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The Efficacy of Whole-Course Local Simultaneous Integrated Boost Intensity-Modulated Radiotherapy in the Treatment of Locally Advanced Esophageal Cancer and Its Impact on Immune Function

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Abstract: *Objective:* To analyze the efficacy of whole-course local simultaneous integrated boost intensity-modulated radiotherapy (SIB-IMRT) on patients with locally advanced esophageal squamous cell carcinoma (ESCC). *Methods:* 88 patients with ESCC admitted to the hospital between October 2022 and October 2024 were selected and randomly divided into two groups using a random number table. The experimental group received SIB-IMRT treatment, while the control group received conventional intensity-modulated radiotherapy (C-IMRT). The objective remission rate, immune function, tumor markers, and adverse reaction rate were compared between the two groups. *Results:* The objective remission rate in the experimental group was higher than that in the control group ($P < 0.05$). Before treatment, there was no difference in immune function levels and tumor marker levels between the two groups ($P > 0.05$). After treatment, the immune function levels in the experimental group were better than those in the control group, and the tumor marker levels were lower than those in the control group ($P < 0.05$). The adverse reaction rate in the experimental group was lower than that in the control group ($P < 0.05$). *Conclusion:* SIB-IMRT can improve the objective remission rate of patients with ESCC, protect their immune function, down-regulate tumor marker levels, and prevent side effects after treatment.

Keywords: Whole-course local simultaneous integrated boost intensity-modulated radiotherapy; Locally advanced esophageal squamous cell carcinoma; Efficacy; Immune function

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1. Introduction

Esophageal cancer is a type of cancer with a high incidence rate, especially among male populations, and the

5-year survival rate after diagnosis is around 20% [1]. The disease often lacks typical symptoms in its early stages, has a strong concealment, and is mostly diagnosed in the locally advanced stage. The treatment of patients with ESCC is challenging and requires concurrent chemoradiotherapy to control target lesions and improve disease prognosis. Intensity-modulated radiotherapy is a commonly used treatment for this disease, which can accurately control the irradiation dose to the target area, effectively treat the disease while protecting surrounding healthy tissues, and thus reduce the harmfulness of radiotherapy. SIB-IMRT is a newer type of intensity-modulated radiotherapy technology that can simultaneously carry out prophylactic irradiation therapy and tumor boost therapy, thereby reducing the time required for radiotherapy, evenly distributing the irradiation dose to each target area, and improving the targeted treatment [2]. Furthermore, SIB-IMRT can reduce the negative impact of radiotherapy on patients' immune function, which is beneficial to improving their quality of life, making it a highly feasible treatment option. Based on this, the study selected 88 patients with ESCC to evaluate the impact of SIB-IMRT treatment on clinical efficacy and immune function.

2. Materials and methods

2.1. General information

A total of 88 patients with ESCC admitted to the hospital between October 2022 and October 2024 were selected and randomly divided into two groups using a random number table. The experimental group consisted of 44 patients, including 29 male patients and 15 female patients, with ages ranging from 36 to 78 years old and a mean age of (48.95 ± 5.17) years old. The tumor diameters ranged from 2.5 to 6.8 cm, with a mean diameter of (4.55 ± 0.78) cm. The tumor locations were as follows: 14 cases in the upper thoracic segment, 22 cases in the middle thoracic segment, and 8 cases in the lower thoracic segment. The control group also consisted of 44 patients, including 28 male patients and 16 female patients, with ages ranging from 34 to 79 years old and a mean age of (49.07 ± 5.28) years old. The tumor diameters ranged from 2.2 to 6.9 cm, with a mean diameter of (4.61 ± 0.80) cm. The tumor locations were as follows: 13 cases in the upper thoracic segment, 24 cases in the middle thoracic segment, and 7 cases in the lower thoracic segment. There was no significant difference between the two groups ($P > 0.05$).

The inclusion criteria were: Pathologically diagnosed with esophageal cancer, in the cT3-4N + M0 stage; tumor type is squamous cell carcinoma; normal communication ability; expected survival time is longer than half a year; basic information is relatively complete. The exclusion criteria included: presence of clear contraindications for intensity-modulated radiotherapy; abnormal organ function; acute or chronic infection; distant metastasis of the tumor; combined with other cancers; withdrawal in the middle of the treatment.

2.2. Methods

The chemotherapy methods for both groups were the same, using a combination of paclitaxel, cisplatin, and capecitabine (three-drug combination): paclitaxel injection was administered at a dose of 135 mg/m^2 via intravenous infusion on D1. Cisplatin for injection was administered at a dose of 20 mg/m^2 via intravenous infusion from D1 to D3. Capecitabine was administered orally at a daily dose of 2000 mg/m^2, divided into two administrations, from D1 to D14. One treatment course consisted of 21 days.

Both groups underwent radiotherapy using a linear accelerator, maintaining a supine position with a thermoplastic mask to fix the body position. CT scans were performed on the chest and entire neck area,

followed by three-dimensional reconstruction. The treatment target area was delineated based on the three-dimensional image, and the primary lesion and lymph node metastasis locations were determined. The clinical target volume (CTV) was defined as the above areas extended by 0.8–1.0 cm, and the planning target volume (PTV) was defined as the CTV extended by 0.5–0.8 cm. PTV1 was defined as the esophageal lymph node location, which was further extended by 0.5–1.0 cm based on the drainage area. The dose-volume limits for organs at risk were as follows: the lung V5 Gy should not exceed 60%, V20 Gy should not exceed 28%, and V30 Gy should not exceed 20%. The spinal cord Dmax should not exceed 45 Gy, the heart Dmean should not exceed 30 Gy, V30 should not exceed 40%, and V40 should not exceed 30%.

The control group received C-IMRT treatment: a single irradiation dose of 1.8-2.0 Gy was administered, first irradiating PTV and then PTV1. PTV was irradiated with 2 Gy per fraction, once per day, 5 times per week, for a total of 25 fractions. PTV1 was irradiated with 2 Gy per fraction, once per day, 5 times per week, for a total of 5 fractions. This constituted one treatment course.

The experimental group received SIB-IMRT treatment: PTV and PTV1 were irradiated simultaneously. PTV was irradiated with 1.8 Gy per fraction, once per day, 5 times per week, for a total of 30 fractions. PTV1 was irradiated with 2 Gy per fraction, once per day, 5 times per week, for a total of 30 fractions. This constituted one treatment course. The treatment cycle for both groups was one course.

2.3. Observation indices

(1) Immune function: Venous blood was collected in a fasting state with a blood volume of 5ml. Flow cytometry was used to evaluate the levels of CD^{3+}, CD^{4+}, and CD^{8+}, and the ratio of CD^{4+}/CD^{8+} was calculated.

(2) Tumor markers: After fasting blood collection, centrifugation was performed for 10 minutes at a speed of 3000r/min. The following indicators were evaluated using enzyme-linked immunosorbent assay (ELISA): (a) Carbohydrate antigen 125 (CA125); (b) Squamous cell carcinoma antigen (SCC); (c) Cytokeratin protein fragment 19 (CYFRA21-1); (d) Carcinoembryonic antigen (CEA).

(3) Adverse reaction rate: The incidence of radiation esophagitis, leukopenia, radiation pneumonia, upper gastrointestinal reactions, and neutropenia were observed.

2.4. Evaluation criteria for therapeutic effect

Complete remission (CR) refers to the disappearance of lesions without the appearance of new lesions; Partial remission (PR) refers to a reduction in the diameter of target lesions by more than 30% compared to the baseline value, without progression of non-target lesions or the appearance of new lesions; Stable disease (SD) refers to a reduction in the diameter of target lesions by 20–30% compared to the baseline value, without progression of non-target lesions or the appearance of new lesions; Progressive disease (PD) refers to a reduction in the diameter of target lesions by less than 20% compared to the baseline value, progression of non-target lesions, or the discovery of new lesions. Objective remission rate = CR% + PR%.

2.5. Statistical analysis

Data processing was performed using SPSS 28.0 software. Measurement data were expressed as mean ± standard deviation (± s), and comparisons between groups were made using t-tests. Count data were expressed as frequencies and percentages (n/%), and comparisons between groups were made using chi-square (x^2) tests.

Statistical significance was set at $P < 0.05$.

3. Results

3.1. Comparison of objective remission rates between the two groups

The objective remission rate in the experimental group was higher than that in the control group ($P < 0.05$).

Table 1. Comparison of objective remission rates between the two groups (n/%)

Grouping	CR	PR	SD	PD	Objective remission rate
Experimental group(n=44)	14(31.82)	23(52.27)	5(11.36)	2(4.55)	84.09(37/44)
Reference group(n=44)	17(38.64)	11(25.00)	11(25.00)	5(11.36)	63.64(28/44)
x^2	-	-	-	-	4.768
P	-	-	-	-	0.029

3.2. Comparison of immune function between the two groups

Before treatment, there was no difference in immune function levels between the two groups ($P > 0.05$). After treatment, the immune function level in the experimental group was better than that in the control group ($P < 0.05$).

Table 2. Comparison of immune function between the two groups (±s)

Grouping	CD^{3+}(%)		CD^{4+}(%)	
	Before treatment	After treatment	Before treatment	After treatment
Experimental group(n = 44)	60.15 ± 5.94	55.34 ± 4.82	34.18 ± 3.64	30.11 ± 3.15
Reference group(n = 44)	60.72 ± 5.88	50.46 ± 4.76	34.23 ± 3.67	27.12 ± 3.10
t	0.452	4.778	0.064	4.488
P	0.652	＜ 0.001	0.949	＜ 0.001

Grouping	CD^{8+}(%)		CD^{4+}/CD^{8+}	
	Before treatment	After treatment	Before treatment	After treatment
Experimental group(n = 44)	24.86 ± 3.43	30.11 ± 3.89	1.38 ± 0.44	0.99 ± 0.13
Reference group(n = 44)	24.90 ± 3.46	33.95 ± 3.71	1.40 ± 0.48	0.84 ± 0.11
t	0.054	4.738	0.204	5.843
P	0.957	＜ 0.001	0.839	＜ 0.001

3.3. Comparison of tumor markers between the two groups

Before treatment, there was no difference in tumor marker levels between the two groups ($P > 0.05$). After treatment, the tumor marker levels in the experimental group were lower than those in the control group ($P < 0.05$).

Table 3. Comparison of tumor markers between the two groups (±s)

Grouping	CA125(ng/ml)		SCC(ng/ml)	
	Before treatment	After treatment	Before treatment	After treatment
Experimental group(n = 44)	78.21 ± 9.32	23.17 ± 3.60	78.21 ± 9.32	23.17 ± 3.60
Reference group(n = 44)	78.18 ± 9.24	29.43 ± 3.99	78.18 ± 9.24	29.43 ± 3.99
t	0.015	7.727	0.015	7.727
P	0.988	＜ 0.001	0.988	＜ 0.001
Grouping	**CYFRA21-1(ng/ml)**		**CEA(μg/L)**	
	Before treatment	**After treatment**	**Before treatment**	**After treatment**
Experimental group(n = 44)	2.79 ± 0.38	1.82 ± 0.47	2.79±0.38	1.82 ± 0.47
Reference group(n = 44)	2.81 ± 0.42	2.25 ± 0.53	2.81±0.42	2.25 ± 0.53
t	0.234	4.027	0.234	4.027
P	0.815	＜ 0.001	0.815	＜ 0.001

3.4. Comparison of adverse reaction rates between the two groups

The adverse reaction rate in the experimental group was lower than that in the control group ($P < 0.05$).

Table 4. Comparison of adverse reaction rates between the two groups (n/%)

Grouping	Radiation esophagitis	Leukopenia	Radiation pneumonitis	Upper gastrointestinal reaction	Neutropenia	Incidence
Experimental group (n = 44)	3(6.82)	1(2.27)	0	1(2.27)	0	11.36(5/44)
Reference group(n = 44)	10(22.73)	2(4.55)	2(4.55)	2(4.55)	1(2.27)	38.64(17/44)
x^2	-	-	-	-	-	8.727
P	-	-	-	-	-	0.003

4. Discussion

Esophageal cancer is a highly malignant disease with no radical treatment available. The clinical control of local tumors is challenging and requires systematic treatment. ESCC refers to the advanced stage of esophageal cancer, where the lesion range is large, and the long-term efficacy of surgical resection is generally poor. Therefore, concurrent chemoradiotherapy is often adopted [3, 4]. Intensity-modulated radiotherapy (IMRT) is a new treatment approach in radiation oncology. Compared with conventional radiotherapy, IMRT can protect healthy tissues and organs, has strong conformality, can increase the irradiation dose to the target lesion area, and reduce damage to surrounding tissues and organs. This can improve the local tumor control rate and prognosis of esophageal cancer [5].

C-IMRT is a commonly used IMRT method for ESCC, which requires irradiating the planning target volume (PTV) first and then the PTV1, which can easily lead to cancer cell residual and a high disease recurrence rate. SIB-IMRT can compensate for the deficiencies of the above therapy. It simultaneously carries out irradiation treatment operations for PTV and PTV1, and can reasonably divide the irradiation dose, ending

the treatment operations of the two target areas at the same time [6].

The results showed that the objective remission rate of the experimental group was higher than that of the reference group ($P < 0.05$). The results are consistent with the findings of Guo *et al.* [7]. The specific analysis reasons are as follows: SIB-IMRT has the advantages of precise and effective treatment, which can reasonably distribute the irradiation dose of the planning target area and achieve simultaneous treatment of the two target areas with different doses. This can inhibit the proliferation process of tumor cells, promote the absorption of target lesions, and prevent the formation of new lesions [8, 9]. In addition, SIB-IMRT can take the target lesion as the center point of radiation therapy, thereby solving the inherent contradiction between large-area target lesions and dose increase amplitude. It can increase the radiation dose of target lesions on the basis of the same radiotherapy time, thus improving treatment effectiveness [10].

T lymphocyte subsets can maintain existing immune function and block the massive proliferation of tumor cells [8]. Intensity-modulated radiotherapy can inevitably cause body damage, thereby reducing immune function [11]. In this study, the immune function level of the experimental group after treatment was better than that of the reference group ($P < 0.05$). The specific analysis reason is that SIB-IMRT can precisely control the irradiation time of each planning target area during treatment, with less interference to healthy tissues and organs, reducing the irradiation dose in this area, and thereby reducing the damage of radiotherapy to the immune system [12].

The disease progression of ESCC is related to a variety of tumor markers, that is, as the lesion increases, the level of tumor markers will increase accordingly, and there is a positive correlation between the two [13]. In this study, the level of tumor markers in the experimental group after treatment was lower than that in the reference group ($P < 0.05$). The specific analysis reason is that SIB-IMRT has a higher number of irradiations, which can efficiently kill cancer cells in the planned target area and prevent their continued growth and proliferation, thus down-regulating the level of tumor markers. In addition, the adverse reaction rate of the experimental group was lower than that of the reference group ($P < 0.05$). The specific reason for the analysis is that the irradiation dose of SIB-IMRT is more accurate, which can reduce the toxic and side effects of intensity-modulated radiotherapy, maximize treatment safety, and prevent a variety of adverse reactions [14, 15].

5. Conclusion

In summary, SIB-IMRT has a good therapeutic effect on ESCC, which can improve patients' objective remission rate, immune function, and tumor marker levels. It can actively prevent adverse reactions after treatment and has high therapeutic value. Therefore, it can be used as a common treatment method for patients with this disease.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Du F, Wang G, Wei Z, 2022, Clinical Study on Concurrent Chemotherapy with Intensity-Modulated Radiotherapy and S-1 or Capecitabine in the Treatment of Advanced Esophageal Cancer in Middle-Aged and Elderly Patients.

Chinese Journal of Medicine, 57(4): 389–392.

[2] Fu S, Jin W, Yu D, 2024, The Effect of Simultaneous Integrated Boost Intensity-Modulated Radiotherapy on Patients with Locally Advanced Esophageal Cancer. Chinese and Foreign Medical Research, 22(1): 117–120.

[3] Zhang W, Ren L, Jiang C, et al., 2023, The Effect of Simultaneous Integrated Boost Intensity-Modulated Radiotherapy on Locally Advanced Esophageal Cancer and Its Impact on 3-Year Survival Rate. Clinical Misdiagnosis and Mistherapy, 36(1): 41–44.

[4] Cao S, Zhang R, 2024, Effects of CT Simulation-Guided Three-Dimensional Conformal Intensity-Modulated Radiotherapy on Serum Tumor Markers and Quality of Life in Patients with Advanced Esophageal Cancer. Modern Medical Imaging, 33(1): 29–32.

[5] Wang Y, 2024, Effects of Concurrent Chemotherapy and Intensity-Modulated Radiotherapy on Serum Tumor Marker Levels and Quality of Life in Patients with Advanced Esophageal Cancer. Reflexotherapy and Rehabilitation Medicine, 5(9): 149–151, 159.

[6] Yang Y, Shao Y, Ma Z, et al., 2023, Effects of Intensity-Modulated Radiotherapy Combined with Chemotherapy on Imaging Findings and Quality of Life in Patients with Advanced Esophageal Cancer. Modern Medicine and Health Research (Electronic Edition), 7(8): 40–42.

[7] Guo Q, Guo R, Li S, 2024, Efficacy of Simultaneous Integrated Boost Intensity-Modulated Radiotherapy in the Treatment of Locally Advanced Esophageal Cancer and Its Impact on Immune Function. Jilin Medical Journal, 45(11): 2703–2706.

[8] Zhao Y, 2021, Clinical Application of Intensity-Modulated Radiotherapy Combined with Chemotherapy in the Treatment of Locally Advanced Non-Surgical Esophageal Cancer. Inner Mongolia Medical Journal, 53(7): 784–786.

[9] Yu X, 2021, Clinical Study of Intensity-Modulated Radiotherapy Combined with Cisplatin and Paclitaxel Double-Drug Concurrent Chemotherapy in the Treatment of Locally Advanced Esophageal Cancer. Clinical Medicine, 41(1): 52–54.

[10] Lan K, Guo R, Chen J, et al., 2024, Study on the Value of Endoscopic Titanium Clip Marking in Delineating the Target Volume During Radical Intensity-Modulated Radiotherapy for Patients with Unresectable Locally Advanced Esophageal Cancer. Chinese Journal of Medicinal Guide, 26(8): 808–813.

[11] Xu X, Xing Y, Zhang L, et al., 2024, Effect of Micro-Adjustment Balance Prescription No.3 on the Efficacy of Intensity-Modulated Radiotherapy for Esophageal Cancer Patients. Naval Medical Journal, 45(6): 624–628.

[12] Tai G, Wang G, Cui X, et al., 2024, Evaluation of the Efficacy of Simultaneous Integrated Boost Intensity-Modulated Radiotherapy and Sequential Radiotherapy in Cervical and Upper Thoracic Esophageal Cancer. Chinese Journal of Biomedical Engineering, 30(2): 130–134.

[13] Wang H, Guo F, Che Y, et al., 2024, Study on the Deviation Between the Center of the Intensity-Modulated Radiotherapy Plan and the Center of the Target Volume in Esophageal Cancer. China Medical Equipment, 39(11): 44–50.

[14] Shui M, Ye D, Wen J, et al., 2023, Effect and CT Findings of Intensity-Modulated Radiotherapy Combined with Chemotherapy in the Treatment of Esophageal Cancer. Journal of Molecular Imaging, 46(1): 83–87.

[15] Guo N, Wang W, Wang Y, et al., 2022, The Impact of Simultaneous Integrated Boost Intensity-Modulated Radiotherapy on the Long-Term Prognosis of Patients with Cervical and Upper Thoracic Esophageal Cancer. Chinese Journal of Radiology and Protection, 42(1): 32–39.