection in patients with esophageal carcinoma

Factor	Regression coefficient	S.E.	Wald	OR	95% CI	*P*
Age	0.225	0.163	2.583	3.281	0.672-7.587	0.102
Postoperative hypoproteinemia	0.503	0.342	6.079	3.968	1.341-9.885	0.003
Combined with diabetes	0.489	0.291	6.449	4.839	1.452-11.557	0.012
Surgical approach	0.522	0.181	12.889	6.709	1.519-13.752	0.004

in patients, which was consistent with our experimental conclusions. Another study [20] explored thoracoscopic techniques and found that it magnified the surgical field of view to a greater extent, allowing the surgeon to perform surgery in a clear and accurate field of view to reduce the damage. It has been shown [21] that the use of TCL in patients with EC can effectively reduce the amount of bleeding in patients during surgery, shorten the patient's LOS, and promote patient recovery. All the above results provide supporting evidence for our conclusions. The infection rate of patients with EC after surgery was further explored. First, postoperative infection rates between the two groups were compared. It was found that the postoperative infection rate of patients in the SG was lower than that in the CG ($P<0.05$), suggesting that TCL surgery is safer and can effectively decrease postoperative infections in patients. A previous study [22] has shown that the use of TCL can effectively reduce the postoperative complications in patients with EC, including postoperative infections. Second, in order to further explore the risk factors for postoperative infection in patients with EC, logistic regression analysis was performed and it showed that postoperative hypoproteinemia, diabetes mellitus, and surgical methods were independent risk factors for postoperative infection. Hypoproteinemia is observed in many patients undergoing surgery. If not corrected in time, it will lead to a decrease in the patient's immunity, which significantly increases the risk of infection [23]. It has been previously reported that postoperative hypoproteinemia is an independent risk factor for postoperative infection in patients with oral cancer [24]. Furthermore, postoperative hypoproteinemia is an independent risk factor for death and respiratory infections in patients with EC during hospitalization [25]. For diabetic patients, long-term hyperglycemia can increase plasma osmotic pressure, thus decreasing phagocytosis and chemotaxis of white blood cells, which further reduces their immune function and leads to an increased risk of infection [26]. The surgical approach is an independent risk factor for postoperative infection in patients with EC. Since TCL is more effective than the conventional open-thoracic radical surgery for EC, it can effectively avoid damage to the intercostal and diaphragm muscles of patients, thereby reducing the pain of patients and prompting their early mobility. All of these promote recovery of the patient's immune function after surgery and reduce the incidence of infection [27].

In summary, compared with the traditional radical surgery for EC, TCL and resection of EC can effectively reduce trauma, improve lymph node dissection rate, promote postoperative recovery, and reduce postoperative infection, which is worthy of clinical application and promotion. Hypoproteinemia, diabetes mellitus, and surgical procedures are independent risk factors for postoperative infection in patients with EC. However, with the development of medical technology, the attention and understanding of these high-risk factors can effectively improve postoperative EC infection. Nevertheless, this study had some limitations. For example, the efficacy of patients with EC through TCL and thoracoscopic or laparoscopic surgery alone was not analyzed, which still leaves some gaps in the search for the best treatment strategy for EC. Due to the small number of cases in our study, there might be some inaccuracies in the analysis of independent risk factors for postoperative infection. Therefore, in future studies, multi-center experiments with large samples should be carried out to provide more experimental evidence for TCL promotion and more accurate data for risk assessment.

Disclosure of conflict of interest

None.

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