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Original Article

The effects of radiotherapy after thoracic and laparoscopic surgery on patients with esophageal cancer and on their prognoses

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Abstract: Objective: This paper aimed to explore the effects of radiotherapy after thoracic and laparoscopic surgery (TLS) in patients with esophageal cancer and on their prognoses. Methods: Altogether 118 patients with esophageal cancer diagnosed in our hospital were recruited as the study cohort and randomly divided into a postoperative radiotherapy group (59 cases) and a postoperative chemotherapy group (59 cases). All the patients were treated with TLS. In addition to the TLS, the patients in the postoperative radiotherapy group underwent radiotherapy, and the patients in the postoperative chemotherapy group were administered cisplatin and 5-fluorouracil (PF) chemotherapy. Before the treatment and at 6 months after the treatment, the serum carbohydrate antigen 199 (CA199), carbohydrate antigen 153 (CA153), and carcinoembryonic antigen (CEA) levels were measured using immunity transmission turbidity (ITT). The expression levels of Bax and Bcl-2 in the peripheral blood mononuclear cells (PBMCs) were measured using Western blot (WB). The $CD4^+$, $CD8^+$ and $CD3^+$ levels in the peripheral venous blood were measured using a flow cytometer. The two groups were compared in terms of their effective treatment rates, their incidences of complications, and their postoperative survival rates. Results: After the treatment, the serum CEA, CA153, and CA199 levels in the postoperative radiotherapy group were significantly lower than they were in the postoperative chemotherapy group ($P<0.05$). After the treatment, the expression level of Bcl-2 was significantly lower in the postoperative radiotherapy group, but the Bax expression level was significantly higher in the postoperative radiotherapy group ($P<0.05$). After the treatment, there were no statistically significant differences in the $CD4^+$, $CD3^+$ or $CD8^+$ levels between the two groups ($P>0.05$). After the treatment, the overall response rate (ORR) and the total incidence of adverse reactions were significantly higher in the postoperative radiotherapy group ($P<0.05$). After the treatment, the 1-year, 3-year, and 5-year survival rates were significantly elevated in the postoperative radiotherapy group ($P<0.05$). Conclusion: Compared with the esophageal cancer patients treated with chemotherapy after TLS, the serum CA153, CA199, and CEA levels were significantly improved in the patients treated with radiotherapy. The Bcl-2 and Bax levels in the PBMCs tended close to normal. Therefore, undergoing radiotherapy after TLS is markedly effective in prolonging patients' survival times and improving their prognoses.

Keywords: Thoracic and laparoscopic surgery, radiotherapy, esophageal cancer, immune function, prognosis

Introduction

Also known as carcinoma of the esophagus, esophageal cancer is a malignant tumor derived from the esophageal epithelium and a common malignant tumor of the digestive system. China is among the areas with a high incidence of the disease, and about 300,000 Chinese people die from it every year [1]. Esophageal cancer has unapparent early symptoms. Patients with the disease experience varying degrees of discomfort when swallowing rough and hard food, and the slow swallowing of food causes feelings of stagnation and foreign bodies, so a typical symptom of the disease is progressive dysphagia [2]. At present, the pathogenesis of esophageal cancer is not completely clear in clinical practice. Most studies find that its occurrence is related to tumor markers, including the Bax and Bcl-2 expressions in peripheral blood mononuclear cells (PBMCs) and the T lymphocyte subsets in the

peripheral blood [3]. Clinical studies have confirmed that thoracic and laparoscopic surgery (TLS) are effective esophageal cancer treatments, but most patients still experience a recurrence and metastasis of the disease after the surgery, so choosing effective postoperative adjuvant therapies is of great importance for inhibiting recurrence and metastasis [4]. After TLS, patients with esophageal cancer are usually treated with radiotherapy and chemotherapy as adjuvant therapies. Because chemotherapy has significant side effects and results in local reactions (allergy, hair loss, redness) and general reactions (anemia, weight loss, loss of appetite), patients undergoing chemotherapy need to be hospitalized for observation and treatment. Because radiotherapy can be used for the local treatment of tumors and because its duration is short, patients undergoing radiotherapy do not require hospitalization, hence, it has been widely used in clinical practice. After postoperative radiotherapy and chemotherapy, the quality of life and the tumor recurrence and metastasis rates of patients with esophageal cancer are not explored in this study, which therefore has limitations. The T lymphocyte subset levels in esophageal cancer patients are lower than they are in healthy people. Radiotherapy and chemotherapy cause an immune imbalance of T lymphocytes and inhibit immune functions, so patient prognosis can be improved by monitoring patients' cellular immune functions in clinical practice [5, 6]. In our study, we observed the effects of radiotherapy on treating patients with esophageal cancer after TLS, as well as on their survival rates, tumor markers, Bax and Bcl-2 expressions, and T lymphocyte subsets. The results are as follows.

Materials and methods

Research cohort

Altogether 118 patients with esophageal cancer admitted to The First Affiliated Hospital of Anhui Medical University from January 2014 to January 2015 were recruited as the study cohort and randomly divided into the postoperative radiotherapy group (59 cases) and the postoperative chemotherapy group (59 cases). The postoperative chemotherapy group consisted of 36 males and 23 females, who were ranged in age from 31 to 64 years old with an average age of (45.1±18.0) years. According to their pathological classifications, there were 29 patients with squamous cell carcinoma and 30 patients with adenocarcinoma in this group. According to TNM staging, there were 17 patients in stage I, 23 patients in stage II, and 19 patients in stage III in this group. The postoperative radiotherapy group consisted of 31 males and 28 females, who ranged in age from 36 to 62 years old with an average age of (46.6±14.6) years. According to their pathological classifications, there were 27 patients with squamous cell carcinoma and 32 patients with adenocarcinoma in this group. According to their TNM staging, there were 15 patients in stage I, 26 patients in stage II and 18 patients in stage III in this group. There were no statistically significant differences in the above data between the two groups ($P>0.05$). All the patients and their families were informed of this study and signed the consent forms. This study was approved by the Ethics Committee of The First Affiliated Hospital of Anhui Medical University.

Inclusion criteria: The patients in both groups met the diagnostic criteria of the *Guidelines for the Diagnosis and Treatment of Esophageal Cancer* [5], patients whose surgical sites were the thoracic and abdominal esophagus, patients who had undergone radical surgery for esophageal cancer using a thoracoscope and a laparoscope, patients without distant migration or obvious tumor invasion.

Exclusion criteria: Patients with surgical contraindications, patients with a distant migration of cancer cells, patients comorbid with other tumors, patients with severe pleural adhesions, and patients with hepatitis or autoimmune diseases.

Therapeutic methods

TLS was performed on the patients in both groups. The patients in the postoperative chemotherapy group underwent chemotherapy at 3 weeks after the surgery. Cisplatin and 5-fluorouracil (PF) were used: 100 mg/m^2 of Nedaplatin (Jiangsu Aosaikang Pharmaceutical Co., Ltd., China) on the first day and 1.0 g/m^2 of 5-fluorouracil (Tianjin Taihe Pharmaceutical Co., Ltd., China) on the first to the fifth days). The medication was repeated every 21-28 days (the chemotherapy interval in the postopera-

tive chemotherapy group during the concurrent radiotherapy was 28 days). The treatment was continued for 6 months.

The patients in the postoperative radiotherapy group underwent radiotherapy at 3 weeks after the surgery, through the irradiation of the anterior median vertical fields, the cross-fire irradiation of the left, right and posterior fields, the irradiation of the anterior-posterior fields, and the cross-fire irradiation of three posterior fields. The dosage was 60 Gy/30 times, and the maximum dose was ≤ 66 Gy/30 times, with an irradiation interval of 1 month. The radiotherapy treatment was continued for 6 months. During the treatment, outpatient follow-ups or out-of-hospital telephone follow-ups were conducted to determine the recurrence and metastasis of the esophageal cancer. If recurrence and metastasis occurred, targeted drugs were used for the treatment according to each patient's conditions.

Outcome measures

The main outcome measures consisted of the serum carcinoembryonic antigen (CEA), serum carbohydrate antigen 153 (CA153), and serum carbohydrate antigen 199 (CA199) levels, the T lymphocyte subset levels in the peripheral venous blood, the Bax and Bcl-2 expression in the PBMCs, and the clinical efficacy and postoperative survival status. The secondary outcome measure was the incidence of adverse reactions.

Main outcome measures: (1) Measuring the CEA, CA153, and CA199 levels. Before the treatment and at 6 months after the treatment, fasting venous blood (3 mL) was collected from the patients in both groups in the morning, and the serum was separated. The CEA, CA153, and CA199 levels were measured using the field of agglutination reaction using immunity transmission turbidity (Shanghai YuDuo Biology Science and Technology Co., Ltd., China). The measured proteins had wide ranges and high sensitivities. Antibody diluent (Wuhan ChunDu Biology Science and Technology Co., Ltd., China) was used to dilute the serum to the required concentration. Next, the diluted serum was stored in a refrigerator (4°C) for 1-2 weeks, and then stored in a freezer (-20°C) for 4-5 weeks. Finally, it was diluted to the required concentration with the reaction solution.

(2) The Bax and Bcl-2 expressions. Before the treatment and at 6 months after the treatment, anticoagulated peripheral venous blood (5 mL) was collected from the patients in both groups. After Hanks solution (Shanghai QiMing Biology Science and Technology Co., Ltd., China) was used for equal dilution, the PBMCs and whole-cell proteins were separated and extracted according to the kit's instructions for the cell separation and extraction (TianGen Biochemical Technology Co., Ltd., China). BCA was used to quantify the proteins. The protein (50 μg) was added into 2* SDS gel buffer (Shanghai Rongbai Biology Technology Co., Ltd., China), and heated to 100°C for 5 min, which was helpful for its denaturation. After the gel electrophoresis, the protein was transferred to the membrane, which was removed, fixed in 5% skimmed milk (Beijing Reanta Biology Technology Co., Ltd., China) at 4°C and sealed for 1 h. The primary antibodies were diluted with 0.05%-0.1% TBST (1:1000 for Bax and Bcl-2, 1:2000 for the internal reference GAPDH). The Bax antibody was purchased from Wuhan Yipu Biotechnology Co., Ltd., China. The Bcl-2 antibody was purchased from the Shanghai Caiyou Industry Co., Ltd, China. The GAPDH antibody was purchased from the Wuhan Fine Biotech Co., Ltd., China. After the dilution, the antibodies were incubated (4°C) overnight, and then the membrane was washed with 0.05%-0.1% TBST three times for five minutes each time. The secondary antibody was diluted with 0.05%-0.1% TBST (1:10000), and the incubation time with shaking was 1 hour. Once again, the membrane was washed with TBST three times for five minutes each time. DAB was used for the color development, and the protein expression levels were quantitatively analyzed, with GAPDH used as the internal reference.

(3) The T lymphocyte subset levels. The T lymphocyte subset levels were measured using a flow cytometer. Peripheral venous blood was collected from the patients before their treatment and at 6 months after the treatment. 100 μL of ED-TA anticoagulated peripheral venous blood was added into three test tubes, 600 μL of red blood cells were dissolved for 10 min, the blood was centrifuged at 1200 r/min for 5 min to remove the supernatant, 5 μL FITC anti-mouse CD3 antibody (BioLegend) was added into the first test tube, 5 μL FITC anti-mouse CD3 antibody + 10 μL PE anti-mouse CD4 anti-

Table 1. Comparison of the two groups' basic data ($\bar{x}$ ± sd)

Group	Postoperative chemotherapy group (n=59)	Postoperative radiotherapy group (n=59)	t/χ^2	P
Gender			0.863	0.353
Male	36	31		
Female	23	28		
Average age (years)	45.1±18.0	46.6±14.6	0.497	0.620
Pathological type (cases)			0.136	0.712
Squamous cell carcinoma	29	27		
Adenocarcinoma	30	32		
TNM staging			0.336	0.846
Stage I	17	15		
Stage II	23	26		
Stage III	19	18		

body (BioLegend) to the second test tube, and 5 μL FITC anti-mouse CD3 antibody + 10 μL PE anti-mouse CD8 antibody (BioLegend) to the third test tube. All of these test tubes were mixed well, incubated at room temperature for 15 min, washed with PBS, and then the samples were analyzed using a BD Accuri C6 flow cytometer.

(4) Evaluation of the clinical efficacy. At 2 months after the radiotherapy and chemotherapy, the clinical efficacy was classified into progression of the disease (PD), complete remission (CR), stable disease (SD), or partial remission (PR), according to *Response Evaluation Criteria in Solid Tumors* (RECIST). CR indicated that the patients' lumen stenosis recovered and their mucosa returned to normal, with smooth esophageal walls and the tumors completely disappeared. PR indicated that the lumen stenosis basically recovered and the smoothness of the esophageal wall edge was general, with the tumors basically disappeared. SD indicated that the lumen stenosis recovered but the smoothness was poor, with a reduced tumor volume. PD indicated that the patient's conditions did not meet the above criteria. Overall response rate (ORR) = (CR + PR) cases/total number of cases *100%.

(5) Postoperative survival status. By telephone or face-to-face follow-ups, all the patients were followed up for 7 years, once every 3 months, to record the occurence and progression of the diseases as well as their recovery and survival. The routine reexaminations included chest CT examinations, esophagoscopies (twice a year), routine blood tests, and examinations of the tumor markers related to esophageal cancer. The 1-, 3-, and 5-year survival rates of the patients were determined. The three rates of those who were lost to follow up and who quit halfway were also included in the postoperative survival status statistics.

Secondary outcome measures: The incidences of adverse reactions. Within 4 months after the radiotherapy or chemotherapy, the incidences of adverse reactions (radiation pneumonitis, radiation esophagitis, adverse reactions of the blood system) in all the patients were observed and compared.

Statistical processing

SPSS 20.0 was used for the data analysis and processing. The measurement data were expressed as the mean ± standard deviation ($\bar{x}$ ± sd) and compared between two groups using independent samples t tests, with the comparisons within groups before and after the treatment conducted using paired t tests. The count data were expressed as (%). χ^2 tests were used for the comparisons between groups, and U tests were used for the comparisons of the ranked data. Log-rank tests were used for the survival analyses. When $P< 0.05$, a difference was considered statistically significant.

Results

Comparison of the basic data

As shown in **Table 1**, there were no statistically significant differences in terms of gender, age, pathological classification, or TNM staging between the two groups ($P>0.05$).

Comparison of the tumor marker levels before and after the treatment

As shown in **Table 2**, before the treatment, there were no statistically significant differences in the tumor marker levels ($P>0.05$). After the treatment, the levels were lower than they

Table 2. Comparison of the tumor marker expression levels before and after the treatment ($\bar{x}$ ± sd)

Group	Postoperative chemotherapy group (n=59)	Postoperative radiotherapy group (n=59)	t	P
CA153 (U/mL)				
Before treatment	52.14±14.63	52.13±14.62	0.004	0.997
After treatment	27.69±2.46	22.52±1.08	14.780	0.001
t	12.660	15.510		
P	0.001	0.001		
CA199 (U/mL)				
Before treatment	215.46±64.23	215.45±64.21	0.001	1.000
After treatment	35.25±2.46	27.12±1.02	23.450	0.001
t	21.540	22.530		
P	0.001	0.001		
CEA (ng/mL)				
Before treatment	159.74±48.24	159.73±48.23	0.001	1.000
After treatment	8.24±1.09	6.24±0.58	12.440	0.001
t	24.120	24.440		
P	0.001	0.001		

Note: The normal value of CA153 is <22 U/mL. The normal value of CA199 is <37 U/mL. The normal value of CEA is <10 ng/mL. CA199: carbohydrate antigen 199; CA153: carbohydrate antigen 153; CEA: carcinoembryonic antigen.

Table 3. Comparison of the Bcl-2 and Bax protein expression levels in the peripheral blood mononuclear cells before and after the treatment ($\bar{x}$ ± sd)

Groups	Postoperative chemotherapy group (n=59)	Postoperative radiotherapy group (n=59)	t	P
Bcl-2				
Before treatment	1.52±0.32	1.59±0.33	1.170	0.245
After treatment	0.87±0.22	0.46±0.10	13.030	0.001
t	12.860	25.170		
P	0.001	0.001		
Bax				
Before treatment	0.62±0.10	0.63±0.11	0.517	0.606
After treatment	1.00±0.25	1.29±0.52	3.861	0.001
t	10.840	8.815		
P	0.001	0.001		

were before the treatment in both groups, and the levels in the postoperative radiotherapy group were lower than they were in the postoperative chemotherapy group (all P<0.001).

Comparison of the Bcl-2 and Bax expressions in the PBMCs before and after the treatment

As shown in **Table 3** and **Figure 1**, before the treatment, there were no statistically significant differences in the Bcl-2 and Bax expressions in the PBMCs between the two groups (P>0.05). After the treatment, the Bcl-2 expression was significantly lower than it was before the treatment, and the Bax expression was significantly higher than it was before the treatment; the Bcl-2 expression in the postoperative radiotherapy group was significantly lower than it was in the postoperative chemotherapy group, and the Bax expression was significantly higher in the postoperative radiotherapy group (P<0.001).

Comparison of the $CD4^+$, $CD8^+$ and $CD3^+$ levels before and after the treatment

As shown in **Table 4** and **Figure 2**, before the treatment, there were no statistically significant differences in the $CD4^+$, $CD8^+$ or $CD3^+$ levels between the two groups (P>0.05). After the treatment, the $CD4^+$ and $CD3^+$ levels were significantly lower than they were before the treatment, and the $CD8^+$ levels were significantly higher than they were before the treatment (P<0.001). After the treatment, there were no statistically significant differences in the levels of the three indicators between the two groups (P>0.05).

Comparison of the clinical efficacy

As shown in **Table 5** and **Figure 3**, the ORR in the postoperative radiotherapy group was significantly higher than it was in the postoperative chemotherapy group (P<0.05).

Comparison of the incidence of adverse reactions

As shown in **Table 6**, the total incidence of adverse reactions in the postoperative radiotherapy group was significantly higher than it was in the postoperative chemotherapy group (P<0.05).

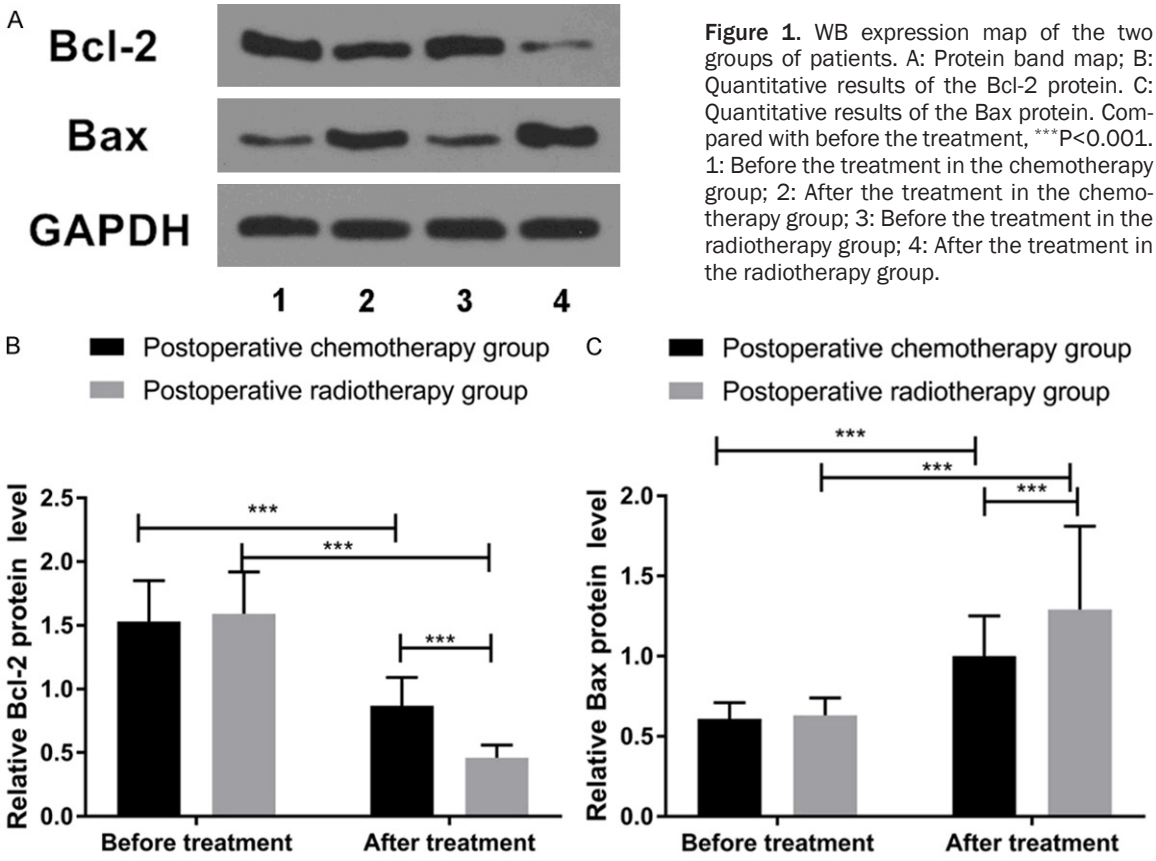

Figure 1. WB expression map of the two groups of patients. A: Protein band map; B: Quantitative results of the Bcl-2 protein. C: Quantitative results of the Bax protein. Compared with before the treatment, ***P<0.001. 1: Before the treatment in the chemotherapy group; 2: After the treatment in the chemotherapy group; 3: Before the treatment in the radiotherapy group; 4: After the treatment in the radiotherapy group.

Table 4. Comparison of the $CD4^+$, $CD8^+$, and $CD3^+$ levels before and after the treatment ($\bar{x} \pm sd$)

Groups	Postoperative chemotherapy group (n=59)	Postoperative radiotherapy group (n=59)	t	P
$CD4^+$ (%)				
Before treatment	34.72±4.37	34.71±4.36	0.012	0.990
After treatment	28.87±3.64	28.13±2.84	1.231	0.221
t	7.901	9.713		
P	0.001	0.001		
$CD8^+$ (%)				
Before treatment	31.72±3.73	31.69±3.71	0.044	0.965
After treatment	38.57±3.96	38.95±4.68	0.476	0.635
t	9.672	9.338		
P	0.001	0.001		
$CD3^+$ (%)				
Before treatment	61.87±7.35	61.86±7.34	0.007	0.994
After treatment	51.96±5.52	51.28±5.37	0.678	0.499
t	8.281	8.936		
P	0.001	0.001		

Comparison of the survival status

As shown in **Table 7** and **Figure 4**, the 1-, 3-, and 5-year survival rates of the patients in the postoperative radiotherapy group were significantly higher than the corresponding rates in the postoperative chemotherapy group (P< 0.05).

Discussion

Esophageal cancer, for which a typical symptom is progressive dysphagia, is a common tumor of the digestive tract, and patients with severe esophageal cancer can even have difficulty swallowing water and saliva. Also, this disease has a complex etiology, which may be related to eating habits, mycotoxin infection, and esophageal injuries [7-9]. As reported by Chen et al. in 2013, postoperative radiotherapy administered to esophageal cancer patients can improve their regional lymph node metastasis, prognoses, and survival rates [10]. A major method for treating malignant tumors, radiotherapy refers to a local therapeutic method for tumors by using α, β, and γ rays and various X rays (produced by radioactive isotopes) or X rays, proton

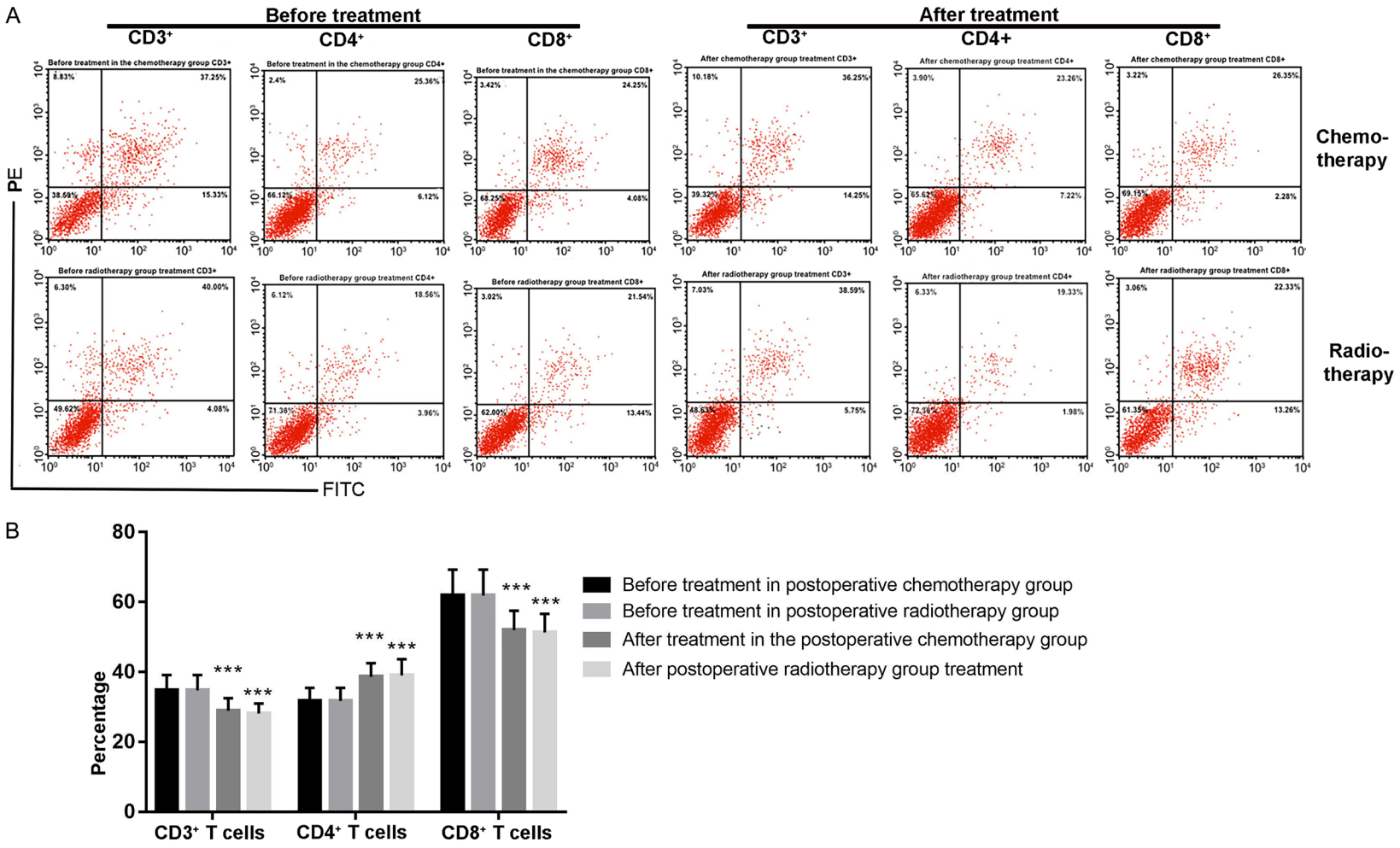

Figure 2. $CD4^+$, $CD8^+$, $CD3^+$ streaming analysis diagram. A: $CD4^+$, $CD8^+$ flow cytometry, $CD3^+$ T cell flow cytometry; B: Comparative histogram of the $CD4^+$, $CD8^+$ and $CD3^+$ levels. Compared with before the treatment, $^{***}P<0.001$.

Table 5. Comparison of the clinical efficacy of the two groups (n, %)

Group	CR	PR	SD	PD	Total effective rate
Postoperative chemotherapy group (n=59)	34 (57.63)	12 (20.34)	6 (10.17)	7 (11.86)	52 (88.14)
Postoperative radiotherapy group (n=59)	41 (69.49)	12 (20.34)	5 (8.47)	1 (1.70)	58 (98.31)
U/χ^2		10.840			4.827
P		0.029			0.028

Note: PD: progression of disease; CR: complete remission; SD: stable disease; PR: partial remission.

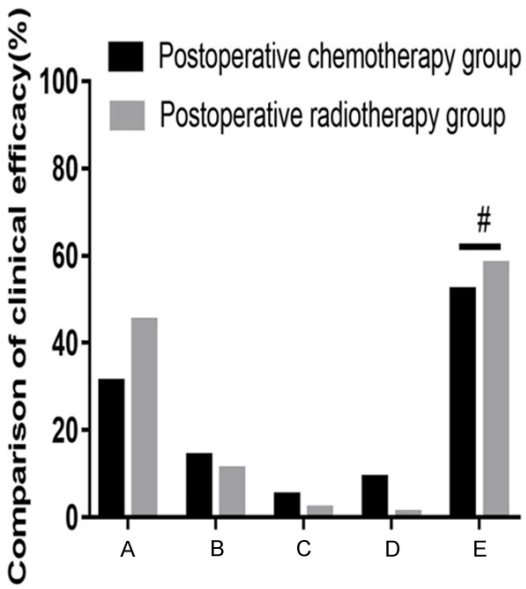

Figure 3. Comparison of the clinical efficacy of the two groups. A: Complete remission; B: Partial remission; C: Disease stability; D: Disease progression; E: Total effective rate. Compared with the postoperative chemotherapy group, #P<0.05.

beams, and electron rays (produced by accelerators) [11, 12]. According to Huang et al., postoperative radiotherapy can inhibit the growth of esophageal cancer cells, promote their apoptosis, and enhance the blocking effect on the G2 phase, as well as improve the radiosensitivity of the cells, so it has satisfactory therapeutic effects [13]. In this study, we mainly explored the changes in the patients' survival rates, supplemented by their tumor markers, their Bcl-2 and Bax expressions, and their $CD4^+$, $CD8^+$ and $CD3^+$ Levels. The results are as follows.

A result of complex evolution, abnormal differentiation, and excessive cell growth, the occurrence of esophageal cancer leads to the abnormal expression of some bioactive substances, and they can be used as the markers to detect this tumor. CA125, CA199, and CEA are three common tumor-related indicators. CA125 is a mucin-like glycoprotein; CA199 is a tumor-associated antigen circulating in the digestive tract and existing in the form of sialomucin; CEA is an acidic glycoprotein on the cell membrane [14, 15]. According to Xueqin and others, CA125 and CEA are highly expressed in the stomach, colon, and pancreas, and they exist in the digestive tract tissues of normal embryos and can be used as indicators for detecting digestive tract tumors [16]. This is consistent with the results of our study. According to Jin et al., the CA199 levels in the patients were lower after the treatment, which inhibits the differentiation and migration of the tumor genes and improves the patients' quality of life [17]. This is consistent with the results of our study. In our study, CA125, CA199, and CEA were highly expressed in the esophageal cancer tissues, and their levels were significantly reduced after the treatment. This suggests that radiotherapy after TLS can reduce the tumor marker levels. Therefore, the above indicators can be used to predict the prognoses of patients with esophageal cancer, inhibit the occurrence and development of this tumor, and improve the patients' survival rates.

As a basic member of the gene family regulating apoptosis, Bcl-2 can inhibit protein apoptosis, but Bax can promote the apoptosis. Anti- and pro-apoptotic proteins form homodimers or heterodimers to regulate apoptosis, and heterodimers can inhibit the apoptosis. Bcl-2 levels in normal esophageal cancer tissues are lower than those in cancer tissues, and the Bax levels are higher in normal esophageal cancer tissues. The regulatory effects of the two genes on the apoptosis of esophageal cancer cells are consistent [18]. T lymphocyte subsets can be used as an important index for judging the body's cellular immune functions. Their quantification helps to diagnose malignant tumors and analyze their pathogenesis and is of great importance for observing the treatment effica-

Table 6. Comparison of adverse reactions between the two groups (n, %)

Groups	Postoperative chemotherapy group (n=59)	Postoperative radiotherapy group (n=59)	χ^2	P
Radiation pneumonia	1 (1.69)	3 (5.08)	1.035	0.309
Radiation esophagitis	0 (0.00)	2 (3.39)	2.034	0.154
Blood system adverse reactions	1 (1.69)	4 (6.78)	1.880	0.170
Total adverse reaction rate	2 (3.39)	9 (15.25)	5.193	0.023

Table 7. Comparison of the survival conditions

Group	Survival rate (%)		
	1 year	3 years	5 years
Postoperative chemotherapy group (n=59)	47 (79.66)	37 (62.71)	28 (47.46)
Postoperative radiotherapy group (n=59)	55 (93.22)	47 (79.66)	39 (66.10)
χ^2	4.627	4.132	4.179
P	0.031	0.042	0.041

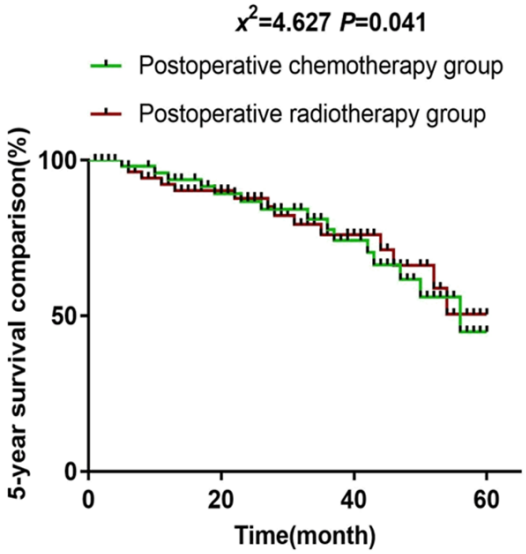

Figure 4. 5-year survival curve of the two groups of patients.

cy and monitoring patient prognosis. $CD4^+$, $CD8^+$ and $CD3^+$ are three common outcome measures. $CD8^+$ T lymphocytes are cytotoxic effector cells that can specifically kill target cells. $CD4^+$ is a type of leucocyte that eliminates and controls various infections. $CD3^+$ is a protein complex involved in the signal transduction of T cells [19]. Wang et al. found that radiotherapy for patients with esophageal cancer produces a kind of nociceptive stimulus, causes stress responses, and inhibits the immune functions of the body's cells in a short time period, thereby reducing the $CD3^+$ and $CD4^+$ levels and increasing the $CD8^+$ levels [20]. This is consistent with the results of our study. In this study, the down-regulation of Bax expression and the up-regulation of Bcl-2 expression reduced the apoptosis of PBMCs.

Esophageal cancer has extremely strong regional differences and invasiveness, which lead to a poor prognosis. Studies have shown that the 5-year survival rate of patients undergoing surgery is about 30% [21]. The survival rate of patients with the disease may be related to age, the types of tumor cells, tumor size, infiltration depth, TNM staging and other factors. In a study by Dilidar et al., all the patients underwent chemotherapy with 5-fluorouracil and cisplatin [22]. The control group patients underwent conventional radiotherapy, and the observation group patients underwent intensity-modulated radiotherapy. The results showed that the patients in the observation group had better efficacy during the menstrual period, a lower incidence of adverse reactions, and higher treatment safety. As reported by Zhou et al., compared with surgery alone, surgery combined with radiotherapy and chemotherapy can effectively reduce the risk of death and increase the patient survival rate [23]. In our study, compared with chemotherapy, radiotherapy after TLS effectively controlled the local lymph node metastasis and increased the patient survival rate.

In summary, for patients with esophageal cancer undergoing TLS, postoperative radiothera-

py can significantly reduce the bleeding volume and the postoperative hospitalization time, and it causes less intraoperative trauma. Moreover, it is markedly effective at regulating the serum CA153, CA199, and CEA levels and the Bcl-2 and Bax expressions, at improving the immune function and the patient prognosis, and at prolonging their survival time.

Disclosure of conflict of interest

None.

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