RESEARCH ARTICLE

Continuous quality improvement of nutrition management during radiotherapy in patients with nasopharyngeal carcinoma

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Abstract

Aim: To investigate the effect of implementing a model for continuous quality improvement in the nutritional management of patients with nasopharyngeal carcinoma (NPC) treated with radiotherapy.

Design methods: In the intervention group ($n = 77$), a model for the continuous quality improvement of efforts at nutrition management was implemented. These efforts included the development of a new process for nutrition management, a system to provide nutritional support and the use of targeted intervention plans to improve nutrition. The time from diagnosis to the administration of radiation therapy, the severity of oral mucositis and dietary factors were recorded and considered in the development of targeted nutrition intervention and nutrition education. The control group ($n = 71$) followed the original procedures for nutrition management.

Results: The study found that the CQI model can decrease the severity of oral mucositis caused by radiation and improve nutritional status in affected patients.

KEYWORDS

continuous quality improvement, FOCUS-PDCA, malnutrition, nasopharyngeal carcinoma, nutrition management, radiotherapy

1 | INTRODUCTION

Nasopharyngeal carcinoma (NPC) is a malignant tumour occurring in the mucosal epithelium of the nasopharynx. According to previously published studies, the occurrence of NPC is mainly related to factors, such as infection with Epstein–Barr virus (EBV), genetic susceptibility and environment (Cui et al., 2017; Ye Qian et al., 2016). Approximately 80% of cases of NPC are reported in China, where the condition seriously endangers people's health and quality of life (Chua et al., 2016). Radiotherapy is the main treatment for NPC. When the condition is diagnosed early, patients can achieve good

results through treatment with radiotherapy alone. When the condition is diagnosed as middle- or late-stage disease, patients may require simultaneous treatment with radiotherapy and chemotherapy (Ribassin-Majed et al., 2017). NPC and the effects of anti-tumour therapy contribute to malnutrition, which has become a common clinical complication in NPC patients. The incidence of malnutrition is highest among patients with NPC who have received radiotherapy (Miao et al., 2017). The main manifestations of malnutrition are progressive wasting, weight loss and oedema in the lower extremities, which is caused by hypoproteinemia (Deng et al., 2019). Malnutrition weakens the immune system, prolongs hospital stay, impairs the

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Juan Ji and Dan-Dan Jiang contributed equally to this work.

localization of radiotherapy and aggravates adverse reactions to radiotherapy, leading to the interruption of treatment and negative effects on prognosis and quality of life (Guo Mingjuan, 2017). Malnutrition during radiotherapy for NPC is, therefore, a serious concern.

Previous studies have shown that reasonable nutritional support has a positive effect on quality of life and prognosis in patients with NPC (Ding Huiping et al., 2018; Jin et al., 2017). Therefore, nutrition management has great significance for patients with NPC who are scheduled to receive radiotherapy.

2 | BACKGROUND

Continuous quality improvement (CQI) is a theory for quality management with a focus on process management and quality control. CQI, which was originally used in enterprise production in the 1980s–1990s, comprises a management philosophy and a set of systematic management methods. In western countries, CQI practices spread to almost all medical institutions (Hunter et al., 2017; Johnson, 2018). In recent years, the use of CQI methods to improve the prognosis of patients has reduced medical costs (Xiaotong, 2018; Xie Xiaoshuai et al., 2018; Xuemei, 2018). FOCUS-PDCA is an acronym used by American hospital organizations for effective quality management (L, 2018). The acronym stands for "Find; Organization; Clarification; Understand; Select; Plan; Do; Check; Act". This approach is an extension of the PDCA cycle, which aims for more careful understanding and analysis of the links in the program in order to improve quality. Healthcare practitioners are asked to follow the steps signified by the acronym: finding problems (find, F); organization (organization, O); clarification (clear, C); understanding (understand, U); selection (select, S); plan, P; implementation (do, D); inspection (check, C); processing (act, A). The corresponding operation procedure is rigorous and requires attentive management at each step in the process. In this study, the FOCUS-PDCA model was used to manage nutrition during radiotherapy in patients with NPC. The aims were to reduce the occurrence of malnutrition in patients with NPC, to improve the tolerance of treatment and quality of life and to standardize nutrition management in the treatment of patients undergoing radiotherapy for NPC.

3 | MATERIAL AND METHODS

3.1 | Subjects

This was a retrospective study. During the period from January 2018 to December 2019, 148 patients with NPC treated by radiotherapy were selected in the Department of Radiotherapy at the first affiliated Hospital of Soochow University. Seventy-one patients seen during the period from January to December 2018 were assigned to the control group. Seventy-seven patients seen during the period from January to December 2019 were assigned to the intervention

group. The inclusion criteria were as follows: (1) Pathological diagnosis of NPC; (2) Patients undergoing initial radiotherapy; (3) Age 18–80 years; (4) No special religious beliefs or dietary restrictions; (5) Provided informed consent and willingness to participate in this study. The exclusion criteria were as follows: (1) Previous or existing severe cognitive impairment and/or mental abnormalities; (2) Complications of NPC with another tumour type or systemic disease; (3) Inability to receive anti-tumour treatment and dropout from the study. Both groups were treated with Intensity Modulation Radiation Therapy (IMRT), with total radiation dose of 68–72 Gy (31–33 cycles), once per day, 5 times/week (6–7 weeks total).

3.2 | Methods

3.2.1 | Intervention group

The first step of the FOCUS implementation methods is signified by F: find a process to improve. The first-line treatment for NPC is radiotherapy. The most common adverse reaction to radiotherapy is oral mucositis, with incidence of nearly 100%. Oral mucositis leads to a decrease in food intake. This decrease, coupled with the consumption of nutrients by the tumour itself, greatly increases the risk of malnutrition in affected patients. The second step is signified by O: organize a team that knows the process. Set up a quality improvement team that includes doctors, nurses with expertise in nutrition, bedside nurses, dieticians and pharmacists. The third step is signified by C: clarify current knowledge of the process and identify existing processes. After receiving radiotherapy for NPC in the ward, nutritional support was provided to educate patients about disease, without attention to the patient's diet, until a significant reduction in intake or until the patient was unable to ingest nutrition orally. The fourth step of the process is signified by U: understand the cause(s) of any variation in process. The causes of malnutrition during radiotherapy were summarized as follows: (1) The current procedure only deals with patients with malnutrition during radiotherapy without early screening and assessment; (2) The medical staff did not pay enough attention to the patient's diet during the treatment; (3) Patients have insufficient knowledge about malnutrition and pay more attention to the effects of tumour therapy; (4) Lack of teamwork and targeted nutrition support programs. The fifth step of the process is signified by S: select the process improvement. In order to select the optimal approach to process improvement, we conducted a comprehensive literature search. Using "nasopharyngeal carcinoma or head and neck tumor and nutrition" as search terms, we searched the Wanfang, China National Knowledge Infrastructure, PubMed and Ovid databases to collect relevant literature. We have adopted measures that are appropriate for our departments: patients with NPC use the whole course of nutrition management. After reviewing the studies collected, the following were identified as steps that might improve the process for treating NPC patients who had received radiotherapy and showed signs of malnutrition. Once diagnosed with NPC, nutritional screening and assessment

should be performed before the initiation of radiotherapy (Zhang Xin et al., 2019). Nutrition education and treatment should be tailored to the patient's condition, nutritional scale scores and various other diet- and nutrition-related blood indicators (Cao Yuandong et al., 2016; Huang et al., 2019; Meng et al., 2019; P, 2020; Su Duanyu, 2016). Based on these results, the following improvements were implemented: multidisciplinary participation in the development of normative nutrition support programs; increased effort on the part of nurses to screen, assess and monitor patient nutritional status; reviews of the nutrition education provided to patients by medical staff; development of a novel protocol for nutritional management in patients with NPC treated with radiotherapy (Figure 1).

The next steps in the FOCUS-PDCA methodology were as follows: P: Plan the improvement and the optimal approach to continued efforts at data collection. The scores of patients on nutritional indexes before radiotherapy, during radiotherapy and after completion of radiotherapy were collected. The data were analysed to characterize changes in nutritional status throughout the course of

radiotherapy. Before and after the intervention, nutrition-related indicators were measured in all patients, hoping to reduce the incidence of malnutrition in NPC patients during radiotherapy, and to verify the effectiveness of the application of the FOCUS-PDCA model to management. D: Do the improvement, data collection and analysis. (1) Develop normative nutrition support programs in five categories as follows: Category A: Patients diagnosed with NPC undergo nutritional screening, assessment and evaluation. Attending healthcare personnel calculate daily caloric requirements, and conduct dietary guidance. Because the tumour consumes a high level of nutrients, patients in this group received a normal diet plus oral nutrition supplementation[1] (ONS)[1]. The formula for calculating ONS dose was:[1] standard weight (women: height – 105 cm, men: height – 100 cm) × 10 kcal/kg (Figure 1); Category B: oral mucositis was classified as grade 0 during radiotherapy, so patients received the same nutrition as before radiotherapy; Category C: oral mucositis was grade 1, so patients received soft food + ONS[1]. If target nutrient levels were not reached, ONS[2] was used; Category D: oral mucositis
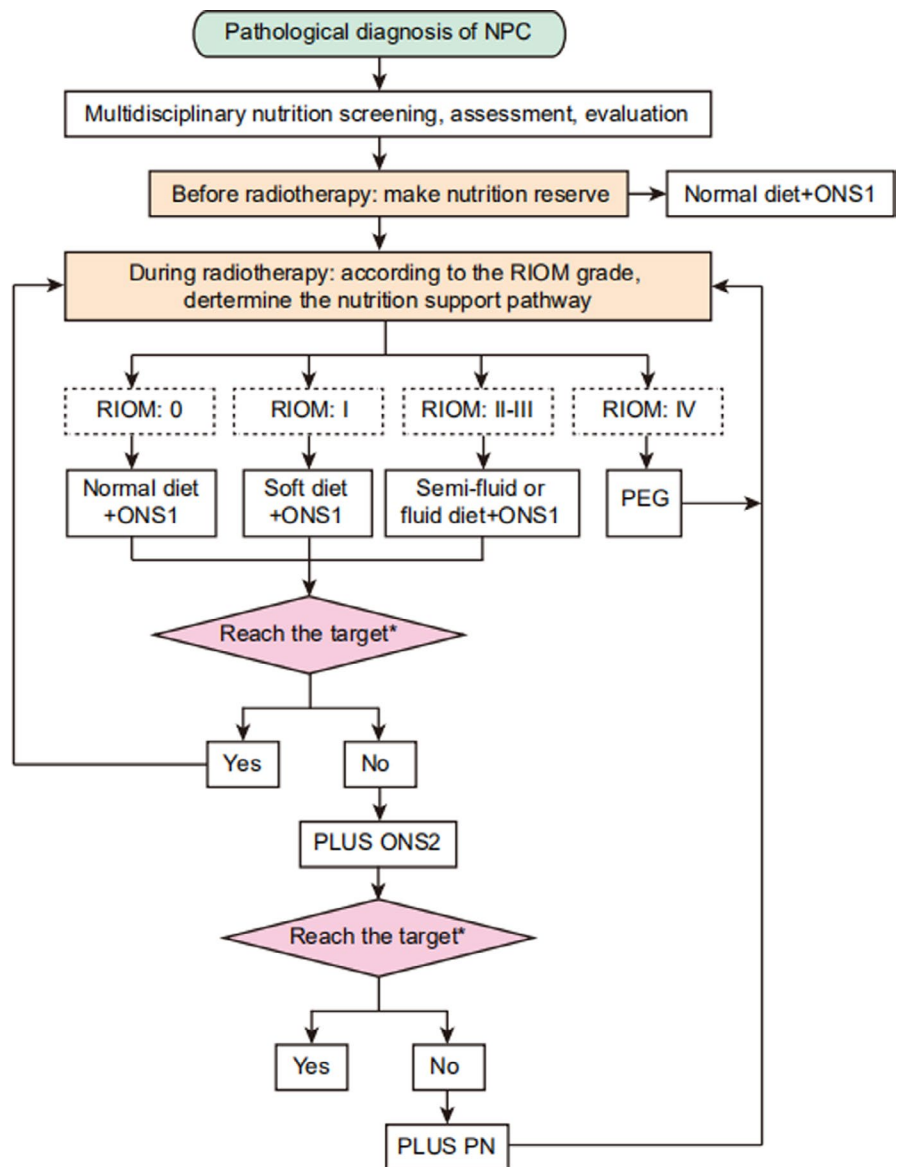

FIGURE 1 Nutrition management for NPC patients receiving radiotherapy. ONS, oral nutrition supplement; PN, parenteral nutrition; RIOM, radiotherapy induced oral mucositis; TPN, total parenteral nutrition. Note ONS1 calorie formula: standard weight (women: height – 105 cm, men: height – 100 cm) × 10 kcal/kg; ONS2 calorie formula: total calorie target – total dietary calories – ONS1 calories; Target total calorie formula: standard weight ××25 kcal/kg + ONS1 calories

grade 2–3, necessitating a fluid diet or a semi-fluid diet + ONS[1] (if the patient did not meet nutrition targets), plus ONS[2]; Category E: patients with grade 4 oral mucositis who are no longer able to ingest food orally and receive percutaneous endoscopic gastrostomy (PEG) tube. (2) Development and implementation of a nutrition management process for patients with NPC (Figure 1). Analysis of the clinical data and the results obtained by literature review showed that the oral reaction in patients with NPC began after 7–10 days of radiotherapy, typically manifesting as dry mouth and sticky saliva. After approximately 20 days of radiotherapy, the severity of oral mucositis was aggravated; the degree of oral mucositis was most serious upon completion of radiotherapy, (Jinlian, 2017; Zhao Lianghui, 2017). Patients with oral mucositis cannot typically ingest food through the mouth, so intervention is provided. The current protocol provides for intervention before radiotherapy; upon the initiation of radiotherapy, the attending healthcare provider should pay daily attention to the patient's diet, dynamically adjust the diet plan and ensure that the patient meets the required target quantity every day. The attending clinician should also record weekly nutritional scores, body weight, the presence of stomatitis and blood indicators related to nutrition. (3) Define the responsibilities of each member. The doctor is responsible for treatment of the patient's disease. The dietician is responsible for formulation of the nutrition plan. The pharmacist is responsible for providing guidance on the patient's medication regimen. The nurse is responsible for the patient's dietary education as well as observation and recording of the eating situation. Each member takes part in daily morning rounds to understand the overall situation of the patient and to formulate the best individualized plan. (4) Patient nutrition education: The incidence of malnutrition in patients with head and neck radiotherapy is particularly high, and the associated harm is great. However, during anti-tumour treatment, patients pay more attention to treatment of the tumour than to nutrition. Patients typically feel that loss of appetite and/or weight are expected adverse reactions. Patients may even feel that nutritional supplementation will accelerate the growth of the tumour. It is, therefore, of the utmost importance to educate the patient about nutrition. It is helpful to tell patients that nutritional support does not accelerate tumour growth or interfere with anti-tumour therapy. Dietary guidance should be individualized to the patients' eating habits. A food model may be used to educate patients who are visual learners. Patients should be educated about the purpose and methodology of oral nutrition. Attention should also be paid to any food intolerance on the part of a given patient. C: Check and study the results. The head nurse regularly checks the nurses' implementation of the new procedures. Nurses with expertise in nutrition are responsible for the training and inspection of bedside nurses. Doctors regularly monitor the issuance and implementation of doctors' orders. Dieticians check for compliance with nutritional protocols. A: Act to maintain improvements in the quality of care administered and to further improve the process. Before and after use of the FOCUS-PDCA model for nutrition management, patients in the midst of radiotherapy should be compared with those who have completed the radiotherapy regimen.

3.2.2 | Control group

The control group was treated with routine care (Devi et al., 2016). For patients with grade 1 oral mucositis, this meant using a super-soft toothbrush that had been soaked in warm water for 30 min before use. Teeth were brushed with fluoride toothpaste without granules. Patients were asked to gargle with a neutral mouthwash such as saline. For those with grade II–III mucositis, if there was no improvement in pain with the administration of medication, or bleeding for more than 2 min, patients were advised not to use a toothbrush. In such cases, oral irrigation was performed. In cases of grade 4 oral mucositis, before attempting to relieve symptoms, patients should be advised not to use a toothbrush or dental floss. Oral irrigation should be performed four times a day, and pain can be treated with the regular use of systemic painkillers. Nurses should teach patients neck care and urge them to practice functional exercises, such as opening their mouths, shrinking their cheeks and tapping their teeth with their tongue. When radiotherapy-induced oral mucositis (RIOM) affects eating, nutritional support is given in five steps (Zhang Xin et al., 2019): education on food and drink + nutrition; nutrition education + ONS; total enteral nutrition (TEN); partial enteral nutrition (PEN) + partial parenteral nutrition (PPN); TPN. The attending clinician should move on to the next step in the protocol when 60% of the target energy requirement is not met for 3–5 days. The attending nurse should observe the patient's eating condition every day and record the degree of stomatitis and the nutrition index score every week until the end of radiotherapy.

3.3 | Observation indicators

3.3.1 | Demographics

The demographic and clinical characteristics analysed in this study included age, sex, level of education, disease stage, body mass index (BMI), white blood cells (WBC), haemoglobin (Hb), lymphocytes (LYM), serum albumin (ALB) and serum pre-albumin (PAB).

3.3.2 | Patient-generated subjective global assessment

The patient-generated subjective global assessment (PG-SGA) is an effective tool with which to assess nutritional status in a tumour patient (Lee, 2019). The PG-SGA is recommended by the American Dietitian Association and the China Anticancer Association's Professional Committee of Cancer Nutrition and Support Therapy for the evaluation of nutrition in people with cancer. The scale may be used for qualitative and quantitative assessment. For a quantitative assessment, the clinician adds together four subsections: patient self-assessment (A score); disease condition (B score); level of stress (C score) and physical examination score (D score). For qualitative assessment, the patient is classified as "A", "B" or "C". A grade

of "A" represents good nutrition (corresponding to a quantitative assessment of 0–1 points), with no need for nutritional intervention. Patients labelled as grade A should be followed with observation. Patients classified as "B" have suspected or moderate malnutrition (2–8 points) and should receive nutrition education from a dietician, alone or in combination with intervention on the part of a doctor or a nurse. Patients classified as grade C have severe malnutrition (> 9 points) with severe symptoms and an urgent need for simultaneous nutritional intervention.

3.4 | Radiation Therapy Oncology Group

The scale provided by the Radiation Therapy Oncology Group is as follows: grade 0, no change; grade I, congestion/may have mild pain, with no need for analgesics; grade II, patchy mucositis with inflammatory serum blood secretion and/or moderate pain requiring analgesics; grade III, fusion fibrous mucositis, with or without severe pain requiring anaesthetics; grade IV, ulceration, bleeding and/or necrosis (Parulekar et al., 1998).

3.5 | Statistical analysis

Statistical analyses were conducted using SPSS 20. The data were tested for normality and variance homogeneity. Normally distributed data are expressed as mean $\pm$ standard deviation and were compared with the two-sample t-test.

4 | RESULTS

4.1 | General comparison of demographics between groups

For this study, the intervention group included 77 patients, and the control group included 71 patients. There was no significant difference between groups in terms of age, sex, disease stage, body weight, nutritional score or blood index ($p > .05$; Table 1).

4.2 | Nutritional status before versus after intervention

After using the FOCUS-PDCA model for nutrition management, analysis showed that BMI and PG-SGA differed significantly between groups ($p < .05$). BMI was significantly higher in the intervention group than in the control group. After radiotherapy, severe malnutrition was more common in the control group than in the intervention group (Table 2). Analysis of blood markers revealed significant differences between groups in levels of Hb, LYM, ALB and PAB ($p < .05$). During radiotherapy, levels of WBC and Hb were lower in the intervention group than in the control group, while levels of LYM, ALB and prealbumin were significantly higher in the intervention group than in the control group (Table 3).

4.3 | Severity of oral mucositis

The rate of radiotherapy was 100% in both groups. During the administration of radiotherapy, one patient in the control group was free of oral mucositis (1.4%); 14 patients in the experimental group (18.2%) were free of oral mucositis. In all cases in the experimental group, the degree of oral mucositis was mild ($p < .01$; Figure 2). After radiotherapy, most patients in both groups had grade 2 oral mucositis; however, 18 cases of grade 1 mucositis were observed in the experimental group (23.4%), and four cases of grade 1 mucositis were observed in the control group (5.6%). The severity of oral mucositis differed significantly between groups ($p < .05$; Figure 3).

5 | DISCUSSION

Nutrition is the material basis for the growth and development of the human body and the maintenance of normal physiological function, and it is one of the indispensable conditions for improving a patient's condition and accelerating his recovery after treatment. Notably, some patients are malnourished before being affected by malignant tumours. In such patients, the toxicity associated with anti-tumour treatment exacerbates their malnutrition. Although the use of IMRT in recent years has effectively reduced treatment-related toxicity in some patients, those patients have not exhibited any significant improvement in nutritional status (Brown et al., 2015). It has been reported (Fuxiang, 2014; Hairong & Hong Jin Province, 2015; Irungu et al., 2015) that 35% of patients with NPC lose >5% of their body weight before treatment, and the incidence of weight loss throughout the course of radiotherapy reaches 46%. Malnutrition not only causes the patient to lose weight, but also leads to the depletion of visceral and body protein. In patients with NPC, such hypoproteinemia impairs enzyme function and other physiological responses, leading to increased immune activity, increased risk for infection and other complications and reduced quality of life. Nutrition interventions in patients with NPC may adopt various forms, including nutrition education and management and ONS, as well as use of a nasogastric feeding tube, percutaneous endoscopic gastrostomy tube fistula (PEG) and/or parenteral nutrition (Cao Yuandong, 2016; Ding Huiping, 2018; Huang et al., 2019; Jin et al., 2017; Meng et al., 2019; Su Duanyu, 2016; Zhang Xin et al., 2019). Such tools may improve nutritional status in patients with NPC. After reviewing the relevant clinical literature and the results of our clinical experience, we adopted an intervention program that comprised comprehensive nutrition management, providing nutritional support to patients from the time of diagnosis onward, in addition to performing targeted nutritional interventions that were tailored to a given patient's nutritional condition and eating habits during radiotherapy.

TABLE 1 Comparison of patient characteristics between groups

Characteristics	Control	Intervention	p
Age (Year)	52.89 ± 12.37	52.19 ± 13.79	.723
Sex			
Male	56	61	.559
Female	15	16	
Educational level			
Illiterate	15	17	.635
Primary school	21	19	
High school	24	20	
College	17	21	
Stage of disease			
I	0	3	.372
II	4	4	
III	41	46	
IV	26	24	
BMI (kg/m^2)			
<18.5	2	0	.243
18.8 ~ 23.9	34	43	
≥24	35	34	
PG-SGA			
≤1	11	14	.415
2–8	60	63	
≥9	0	0	
WBC (10^9/L)	6.21 ± 1.58	6.09 ± 1.72	.494
Hb (g/L)	140.82 ± 12.12	137.29 ± 12.78	.087
LYM (10^9/L)	1.44 ± 0.60	1.42 ± 0.55	.599
ALB (g/L)	45.71 ± 2.52	45.79 ± 3.24	.175
PAB (mg/L)	267.80 ± 45.44	265.25 ± 50.24	.419

Abbreviations: ALB, albumin; BMI, body mass index; Hb, haemoglobin; LYM, lymphocytes; PAB, prealbumin; PG-SGA, patient-generated subjective global assessment; WBC, white blood cell count.

TABLE 2 Comparison of BMI (kg/m^2) and PG-SGA between groups

Group	n	Mid-treatment (BMI)			End of radiotherapy (BMI)			Mid-treatment (PG-SGA)			End of radiotherapy (PG-SGA)		
		<18.5	18.5 ~ 23.9	≥24	<18.5	18.5 ~ 23.9	≥24	(A)	(B)	(C)	(A)	(B)	(C)
Control	71	5	32	34	8	41	22	0	55	16	0	25	46
Intervention	77	1	48	28	1	52	24	0	41	36	0	40	37
X^2		6.214			6.600					9.506	4.201		
p		.045			.037					.002	.040		

The results of this study showed that, during the course of radiotherapy, the control group had five patients with BMI <18.5 kg/m^2 (7%). After the course of radiotherapy, the control group had eight patients with BMI <18.5 kg/m^2 (11%); the intervention group had one patient with BMI <18.5 kg/m^2 (1%). This difference between groups was significant (p < .05), indicating that a comprehensive nutrition management program may reduce the rate of weight loss in patients with NPC who are undergoing radiotherapy.

PG-SGA is one of the scales used most commonly to assess the subjective nutritional status of patients. After a course of radiotherapy, the incidence of severe malnutrition was significantly lower in the nutrition management group, compared with those in the control group (p < .05). Nutritional status was mainly affected by weight, quantity of food ingested and overall activity level, with dietary intake being particularly important. Dietary intake affected the patient's physical strength and weight (Arends et al., 2017).

TABLE 3 Comparison of blood indices between groups

Group	n	Mid-treatment					End of radiotherapy				
		WBC (10^9/L)	Hb (g/L)	LYM (10^9/L)	ALB (g/L)	Prealbumin (mg/L)	WBC (10^9/L)	Hb (g/L)	LYM (10^9/L)	ALB (g/L)	Prealbumin (mg/L)
Control	71	5.32 ± 1.68	126.49 ± 12.28	0.62 ± 0.48	42.35 ± 3.47	233.10 ± 54.27	4.58 ± 1.68	123.15 ± 14.18	0.40 ± 0.27	37.48 ± 3.66	214.66 ± 55.46
Intervention	77	4.77 ± 1.64	122.05 ± 13.63	1.11 ± 0.51	42.89 ± 3.56	252.83 ± 47.02	4.38 ± 1.71	116.69 ± 15.15	0.73 ± 0.40	39.80 ± 4.36	239.01 ± 52.97
t		2.007	2.076	−6.009	−0.925	−2.369	0.700	2.675	−5.763	−3.504	−2.729
p		.047	.040	.000	.356	.019	.485	.008	.000	.001	.007

Participation in a nutrition management program markedly improved nutritional status in NPC patients.

Levels of leucocytes, LYM, ALB, PAB and Hb are often used clinically as objective indicators to evaluate patient nutritional status. Previous studies have shown that these indicators are associated with the cancer patient's responsiveness to treatment, tolerance of complications and long-term survival (Cong & Hu, 2017). The present study found that the difference in WBC between groups was statistically significant only during radiotherapy ($p < .05$). Because tumour-associated inflammatory cells can promote the proliferation and metastasis of tumour cells and affect the number of leucocytes circulating in the blood, the results need to be studied further. The propagation of a malignant tumour will create a state of anaemia and hypoxia, which reduces the body's sensitivity to radiotherapy and chemotherapy. Radiotherapy and chemotherapy aggravate anaemia and hypoxia, creating a vicious cycle (Palta et al., 2017). This study found that Hb levels decreased significantly during radiotherapy in both groups ($p < .05$). Lymphocytes are the main participants in the adaptive immune response and play an important role in the clearance of immune and residual tumour cells, which mediate the immune response during radiotherapy and chemotherapy (Cong & Hu, 2017). Yoding et al. (Yodying et al., 2016) showed that lymphocyte levels were an independent risk factor for survival and prognosis in patients with oesophageal cancer. The results of this study showed that LYM levels decreased significantly throughout the course of radiotherapy, but that this effect was less severe in the intervention group, compared with the control group ($p < .01$). ALB and PAB are important indices for clinicians seeking to determine whether the body is malnourished. Reduced levels of ALB and PAB indicate poor prognosis in the context of many diseases (Cong & Hu, 2017). In a study by Talwar et al. (Talwar et al., 2016) of patients with head and neck tumours undergoing radiotherapy, PAB was a more sensitive indicator of nutritional status than ALB. This finding probably derives from the shorter half-life of PAB. The results of this study showed that, during radiotherapy, levels of ALB and PAB decreased more in the control group than the intervention group ($p < .05$). This finding indicates that a comprehensive effort to supplement nutrient deficiencies may gradually succeed over time.

This study also showed that oral mucositis was significantly less severe in the intervention group, compared with the control group ($p < .05$). These findings are similar to those reported by Cao (Cao Yuandong et al., 2016), which indicated that effective nutritional support is conducive to reducing the adverse reactions associated with radiotherapy.

In this study, the FOCUS-PDCA model was applied for nutrition management in patients with NPC who had received radiotherapy. The results showed that use of the FOCUS-PDCA model significantly improved nutrition status. Notably, CQI is a continuous process, with no clear starting point or ending point. In the implementation of CQI management ideas, each specific improvement is achieved through adherence to the PDCA cycle. For this study, team members held a CQI meeting once a week to discuss and analyse the implementation process and the situation of each patient.
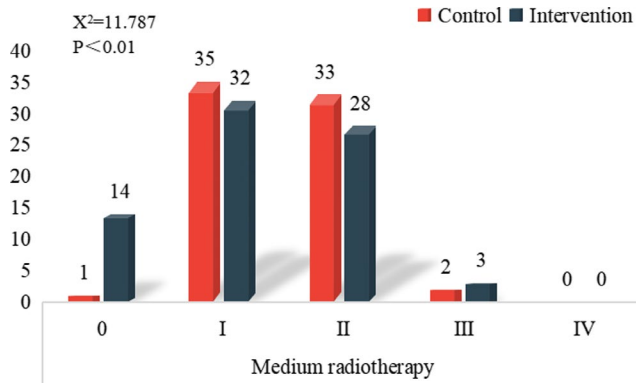
FIGURE 2 Oral mucositis in patients who received moderate radiotherapy
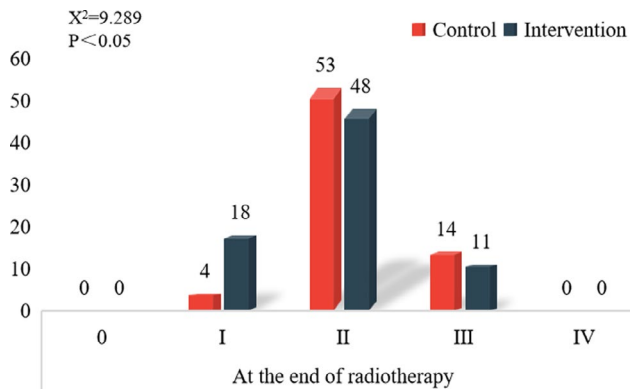

FIGURE 3 Oral mucositis upon completion of radiotherapy

This allowed the clinicians participating in the study to continuously evaluate the effectiveness of the formulated nutrition plan and the nutrition management process, to conduct dynamic tracking and to analyse patient nutritional status as reflected in the data collected. Throughout the course of radiation therapy, patients' nutritional index scores continued to decline, but levels of malnutrition were significantly lower in the intervention group, compared with the control group. Furthermore, the degree of radiation-induced inflammation in the oral cavity mucous membrane was lower in patients who received nutrition management. However, recovery was not accelerated in patients who received nutrition management. Additional long-term studies of the effects of CQI in patients with NPC are required to elucidate these findings.

6 | CONCLUSION

In summary, the FOCUS-PDCA model facilitates the nutritional management of patients with NPC during radiotherapy. The authors of this study, therefore, recommend the promotion and application of this model in clinical practice. In this study, use of the FOCUS-PDCA model decreased the incidence of malnutrition in patients with NPC, but the sample size was small, and no follow-up was conducted. Future

studies with a longer duration of follow-up should be conducted on a larger study population to validate the findings presented above.

7 | RELEVANCE FOR CLINICAL PRACTICE

In China, the incidence of NPC is high, and radiotherapy is the preferred treatment. Adverse reactions to radiotherapy have resulted in a high incidence of malnutrition, which impacts therapeutic efficacy and decreases quality of life among patients. Effective nutrition management is very important to improve the nutritional status of patients and to mitigate adverse reactions to radiotherapy. In this study, effective nutrition management for patients with NPC radiotherapy was conducted through CQI, which has practical guiding significance for clinical practice and can help patients to better tolerate anti-tumour treatment, reduce adverse reactions and improve quality of life.

CONFLICT OF INTEREST
We declare that we have no conflict of interest.

AUTHOR CONTRIBUTIONS
Juan Ji, Ke-yan Qian and Dan-dan Jiang designed/performed most of the investigation, data analysis and wrote the manuscript; Yi-qun Yang designed most of the investigation; Mu-xing Zhang provided nutrition assistance; Zhe Xu contributed to interpretation of the data and analyses. All the authors have read and approved the manuscript.

ETHICAL APPROVAL
This study was approved by the ethics committee of the first affiliated Hospital of Soochow University. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

DATA AVAILABILITY STATEMENT
The datasets generated and analysed during the present study are available from the corresponding author on reasonable request.

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