



# Relationship between postoperative complications of esophageal cancer surgery and season: a retrospective study

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**Background:** Esophageal cancer in China accounts for nearly half of the global esophageal cancer cases. The relationship between the occurrence of postoperative complications of esophageal cancer surgery and seasonal changes is not clear. Our purpose is to clarify the relationship between postoperative complications of esophageal cancer and season, so as to reduce the incidence of complications.

**Methods:** We retrospectively analyzed the medical records of patients undergoing esophageal cancer surgery in our hospital between January 2013 and December 2014. Patients were divided into the summer group (March–August) and the non-summer group (September–February) according to the seasonal climate. Pulmonary, cardiac, and other complications were recorded. Differences in postoperative complications were compared between the two groups by the chi-squared test.

**Results:** In the 251 patients enrolled, the total postoperative complication rate was 37.8%. The occurrence of incision complications in the summer group was significantly higher than that in the non-summer group (10.1% vs. 3.5%,  $P=0.044$ ). Pulmonary and cardiac complications in summer group were significantly rarer than those in the non-summer group (16.7% vs. 27.4%,  $P=0.039$ ; and 8.0% vs. 16.8%,  $P=0.032$ , respectively).

**Conclusions:** During the warm months of the year, clinicians should focus on preventing postoperative incision complications, and they should focus on preventing pulmonary and cardiac complications during the cold months.

**Keywords:** Esophageal cancer; postoperative complications; season

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## Introduction

Global cancer statistics from 2018 show that esophageal cancer is the fifth-leading cause of cancer death in the world (1). In recent years, despite the progress in diagnosis and treatment, esophageal cancer is still one of the most difficult-to-treat malignancies. Esophagectomy is the standard treatment for esophageal cancer, but complications after esophagectomy are an important factor lowering

the quality of life and survival time of patients (2). Since esophageal cancer surgery involves thoracic and abdominal operations, postoperative complications are more common in the chest, heart, gastrointestinal tract, anastomosis, and surgical incision. Complications that are easier to manage, such as poor incision healing and delayed gastrointestinal functional recovery, often only increase the hospitalization time and hospitalization costs. Other complications, such as respiratory failure, circulatory failure, and anastomotic

fistula, are likely to cause serious consequences such as death if they are poorly managed. Therefore, clinicians have been committed to preventing postoperative complications.

In recent years, some studies have shown that the occurrence of postoperative complications is related to seasonal changes; for instance, the chance of postoperative incision infection in patients undergoing surgery in warmer seasons is significantly higher than that in other seasons (3,4). Another study showed that compared with winter and spring, summer and fall had significantly higher incidences of spinal surgery wound infection, which might be related to temperature and humidity (5). In areas with relatively wide temperature variations between the four seasons, the fall and winter seasons are often periods of high incidences of respiratory diseases and cardiovascular and cerebrovascular diseases. A study of 28 large cities in the United States showed that the incidence and mortality of cardiovascular diseases in the general population were significantly higher in winter than in summer (6). The incidence of pneumonia after coronary artery bypass grafting (CABG) has strong seasonality, which is significantly higher in fall and winter than in spring and summer, and this may also be observed in other cardiothoracic surgeries (7).

Thus, in areas with distinct seasons, seasonal changes play an important role in the occurrence of postoperative complications. However, there is no detailed report on whether the season affects the postoperative complications of esophageal cancer surgery. To this end, we retrospectively analyzed the relationship between postoperative complications of esophageal cancer and the season in our hospital in recent years. This study may provide evidence that will help with the prevention and treatment of postoperative complications. We present the following article in accordance with the STROBE reporting checklist (available at <https://atm.amegroups.com/article/view/10.21037/atm-21-5050/rc>).

## Methods

### *Clinical data*

We retrospectively collected the data of patients who were hospitalized in a ward of the thoracic surgery department between January 2013 and December 2014 in our hospital and received minimally invasive esophagectomy (MIE) performed by the lead surgical team. The demographic information, diagnosis and treatment process, and radiological images of the patients were obtained from the

hospital electronic medical record system. To minimize the bias inherent to retrospective studies, the patients in this study had to meet the following requirements: (I) postoperative pathological diagnosis of esophageal cancer; (II) video-assisted thoracoscopic surgery (VATS); (III) perioperative management in the same ward as the surgery; and (IV) the same lead surgeon for all patients. The exclusion criteria were (I) the pathological results did not support the diagnosis of esophageal cancer; (II) the surgical method was thoracotomy or conversion to thoracotomy; (III) the treatment process was not recorded in detail; and (IV) the discharge procedures were not completed normally. In the end, 251 patients met the criteria, including 184 males (73.3%) and 67 females (26.7%), with an average age of 62 (57–68) years old. The basic information of the patients is shown in *Table 1*.

### *Study methods*

We analyzed the following indicators: age, sex, smoking history, tumor location, tumor pathological type, neoadjuvant therapy, surgical duration, intraoperative blood loss, postoperative hospital stay, and lymph node dissection. Postoperative complications included pulmonary complications (pneumonia, atelectasis, pleural effusion, pneumothorax, mediastinal inflammation, respiratory failure), cardiac complications (arrhythmia, heart failure), gastrointestinal complications (ascites, delayed gastric emptying), incision complications (incision infection, incision fat liquefaction), recurrent laryngeal nerve injury, deep vein thrombosis, chylothorax, bacteremia, and hospital mortality. According to the climate of Henan, China, the patients were divided into two groups: the summer surgery group (March to August) and the non-summer group (September to February).

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Medical Ethics Committee of Henan Cancer Hospital (No. 2018134) and individual consent for this retrospective analysis was waived.

### *Statistical analysis*

All data were statistically analyzed with SPSS 26.0. A normality test was run on the continuous variables. T test was used for the analysis of data with a normal distribution, and the Mann-Whitney U test was used for the analysis of data with a nonnormal distribution. For the categorical

**Table 1** Baseline demographic and clinical characteristics of patients

Characteristic	Summer group (n=138)	Non-summer group (n=113)	P
Age (years)	62 [57–68]	62 [57–67]	0.783
Sex			0.077
Male	95 (68.8%)	89 (78.8%)	
Female	43 (31.2%)	24 (21.2%)	
Smoking (yes)	66 (47.8%)	70 (61.9%)	0.025
Diabetes (yes)	8 (5.8%)	9 (8.0%)	0.497
Location of tumor			0.643 <sup>†</sup>
Neck	2 (1.4%)	1 (0.9%)	
Upper	25 (18.1%)	14 (12.8%)	
Middle	55 (39.9%)	50 (45.9%)	
Lower	56 (40.6%)	44 (40.4%)	
NCT	34 (24.6%)	38 (33.6%)	0.117
Operation time (min)	220 [180–240]	220 [187–255]	0.293
Postoperative hospital stay (day)	14 [9–21]	14 [10–21]	0.584
Blood loss in mL	50 [50–112]	80 [30–115]	0.913
Lymphadenectomy			0.550 <sup>†</sup>
2-Field	133 (96.4%)	107 (94.7%)	
3-Field	5 (3.6%)	6 (5.3%)	
No. of harvested lymph nodes	15 [11–19]	18 [15–24]	<0.001
Histology			0.285 <sup>†</sup>
Squamous cell carcinoma	112 (81.2%)	95 (84.1%)	
Adenocarcinoma	1 (0.7%)	1 (0.9%)	
Adenosquamous carcinoma	17 (12.3%)	7 (6.2%)	
Other	8 (5.8%)	10 (8.8%)	
pTNM staging 7 <sup>th</sup>			0.250
pCR	5 (3.6%)	8 (7.1%)	
I	22 (15.9%)	23 (20.4%)	
II	73 (52.9%)	51 (45.1%)	
III	38 (27.5%)	29 (25.7%)	
IV	0	2 (1.8%)	

<sup>†</sup>, Fisher's exact test. NCT, neoadjuvant chemotherapy; pCR, pathological complete response.

**Table 2** Details of postoperative complications in the two groups

Variable	Summer group (n=138)	Non-summer group (n=113)	P	Difference (95% CI)
Respiratory complications (total)	23 (16.7%)	31 (27.4%)	0.039	10.77% (0.45–21.08%)
Pneumonia	11 (8.0%)	21 (18.6%)	0.012	10.61% (2.14–19.09%)
Atelectasis	2 (1.4%)	9 (8.0%)	0.025 <sup>†</sup>	6.52% (1.14–11.89%)
Pleural effusions	4 (2.9%)	5 (4.4%)	0.735 <sup>†</sup>	1.53% (–3.19–6.24%)
Pneumothorax	2 (1.4%)	3 (2.7%)	0.660 <sup>†</sup>	1.21% (–2.37–4.78%)
Mediastinitis	2 (1.4%)	3 (2.7%)	0.660 <sup>†</sup>	1.21% (–2.37–4.78%)
Respiratory failure	1 (0.7%)	4 (3.5%)	0.178 <sup>†</sup>	2.82% (–0.87–6.50%)
Cardiac complications (total)	11 (8.0%)	19 (16.8%)	0.032	8.84% (0.60–17.09%)
Myocardial arrhythmia	9 (6.5%)	17 (15.0%)	0.027	8.52% (0.75–16.30%)
Heart failure	2 (1.4%)	2 (1.8%)	1 <sup>†</sup>	0.32% (–2.82–3.46%)
Gastrointestinal complications (total)	11 (8.0%)	9 (8.0%)	0.999	–0.01% (–6.74–6.73%)
Anastomotic leak	10 (7.2%)	7 (6.2%)	0.741	–1.05% (–7.25–5.15%)
Peritoneal effusion	1 (0.7%)	0	1 <sup>†</sup>	–0.72% (–2.14–0.69%)
Delayed gastric emptying	0	2 (1.8%)	0.202	1.77% (–0.66–4.20%)
Incision complication	14 (10.1%)	4 (3.5%)	0.044	–6.61% (–12.69% to –0.52%)
Wound infection	3 (2.2%)	2 (1.8%)	1 <sup>†</sup>	–0.40% (–3.84–3.04%)
Fat necrosis	11 (8.0%)	2 (1.8%)	0.027	–6.20% (–11.33% to –1.07%)
Unilateral RLN injury	23 (16.7%)	12 (10.6%)	0.169	–6.05% (–14.47–2.37%)
Deep venous thrombosis	1 (0.7%)	2 (1.8%)	0.590	1.05% (–1.77–3.86%)
Chylothorax	1 (0.7%)	2 (1.8%)	0.590	1.05% (–1.77–3.86%)
Bacteremia	6 (4.3%)	2 (1.8%)	0.301	–2.58% (–6.76–1.60%)
In-hospital mortality	0	0	NA	NA

<sup>†</sup>, Fisher's exact test. RLN, recurrent laryngeal nerve; NA, not available; CI, confidence interval.

variables (baseline characteristics and postoperative complications), the chi-squared test or Fisher's exact test was used to compare the two groups of patients. All tests were two-sided tests with a significance level of 0.05.

## Results

Among the 251 patients, 114 had postoperative complications, for an incidence of 45.4%. The proportion of smokers and the mean number of lymph nodes dissected per patient in the non-summer group were significantly higher than those in the summer group.

In the analysis of postoperative complications, the incidence of incision complications in the non-summer

group was lower than that in the summer group ( $P < 0.05$ ). The difference and 95% confidence interval (CI) of complications between the two groups was –6.61% (–12.69% to –0.52%). The pulmonary complication rate and cardiac complication rate in the non-summer group were higher than those in the summer group ( $P < 0.05$ ). The differences between the two groups of complications and the difference of 95% CI were 10.77% (0.45–21.08%) and 8.84% (0.60–17.09%), respectively.

There were no cases of death during hospitalization in either group, and no significant difference was observed in other postoperative complications between the two groups. Details of postoperative complications in the two groups are shown in *Table 2*.

## Discussion

Esophageal cancer can be divided into squamous-cell carcinoma and adenocarcinoma based on the pathology. The risk factors and epidemiology of different histological types are very different. Squamous-cell carcinoma is predominant in China and accounts for nearly half of the cases of esophageal cancer worldwide (8). In the past 30 years, the number of new cases and deaths due to esophageal cancer in China has been increasing and will continue to increase in the near future. It is predicted that the numbers of new cases and deaths will increase by approximately 1.5 times in the next 25 years (9). In China, men have a higher incidence and mortality of esophageal cancer than women, as do rural areas over urban areas. This distribution has led esophageal cancer to be called a “poor people’s disease”. In this regard, how to reduce the economic burden of patients and improve the quality of life by reducing postoperative complications is particularly important.

Compared with thoracotomy, VATS significantly ( $P=0.470$ ) reduces the total number of postoperative complications of patients (incidences of 38.1% *vs.* 33.8%) (10), both of which rates are similar to our total postoperative complication rate of 37.8%. The occurrence of postoperative complications is related to a variety of factors, such as subjective factors, including preoperative health status, intraoperative operation procedures, anesthesia status, and postoperative rehabilitation care. Some studies have shown that seasonal changes can also affect the occurrence of postoperative complications, which may be related to seasonal temperature changes (3,7,11). Our hospital is in central China, where the temperature varies widely between the four seasons. To study whether the postoperative complications of esophageal cancer surgery are related to seasonal changes, we defined summer as March to August and non-summer as September to February, according to the climate of Henan. Patients were divided into two groups in this study to analyze the relationship between postoperative complications and season.

In our study, the most common postoperative complications were pulmonary-related complications, of which the most common was pulmonary inflammation. This phenomenon is due to various factors, such as the patient’s age, smoking history, underlying disease, health status, lung traction during thoracic surgery, postoperative cervical anastomotic leakage, long-term bed rest, and poor

breathing exercise performance. The main measures to prevent postoperative pneumonia, based on these factors, are strong perioperative health education and extra care taken by the surgeon. However, a study reported that the incidence of pneumonia in fall and winter after CABG was significantly higher than that in spring and summer and may persist in other cardiothoracic surgeries, suggesting preoperative vaccination to improve the prognosis of high-risk patients (7). Our study also found that pulmonary complications were more common after non-summer operations than summer ones (27.4% *vs.* 16.7%,  $P=0.039$ ), especially pneumonia (18.6% *vs.* 8.0%,  $P=0.012$ ). This may be related to irritation of the respiratory tract in the fall and winter due to lower temperatures and seasonal influenza.

Cardiac-related postoperative complications were more common in the non-summer group than in the summer group, with arrhythmia predominating (15.0% *vs.* 6.5%,  $P=0.027$ ). This is in line with a survey of the incidence of cardiovascular diseases in the general population in the United States (6). Such patterns may be caused by the decrease in temperature in fall and winter leading to sympathetic nerve excitement and changes in endocrine signaling and metabolism. New-onset atrial fibrillation after esophagectomy that requires treatment has been associated with patient mortality (12). This suggests that we should pay close attention to postoperative heart rate changes in patients, especially new-onset arrhythmias. On the other hand, some studies have shown that among the postoperative complications of thoracic surgery, the occurrence of supraventricular tachyarrhythmias is not correlated with the winter or summer season (13). This difference may be due to the different types of arrhythmias studied.

Unlike pulmonary and cardiac complications, postoperative incision-related complications cannot be completely eliminated in any surgery. Postoperative incision complications can be significantly more common after some procedures, such as orthopedic surgery (3,5,11), body-contouring surgery (4), and deep brain stimulation (14). In our study, incision complications were more common in the summer group (10.1%) than the non-summer group (3.5%) ( $P=0.044$ ), in line with the above studies. We think this was mainly because high temperatures were not conducive to incision healing. It also suggests that we should pay special attention to active dressing changes in spring and summer and observe the healing of incisions while minimizing the chance of exposure in a high-temperature environment.

Other postoperative complications, such as pleural

effusion, ascites, and chylothorax, have shown similar rates after thoracic surgeries performed in winter *vs.* summer (13). Although the surgeries in that study were different, they were all thoracic surgeries, and the results were similar to our study. A study on postoperative complications of bariatric surgery in the United States reported that although adverse events, such as deep vein thrombosis and sepsis, were rare, they were more likely to occur in the cold season than in summer (15). We found no significant seasonal difference in these complications. The incidence of anastomotic fistula in the postoperative summer group and the non-summer group was 7.2% and 6.2%, respectively ( $P=0.741$ ). The occurrence of fistula seriously lowers the survival and life quality of patients. Therefore, surgeons have been working on how to reduce the occurrence of fistulas. The patients included in our study all had cervical anastomosis after three-incision VATS, and Li's anastomosis method was used to reduce the occurrence of fistula as much as possible (16).

Our study found that the occurrence of postoperative complications of esophageal cancer surgery is related to seasonal changes, which can guide clinicians to focus on the prevention of complications in the corresponding seasons, so as to reduce the occurrence of complications and improve the life quality of patients. Although our study used inclusion and exclusion criteria to reduce the bias of the study as much as possible, there were still limitations. First, it was a retrospective study, whose inherent bias could not be avoided. Second, the purpose of our study was related to seasonal variation, and the large temperature difference between seasons in different geographical locations directly leads to the fact that the seasons and months of different studies are not consistent with each other, resulting in poor comparability. Third, the proportion of smokers and the mean number of lymph nodes dissected per patient in the non-summer group were significantly higher than those in the summer group, which may affect postoperative complications. Finally, this study was based on a single surgeon's data, which may have slanted the study results.

## Conclusions

The occurrence of postoperative complications of esophageal cancer surgery has a clear relationship with seasonal changes. In the spring and summer seasons, with relatively high temperatures, the prevention of incision-related complications should be a focus. In the colder fall and winter seasons, we should focus on the occurrence of

pulmonary and cardiac complications, especially pneumonia and arrhythmia, to prevent serious complications. Doing so can be one way to reduce postoperative complications, reduce the economic burden on patients, and improve their quality of life.

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## Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at <https://atm.amegroups.com/article/view/10.21037/atm-21-5050/rc>

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*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at <https://atm.amegroups.com/article/view/10.21037/atm-21-5050/coif>). The authors have no conflicts of interest to declare.

*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. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Medical Ethics Committee of Henan Cancer Hospital (No. 2018134) and individual consent for this retrospective analysis was waived.

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