Analysis of prognostic factors and study on nutritional support for chronic heart failure in menopausal women

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Running title: Nutritional interventions in menopausal women

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ABSTRACT

Background and Objectives: Menopausal women with chronic heart failure (CHF) exhibit unique physiological characteristics and prognostic features. The aim of this study is to analyze the significant predictive factors for the prognosis of chronic heart failure in menopausal women and the impact of different nutritional interventions on prognosis. **Methods and Study Design:** A total of 270 menopausal women with CHF were enrolled in the study and divided into two groups based on the nutritional intervention received. Analyze the significant predictive factors of all-cause mortality, readmission rate, deterioration of cardiac function, deterioration of nutritional status, and deterioration of quality of life, as well as the impact of nutritional intervention on these prognoses. Build a risk score model based on significant factors in the prognostic model. Evaluate the predictive ability of the model through the ROC curve. **Results:** Multivariate logistic regression analysis showed that NYHA grading BNP, eGFR, The level of estradiol (E2) and nutritional intervention are significant influencing factors in multiple prognostic indicators, among which the enhanced nutritional support and micronutrient supplementation program in nutritional intervention have a significant protective effect on poor prognosis. The constructed nutritional risk model has good discriminative ability and robustness in predicting prognosis. **Conclusions:** This study identified menopausal characteristics, NYHA classification, BNP, eGFR, and estradiol levels as important prognostic predictors in menopausal women with CHF. Enhanced nutritional support and micronutrient supplementation significantly improved patient prognosis. The risk model based on nutritional intervention provides scientific basis for the management strategy of chronic heart failure in menopausal women.

Key Words: perimenopause, chronic heart failure, nutritional intervention, prognosis prediction, prognostic factors

INTRODUCTION

Chronic heart failure (CHF) is a global health problem with high prevalence and mortality rates, and its diagnosis, treatment, and other aspects face severe challenges, especially in menopausal female patients.[1, 2, 3] Menopausal women experience a rapid decline in estrogen levels, accompanied by metabolic disorders, abnormal endothelial function, and increased inflammatory responses, which further promote the progression of chronic heart failure.. In addition, the menopausal stage is often accompanied by various symptoms, including hot flashes, night sweats, insomnia, and emotional fluctuations, which not only affect the patient's

quality of life but may also have adverse effects on cardiovascular function through indirect pathways.[4, 5, 6, 7] In recent years, SGLT2 inhibitors (such as dapagliflozin and empagliflozin), ARNI medications like sacubitril-valsartan, and beta-blockers such as metoprolol and bisoprolol have shown significant benefits in the treatment of CHF. These drugs not only improved the symptoms of patients, but also significantly reduced the hospitalization and mortality rates of heart failure patients. However, drug therapy is only a part of managing chronic heart failure, and nutritional intervention as a non pharmacological treatment strategy has received increasing research attention in recent years.

Nutritional intervention, as an important component of chronic heart failure nursing, has shown certain clinical value in improving patients' nutritional status, cardiac function, and quality of life.[8, 9] Current research indicates that enhanced nutritional support (high protein, high calorie diet) and micronutrient supplementation can improve the prognosis of chronic heart failure, while Omega-3 fatty acids, as anti-inflammatory and metabolic regulators, also play a role in cardiovascular disease.[10, 11, 12] However, there is currently a lack of research on the impact of different nutritional interventions on the prognosis of menopausal women, as well as systematic analysis of key predictive factors. In addition, due to the complexity of heart failure progression, hormone changes, and metabolic disorders in menopausal women, existing universal risk prediction models may not fully reflect the characteristics of this population. Therefore, it is necessary to establish risk models specifically for this population.

This study involved 270 menopausal women with CHF who were assigned to one of two nutritional intervention strategies: enhanced nutritional support combined with micronutrient supplementation or basic nutritional support combined with Omega-3 fatty acid supplementation. First, we compared the baseline characteristics of the two groups, including menopause-related information, CHF characteristics, and biochemical indicators. Second, we performed multivariate logistic regression analysis to identify significant predictors of all-cause mortality, rehospitalization rates, cardiac function deterioration, nutritional status decline, and quality of life deterioration. Finally, based on the significant factors identified in multiple prognostic models, we calculated their average regression coefficients to construct an integrated risk model, which was evaluated for predictive ability and robustness using ROC curves.

By constructing a risk model tailored to menopausal women, we aim to provide new perspectives and guidance for precise management and optimized nutritional intervention strategies for this population. This study not only addresses gaps in the current literature but

also provides a more systematic and comprehensive theoretical foundation for the management of CHF in menopausal women.

MATERIALS AND METHODS

Patients

This study was a retrospective observational cohort study involving menopausal women with chronic heart failure (CHF) who were admitted to the cardiology department of our hospital between January 2019 and October 2021, with a follow-up period of three years. Inclusion criteria were as follows: age $45-68$ years, in perimenopause or postmenopause; meeting the diagnostic criteria for CHF (according to the 2021 ESC Heart Failure Guidelines); disease duration ≥ 1 year; oral nutrition as the primary intake method, with no significant gastrointestinal dysfunction; and complete clinical and follow-up data. Exclusion criteria included: concurrent advanced malignancies or severe infections; acute heart failure or the need for mechanical support devices; special nutritional interventions within one month prior to admission; or loss to follow-up or missing data during the study period.

Nutritional intervention strategies

The nutritional interventions in this study included two approaches: enhanced nutritional support + micronutrient supplementation (Combination 1) and basic nutritional support + Omega-3 fatty acid supplementation (Combination 2). In the enhanced nutritional support program, for patients with mild chronic heart failure (NYHA I-II), the protein intake is 1.2 g/kg/d, the calorie intake is 30 kcal/kg/d, the vitamin D intake is 800 IU per day, and the calcium intake is 500 mg per day. Patients with moderate chronic heart failure (NYHA III) have a daily protein intake of 1.2-1.4 g/kg/d, a daily calorie intake of 30-35 kcal/kg/d, a daily vitamin D intake of 800-1000 IU, and a daily calcium intake of 500-800 mg. For patients with severe chronic heart failure (NYHA IV), the daily protein intake is 1.4-1.5 g/kg/d, the daily calorie intake is 35-40 kcal/kg/d, the daily vitamin D intake is 1000 IU, and the daily calcium intake is 800-1000 mg. According to the patients' needs, appropriate antioxidants (such as vitamin C and E) should be supplemented to improve their nutritional status, enhance immune function, and support cardiac function repair. If necessary, medical nutritional supplements should be supplemented. The intervention duration is 3 months. The basic nutritional support program is applicable to patients with all degrees of chronic heart failure, mainly providing standard protein (0.8-1.0 g/kg/d) and moderate calories (25-30 kcal/kg/d), and supplementing

1-2 g of Omega-3 fatty acids (mainly sourced from EPA and DHA) daily to suppress inflammatory reactions, improve cardiovascular function, and provide metabolic protection; The supplement forms include deep-sea fish oil capsules or Omega-3 rich meals, such as salmon, sardine, etc. The intervention duration is 3 months.

Data collection

Data collected included baseline information, follow-up data, and laboratory results: age, BMI, disease duration, presence of hypertension, diabetes mellitus, chronic kidney disease, types of medications used (ACE inhibitors, Angiotensin II Receptor Blockers), menopausal duration, NYHA functional classification, heart failure type (HFrEF, HFpEF, HFmrEF), BNP, serum protein, albumin, prealbumin, hs-CRP, eGFR, 25-OH vitamin D, estradiol (E2), and severity of symptoms such as hot flashes, night sweats, insomnia, and mood swings (assessed by Kupperman index). Outcomes included all-cause mortality, rehospitalization rates, cardiac function deterioration (⩾1 NYHA class increase), nutritional status decline (NRS-2002 score reduction compared to baseline), and quality of life deterioration (≥5-point reduction in KCCQ score).

Statistical analysis

Categorical variables were analyzed using Chi-square tests or Fisher's exact tests, while continuous variables were compared using independent-sample t-tests or Mann-Whitney U tests to assess baseline differences between the two nutritional intervention groups. Multivariate logistic regression was conducted to identify significant predictors of all-cause mortality, rehospitalization rates, cardiac function deterioration, nutritional status decline, and quality of life deterioration. Factors that were significant in at least four prognostic models were selected, and their average regression coefficients across five models were calculated. The nutritional risk model was constructed using the following formula:

Risk Score = Average $Coef_{[1]}$ * $Factor_{[1]}$ + Average $Coef_{[2]}$ * $Factor_{[2]}$ + …… Average $Coef_{[n]}$ * $Factor_{[n]}$

Finally, ROC curves were used to evaluate the predictive ability of the risk model for the five prognostic outcomes, with AUC values assessing the model's discriminatory performance, robustness, and applicability. All statistical analyses were performed using R software (v4.4.1), with two-sided *p*-values <0.05 considered statistically significant.

RESULTS

Baseline characteristics of menopausal chronic heart failure patients

The average age of the patients was 57.42 years, with a BMI of 25.56. The prevalence of hypertension was 10.37%, diabetes mellitus was 7.04%, and chronic kidney disease was 22.22%. Regarding medication use, 79.26% of the patients were on ACE inhibitors, and 15.19% were using Angiotensin II Receptor Blockers (ARBs). 24.44% of the patients were in the perimenopausal stage, 48.15% in the early postmenopausal stage, and 27.41% in the late postmenopausal stage. Most patients experienced mild hot flashes (56.67%) and night sweats (63.7%). 73.33% of patients had mild or no mood swings, and 50% had moderate insomnia symptoms. The average disease duration of chronic heart failure was 4.82 years, with 50.74% of patients classified as HFrEF, 41.48% as HFpEF, and 7.78% as HFmrEF. 6.67% of patients were classified as NYHA Class I, 59.26% as NYHA Class II, 31.48% as NYHA Class III, and 2.59% as NYHA Class IV. No significant differences were found between the two groups for these indicators (Table 1).

Baseline differences in biochemical indicators between two nutritional intervention groups

Patients in Combination 1 had higher BNP levels (371.59 pg/mL vs. 294.07 pg/mL, p=0.00267), indicating more severe CHF. In contrast, patients in Combination 2 had better renal function (eGFR: 52.09 mL/min/1.73m² vs. 44.82 mL/min/1.73m², p=0.00166) and higher estradiol (E2) levels (25.09 pg/mL vs. 22.51 pg/mL, p=0.00246). No significant differences were found between the groups in serum protein, albumin, prealbumin, hs-CRP, hemoglobin, or 25-OH vitamin D levels (all p>0.05) (Table 2).

Multivariate logistic regression to identify key prognostic factors in menopausal women with CHF

For all-cause mortality, menopausal duration (OR=1.940, p=0.001) and NYHA classification (OR=2.505, p<0.001) were major risk factors, indicating that longer menopausal duration and worse cardiac function were associated with higher mortality risk. Nutritional intervention (OR=0.331, p<0.001) was a significant protective factor, with enhanced nutritional support reducing mortality risk. E2 levels (OR=0.944, p=0.022) and eGFR (OR=0.970, p=0.010) also showed protective effects, highlighting the importance of hormone levels and renal function in improving survival prognosis.

For rehospitalization rates, insomnia (OR=1.683, p=0.020) and NYHA classification (OR=2.241, p<0.001) were significant risk factors, indicating that severe insomnia and worse

cardiac function were strongly associated with higher rehospitalization risk. Nutritional intervention (OR=0.399, p=0.004) again showed significant protective effects, reducing the risk of rehospitalization. BNP levels (OR=1.003, p=0.002) and E2 levels (OR=0.914, p<0.001) were also influential factors, with changes in cardiac biomarkers and hormone levels emphasizing their roles in rehospitalization risk.

For cardiac function deterioration, risk factors included insomnia (OR=2.064, p=0.003) and NYHA classification (OR=2.547, p<0.001), showing that higher insomnia severity and worse cardiac function increased the likelihood of deterioration. Nutritional intervention (OR=0.287, p<0.001) was a protective factor, significantly aiding in maintaining cardiac function. Renal function (eGFR: OR=0.955, p<0.001) was also a protective factor, indicating that good renal function slows the progression of cardiac deterioration.

For nutritional status deterioration, the primary risk factors were insomnia (OR=2.208) and NYHA classification (OR=2.136). Conversely, nutritional intervention (OR=0.307) was a significant protective factor, reducing the risk of nutritional deterioration. Lower BNP levels (OR=0.997), higher E2 levels (OR=0.921), and better renal function (eGFR: OR=0.961) were additional protective factors, supporting the importance of stable cardiac biomarkers, hormonal levels, and renal health in maintaining nutritional status.

For quality of life deterioration, insomnia (OR=1.548) and NYHA classification (OR=2.547) were significant risk factors, indicating that sleep disturbances and impaired cardiac function significantly reduced quality of life. Nutritional intervention (OR=0.430) showed significant protective effects, improving patients' quality of life. BNP levels (OR=1.004) were a risk factor for reduced quality of life, while higher E2 levels (OR=0.952) and better renal function (eGFR: OR=0.960) were protective factors. These findings suggest that optimizing cardiac function, improving sleep quality, providing enhanced nutritional support, and maintaining healthy hormone levels and renal function are key strategies for improving quality of life (Table 3).

Construction of nutritional risk model

A model was constructed using eGFR, E2, nutritional intervention type, insomnia severity, and NYHA classification. ROC curves were used to evaluate the model’s predictive performance for all-cause mortality, rehospitalization rates, cardiac function deterioration, nutritional status deterioration, and quality of life deterioration. The AUC values for these five outcomes were 0.715, 0.754, 0.727, 0.744, and 0.731, respectively (Figure 1A-E) (Table 4), demonstrating the model's robustness and effectiveness across multiple prognostic

indicators. In addition, we also used 30% of the sample size as an internal validation set to verify the performance of the risk model. The results showed that the predictive performance of the risk model remained excellent in the validation set, with AUC values of 0.702, 0.736, 0.780, 0.733, and 0.728 for predicting all-cause mortality, readmission rate, deterioration of cardiac function, deterioration of nutritional status, and deterioration of quality of life, respectively. Among them, the ability to predict deterioration of cardiac function was slightly higher than others (Figure 2A-E) (Table 4).

DISCUSSION

This study is the first to analyze prognostic factors in menopausal women with chronic heart failure (CHF) and evaluate the effects of different nutritional interventions. It also establishes a risk model for nutritional intervention. The results demonstrate that enhanced nutritional support combined with micronutrient supplementation significantly reduces all-cause mortality, rehospitalization rates, cardiac function deterioration, nutritional status deterioration, and quality of life deterioration, providing new scientific evidence for the precision management of menopausal women with CHF.

Enhanced nutritional support and micronutrient supplementation, which include high-protein and high-calorie diets along with supplementation of vitamin D, calcium, and antioxidants, significantly improved patients' nutritional status, enhanced immune function, and reduced the cardiovascular damage caused by chronic inflammation. On the other hand, Omega-3 fatty acid supplementation, as the core of basic nutritional support, provided cardiovascular protective effects through anti-inflammatory, metabolic regulation, and vascular function improvement. The study's findings suggest that enhanced nutritional support offers more pronounced protective effects in menopausal women, potentially due to their higher nutritional risks and metabolic demands. The decline in estrogen levels makes them more prone to bone loss, muscle wasting, and chronic inflammation. Enhanced nutritional support, by providing high-protein (≥1.2 g/kg/day) and high-calorie diets (30-35 kcal/kg/day), and supplementing vitamin D, calcium, and antioxidants (e.g., vitamins C and E), effectively improved nutritional status, boosted immune function, and alleviated oxidative stress and inflammation. High protein intake promoted muscle and myocardial repair, while high-calorie diets met the energy metabolism needs of CHF patients. Specific micronutrient supplementation also alleviated menopausal symptoms (e.g., insomnia and fatigue), significantly improving cardiac function, nutritional status, and quality of life. This

personalized and targeted nutritional intervention is particularly suitable for this high-risk population of menopausal women.

Insomnia and NYHA classification are risk factors for the prognosis of menopausal women with chronic heart failure. This may be because insomnia enhances sympathetic nerve activity, inhibits vagus nerve function, promotes inflammatory response and metabolic disorders, leading to increased cardiovascular burden, decreased immune function, and decreased quality of life.[13,14] In addition, insomnia may also reduce patients' compliance, thereby increasing the possibility of poor prognosis. YHA grading is a key indicator for evaluating cardiac dysfunction, with higher grades reflecting severe cardiac dysfunction in patients, leading to subsequent blood circulation and oxygen supply mismatch, multiple organ dysfunction, and higher readmission rates.[15,16] Meanwhile, high-level patients have higher metabolic demands and poorer compliance, further increasing the risk of poor prognosis. Therefore, these two factors play an important role in the treatment of chronic heart failure and need to be given special consideration when evaluating the prognosis of chronic heart failure in menopausal women.

The results of multiple logistic regression indicate that eGFR (glomerular filtration rate) and E2 (estradiol) are protective factors for multiple adverse prognostic indicators.[17, 18] This may be because higher eGFR levels reflect good renal function, which can maintain fluid balance, promote metabolite excretion and electrolyte regulation, reduce cardiac burden, and lower the risk of cardiorenal syndrome and systemic inflammatory response.[19] Moreover, patients with good kidney function have a higher tolerance to heart failure drugs and may have better treatment outcomes. Higher E2 levels promote the cardiovascular protective effect of estradiol, which can make blood vessels healthier, protect the heart, and regulate lipid metabolism, thereby reducing the progression of chronic heart failure.[20] Meanwhile, estradiol can alleviate common symptoms in menopausal women, such as insomnia and emotional fluctuations, and to some extent improve their quality of life and enhance heart vitality.[21] These effects collectively indicate the importance of optimizing kidney function and hormone levels in the treatment of heart failure in menopausal women.

The nutritional risk model we constructed has good performance in predicting multiple prognostic indicators, which demonstrates the reliability and practicality of our model. It can comprehensively evaluate the prognosis of menopausal chronic heart failure patients from multiple indicators and has high clinical value. It can provide reference standards for doctors to carry out nutritional interventions on patients. If the model score is high, it indicates that the expected effect of the nutritional intervention plan is not good. Conversely, if the model

score is low, it indicates that the patient may benefit from this nutritional intervention plan. In addition, our model that integrates multiple risk factors and protective factors also addresses the limitations of single factor and single outcome, enhances the generalization ability of the nutritional risk assessment model, and provides strong support for the comprehensive management and scientific decision-making of chronic heart failure patients, especially menopausal women.

The main advantage of this study is the first systematic analysis of the nutritional intervention effect on chronic heart failure in menopausal women, and the construction of an integrated risk score through a multiple regression model. However, the research also has certain limitations. Firstly, we are a retrospective study and there may be some bias in selecting data; Secondly, due to the limited sample size, the universality of our results is not high enough; In addition, this study only explored different measures of nutritional intervention and did not further analyze the specific dosage. Future research can explore this part in depth.

Conclusion

This study emphasizes the key role of enhanced nutritional support and micronutrient supplementation in the management of chronic heart failure in menopausal women. Meanwhile, NYHA grading, BNP, eGFR, and estradiol levels are important predictive factors that should be given sufficient attention in clinical management. The constructed risk model has good comprehensive predictive ability. This study provides precise guidance for the management of chronic heart failure patients in menopausal women. However, given the small sample size and retrospective nature of the study, further validation of the research results requires larger prospective randomized controlled trials.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest. ?

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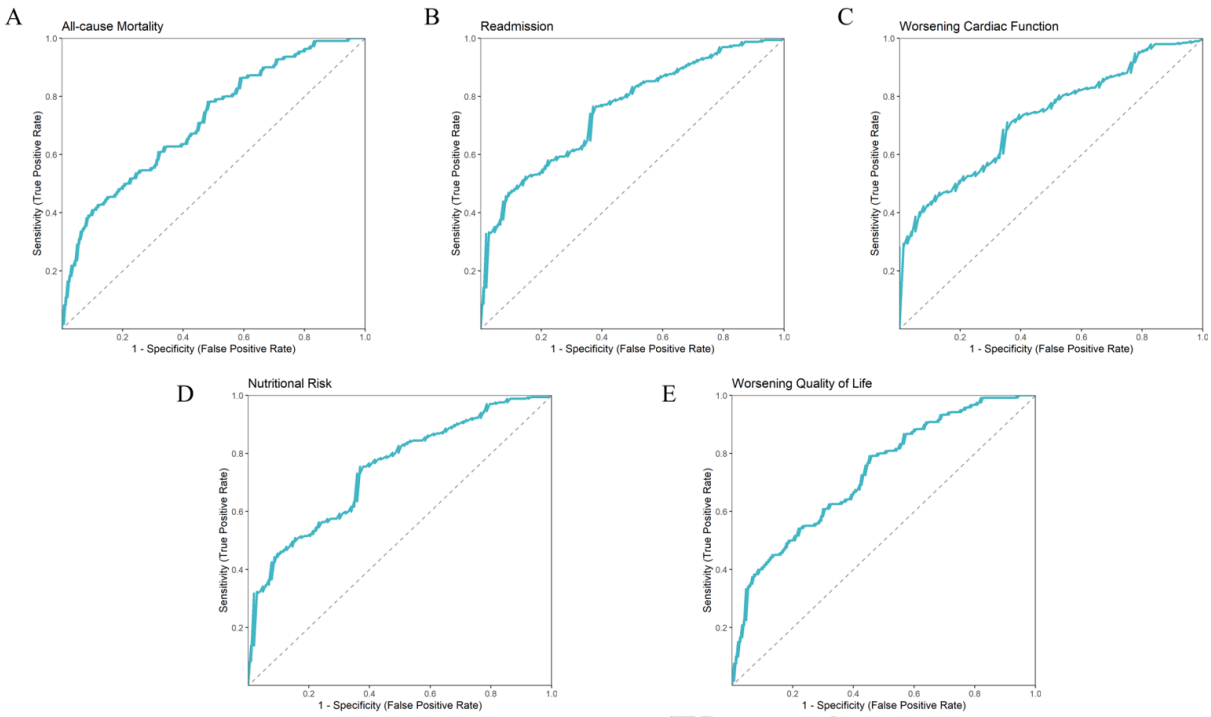

Figure 1. Nutritional risk model predictions: (A) All-cause mortality, (B) Rehospitalization rate, (C) Cardiac function deterioration, (D) Nutritional status deterioration, (E) Quality of life deterioration

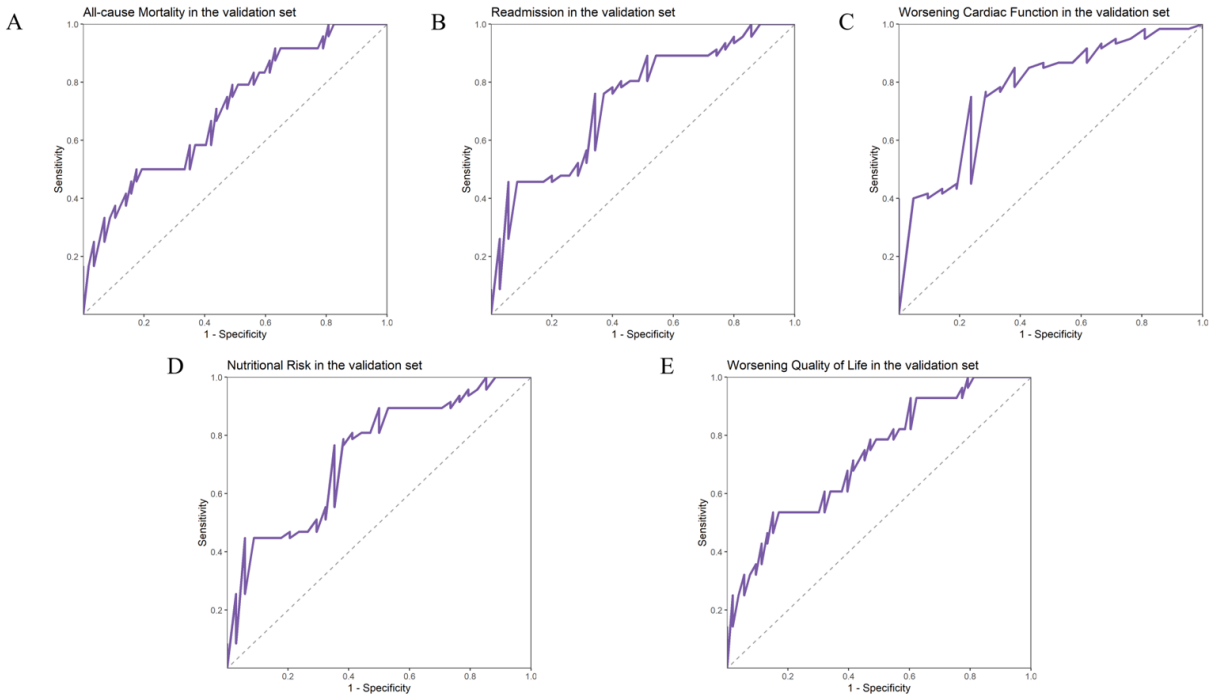

Figure 2. Internal validation of nutritional risk model prediction (A) All-cause mortality, (B) Rehospitalization rate, (C) Cardiac function deterioration, (D) Nutritional status deterioration, (E) Quality of life deterioration

Table 1. Baseline information for two nutritional intervention methods

	All Patients (n=270)	Combination 1 (n=175)	Combination 2 (n=95)	*p*-value
Age	57.42 (45.07-67.89)	57.07 (45.07-67.89)	58.49 (45.43-67.34)	0.665
BMI	25.56 (18.53-34.95)	25.36 (18.56-34.95)	25.86 (18.53-34.84)	0.436
Hypertension				0.068899
Yes	28 (10.37%)	23 (13.14%)	5 (5.26%)	
No	242 (89.63%)	152 (86.86%)	90 (94.74%)	
Diabetes Mellitus				0.6847536
Yes	19 (7.04%)	11 (6.29%)	8 (8.42%)	
No	251 (92.96%)	164 (93.71%)	87 (91.58%)	
Chronic Kidney Disease				0.4639994
Yes	60 (22.22%)	36 (20.57%)	24 (25.26%)	
No	210 (77.78%)	139 (79.43%)	71 (74.74%)	
ACE inhibitors				0.0684766
Yes	214 (79.26%)	145 (82.86%)	69 (72.63%)	
No	56 (20.74%)	30 (17.14%)	26 (27.37%)	
Angiotensin II Receptor Blockers				0.7029008
Yes	41 (15.19%)	25 (14.29%)	16 (16.84%)	
No	229 (84.81%)	150 (85.71%)	79 (83.16%)	
Menopause Duration				8.27E-02
Perimenopausal Women	66 (24.44%)	39 (22.29%)	27 (28.42%)	
Early Postmenopause	130 (48.15%)	93 (53.14%)	37 (38.95%)	
Late Postmenopause	74 (27.41%)	43 (24.57%)	31 (32.63%)	
Menopausal Symptoms				
Hot Flashes				9.71E-02
Mild or None	153 (56.67%)	92 (52.57%)	61 (64.21%)	
Moderate	65 (24.07%)	49 (28%)	16 (16.84%)	
Severe	52 (19.26%)	34 (19.43%)	18 (18.95%)	
Night Sweats				0.0578904
Mild or None	172 (63.7%)	104 (59.43%)	68 (71.58%)	
Moderate	75 (27.78%)	57 (32.57%)	18 (18.95%)	
Severe	23 (8.52%)	14 (8%)	9 (9.47%)	
Mood Swings				0.0682278
Mild or None	198 (73.33%)	135 (77.14%)	63 (66.32%)	
Moderate	61 (22.59%)	32 (18.29%)	29 (30.53%)	
Severe	11 (4.07%)	8 (4.57%)	3 (3.16%)	
Insomnia				0.0955782
Mild or None	100 (37.04%)	71 (40.57%)	29 (30.53%)	
Moderate	135 (50%)	79 (45.14%)	56 (58.95%)	
Severe	35 (12.96%)	25 (14.29%)	10 (10.53%)	

Table 1. Baseline information for two nutritional intervention methods (cont.)

	All Patients (n=270)	Combination 1 (n=175)	Combination 2 (n=95)	*p*-value
Chronic Heart Failure Disease Course (year)	4.82 (1.00-7.00)	4.67 (1.00-6.97)	5.21 (1.45-7.00)	0.08435
Heart Failure Classification				0.1114387
HFrEF	137 (50.74%)	87 (49.71%)	50 (52.63%)	
HFpEF	112 (41.48%)	70 (40%)	42 (44.21%)	
HFmrEF	21 (7.78%)	18 (10.29%)	3 (3.16%)	
NYHA Functional Classification				0.5660668
NYHA Class I	18 (6.67%)	12 (6.86%)	6 (6.32%)	
NYHA Class II	160 (59.26%)	107 (61.14%)	53 (55.79%)	
NYHA Class III	85 (31.48%)	53 (30.29%)	32 (33.68%)	
NYHA Class IV	7 (2.59%)	3 (1.71%)	4 (4.21%)	

Table 2. Differences in biochemical parameters between the two nutritional intervention methods

	All Patients (n=270)	Combination 1 (n=175)	Combination 2 (n=95)	*p*-value
BNP (pg/mL)	341.43 (121.48-579.68)	371.59 (125.30-579.68)	294.07 (121.48-574.55)	0.00267
Serum Protein (g/L)	62.47 (51.04-72.89)	62.02 (51.04-72.89)	63.30 (51.69-72.64)	0.0936
Albumin (g/L)	31.56 (22.10-42.98)	31.44 (22.10-42.98)	32.48 (22.27-42.87)	0.462
Prealbumin (g/L)	0.18 (0.08-0.30)	0.18 (0.08-0.30)	0.19 (0.08-0.30)	0.161
Estimated Glomerular Filtration Rate (mL/min/1.73m²)	48.55 (28.31-70.99)	44.82 (28.31-70.99)	52.09 (29.60-70.91)	0.00166
hs-CRP (mg/L)	7.31 (2.81-11.58)	7.58 (2.81-11.53)	6.64 (2.81-11.58)	0.288
Hemoglobin (g/L)	108.48 (88.07-129.91)	108.77 (88.07-129.91)	106.49 (88.08-129.44)	0.256
25-OH Vitamin D	15.68 (7.52-22.89)	15.13 (7.52-22.85)	16.24 (7.59-22.89)	0.48
Estradiol (E2)	23.09 (13.01-32.96)	22.51 (13.07-32.74)	25.09 (13.01-32.96)	0.00246

Table 3. Multivariate logistic regression analysis of factors affecting the prognosis of menopausal women with chronic heart failure

	Estimate	Std error	Statistic	*p* value	OR	CI-lower	CI-upper
All-cause Mortality							
Menopause duration	0.663	0.203	3.263	0.001	1.940	1.303	2.889
Hot flashes	0.090	0.205	0.438	0.661	1.094	0.732	1.634
Insomnia	-0.052	0.217	-0.241	0.810	0.949	0.620	1.452
NYHA	0.918	0.207	4.442	0.000	2.505	1.671	3.757
Nutritional intervention	-1.107	0.301	-3.676	0.000	0.331	0.183	0.597
BNP	-0.001	0.001	-1.286	0.198	0.999	0.996	1.001
Disease course	-0.116	0.080	-1.451	0.147	0.890	0.761	1.042
E2	-0.058	0.025	-2.295	0.022	0.944	0.899	0.991
eGFR	-0.030	0.012	-2.570	0.010	0.970	0.948	0.994
Readmission							
Menopause duration	-0.047	0.195	-0.241	0.809	0.954	0.651	1.399
Hot flashes	0.117	0.203	0.577	0.564	1.124	0.755	1.673
Insomnia	0.520	0.223	2.335	0.020	1.683	1.087	2.605
NYHA	0.807	0.213	3.796	0.000	2.241	1.478	3.400
Nutritional intervention	-0.920	0.317	-2.906	0.004	0.399	0.214	0.741
BNP	0.003	0.001	3.098	0.002	1.003	1.001	1.005
Disease course	0.157	0.080	1.965	0.049	1.170	1.000	1.369
E2	-0.090	0.026	-3.488	0.000	0.914	0.869	0.962
eGFR	-0.030	0.012	-2.556	0.011	0.970	0.948	0.994
Worsening Cardiac Function							
Menopause duration	0.155	0.205	0.756	0.450	1.167	0.782	1.743
Hot flashes	0.158	0.217	0.729	0.466	1.171	0.766	1.792
Insomnia	0.725	0.243	2.980	0.003	2.064	1.282	3.323
NYHA	0.362	0.208	1.741	0.082	1.436	0.956	2.157
Nutritional intervention	-1.248	0.356	-3.509	0.000	0.287	0.143	0.577
BNP	-0.002	0.001	-1.902	0.057	0.998	0.996	1.000
Disease course	-0.011	0.082	-0.134	0.893	0.989	0.842	1.162
E2	-0.029	0.027	-1.104	0.269	0.971	0.921	1.024
eGFR	-0.046	0.013	-3.641	0.000	0.955	0.931	0.980
Worsening Nutritional Status							
Menopause duration	0.108	0.203	0.533	0.594	1.114	0.749	1.658
Hot flashes	0.175	0.206	0.847	0.397	1.191	0.795	1.785
Insomnia	0.792	0.236	3.361	0.001	2.208	1.391	3.504
NYHA	0.759	0.211	3.595	0.000	2.136	1.412	3.231
Nutritional intervention	-1.181	0.334	-3.536	0.000	0.307	0.159	0.591
BNP	0.003	0.001	2.779	0.005	1.003	1.001	1.005
Disease course	-0.144	0.082	-1.764	0.078	0.866	0.738	1.016
E2	-0.082	0.027	-3.094	0.002	0.921	0.874	0.971
eGFR	-0.040	0.012	-3.273	0.001	0.961	0.938	0.984
Worsening Quality of Life							
Menopause duration	0.003	0.195	0.015	0.988	1.003	0.684	1.471
Hot flashes	0.232	0.195	1.192	0.233	1.261	0.861	1.848
Insomnia	0.437	0.220	1.991	0.046	1.548	1.007	2.381
NYHA	0.935	0.209	4.479	0.000	2.547	1.692	3.833
Nutritional intervention	-0.845	0.308	-2.743	0.006	0.430	0.235	0.786
BNP	0.004	0.001	3.887	0.000	1.004	1.002	1.006
Disease course	-0.028	0.079	-0.347	0.728	0.973	0.833	1.137
E2	-0.049	0.025	-1.991	0.046	0.952	0.907	0.999
eGFR	-0.041	0.012	-3.425	0.001	0.960	0.938	0.983

Table 4. Predictive ability of the risk model for prognosis

	AUC	AUC-CI-Lower	AUC-CI-Upper	Best-Threshold	youden	Sensitivity	Specificity
All-cause mortality	0.715	0.653	0.777	4.661	0.309	0.409	0.900
Readmission	0.754	0.697	0.811	3.454	0.395	0.765	0.630
Worsening cardiac function	0.727	0.665	0.789	3.449	0.356	0.711	0.645
Worsening nutritional status	0.744	0.685	0.802	3.454	0.386	0.754	0.631
Worsening quality of life	0.731	0.671	0.790	3.473	0.338	0.792	0.547
In the validation set							
All-cause mortality	0.702	0.578	0.827	4.357	0.325	0.500	0.825
Readmission	0.736	0.626	0.846	3.458	0.418	0.761	0.657
Worsening cardiac function	0.780	0.668	0.892	3.359	0.512	0.750	0.762
Worsening nutritional status	0.733	0.622	0.845	3.420	0.413	0.766	0.647
Worsening quality of life	0.728	0.612	0.843	4.327	0.385	0.536	0.849