


Predictive Modeling of Clinical Efficacy for ^{125}I Brachytherapy in Head and Neck Tumors Using Lasso-Logistic Regression

Yun Liu¹, Lai Xu², Yakun Fang², Chao Yan³ 

¹Department of Nephrology, Qilu Hospital (Qingdao), Cheeloo College of Medicine, Shandong University, Qingdao, 266035, People's Republic of China; ²Department of Obstetrics, Qingdao Municipal Hospital, Qingdao, 266071, People's Republic of China; ³Department of Radiation Oncology, Qilu Hospital (Qingdao), Cheeloo College of Medicine, Shandong University, Qingdao, 266035, People's Republic of China

Correspondence: Chao Yan, Department of Emergency, Qilu Hospital (Qingdao), Cheeloo College of Medicine, Shandong University, No. 758 Hefei Road, Shibei District, Qingdao City, Shandong Province, 266035, People's Republic of China, Tel +86 0532 88735360, Email yc028979@qlyyqd.com

Background: In view of the differences in the clinical efficacy of ^{125}I radioactive particle brachytherapy for head and neck tumors, this study aims to systematically analyze the key factors affecting its efficacy, and build a reliable prediction model to provide a scientific basis for clinical precise evaluation and personalized treatment plan formulation.

Methods: Retrospective analysis of 174 patients (2020–2024) divided into training (n=122) and validation (n=52) sets. Efficacy was assessed using RECIST criteria. Lasso Logistic regression identified independent factors, and a nomogram model was constructed and evaluated.

Results: The study confirmed that patients' age, tumor stage, tumor diameter, particle implantation dose and serum tumor marker level were independent factors affecting the clinical efficacy ($P < 0.05$). The nomogram prediction model has excellent performance, and the c-index values in the training set and the validation set are 0.867 and 0.725, respectively, showing good discrimination ability; The results of calibration curve showed that the predicted value was in good agreement with the actual value, and the average absolute errors of the two groups were 0.114 and 0.133, respectively; In Hosmer lemeshow test, the training set $\chi^2=7.422$ ($P=0.491$), the validation set $\chi^2=12.086$ ($P=0.147$), suggesting that the model fitting effect is ideal; The area under the ROC curve in the training set and the validation set was 0.860 (95% CI:0.767–0.953) and 0.750 (95% CI:0.501–0.999), respectively, which showed high sensitivity and specificity.

Conclusion: The model effectively predicts ^{125}I brachytherapy outcomes, aiding clinical evaluation and supporting precision treatment for head and neck tumors.

Keywords: brachytherapy, head and neck tumors, influencing factor, ^{125}I radioactive particles, lasso-logistic regression, prediction models

Introduction

Head and neck tumor is a common malignant tumor, which seriously threatens the life, health and quality of life of patients. As a local treatment, brachytherapy with ^{125}I radioactive particles has been widely used in the treatment of head and neck tumors due to its advantages of continuous release of low dose radiation in the tumor tissue and little damage to the surrounding normal tissues.¹ However, clinical practice has found that there are significant differences in the efficacy of this treatment among different patients. In some patients, the tumor is effectively controlled, and the symptoms are obviously relieved; In other patients, the treatment effect is poor and tumor progression even occurs. To deeply explore the factors affecting the clinical efficacy of brachytherapy with ^{125}I -radioactive particles for head and neck tumors and construct an accurate prediction model are of great significance for guiding clinical treatment decisions and improving treatment effects.² At present, ^{125}I radioactive particles brachytherapy has become an important means of head and neck cancer, but the existing efficacy prediction models are mostly built based on single center data. Such single center models are limited by the single source of samples, the differences in patients' baseline characteristics, the heterogeneity of treatment options, the imbalance of regional medical resources and other issues, resulting in insufficient applicability and

generalization ability in different clinical environments. The model is prone to prediction bias when applied, which is difficult to meet the needs of precision treatment in a multicenter clinical scenario. The traditional single factor analysis method is difficult to fully consider the complex interaction between multiple factors, which easily leads to the result deviation. Lasso-Logistic regression analysis can screen out the key variables among many potential influencing factors, effectively avoid the multicollinearity problem and improve the accuracy and stability of the model.³ Constructing Nomogram prediction model based on the screened independent influencing factors can convert complex statistical results into intuitive and visual nomograms, which is convenient for clinicians to quickly assess the risks of treatment efficacy of patients and provides strong support for formulating individual treatment plans.^{4,5} Previous studies have shown that nomogram model has shown good prediction performance in prostate cancer, breast cancer and other fields. For example, in the prediction of biochemical recurrence after radical prostatectomy, the c-index of nomogram model reached 0.82, significantly improving the accuracy of clinical decision-making; In the selection of adjuvant treatment for breast cancer, the calibration curve is highly consistent with the actual survival data, providing a quantitative basis for individualized treatment.

The purpose of this study was to systematically explore the factors affecting the clinical efficacy of brachytherapy with ¹²⁵I radioactive particles for head and neck tumors by using Lasso-Logistic regression analysis, and to construct and verify a prediction model with clinical practical value, so as to provide the basis for optimizing clinical treatment strategies.

Population and Methods

Study Population

The clinical data of 174 patients with head and neck tumors who received brachytherapy with ¹²⁵I radioactive particles in our hospital from January 2020 to January 2024 were retrospectively analyzed. Inclusion criteria: (1) Head and neck tumor confirmed by histopathology or cytology; (2) I radioactive particle brachytherapy is received, and the particle implantation operation meets the relevant specifications; (3) No other anti-tumor treatments that may affect the efficacy evaluation of this treatment have been received before the treatment, such as radical radiotherapy and chemotherapy; (4) Complete follow-up data are available after treatment, with the follow-up period of not less than 6 months; (5) The patient signed informed consent and voluntarily participated in this study. Exclusion criteria: (1) Patients who were accompanied with severe dysfunction of heart, liver, kidney and other important organs, and could not tolerate surgery and radioactive particle implantation treatment; (2) There is distant metastasis, and metastasis is the main focus of treatment; (3) Severe complications occur during the treatment, resulting in the interruption of treatment or failure to complete as planned; (4) Clinical data are seriously missing for accurate efficacy evaluation. This study was approved by the Hospital Ethics Committee.

General Demographic Information

Information such as the age, gender, body mass index (BMI), smoking history, alcohol consumption history, and physical status score (ECOG score)⁶ of the patients were collected. ECOG score: 0 point, the activity was completely normal, without any difference from the activity before the onset; 1 point, being able to move freely and engage in light physical activities, including general housework or office work, but not engaged in heavier physical activities; 2 points, can move around freely and take care of themselves, but has lost the ability to work, not less than half of the time can get up during the day; 3 points, life can only take care of themselves, more than half of the time in bed or in a wheelchair during the day; 4 points, bedridden, unable to take care of themselves; 5 points, death.

Disease-Related Information

Information such as pathological type of the tumor (such as squamous cell carcinoma and adenocarcinoma), TNM staging (according to TNM staging standard established by union for international cancer control (UICC)),⁷ primary site of the tumor (oral cavity, nasal cavity, pharynx and larynx), and tumor diameter were recorded. Serum tumor marker

levels including carcinoembryonic antigen (CEA), squamous cell carcinoma antigen (SCCA), and carbohydrate antigen 125(CA125) were collected before treatment.

Treatment-Related Parameters

Relevant parameters of I radioactive particle implantation were recorded in detail, including particle implantation dose (calculated and determined according to tumor volume and peripheral dose requirements), particle activity, implantation mode (template-guided implantation, ultrasonic-guided implantation, CT-guided implantation, etc), number of implantation needles, and particle distribution uniformity.

Efficacy Evaluation Criteria

The efficacy of patients after treatment was evaluated according to the RECIST)1.1 version 1.1.⁸ Complete remission (CR): all target lesions disappeared, no new lesions appeared, and the tumor markers returned to normal and maintained for at least 4 weeks; Partial response (PR): the sum of the longest diameters of the target lesions is reduced by more than or equal to 30% compared with that before treatment, and the disease is maintained for at least 4 weeks; Stable disease (SD): the sum of the longest diameters of the target lesions decreases by less than 30%, or increases by less than 20%; Disease progression (PD): the sum of the longest diameters of the target lesions increases by $\geq 20\%$ compared with that before treatment, or new lesions appear. CR and PR were defined as being therapeutically effective, while SD and PD were defined as not being effective.

Statistical Analysis

SPSS26.0 and R 4.2.0 were used for data analysis. The measurement data were expressed by $\bar{x}\pm s$, and the comparison between the two groups was made by independent sample *T* test. If the data does not meet the normal distribution, Mann–Whitney *U*-test is used. Counting data were expressed by the number of cases and percentage (%), and the comparison between groups was made by χ^2 test or Fisher exact test. Lasso regression was used to screen variables, and the selected variables were used as independent variables, and whether the treatment was effective (effective=1, ineffective=0) was used as dependent variables. Multivariate Logistic regression analysis was carried out to construct Nomogram prediction model. Bootstrap method (repeated sampling for 1000 times) was used for internal verification. The curve of receiver's operating characteristics (ROC) was drawn to calculate the area under the curve (AUC) to evaluate the prediction efficiency of the model, and the calibration curve was drawn to evaluate the consistency between the predicted value and the actual value of the model. Hosmer-Lemeshow test was used to evaluate the goodness of fit of the model. $P < 0.05$ was statistically significant.

Results

Comparison of Baseline Data and Treatment Efficacy Between Training Set and Validation Set

Training centralized treatment was effective in 95 cases (77.87%), and validation centralized treatment was effective in 41 cases (78.85%). There was no statistically significant difference ($P > 0.05$) in the treatment effectiveness and clinical characteristics between the training set and the validation set, as shown in [Table 1](#).

Comparison of Baseline Data Between Effective Group and Ineffective Group

Among the 122 patients, 95 cases were treated effectively, with the effective rate of 77.87%, and 27 cases were treated ineffectively. There were significant differences in age, tumor stage, tumor diameter, particle implantation dose, serum CEA, SCCA, and CA125 levels between the effective group and the ineffective group ($P < 0.05$), as shown in [Table 2](#).

Lasso Regression Analysis Results

Variable screening was performed using Lasso regression. After 50-fold cross-validation, seven potential influencing factors were finally screened, namely, age, tumor stage, tumor diameter, particle implantation dose, serum CEA, SCCA and CA125 levels. The specific results are shown in [Figures 1 and 2](#).

Table 1 Comparison of Baseline Data Between Training and Validation Sets

Variable		Training Set (n=122)	Validation Set (n=52)	χ^2/t	P
Age (Years)		55.62±6.35	56.14±6.58	0.489	0.625
BMI (kg/m ²)		22.65±2.31	22.48±2.29	0.445	0.656
Gender	Male	71 (58.20)	26 (50.00)	0.993	0.319
	Female	51 (41.80)	26 (50.00)		
Smoking history	Yes	45 (36.89)	19 (36.54)	0.001	0.965
	No	77 (63.11)	33 (63.46)		
Drinking history	Yes	34 (27.87)	14 (26.92)	0.016	0.898
	No	88 (72.13)	38 (73.08)		
ECOG score	2–4 points	36 (29.51)	18 (34.62)	0.444	0.505
	0–1 point	86 (70.49)	34 (65.38)		
Pathological type	Squamous cell carcinoma	47 (38.52)	20 (38.46)	0.021	0.989
	Glandular cancer	41 (33.61)	17 (32.69)		
	Other	34 (27.87)	15 (28.85)		
Tumor staging	Stage III, IV	55 (45.08)	24 (46.15)	0.017	0.896
	Stages I, II	67 (54.92)	28 (53.85)		
Primary site of tumor	Oral cavity	28 (22.95)	10 (19.23)	0.735	0.947
	Nasal cavity	18 (14.75)	10 (19.23)		
	Swallow	31 (25.41)	13 (25.00)		
	Throat	25 (20.49)	10 (19.23)		
	Other	20 (16.39)	9 (17.31)		
Tumor diameter (cm)		3.45±1.12	3.52±1.15	0.374	0.708
Particle implantation dose (mCi)		59.86±9.82	60.14±10.23	0.170	0.865
Implantation method	Template guidance	39 (31.97)	17 (32.69)	0.029	0.985
	Ultrasonic guidance	32 (26.23)	13 (25.00)		
	CT guidance	51 (41.80)	22 (42.31)		
Combination therapy	Yes	39 (31.97)	16 (30.77)	0.024	0.876
	No	83 (68.03)	36 (69.23)		
CEA (ng/mL)		7.13±2.80	7.22±2.76	0.194	0.845
SCCA (ng/mL)		2.02±0.71	1.95±0.74	0.587	0.557
CA125 (U/mL)		38.37±11.46	37.48±11.63	0.466	0.641

Logistic Regression Analysis of Clinical Efficacy

The variables screened out by Lasso regression were used as independent variables, and treatment effectiveness was used as dependent variable. Multi-factor Logistic regression analysis was performed (Table 3). The results showed that age, tumor stage, tumor diameter, particle implantation dose, and serum CEA, SCCA, and CA125 levels were the independent factors affecting the clinical efficacy of brachytherapy with ¹²⁵I-radioactive particles for head and neck tumors ($P < 0.05$), as shown in Table 4.

Construction of Nomogram Prediction Model

The Nomogram prediction model constructed based on the Lasso regression screening results is shown in Figure 3. In the model, each risk factor corresponded to a different score range. By adding the scores corresponding to each factor of patients, the corresponding treatment effective probability could be found on the total score axis.

**Table 2** Comparison of Baseline Data of Valid Group and Invalid Group

Variable		Ineffective group (n=27)	Effective group (n=95)	χ^2/t	P
Age (years)		57.59±6.48	54.23±6.03	2.513	0.013
BMI (kg/m ²)		22.51±2.45	22.74±2.16	0.473	0.636
Gender	Male	16 (59.26)	55 (57.89)	0.016	0.899
	Female	11 (40.74)	40 (42.11)		
Smoking history	Yes	10 (37.04)	35 (36.84)	0.001	0.986
	No	17 (62.96)	60 (63.16)		
Drinking history	Yes	8 (29.63)	26 (27.37)	0.053	0.817
	No	19 (70.37)	69 (72.63)		
ECOG score	2–4 points	12 (44.44)	24 (24.26)	3.718	0.053
	0–1 point	15 (55.56)	71 (74.74)		
Pathological type	Squamous cell carcinoma	9 (33.33)	38 (40.00)	4.998	0.082
	Glandular cancer	6 (22.22)	35 (36.84)		
	Other	12 (44.44)	22 (23.16)		
Tumor staging	Stage III, IV	18 (66.67)	37 (38.95)	6.524	0.010
	Stages I, II	9 (33.33)	58 (61.05)		
Primary site of tumor	Oral cavity	6 (22.22)	22 (23.16)	0.173	0.996
	Nasal cavity	4 (14.81)	14 (14.74)		
	Swallow	7 (25.93)	24 (25.26)		
	Throat	5 (18.52)	20 (21.05)		
	Other	5 (18.52)	15 (15.79)		
Tumor diameter (cm)		3.84±1.20	3.22±1.03	2.659	0.008
Particle implantation dose (mCi)		56.36±8.16	61.52±10.54	2.349	0.020
Implantation method	Template guidance	8 (29.63)	31 (32.63)	0.118	0.942
	Ultrasonic guidance	7 (25.93)	25 (26.32)		
	CT guidance	12 (44.44)	39 (41.05)		
Combination therapy	Yes	12 (44.44)	27 (28.42)	2.482	0.115
	No	15 (55.56)	68 (71.58)		
CEA (ng/mL)		8.36±3.11	6.94±2.06	2.796	0.006
SCCA (ng/mL)		2.25±0.95	1.85±0.64	2.552	0.012
CA125 (U/mL)		41.37±14.68	35.57±10.59	2.292	0.023

Evaluation and Verification of Nomogram Column Line Prediction Model

In the training set and validation set, the C-index of the nomogram model was 0.867 and 0.725, respectively, indicating that the model had good discrimination. It is worth noting that factors such as advanced tumor stage (OR=3.135), larger tumor diameter (OR=1.656), and older age (OR=1.098) are associated with reduced treatment effectiveness. A higher OR value for these variables indicates an increased risk of ineffective response. The calibration curve showed good agreement between the predicted and actual values with mean absolute errors of 0.114 and 0.133 for the active and inactive groups, respectively. The results of Hosmer-Lemeshow test showed that the training set $\chi^2=7.422$, and $P=0.491$; The validation set $\chi^2=12.086$, $P=0.147$, suggesting that the model fitting degree was good. The areas under the ROC curves in the training set and validation set were 0.860 (95% CI: 0.767–0.953) and 0.750 (95% CI: 0.501–0.999) respectively, the sensitivities were 0.842 and 0.806, and the specificities were 0.750 and 0.821, respectively, demonstrating that the model had good predictive value in both groups. The calibration curve and ROC curve are shown in Figures 4 and 5, respectively.

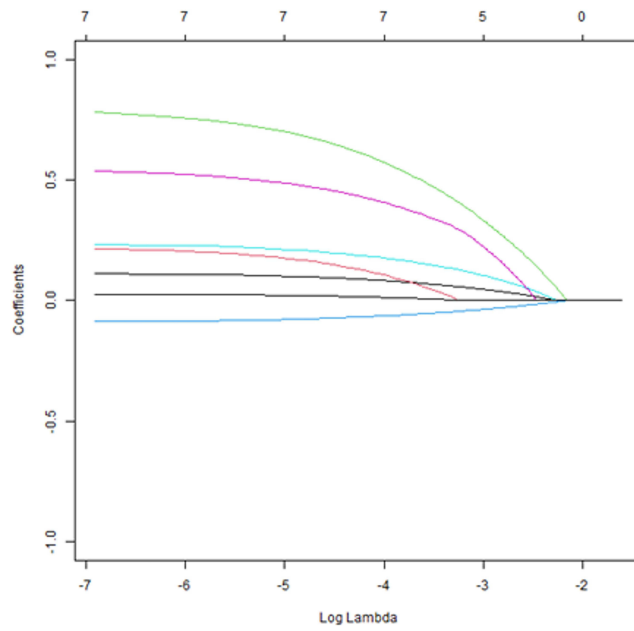


Figure 1 Path of Lasso regression coefficient.

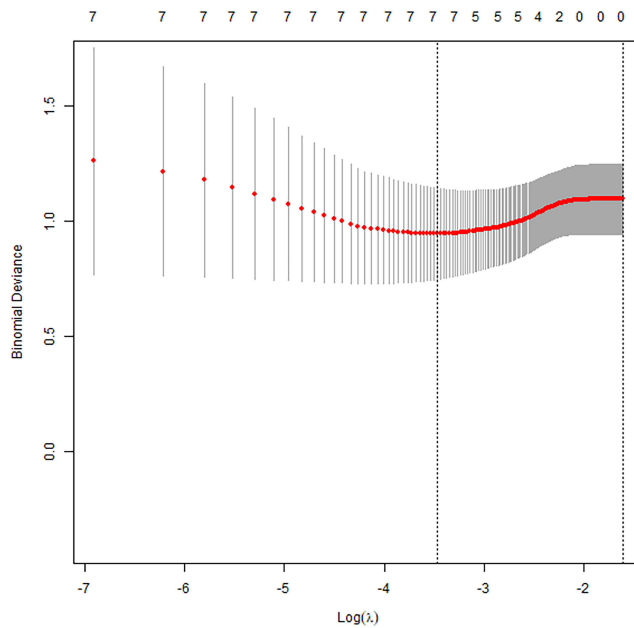


Figure 2 Lasso regression cross-validation results.

Analysis of Decision Curve of Nomogram Prediction Model

The decision curve showed that when the threshold probability was within the range of 0.10–0.90, the decision to apply the nomogram model constructed in this study to predict the therapeutic efficacy had more clinical benefits than the decision that all the treatments were effective or all the treatments were ineffective before surgery, as shown in Figure 6.

Table 3 Variable Assignment Method

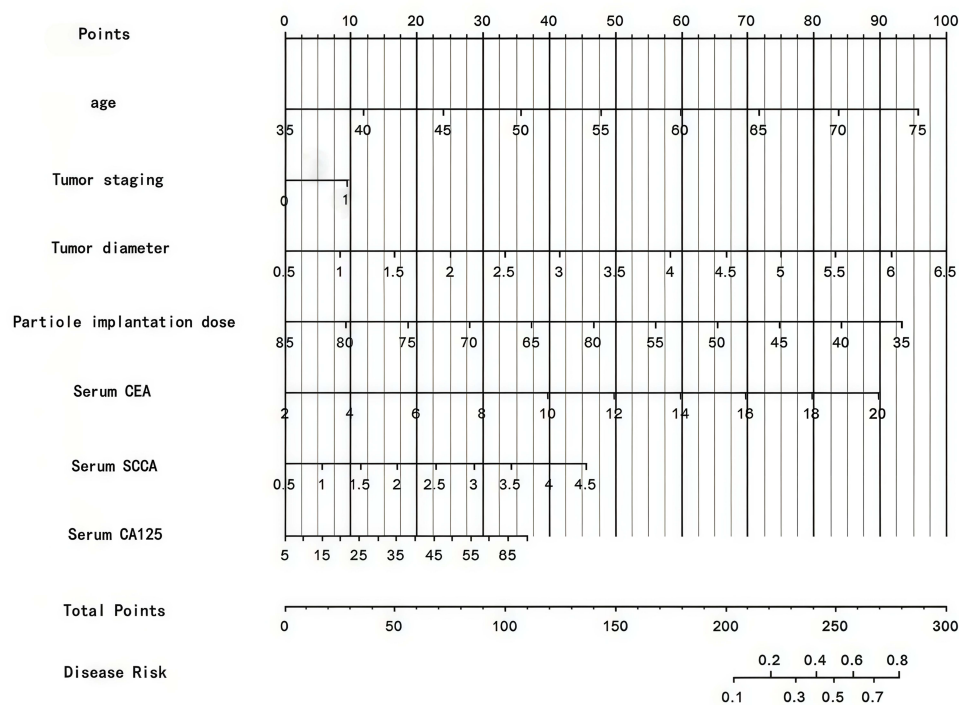
Variable	Meaning	Evaluation
X1	Age	Continuous variable
X2	Tumor staging	Stage I-II=0, stage III-IV=1
X3	Tumor diameter	Continuous variable
X4	Particle implantation dose	Continuous variable
X5	Serum CEA	Continuous variable
X6	Serum SCCA	Continuous variable
X7	Serum CA125	Continuous variable
Y	Is the treatment effective	Effective=0, ineffective =1

Table 4 Logistic Regression Analysis of Clinical Efficacy

Variable	B	Standard error	Wald	P	OR	95% CI
Age	0.093	0.039	5.831	0.016	1.098	1.018~1.184
Tumor staging	1.143	0.459	6.190	0.013	3.135	1.274~7.712
Tumor diameter	0.504	0.205	6.072	0.014	1.656	1.109~2.472
Particle implantation dose	-0.052	0.023	5.119	0.024	0.950	0.908~0.993
Serum CEA	0.249	0.098	6.469	0.011	1.282	1.059~1.553
Serum SCCA	0.757	0.311	5.913	0.015	2.132	1.158~3.923
Serum CA125	0.043	0.020	4.906	0.027	1.044	1.005~1.085

Discussion

In this study, 174 patients with head and neck tumors treated with brachytherapy with ^{125}I -radioactive particles were retrospectively analyzed. Lasso-Logistic regression was used to screen out the independent factors affecting the clinical

**Figure 3** Nomogram prediction model.

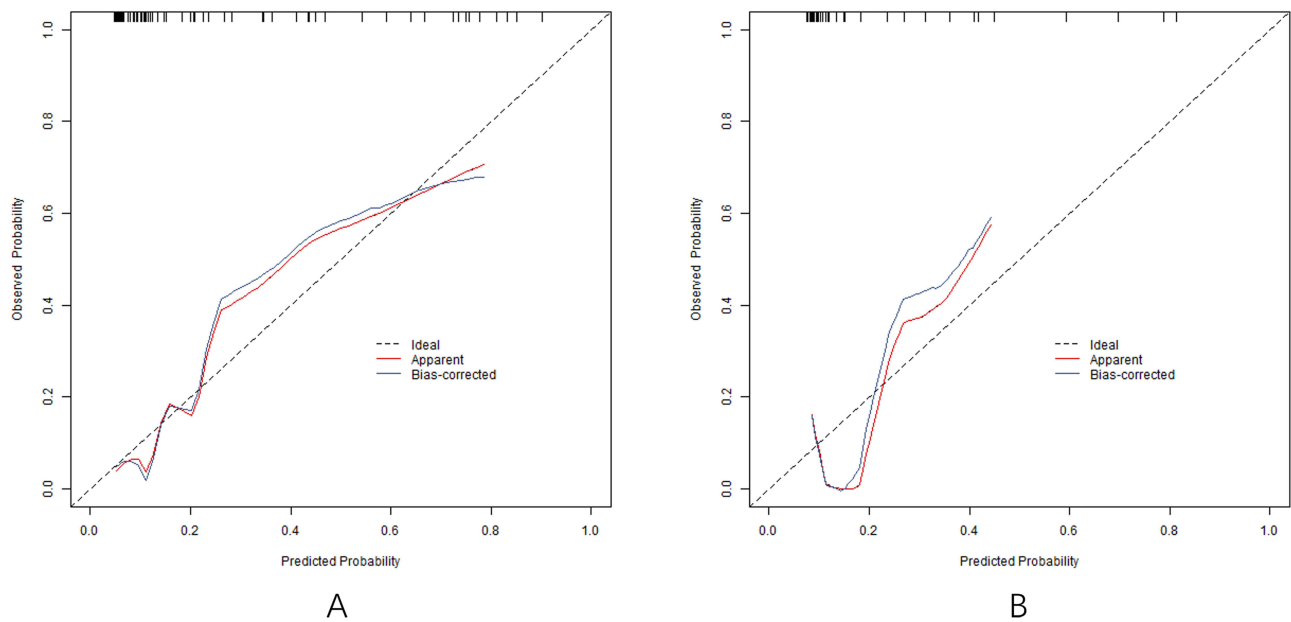


Figure 4 Calibration curve (A) training set, (B) validation set.

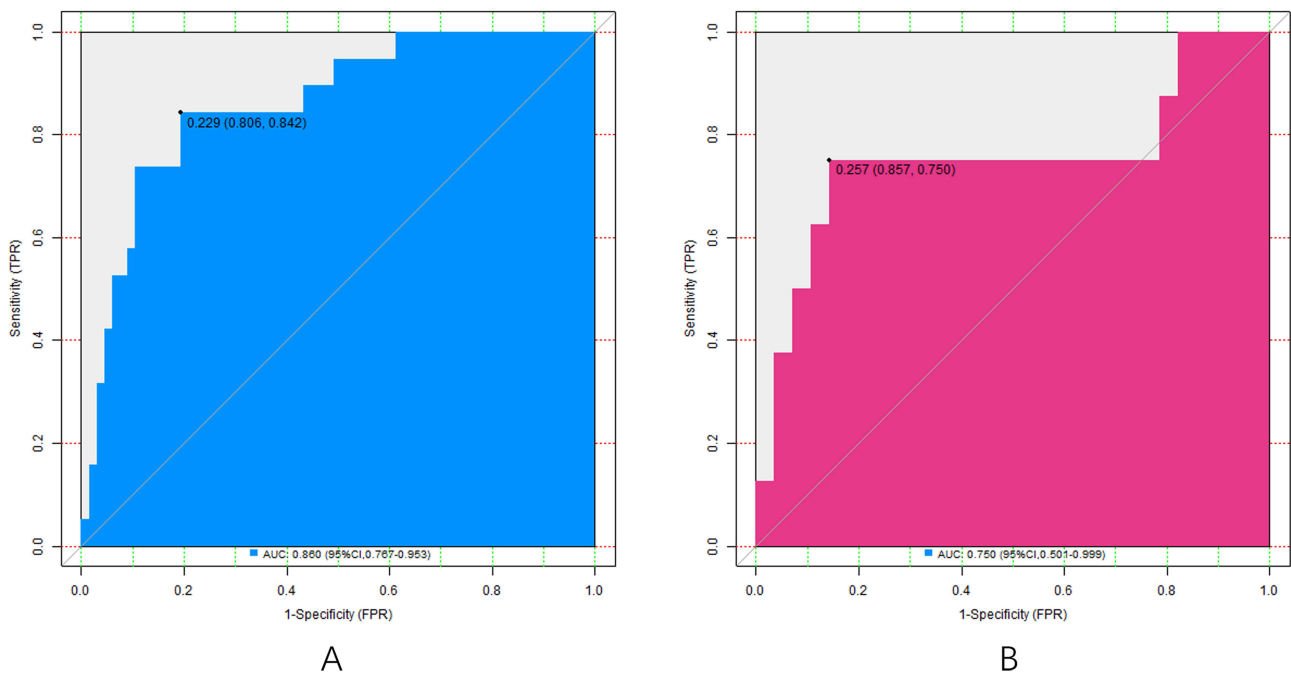


Figure 5 ROC curve (A) training set, (B) validation set.

efficacy and Nomogram prediction model was constructed. The model has good prediction efficiency in internal verification, and provides a powerful tool for clinical evaluation of patients' treatment effects.

Among many influencing factors, the influence of age on the curative effect of treatment cannot be ignored. This study showed that age was one of the independent factors affecting the clinical efficacy of brachytherapy with ¹²⁵I radioactive particles for head and neck tumors. With the growth of age, the function of various organs of the human body gradually declined, including the immune system, cell repair ability, etc. Elderly patients have poor tolerance to radiation. When receiving ¹²⁵I radioactive particles therapy, normal tissues are more vulnerable to radiation damage and the repair

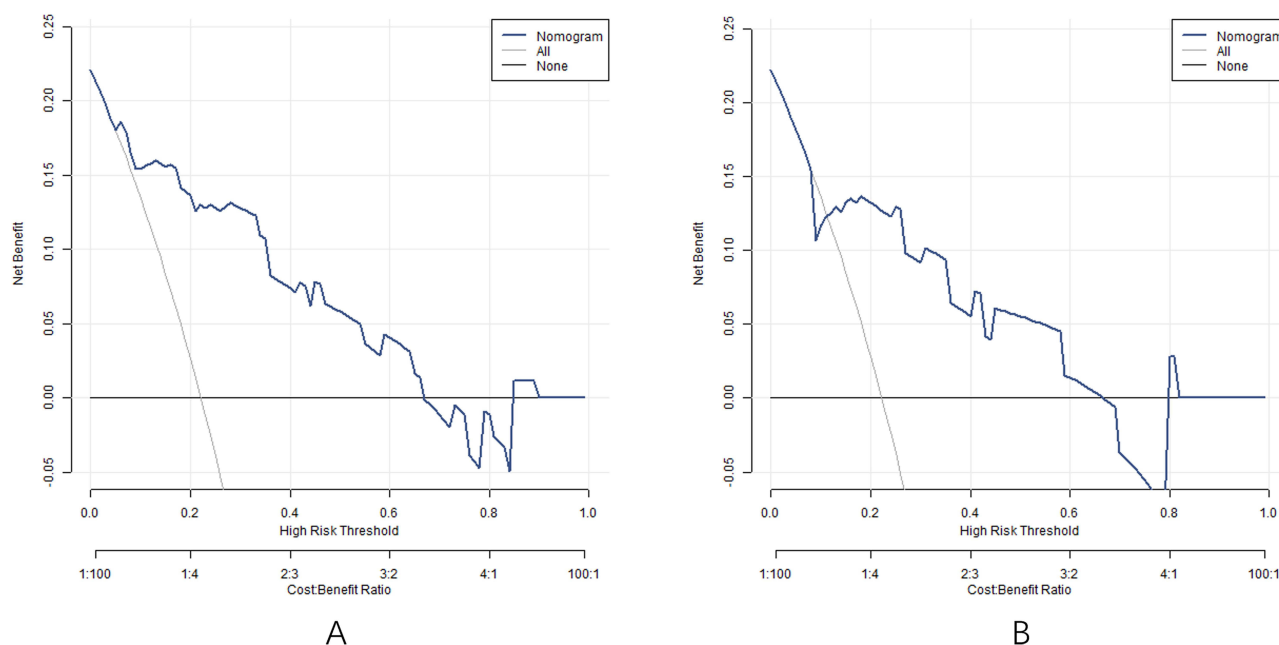


Figure 6 Decision curve (A) training set, (B) validation set.

ability of the damaged tissues is weakened.⁹ At the same time, elderly patients may be combined with a variety of basic diseases, further affecting the body's response to treatment and recovery ability, thereby reducing the effectiveness of treatment. For example, studies have shown that older patients with head and neck tumors have a relatively high probability of complications after receiving radioactive particle therapy, which not only affects the quality of life of patients, but may interfere with the follow-up treatment and ultimately affect the treatment effect.¹⁰ Therefore, in clinical practice, for elderly patients, doctors should be more cautious in the assessment of treatment risk, and fully consider the patient's body condition when formulating treatment plans, such as appropriately adjusting the particle implantation dose, and closely monitoring the adverse reactions during the treatment, so as to improve the safety and effectiveness of treatment. Tumor staging is also a key contributing factor. Tumor staging reflects the extent of tumor development and spread. In this study, the treatment efficiency of patients with stage III–IV tumors was significantly lower than that of patients with stage I–II tumors. This is because advanced tumors (stage III–IV) tend to be large and have a wide range of invasion, which may infringe upon important surrounding tissues and organs, or even cause distant metastasis.¹¹ At this time, it is difficult to completely control tumor growth by relying on brachytherapy with ¹²⁵I radioactive particles alone. By contrast, early (stage I–II) tumors are localized to the primary site and have a small size. The particles can act on the tumor tissue more accurately after implantation, resulting in high local control rate. For example, in patients with stage I head and neck tumors, particle implantation can be more evenly distributed inside the tumor to allow tumor cells to fully receive the radiation dose, thereby achieving better therapeutic effects. In patients with stage IV, because the tumor has spread, even if particle implantation can control the local tumor, distant metastasis may still lead to treatment failure.¹² Therefore, for patients with advanced tumors, clinicians usually need to consider the combination of other treatments, such as surgery, chemotherapy, and immunotherapy, to improve the local control rate and patient survival rate. An accurate assessment of tumor staging is critical to the selection of an appropriate therapeutic strategy before treatment planning. Tumor diameter is closely related to therapeutic efficacy. A larger tumor diameter often means a greater number of tumor cells and more complex blood supply and metabolism within the tumor. It has been found in the present study that the larger the tumor diameter is, the worse the therapeutic effect will be.¹³ This may be due to the fact that it is difficult to achieve uniform distribution of particle implantation when the tumor diameter is increased, resulting in that some tumor cells cannot obtain enough radiation dose, thus affecting the therapeutic effect. Furthermore, large tumors may present with hypoxic cells, which are relatively insensitive to radiation, further reducing the

effectiveness of treatment. For example, when the diameter of the tumor exceeds a certain range, the dose distribution may be uneven after particle implantation. The cells at the edge of the tumor receive a higher dose, while the cells at the central part receive an insufficient dose, making it difficult for the cells at the central part of the tumor to be completely killed, and increasing the risk of tumor recurrence.¹⁴ Therefore, in clinical treatment, for patients with large tumor diameters, physicians may need to adjust the method, number, or dose of particle implantation to ensure that tumor tissue can receive an adequate dose of radiation. At the same time, it is also possible to consider other treatment methods in combination, such as preoperative neoadjuvant chemotherapy to reduce the size of the tumor before particle implantation, in order to improve the therapeutic effect. The dose of particle implantation is directly related to the success or failure of treatment. This study showed that the dose of particle implantation was an important factor affecting the clinical efficacy. Appropriate particle implantation dose can effectively kill tumor cells while minimizing the damage to the surrounding normal tissues.¹⁵ Too low a dose may fail to completely kill the tumor cells, resulting in tumor residue or recurrence; High dose may increase the incidence of complications in normal tissues, affecting the quality of life of patients and subsequent treatment. For example, in actual clinical practice, if the particle implantation dose is insufficient, the tumor cells may not be completely inhibited, and the tumor may continue to grow after treatment. On the contrary, if the dose is too high, the surrounding normal tissues such as salivary glands and nerves may be excessively irradiated, resulting in complications such as dry mouth and nerve damage, seriously affecting the quality of life of the patient. Therefore, when formulating the particle implantation therapy, doctors need to accurately calculate the particle implantation dose according to the comprehensive factors such as the size, location, pathological type of the tumor and the body condition of the patient.¹⁶ At the same time, advanced imaging technology and treatment planning system ensure that the particles can be accurately implanted into the tumor tissue and realize uniform distribution, so as to improve the treatment effect and reduce the risk of complications. Serum tumor marker levels such as CEA, SCCA, and CA125 are important in assessing the efficacy of treatment. The level changes of these tumor markers are closely related to the occurrence and development of tumors. In this study, there was a significant difference in serum tumor marker levels between the effective group and the ineffective group. CEA is a broad-spectrum tumor marker that can be elevated in a variety of malignant tumors. High cell viability often indicates high activity of tumor cells, rapid disease progression or the possibility of metastasis.¹⁷ SCCA are specific markers of squamous cell carcinoma and play an important role in the diagnosis, condition monitoring and prognostic evaluation of squamous cell carcinoma in the head and neck region. For CEA and CA125, considering the selection of specific markers for head and neck tumors, this study further verified the correlation between CEA and curative effect, but it should be combined with other indicators in clinical application.¹⁸ For example, a persistently elevated serum CEA level in a patient may mean that tumor cells are more resistant to I-particle therapy, which may be less effective. Therefore, regular monitoring of serum tumor markers during clinical treatment can timely understand the changes of tumors and evaluate the treatment effect. For patients with high levels of tumor markers, doctors may consider adjusting the treatment regimen, such as combined targeted therapy or immunotherapy, to enhance the therapeutic effect.¹⁹

The Nomogram prediction model constructed in this study has good prediction performance. By integrating multiple independent influencing factors such as age, tumor stage, tumor diameter, particle implantation dose, and serum tumor marker level, the model can convert complex statistical results into intuitive and visual nomograms, which is convenient for clinicians to quickly assess the treatment efficacy risk of patients. The C-index values of the model in the effective group and the ineffective group were 0.867 and 0.725, respectively. The calibration curve showed that the predicted value was in good agreement with the true value. The results of Hosmer-Lemeshow test suggested that the model had a good fit. The area under the ROC curve in two groups also reached a high level, and the sensitivity and specificity were good. All these indicators showed that the model could distinguish between effective patients and ineffective patients, and provided strong support for clinical decision-making. For example, before a patient receives treatment, doctors can score according to various indicators of the patient on the Nomogram nomogram, so as to predict the treatment effect of the patient. For high-risk patients who are predicted to have poor treatment effect, more active treatment strategies can be formulated in advance, such as combining multiple treatment methods or adjusting the treatment dose, in order to improve the treatment success rate.²⁰ As a visual prediction tool, nomogram has been widely used in clinical decision-making of multiple cancers. In the field of prostate cancer, the nomogram model built by Kattan et al¹ integrates the

patient's PSA level, Gleason score and other multidimensional data, and the c-index for predicting the risk of biochemical recurrence after radical surgery is 0.82, which is 15% higher than the traditional staging system; In the study of breast cancer, the nomogram developed by Van de ven et al² based on the data of more than 100,000 patients has a prediction accuracy of 78% for pathological complete remission of neoadjuvant chemotherapy, effectively guiding the stratification of treatment options. These results verify the advantages of nomogram in integrating multifactorial variables and transforming complex statistical results into clinical practical tools, and provide a theoretical and practical basis for the application of this research model in the field of head and neck cancer.

However, there are some limitations in this study, and no external verification has been conducted. The main reason is that external verification needs to collect a large amount of case data from different medical institutions, involving multi-center collaboration. In the actual operation process, there may be differences in case selection criteria, treatment methods, and test methods in different hospitals, which increases the difficulty of data collection and unified management. At the same time, multi-center collaboration requires a large amount of time and resources, including human, material and financial resources.²¹ At the time of this study, due to time and resource constraints, it was difficult to complete the collection, collation and analysis of multi-center data in a short period of time. In addition, patient groups in different regions may have differences in ethnicity, living environment, and basic diseases, which may affect the external applicability of the model. Therefore, future research needs to actively carry out a multi-center large sample prospective study to externally verify the model constructed in this study and further test the generalization ability of the model in different medical environments and patient groups, in order to improve the model and enhance its clinical application value.²²

In summary, a retrospective analysis of 122 patients with head and neck tumors treated with brachytherapy with ¹²⁵I-radioactive particles in this study identified that age, tumor stage, tumor diameter, particle implantation dose, and serum CEA, SCCA, and CA125 levels are the independent factors affecting clinical efficacy. The Nomogram prediction model constructed based on these factors has good prediction performance in internal verification, and provides an intuitive and effective tool for clinicians to evaluate the treatment effect of patients. With this model, doctors can layer the risks of patients before treatment. For high-risk patients, more personalized treatment options can be formulated, such as adjusting the particle implantation dose, combined with other treatment methods, to improve the treatment effect and improve the prognosis of patients. Although this study has the limitation of not performing external validation, it laid a foundation for subsequent research. In the future, we should actively carry out multi-center large sample prospective research, conduct external validation of the model, and further explore other factors that may affect the therapeutic efficacy, such as gene polymorphism and tumor microenvironment, so as to continuously improve the prediction model, so that it can better serve the clinical practice and provide more accurate and effective treatment for patients with head and neck tumors.

Conclusion

The prediction model constructed in this study has good predictive value for the clinical efficacy of ¹²⁵I radioactive particle brachytherapy for head and neck tumors, can effectively assist clinicians to evaluate the treatment effect, and provide strong support for promoting individualized precision treatment of head and neck tumors.

Data Sharing Statement

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of The Qilu Hospital (Qingdao), Cheeloo College of Medicine, Shandong University (No. 2020QL-1147), and informed consent was obtained from all patients. This study was conducted in accordance with the Declaration of Helsinki.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

There is no funding to report.

Disclosure

The authors declare that they have no competing interests.

References

- Zhang G, Wu Z, Yu W, et al. Clinical application and accuracy assessment of imaging-based surgical navigation guided 125I interstitial brachytherapy in deep head and neck regions. *J Radiat Res.* 2022;63(5):741–748. doi:10.1093/jrr/rrac034
- Zhang Y, Liang Y, Liu Z, et al. Efficacy of radioactive 125I seed implantation in treating inoperable or refused operation head and neck cancers. *J Cancer Res Ther.* 2024;20(2):642–650. doi:10.4103/jert.jert_1891_23
- Liu H, Ye Z, Wang X, et al. Comprehensive analysis of the functions, prognostic and diagnostic values of RNA binding proteins in head and neck squamous cell carcinoma. *J Stomatol Oral Maxillofac Surg.* 2024;125(4S):101937. doi:10.1016/j.jormas.2024.101937
- Massacesi M, Dinapoli N, Fuga V, et al. A predictive nomogram for trismus after radiotherapy for head and neck cancer. *Radiother Oncol.* 2022;173:231–239. doi:10.1016/j.radonc.2022.05.031
- Liu K, Lin C, Xu Z, et al. Prognostic analysis and nomogram establishment in patients with head and neck myoepithelial carcinoma. *Eur Arch Otorhinolaryngol.* 2022;279(8):4093–4102. doi:10.1007/s00405-022-07269-y
- Ferris RL, Flamand Y, Weinstein GS, et al. Phase II Randomized Trial of Transoral Surgery and Low-Dose Intensity Modulated Radiation Therapy in Resectable p16+ Locally Advanced Oropharynx Cancer: an ECOG-ACRIN Cancer Research Group Trial (E3311). *J Clin Oncol.* 2022;40(2):138–149. doi:10.1200/JCO.21.01752
- Bunnell AM, Nedrud SM, Fernandes RP. Classification and staging of melanoma in the head and neck. *Oral Maxillofac Surg Clin North Am.* 2022;34(2):221–234. doi:10.1016/j.coms.2021.12.001
- Iannessi A, Beaumont H, Liu Y, et al. RECIST 1.1 and lesion selection: how to deal with ambiguity at baseline[J]? *Insights Imaging.* 2021;12(1):36. doi:10.1186/s13244-021-00976-w
- Dasgupta S, Chakrabarti S, Deb AR. Tumor infiltrating lymphocytes in head and neck squamous cell carcinoma - Evaluation and clinical impact. *J Cancer Res Ther.* 2022;18(1):49–54. doi:10.4103/jert.JCRT_830_20
- Chen AM. Management of unknown primary head and neck cancer with radiation therapy in the era of human papillomavirus (HPV): no longer cutting down the tree to get an apple. *Radiother Oncol.* 2023;189:109952. doi:10.1016/j.radonc.2023.109952
- Lee YA, Lee H, Im SW, et al. NTRK and RET fusion-directed therapy in pediatric thyroid cancer yields a tumor response and radioiodine uptake. *J Clin Invest.* 2021;131(18):e144847. doi:10.1172/JCI144847
- He S, Tian S, Xu N, et al. Particle implantation combined with chemotherapy for rhabdomyosarcoma of the head and neck: a 8-year long-term follow-up case report. *Cancer Innov.* 2023;2(3):233–236. doi:10.1002/cai.21
- Cao J, Zhang M, Xie F, et al. Exosomes in head and neck cancer: roles, mechanisms and applications. *Cancer Lett.* 2020;494:7–16. doi:10.1016/j.canlet.2020.07.005
- Sun J, Liu S, Fu K, et al. Clinicopathological characteristics and outcomes of 23 patients with secretory carcinoma of major salivary glands. *Sci Rep.* 2021;11(1):22639. doi:10.1038/s41598-021-01970-4
- Tian SQ, Wang JJ, Ji Z, et al. [Validation of calculation method for dose distribution around radioactive iodine-125 particles based on AAPM TG43 report]. *Zhonghua Yi Xue Za Zhi.* 2023;103(3):199–204. doi:10.3760/cma.j.cn112137-20220809-01718
- Popovtzer A, Mizrahi A, D'Andrea MA, et al. Extended follow-up outcomes from pooled prospective studies evaluating efficacy of interstitial alpha radionuclide treatment for skin and head and neck cancers. *Cancers.* 2024;16(13):2312. doi:10.3390/cancers16132312
- Lee KB, Tanenbaum MT, Wang A, et al. Impact of head and neck radiation on long-term outcomes after carotid revascularization. *J Vasc Surg.* 2024;80(2):422–430. doi:10.1016/j.jvs.2024.03.441
- Dai X, Wei B, He Y, et al. Postoperative efficacy of low-temperature plasma radiofrequency ablation in elderly patients with laryngeal carcinoma and its influences on tum or markers and COX-2 and VEGF expressions in laryngeal carcinoma tissues. *J BUON.* 2020;25(4):1969–1975.
- Tang X, Li R, Wu D, et al. Development and validation of an ADME-related gene signature for survival, treatment outcome and immune cell infiltration in head and neck squamous cell carcinoma. *Front Immunol.* 2022;13:905635. doi:10.3389/fimmu.2022.905635
- Zhu RQ, Zhang YM, Luo XY, et al. A novel nomogram and risk classification system for predicting overall survival in head and neck squamous cell cancer with distant metastasis at initial diagnosis. *Eur Arch Otorhinolaryngol.* 2023;280(3):1467–1478. doi:10.1007/s00405-022-07716-w
- Zhang Y, Ma S, Cai J, et al. Sequential P-GEMOX and radiotherapy for early-stage extranodal natural killer/T-cell lymphoma: a multicenter study. *Am J Hematol.* 2021;96(11):1481–1490. doi:10.1002/ajh.26335
- Zhong L, Dong D, Fang X, et al. A deep learning-based radiomic nomogram for prognosis and treatment decision in advanced nasopharyngeal carcinoma: a multicentre study. *EBioMedicine.* 2021;70:103522. doi:10.1016/j.ebiom.2021.103522

Cancer Management and Research

Publish your work in this journal

Cancer Management and Research is an international, peer-reviewed open access journal focusing on cancer research and the optimal use of preventative and integrated treatment interventions to achieve improved outcomes, enhanced survival and quality of life for the cancer patient. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/cancer-management-and-research-journal>

Dovepress
Taylor & Francis Group