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RESEARCH

A dynamic online nomogram for predicting nutritional risk in nasopharyngeal carcinoma patients after radiotherapy

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Abstract

Purpose Malnutrition is a prevalent and detrimental complication in patients with nasopharyngeal carcinoma (NPC) undergoing radiotherapy. Early identification and intervention are crucial for optimizing outcomes.

Methods We retrospectively analyzed data from 383 patients with NPC who underwent radiotherapy. We employed logistic regression analysis to identify risk factors for malnutrition and developed a nomogram for its prediction. The nomogram was internally and externally validated using bootstrap methods and calibration curves.

Results Body mass index (BMI), chemotherapy cycles, central venous catheter (CVC), and alanine aminotransferase (ALT) were identified as independent risk factors for malnutrition. The nomogram demonstrated good discriminatory ability (AUC: 0.786 in the training set, 0.687 in the validation set) and clinical utility, with high net benefit in decision curve analysis.

Conclusions This nomogram offers a practical tool for predicting nutritional risk in patients with NPC undergoing radiotherapy. Its application can facilitate early identification of at-risk patients and guide targeted interventions to improve clinical outcomes.

Keywords Nasopharyngeal carcinoma · Radiotherapy · Nutritional risk · Prediction · Nomogram

Introduction

As medical technology advances, radiotherapy has emerged as a pivotal therapeutic modality for individuals with nasopharyngeal carcinoma (NPC) [1]. Although radiotherapy can effectively eradicate tumor cells, it will inevitably cause some adverse reactions [2]. Notably, the impact of radiotherapy on the nutritional status of patients is profound. Research indicates a high prevalence of malnutrition among patients with NPC following radiotherapy, a condition that critically undermines their quality of life and clinical outcomes [3, 4]. Consequently, the early detection of nutritional risk in these patients and the implementation of targeted interventions are imperative to enhance their prognosis.

In recent years, the application of nutritional risk assessment tools has become increasingly prevalent in clinical settings. Instruments such as the Nutrition Risk Screening 2002 (NRS 2002) [5] and the Patient-Generated Subjective Global Assessment (PG-SGA) [6] are commonly employed. Nevertheless, the heterogeneity of patient populations and the variability of diseases preclude the existence of a universally accepted gold standard for nutritional risk evaluation.

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Radiotherapy, while effective in targeting tumor cells, inadvertently inflicts damage upon surrounding normal tissues. This collateral damage manifests as oral mucositis, dysphagia, and a diminished appetite, collectively impairing the patient's nutritional intake [7]. Furthermore, the inflammatory response incited by radiotherapy heightens the patient's energy expenditure, exacerbating the risk of malnutrition [8]. As reported by Zhuang et al. [9], 52.00% of patients were identified as malnourished according to the NRS2002. In the study by Hong et al. [10], it was demonstrated that 20.19% of patients experienced a 10% loss in body weight following radiotherapy, a finding that indicates malnutrition significantly compromises both treatment tolerance and quality of life in this patient population.

Malnutrition can compromise immune function [11], increase the risk of complications [12], prolong hospital stays, and even impact survival rates [13]. Early identification and intervention of nutritional risk in patients with NPC after radiotherapy is crucial for reducing the incidence of malnutrition-related complications and for improving the quality of life and treatment tolerance of these patients [14]. Therefore, investigating the predictors of nutritional risk in patients with NPC following radiotherapy is of great significance for developing targeted nursing interventions. This research can help in formulating proactive and personalized care plans, thereby optimizing patient outcomes.

Nomogram prediction model is a visual evaluation tool based on logistic regression analysis and has been widely used for cancer prognosis [15, 16]. In contrast to conventional evaluation methods, the Nomogram offers a more intuitive framework that allows medical personnel to rapidly comprehend and apply it [17]. The model developed in this study is poised to serve as a valuable tool for the risk assessment of patients with NPC who are undergoing radiotherapy. Its application has the potential to enhance the relevance of risk assessments, optimize the allocation of medical resources, and improve the efficiency of nursing care. Importantly, a wealth of existing research indicates that malnutrition is a pivotal factor contributing to the unfavorable prognosis in patients with NPC [18, 19]. The nomogram constructed within this study is designed to identify nutritional risks in these patients at an early stage. This enables the formulation of targeted nursing interventions, which could significantly reduce the incidence of malnutrition-related complications and ultimately improve patient outcomes.

Methods

Study population

In this investigation, we retrospectively selected patients who were admitted to Nanfang Hospital and Zhujiang Hospital of Southern Medical University between January 2021 and January 2023.

The following were the criteria for inclusion: (I) a diagnosis of NPC confirmed by pathological examination, (II) completion of radical radiotherapy, (III) age of 18 years or older, and (IV) availability of comprehensive medical and follow-up records.

The exclusion criteria were (I) concurrent other malignancies or metastatic diseases, (II) the presence of significant medical conditions or complications, (III) mental illness or cognitive dysfunction, and (IV) severe malnutrition.

Patients were allocated to either the training set (comprising 258 cases at Nanfang Hospital of Southern Medical University) or the validation set (consisting of 125 cases at Zhujiang Hospital of Southern Medical University) based on the hospital of treatment. The training set was employed for model development and internal validation, whereas the validation set was reserved for external validation of the model. Figure 1 presents the exclusion criteria and the patient recruitment process. (Details of baseline characteristics of patients in both centres are presented in Supplementary Table 1.)

Measures

Sociodemographic data for cancer patients, encompassing age, sex, marital status, smoking history, alcohol consumption, TNM stage, clinical stage, body mass index (BMI), presence of a central venous catheter (CVC), and number of chemotherapy cycles, were extracted from the hospital's electronic medical record system. Symptomatological data included radiation-induced oral mucositis (RTOM) and clusters of digestive symptoms. Laboratory parameters, such as Epstein-Barr virus (EBV) replication, alanine aminotransferase (ALT), aspartate aminotransferase (AST), total protein, serum albumin, white blood cell count, neutrophil count, red blood cell count, and hemoglobin level, were obtained from patients when they were not undergoing radiotherapy. Outcome measures will be gathered during a single hospital visit following the completion of radiotherapy.

To ensure patient privacy, all personal identifiers were removed from the dataset. All study protocols were reviewed and approved by the Southern Hospital Clinical Research Ethics Committee (NFEC-2018–013).

Outcome index

The NRS2002 scale [20] was employed to assess the nutritional risk of patients upon their subsequent admission following radiotherapy. The screening encompassed three dimensions: the severity of the disease (0–3 points), the patient's nutritional status (0–3 points), and age (with an additional point added to the total score for individuals aged

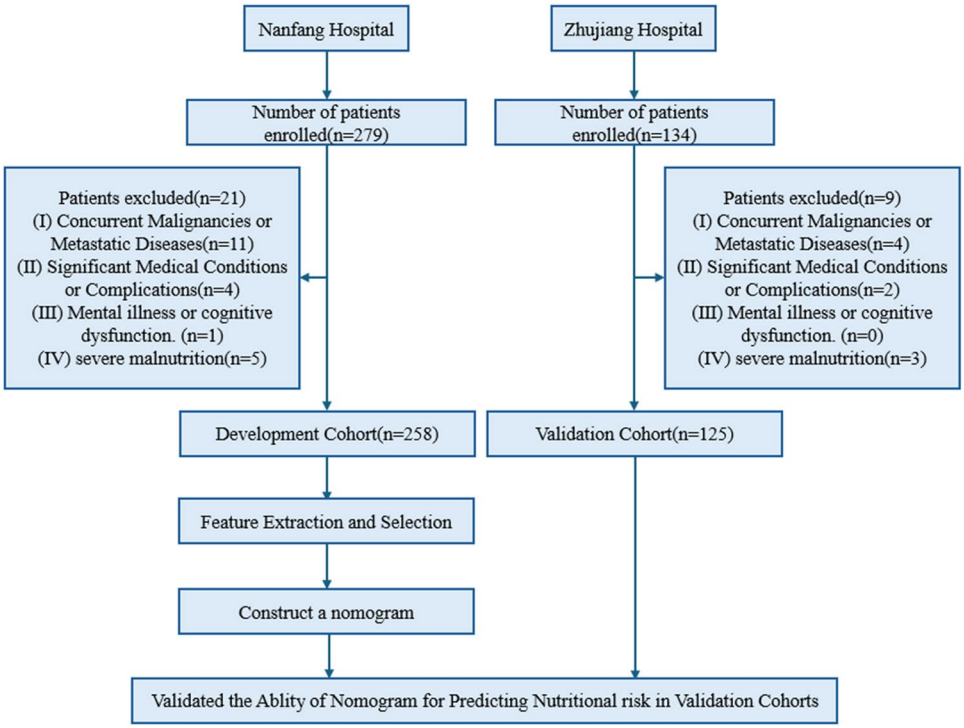

Fig. 1 Patient recruitment process at two centers

70 years or older). The composite score ranges from 0 to 7 points. A higher NRS2002 score correlates with a greater nutritional risk, and a total score exceeding 3 signifies that the patient is at risk for malnutrition.

Statistical analysis

Data analysis was performed using SPSS version 27.0. For missing values, we employed a systematic approach based on the nature of the variables:

- For continuous variables that followed a normal distribution, missing values were imputed using the mean.
- For continuous variables that did not follow a normal distribution, missing values were imputed using the median.
- For categorical or ordinal data, missing values were imputed using the mode.

Continuous variables that deviated from a normal distribution were described using median and interquartile range (IQR) and compared with the Mann–Whitney *U* test. In contrast, normally distributed continuous variables were characterized by their mean values and compared using independent samples *t*-tests. Categorical variables were presented as frequencies and percentages and analyzed using chi-square tests. To identify potential predictors, we conducted both univariate and multivariate logistic regression analyses.

Initially, univariate logistic regression was employed to explore the association between the non-nutritional risk (N-NR) group and the nutritional risk (NR) group. Variables with a *p*-value less than 0.05 were considered for inclusion in the multivariate analysis. Subsequently, a multivariate logistic regression analysis with a stepwise approach was conducted, treating NR status as the dependent variable, while other significant variables were entered as independent variables. The odds ratio (OR) and their corresponding 95% confidence intervals (CI) were computed to quantify the effect sizes. Forest plots were utilized to visually represent the results. Statistical significance was determined using a two-tailed test, with a significance level set at $p < 0.05$.

We developed a nomogram to predict outcomes using R version 4.4.1 and the "rms" package. This predictive tool was constructed by incorporating significant risk factors identified through multivariate analysis. The nomogram features individual scores for each variable, which, when summed, yield a total score. This aggregate score corresponds to the estimated probability of the outcome of interest. The nomogram's discriminatory ability was assessed by calculating the area under the receiver operating characteristic (ROC) curve (AUC). Sensitivity and specificity were determined based on a predefined cut-off point. Internal validation and assessment of the model's stability were performed using the bootstrap method and the Hosmer–Lemeshow test, respectively. Furthermore, the model's performance and clinical applicability were evaluated through calibration curves and decision curve analysis (DCA), which provide a quantitative measure of its utility in clinical settings.

Results

Participant characteristics

Finally, 383 patients with NPC were enrolled. Of these, 258 patients were allocated to the training cohort, and 125 were assigned to the validation cohort. In the training cohort, BMI ($p < 0.001$), CVC ($p = 0.018$), chemotherapy cycles ($p < 0.001$), ALT ($p < 0.001$), and erythrocyte ($p = 0.033$) were significantly associated with NR. The demographic characteristics of the patients in the training cohort are detailed in Table 1, and those of the validation cohort are provided in Supplementary Table 2.

Logistic regression variable screening results

Figures 2 and 3 depict the outcomes of the variable screening process using logistic regression. Figure 2 illustrates the results of univariate analysis, identifying five variables that were significantly associated with NR. These variables were subsequently included as potential predictors in the multivariate logistic regression analysis. As depicted in Fig. 3, the multivariate analysis revealed that BMI, chemotherapy cycles, CVC, and ALT were independent predictors of NR.

Nomogram construction and validation

We constructed a nomogram for predicting NR based on the identified independent predictors, and the nomogram was developed through multiple logistic regression analysis (Fig. 4). The nomogram allows for the projection of individual predictor points onto a top scale, which are then summed to yield a total score. This total score corresponds to a specific probability of NR, with higher scores indicating a greater likelihood of NR.

We conducted both internal and external validations of the nomogram. The findings indicate that the nomogram is a dependable instrument for predicting NR in patients with cancer. The Hosmer–Lemeshow test for the calibration of the training set yielded a p-value of $0.181 > 0.05$, suggesting good calibration. In the training and validation sets, the AUC for the nomogram was 0.786 (95% CI, 0.722 to 0.851) and 0.687 (95% CI, 0.581 to 0.793), respectively (Fig. 5). For the training set, the Youden index was 0.539, with a cutoff value of 0.453. At this threshold, the nomogram's sensitivity was 0.701, and its specificity was 0.838.

The calibration curve is depicted in Fig. 6. This curve was generated using the bootstrap method, which was repeated 1000 times. The results revealed that both the corrected-deviation curve and the apparent curve closely aligned with the reference line, indicating that the predicted risk of NR closely corresponded to the observed risk. Furthermore, we constructed DCA curves to assess the clinical utility of the nomogram. The DCA results indicate that the net benefit of the model ranges from approximately 9 to 100% in the training set and from 13 to 66% in the validation set, suggesting that the model confers a substantial benefit for clinical decision-making (Fig. 7). An online program, developed using R's "DynNom" package, is available at (https://zbx809021704.shinyapps.io/DynNomapp/). Users can input parameters and then click the "Predict" button to obtain the probability of NR (Fig. 8).

Discussion

In the present study, 30.23% of patients with NPC suffered from malnutrition following radiotherapy. The risk factors for malnutrition identified included BMI, CVC, chemotherapy cycles, and ALT. The incidence of malnutrition observed in this study was 21.77% lower than the rate reported by Zhuang et al., yet approximately 10% higher than the figure cited by Hong et al. Whereas Zhuang's research encompassed all head and neck cancers, Hong's study was confined to individuals aged 18 to 70 years. In this study, the population included adults aged 18 years and older, with the elderly demonstrating a poorer nutritional status and an increased susceptibility to malnutrition.

Our data indicate that patients with lower BMI are at a significantly heightened risk of malnutrition, a condition that may arise from a confluence of factors. Primordially, BMI serves as a proxy for an individual's overall nutritional status. A low BMI typically signifies inadequate energy and nutrient intake, which is a direct antecedent of malnutrition [21]. Moreover, the gastrointestinal toxicity induced by radiotherapy can lead to a loss of appetite and compromised digestive and absorptive functions, as well as symptoms such as nausea and vomiting [22], all of which directly impinge upon the patient's nutritional intake.

Secondly, radiotherapy, as a treatment modality, can profoundly influence the metabolic activity of patients. While its primary aim is to target tumor cells, it may inadvertently cause harm to adjacent healthy tissues, thereby magnifying metabolic disruptions in the patient [23]. For individuals with a low BMI, the body's energy reserves are often depleted, which complicates the ability of these patients to sustain a normal nutritional status throughout the duration of their radiotherapy treatment.

Indeed, our findings align with the established literature that identifies BMI as a crucial metric for evaluating nutritional risk in cancer patients [24–26]. However, our study differentiates itself by concentrating on a distinct cohort—those with NPC post-radiotherapy. This focus allows us to

Table 1 Socio-demographic characteristics of training set ($N = 258$)

Variables	Total ($N = 258$)	N-NR, ($N = 180$)	NR, ($N = 78$)	p value
Age, mean ± SD	46.86 ± 12.20	47.11 ± 11.57	46.31 ± 13.61	0.630
Gender				0.060
Male	189 (73.3)	138 (76.7)	51 (65.4)	
Female	69 (26.7)	42 (23.3)	27 (34.6)	
Marital status				0.357
Married	232 (89.9)	162 (90.0)	70 (89.7)	
Spinsterhood	18 (7.0)	12 (6.7)	6 (7.7)	
Divorced	7 (2.7)	6 (3.3)	1 (1.3)	
Widowed	1 (0.4)	0 (0.0)	1 (1.3)	
Smoking				0.496
Yes	124 (48.1)	84 (46.7)	40 (51.3)	
No	134 (51.9)	96 (53.3)	38 (48.7)	
Alcohol consumption				0.579
Yes	96 (37.2)	65 (36.1)	31 (39.7)	
No	162 (62.8)	115 (63.9)	47 (60.3)	
Family history of cancer				0.089
Yes	27 (10.5)	15 (8.3)	12 (15.4)	
No	231 (89.5)	165 (91.7)	66 (84.6)	
T-stage				0.877
1	19 (7.4)	14 (7.8)	5 (6.4)	
2	32 (12.4)	21 (11.7)	11 (14.1)	
3	139 (53.9)	99 (55.0)	40 (51.3)	
4	68 (26.4)	46 (25.6)	22 (28.2)	
N-stage				0.766
0	8 (3.1)	5 (2.8)	3 (3.8)	
1	45 (17.4)	33 (18.3)	12 (15.4)	
2	80 (31.0)	58 (32.2)	22 (28.2)	
3	125 (48.4)	84 (46.7)	41 (52.6)	
M-stage				0.283
0	230 (89.1)	158 (87.8)	72 (92.3)	
1	28 (10.9)	22 (12.2)	6 (7.7)	
Clinical stage				0.706
I	0 (0.0)	0 (0.0)	0 (0.0)	
II	9 (3.5)	6 (3.3)	3 (3.8)	
III	89 (34.5)	65 (36.1)	24 (30.8)	
IV	160 (62.0)	109 (60.6)	51 (65.4)	
BMI, mean ± SD	23.56 ± 3.55	24.52 ± 3.07	21.34 ± 3.61	**< 0.001**
CVC				**0.018**
Yes	157 (60.9)	101 (56.1)	56 (71.8)	
No	101 (39.1)	79 (43.9)	22 (28.2)	
Chemotherapy cycles, median (P_{25}, P_{75})	2.00 (2.00, 2.00)	2.00 (2.00, 2.00)	2.00 (2.00, 2.25)	**< 0.001**
RTOM				0.336
Yes	189 (73.3)	135 (75.0)	54 (69.2)	
No	69 (26.7)	45 (25.0)	24 (30.8)	
Digestive symptom clusters, median (P_{25}, P_{75})	1.00 (0.00, 2.00)	1.00 (0.00, 2.00)	1.00 (0.00, 2.00)	0.946
EBV replication quantity				0.126
> 1500	85 (32.9)	54 (30.0)	31 (39.7)	
≤ 1500	173 (67.1)	126 (70.0)	47 (60.3)	
ALT, median (P_{25}, P_{75})	18.00 (13.00, 29.00)	20.00 (14.25, 30.75)	14.50 (10.00, 23.25)	**< 0.001**
AST, median (P_{25}, P_{75})	19.00 (16.00, 24.00)	19.00 (17.00, 24.00)	18.50 (15.00, 23.00)	0.194

Table 1 (continued)

Variables	Total ($N = 258$)	N-NR, ($N = 180$)	NR, ($N = 78$)	p value
Total protein, median (P_{25}, P_{75})	70.65 (66.08, 74.13)	70.85 (66.00, 74.20)	70.15 (66.45, 74.03)	0.775
Serum albumin, median (P_{25}, P_{75})	43.10(40.40,45.30)	42.95(40.40,45.40)	43.15 (39.70, 45.15)	0.622
Leukocyte, median (P_{25}, P_{75})	6.73 (5.40, 8.07)	6.78 (5.48, 8.23)	6.66 (5.34, 7.74)	0.530
Neutrophil, median (P_{25}, P_{75})	4.16 (3.26, 5.66)	4.16 (3.24, 5.62)	4.16 (3.31, 5.78)	0.560
Erythrocyte, median (P_{25}, P_{75})	4.15(3.80, 4.51)	4.19 (3.83, 4.58)	4.02 (3.75, 4.39)	**0.033**
Hemoglobin, mean ± SD	122.66 ± 16.17	123.71 ± 16.33	120.26 ± 15.63	0.116

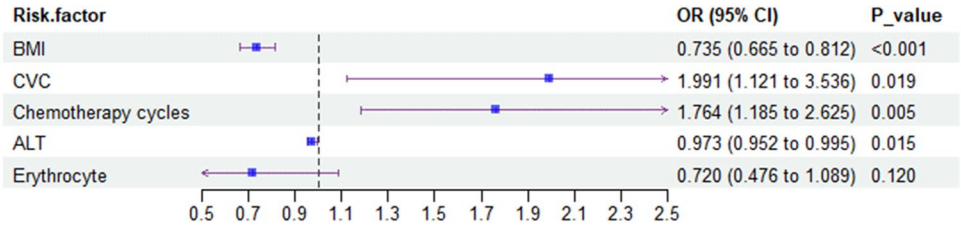

Fig. 2 Odds ratio forest plot of univariate logistic regression

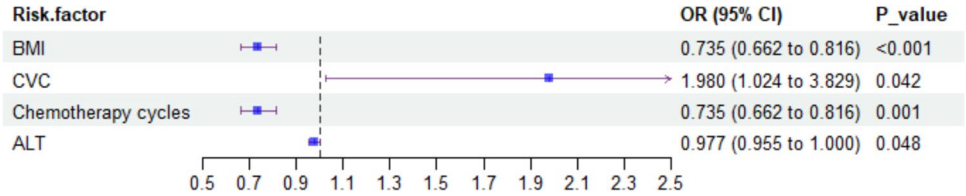

Fig. 3 Odds ratio forest plot of multivariate logistic regression

offer more nuanced and specialized recommendations for the nutritional care of this particular patient population.

In the present investigation, we observed a marked elevation in the risk of malnutrition among patients equipped with a CVC. This observation may be associated with the indication that CVC insertion frequently serves as a proxy for heightened nutritional risk, as these devices are commonly employed in patients necessitating prolonged parenteral nutrition. The utilization of a CVC may indicate a more advanced disease stage or a greater complexity of treatment requirements, both of which can predispose individuals to malnutrition. Furthermore, the presence of a CVC can impede patients' routine activities, impacting their appetite and dietary intake. Long-term reliance on intravenous nutrition is not a complete substitute for normal eating, potentially resulting in nutritional imbalances. A systematic review conducted by Teja et al. [27] revealed that 30.2 out of every 1000 patients with a CVC in place for at least 3 days experienced one or more serious complications, which could compound the risk of malnutrition.

The findings of this study indicate a clear correlation between the number of chemotherapy cycles a patient undergoes and their risk of developing malnutrition. As the number of chemotherapy cycles increases, there is a corresponding rise in the prevalence of malnutrition among patients. One of the contributing factors to this trend may be the side effects associated with chemotherapy drugs.

The research by Hsieh et al. [28] has demonstrated that despite the use of antiemetics, a significant proportion of patients—approximately 60%—continue to suffer from nausea. While vomiting is generally less severe, it is still a concern. These symptoms, collectively known as chemotherapy-induced nausea and vomiting (CINV) [29], have a strong association with the risk of malnutrition. CINV can lead to a decrease in appetite, reduced food intake, and, ultimately, inadequate nutrient absorption, which can exacerbate the risk of malnutrition in patients undergoing chemotherapy.

Another potential factor contributing to the decreased nutritional intake in cancer patients is the alteration in taste perception that often accompanies chemotherapy. Research has indicated that a reduction in energy intake is correlated with taste changes in individuals with advanced cancer [30]. Kiss et al. [31] conducted a systematic review and found that taste alterations in patients with head and neck cancer typically emerge approximately 3 weeks after the initiation of radiotherapy, with the most pronounced changes occurring 2 months post-treatment. The recovery period for taste can range from 3 months to 2 years following therapy, representing a protracted process. This prolonged impairment in taste

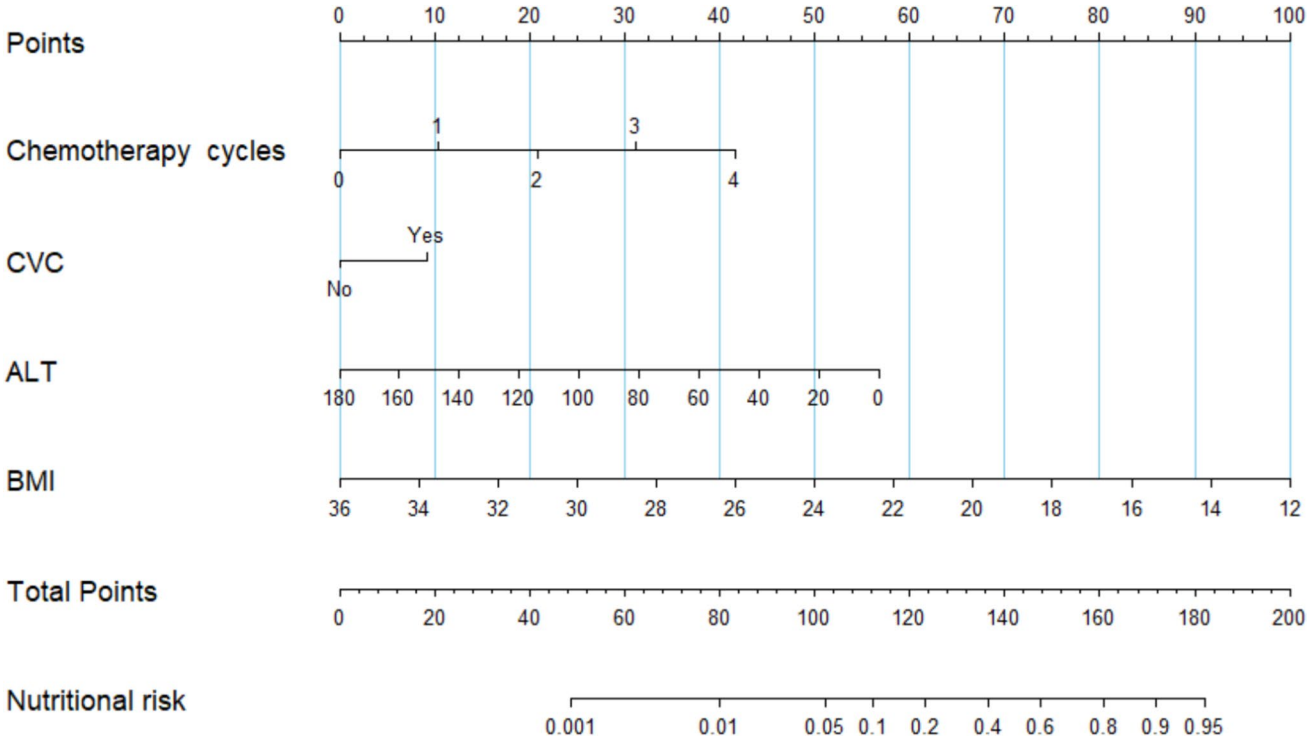

Fig. 4 A nomogram to predict the risk of nutritional risk in cancer patients. On the nomogram, each individual patient's characteristic is represented by a single point (dot) on the scale at the top of the graph. The cumulative score, which is the sum of these individual points, is depicted in the penultimate row as the total number of points. This total score corresponds to a specific probability of nutritional risk

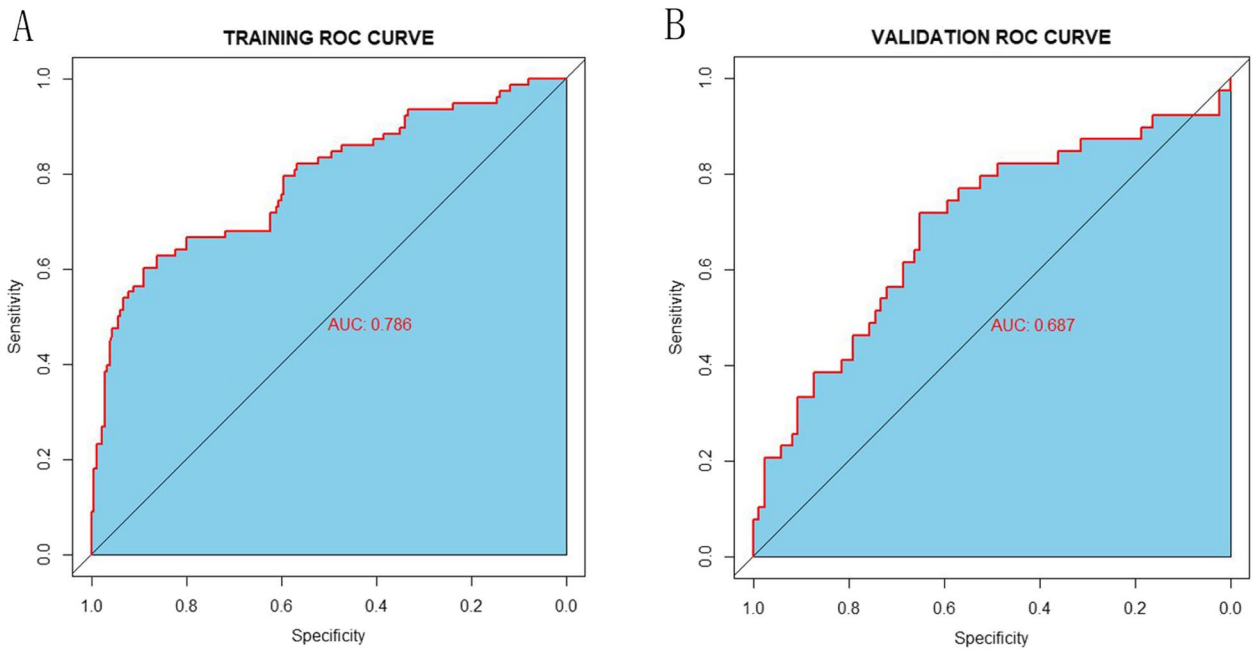

Fig. 5 ROC Curves for the nomogram predicting NR in the training set (**A**) and validation set (**B**). The x-axis represents the false positive rate, whereas the y-axis indicates the true positive rate for the risk prediction. ROC, receiver operating characteristic curve; AUC, area under the curve; NR, nutritional risk

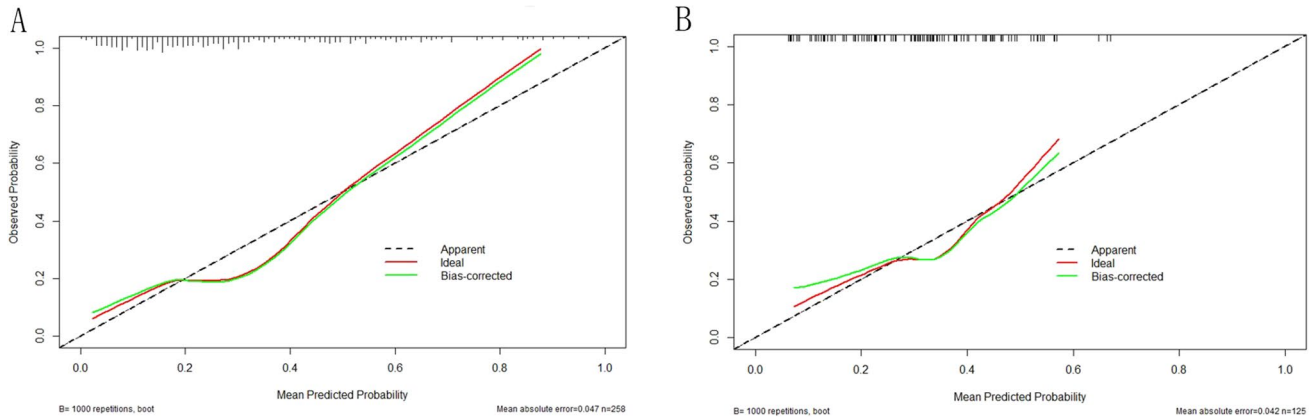

Fig. 6 Calibration curves for the nomogram predicting NR probability in the training set (**A**) and validation set (**B**). Internal validation of the nomogram was conducted using calibration curves derived from 1000 bootstrap samples. The horizontal axis denotes the predicted probability of NR, while the vertical axis represents the observed NR probability. The dashed diagonal line signifies the performance of an ideal model. The green line indicates the nomogram's performance, with closer alignment to the dashed diagonal line indicating superior prediction accuracy. NR, nutritional risk

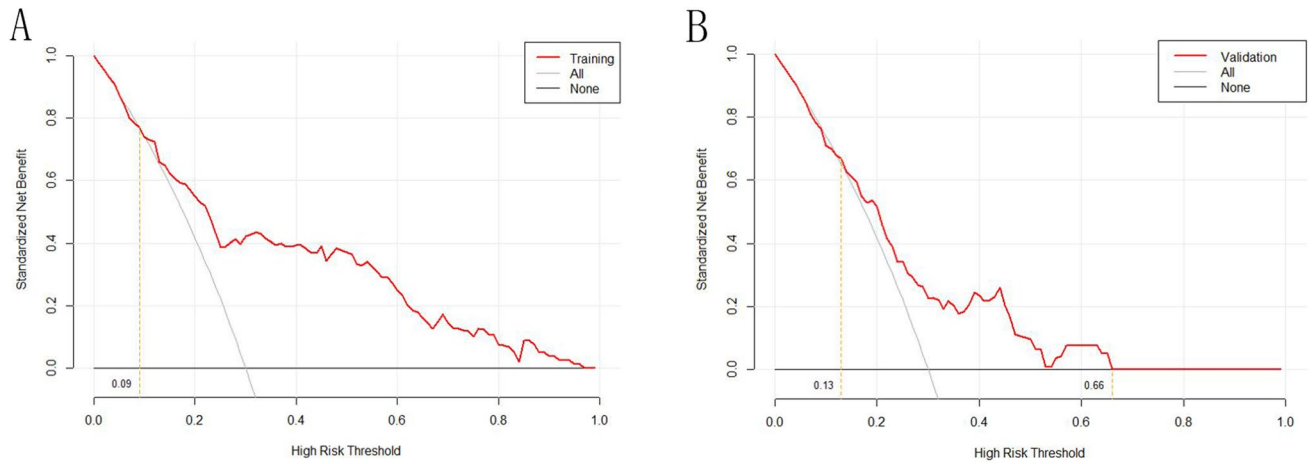

Fig. 7 DCA for the nomogram predicting nutritional risk (NR) probabilities in the training set (**A**) and validation set (**B**). The horizontal axis depicts the threshold probability, while the vertical axis represents the net benefit. The lines extending from the horizontal and vertical axes illustrate the net benefits of various prediction strategies. The DCA demonstrates that the nomogram's use for predicting NR risk confers a substantial net benefit when the threshold probability exceeds 9%. DCA, decision curve analysis; NR, nutritional risk

perception may have a significant impact on the nutritional status of patients with NPC.

The findings of this study indicate that lower ALT levels are positively associated with an elevated risk of malnutrition in patients undergoing radiotherapy, which contrasts with the findings of Konecka et al. [32]. One possible explanation for this discrepancy may lie in the fact that a significant proportion of patients receiving both radiotherapy and chemotherapy resort to parenteral nutrition as a preventive measure against malnutrition. However, a study has demonstrated that parenteral nutrition can markedly elevate ALT concentrations [33], thereby rendering higher ALT levels a protective factor in this particular cohort, a phenomenon that arises under specific clinical circumstances. Zhang's [34] observations from the physiological mechanism suggest that the relationship between low ALT levels and malnutrition in cancer patients can be elucidated through the interplay of interconnected metabolic pathways and cancer-specific adaptations. Glutaminolysis, a critical pathway in cancer cell proliferation, entails the conversion of glutamine to glutamate, followed by the transformation to alpha-ketoglutaric acid (α-KG) via ALT, thereby replenishing the tricarboxylic acid (TCA) cycle. Diminished serum ALT levels may indicate enhanced consumption by cancer cells, which in turn contributes to malnutrition. Aggressive cancer cells, characterized by heightened metabolic rates, further deplete ALT

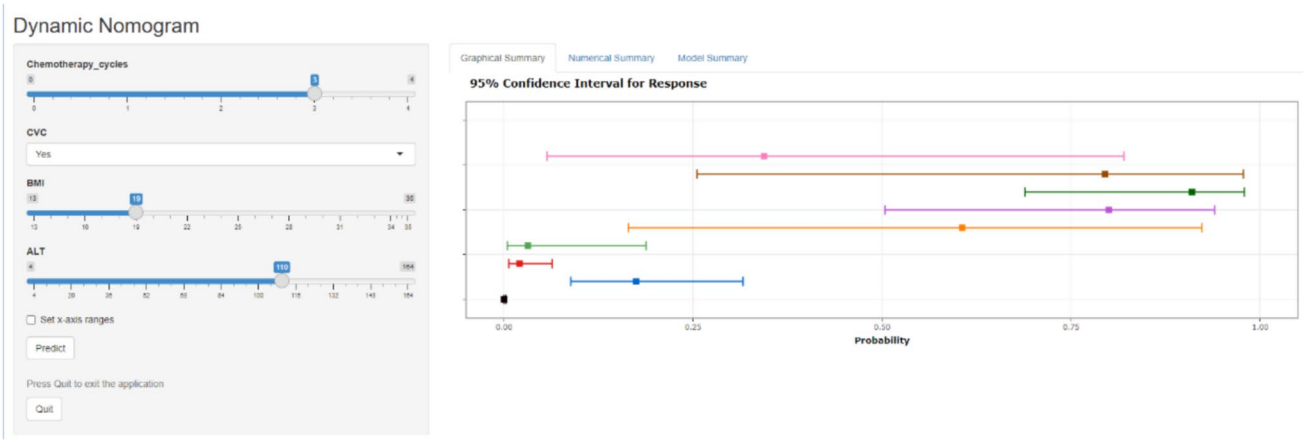

Fig. 8 A dynamic online nomogram to predict nutritional risk in patients with NPC, available at https://zbx809021704.shinyapps.io/DynNomapp/. Clinicians can utilize this tool by selecting appropriate parameters from a drop-down menu, reflecting the patient's individual clinical status. Upon submission of these parameters by clicking the "Predict" button, the system generates the probability of nutritional risk. The "Graph Summary" section visually presents the predicted probability along with a 95% confidence interval. Hovering over the graph reveals the specific parameters contributing to the risk assessment. Additionally, the "Numerical Summary" and "Model Summary" sections provide detailed predictions and model-specific parameters

levels and are associated with a poorer prognosis. Moreover, the Warburg effect, which favors anaerobic glycolysis, frequently results in an increased AST/ALT ratio, a finding that has been linked to unfavorable outcomes. Although changes in liver function induced by radiotherapy could affect ALT levels, no significant liver toxicity was detected in our study. Nonetheless, a deeper exploration of these mechanisms is merited. Panteghini et al. [35], through a multicentric investigation, determined that when individuals with a body mass index (BMI) up to 30 kg/m^2 were included, the upper reference limits (URLs) for ALT were 59 U/L for males and 41 U/L for females. When individuals with a BMI of 25 kg/m^2 or higher were excluded, the URLs for males and females were 49 U/L and 33 U/L, respectively. In light of this study's model, it is advisable to maintain patients' ALT concentrations at a high, yet below the URLs, to potentially mitigate the risk of malnutrition.

Limitations and development

Indeed, several limitations of the current study must be recognized. Firstly, the sample size was modest, which may have constrained the generalizability of our observations. To ascertain the validity and robustness of our findings, a study with a larger cohort is necessary. Secondly, the disparities in baseline patient characteristics between the two centers may influence the overall performance assessment of the model. Thirdly, the prognostic value of ALT levels as an indicator of nutritional risk may not be universally applicable. Additional research across diverse patient populations and at various centers is required to substantiate the use of ALT as a reliable biomarker. Lastly, while the nomogram is more targeted and precise, its reliance on hematological indicators may require patients to undergo additional tests, which could lead to uncertainty or confusion. Additionally, clinicians may face increased workloads due to the need for careful case reviews and individualized assessments. Future studies should focus on expanding the sample size and conducting multi-center studies to enhance the generality and robustness of the findings. It is necessary to further validate ALT as a biomarker of nutritional risk in different populations. In addition, efforts are being made to simplify the assessment process based on regularities, such as applying a large language model to read cases and extract valid information, in order to reduce the workload of medical staff. These advances will pave the way for more accurate and practical nutrition risk assessment and management strategies.

Conclusion

This study underscores the importance of early nutritional risk assessment in patients with NPC undergoing radiotherapy. The developed nomogram holds promise as a practical tool for identifying at-risk patients, guiding targeted interventions, and ultimately improving clinical outcomes. Further research is needed to validate its generalizability and explore its potential impact on patient outcomes.

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Author contribution BXZ and MC performed data analyses and wrote original manuscript; LL, LZ and CG collected data; PJC were responsible for contacting practice agencies; PJC and BXZ conceptualized and designed the study. All authors critically reviewed the manuscript and approved the final manuscript. BXZ and LL contributed equally as co-first authors.

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Data availability No datasets were generated or analysed during the current study.

Code availability The statistical analyses were conducted using SPSS 27.0 for Windows and R software version 4.4.0 (rms package; R Project, Vienna, Austria; http://www.Rproject.org).

Declarations

Ethical approval This study was conducted in accordance with the Declaration of Helsinki, and all participants have signed informed consent. This study was approved by the Nanfang Hospital Ethics Committee (NFEC-2018–013).

Consent to participate Informed consent was obtained from all of the participants in this study.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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