ISSN (electrónico): 1699-5198 - ISSN (papel): 0212-1611 - CODEN NUHOEQ S.V.R. 318

ARÁN

Nutrición Hospitalaria

Trabajo Original

Valoración nutricional

Nutritional assessment of patients with aplastic anemia: comparison of four nutritional screening tools

Evaluación nutricional de los pacientes con anemia aplásica: comparación de cuatro instrumentos de detección nutricional

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Abstract

Introduction: nutritional status can affect the treatment of hospitalized patients, and malnutrition can even lead to death. However, the nutritional status of patients with aplastic anemia (AA) is unclear.

Objective: to assess the nutritional status of aplastic anemia patients with body mass index (BMI) ≥ 24 kg/m^2 (high BMI group) and BMI < 24 kg/m^2 (low BMI group), and to compare the consistency between different nutritional screening tools.

Methods: patients with aplastic anemia hospitalized from January 2016 to December 2020 were collected. We used the combined index generated by Nutritional Risk Index (NRI), Prognostic Nutritional Index (PNI), Control Nutritional Status (CONUT) and Instant Nutritional Assessment (INA) to assess nutritional status of patients with aplastic anemia. Kappa index was used to measure the consistency between different nutritional screening tools. Receiver operating characteristic (ROC) curve was used to evaluate the diagnostic value of different nutritional screening tools.

Results: one hundred and ninety-five patients with aplastic anemia were enrolled. The overall prevalence of malnutrition calculated by the combined index in patients with aplastic anemia was 51.3 %. The malnutrition rates of patients in the low BMI group and high BMI group were 60.9 % and 38.8 %, respectively. The malnutrition rates of very severe aplastic anemia (VSAA) patients, severe aplastic anemia (SAA) patients and ordinary patients were 76 %, 63.8 % and 45.1 %, respectively. Compared with the combined index, NRI had the highest consistency and area under the curve.

Conclusions: the nutritional status of patients with aplastic anemia was very poor; the more serious the disease, the worse the nutritional status. Although the malnutrition rate in the low-BMI group was higher than in the high BMI group, the nutritional status of overweight or obese patients can not be ignored. NRI is the best tool for assessing the nutritional status of patients with aplastic anemia.

Keywords:

Body mass index. Aplastic anemia. Malnutrition. Consistency.

Received: 16/11/2021 • Accepted: 10/07/2022

Yan Wang and Ruirong Xu contributed equally to this study and share corresponding author.

Conflict of interest: the authors declare no conflict of interest.

Author contributions: Xing Tan, Yang Wang, Ruirong Xu, Yanfeng Zhou, Zhaoxia Liu and Fansheng Kong designed this study. Xing Tan, Yu Tian and Zonghong Li collected clinical data and Xing Tan and Yu Tian wrote the paper. Xing Tan, Yu Tian, Siyuan Cui and Zhenzhen Wang analyzed the data. All the authors participated in the revision of this article and unanimously agreed to publish this version.

Acknowledgments: this work was funded by the National Natural Science Foundation of China (82174181 and 81303080) and Shandong Provincial Natural Science Foundation (ZR2020KH023). We thank all the staff in Department of Hematology who are involved in the management and treatment of patients. Thanks to the key Laboratory of Integrated Chinese and Western Medicine Hematology for providing the workplace.

Tan X, Tian Y, Li Z, Cui S, Wang Z, Zhou Y, Liu Z, Kong F, Wang Y, Xu R. Nutritional assessment of patients with aplastic anemia: comparison of four nutritional screening tools. Nutr Hosp 2022;39(6):1289-1297

DOI: http://dx.doi.org/10.20960/nh.03957

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Resumen

Introducción: el estado nutricional puede afectar el tratamiento de los pacientes hospitalizados y la malnutrición puede incluso causar la muerte. Sin embargo, el estado nutricional de los pacientes con anemia aplásica (AA) no está claro.

Objetivo: evaluar el estado nutricional de pacientes con anemia aplásica con índice de masa corporal (IMC) ≥ 24 kg/m^2 (grupo de IMC mayor) e IMC < 24 kg/m^2 (grupo de IMC inferior), y comparar la consistencia entre diferentes herramientas de cribado nutricional.

Métodos: se recogieron datos de pacientes con anemia aplásica hospitalizados entre enero de 2016 y diciembre de 2020. El estado nutricional de los pacientes con anemia aplásica se evaluó utilizando un índice compuesto por el índice de riesgo nutricional (NRI), el índice de pronóstico nutricional (PNI), el índice de estado nutricional controlado (CONUT) y la evaluación nutricional instantánea (INA). El índice Kappa se utilizó para medir la coherencia entre los diferentes instrumentos de detección nutricional. Las curvas de características operativas de los sujetos (ROC) se utilizaron para evaluar el valor diagnóstico de las diferentes herramientas de detección nutricional.

Resultados: un total de 195 pacientes con anemia aplásica fueron incluidos en el estudio. La prevalencia global de desnutrición calculada por el índice combinado en pacientes con anemia aplásica fue del 51,3 %. Las tasas de desnutrición de los pacientes en el grupo de bajo IMC y el grupo de alto IMC fueron 60,9 % y 38,8 %, respectivamente. Las tasas de desnutrición en pacientes con anemia aplásica muy grave (VSAA), anemia aplásica grave (SAA) y pacientes comunes fueron del 76 %, 63,8 % y 45,1 %, respectivamente. En comparación con el índice compuesto, NRI tiene la mayor consistencia y área bajo la curva.

Conclusiones: el estado nutricional de los pacientes con anemia aplásica es muy deficiente; a mayor gravedad de la enfermedad, peor estado nutricional. Aunque la tasa de malnutrición en el grupo con bajo IMC es mayor que en el grupo con alto IMC, no se puede pasar por alto el estado nutricional de los pacientes con sobrepeso u obesidad. El NRI es la mejor herramienta para evaluar el estado nutricional de los pacientes con anemia aplásica.

Palabras clave:

Índice de masa corporal. Anemia aplásica. Malnutrición. Consistencia.

INTRODUCTION

It is reported that the incidence of malnutrition in hospitalized patients was 22.0 % (1). Malnutrition is not only closely related to disease severity, but also brings negative effects such as increased risk of infection and death to patients (2-4). In recent years, nutritional assessment has been actively carried out in cancer, diabetes, heart failure and other diseases (5-7). These studies remind clinicians to implement necessary nutritional interventions when treating these diseases, which will greatly improve the prognosis of patients. However, data on nutritional status of patients with aplastic anemia (AA) are rarely reported.

When assessing the nutritional status of patients, we cannot only focus on the low body mass index (BMI) patients. Overweight and obesity are gradually becoming a public health problem that cannot be ignored (8). Overweight and obese people are also at risk for malnutrition. For example, Leibovitz et al. found that 23.2 % of overweight patients and 24.8 % of obese patients suffered from malnutrition, and malnutrition will significantly increase the length of hospital stay and the risk of death for overweight or obese patients (9). However, comprehensive assessment scales including Nutritional Risk Screening 2002 (NRS2002) and Subjective Global Nutritional Assessment (SGA) have strongly relied on low BMI or weight loss (10,11). These comprehensive assessment scales may reduce overall malnutrition rates because they largely ignore overweight or obese patients (12).

In order to clarify the nutritional status of aplastic anemia patients, in this study, patients were divided into low BMI group (BMI < 24 kg/m^2) and high BMI group (BMI ≥ 24 kg/m^2) and the combined index generated by four simple and objective nutritional screening tools (Nutritional Risk Index [NRI], Prognostic Nutritional Index [PNI], Control Nutritional Status [CONUT] and Instant Nutritional Assessment [INA]) was used to assess the nutritional status of the above two groups. These four nutritional screening tools obtain the corresponding results by calculating the patient's objective laboratory data, and have been extensively verified (13-16).

MATERIALS AND METHODS

PATIENTS

This study was a retrospective study. The study population was hospitalized patients who were newly diagnosed with aplastic anemia in the Department of Hematology from January 2016 to December 2020. Our exclusion criteria were as follows: a) patients with age < 18 years; b) patients with blood transfusion records before admission; and c) patients with incomplete medical records. This study has been approved by the Ethics Committee of the Affiliated Hospital of Shandong University of Traditional Chinese Medicine. The patient's identity information was anonymized, so the patient informed consent was exempted.

DATA COLLECTION

Patients' demographic information (gender, age, height, weight) and laboratory data (white blood cell count [WBC], neutrophil count [ANC], lymphocyte count [LY], red blood cell count [RBC], hemoglobin [Hb], platelet count [PLT], reticulocyte count [RET], serum albumin [ALB], C-reactive protein [CRP] and total cholesterol [TC]) were collected. The laboratory data required for nutritional assessment came from the same batch of blood samples collected at the time of admission. Blood routine were detected by automated hematology analyzer XN-Series (product standard number: YZP/JAP 2342-2012). The biochemical indexes were detected by AU680 automatic biochemical analyzer (instrument serial number: 2013072477).

NUTRITIONAL ASSESSMENT

All patients underwent nutritional assessment within 48 hours after admission. We divided the patients into low BMI group

and high BMI group using 24 kg/m^2 as a threshold. All patients included in this study were Chinese and, in China, overweight or obesity was defined as BMI ≥ 24 kg/m^2 (17). We used NRI, PNI, CONUT and INA to assess nutritional status of patients with aplastic anemia.

NRI = [1.519 * ALB (g/l)] + 41.7 * (current / ideal weight) (18). The ideal weight of all patients was calculated by Lorentz equations: male = height – 100 – [(height – 150) / 4]; female = height – 100 – [(height – 150) / 2.5]. NRI ≥ 100 was defined as no malnutritional risk, and 97.5 ≤ NRI < 100, 83.5 ≤ NRI < 97.5, and NRI < 83.5 were defined as mild, moderate and severe malnutritional risk, respectively.

PNI = [10 × ALB (g/dl)] + [0.005 × LY (mm^3)]. PNI ≥ 38 was defined as no malnutritional risk, 35 ≤ PNI < 38 was defined as moderate malnutritional risk, PNI < 35 was defined as severe malnutritional risk, and there was no mild malnutritional risk in the classification of PNI (19).

CONUT was developed in 2005 (20). It consists of three parts: ALB, LY and TC. CONUT 0-1 was defined as no malnutritional risk, whereas 2-4, 5-8 and 8-12 were defined as mild, moderate and severe malnutritional risk, respectively.

INA consisted of a classification of four degrees of nutritional status: 1st degree: ALB ≥ 35 g/L, LY ≥ 1.5 × 10^9 g/l; 2nd degree: ALB ≥ 35 g/l, LY < 1.5 × 10^9 g/l; 3rd degree: ALB < 35 g/l, LY ≥ 1.5 × 10^9 g/l; 4th degree: ALB < 35 g/l, LY < 1.5 × 10^9 g/l (21). Either ALB < 35 g/l or LY < 1.5 × 10^9 was considered as malnutritional risk.

We combined the evaluation results of NRI, PNI, CONUT and INA into a combined index (22). If a patient was defined as malnutritional risk to any degree by any three of the four screening tools, the person was diagnosed as malnourished by the combined index. The combined index was considered as our hypothetical gold standard.

STATISTICAL ANALYSIS

One-way ANOVA was used for measuring data conforming to normal distribution among the three groups. If the data did not conform to normal distribution, the rank-sum test was used, and the Chi-squared test was used for counting data. Kappa index was used to measure the consistency between different nutritional screening tools. Sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio were used to judge the effectiveness of different nutritional screening tools. ROC curve was used to evaluate the diagnostic value of different nutritional screening tools. All data were expressed as mean ± standard deviation and $p < 0.05$ was considered as significant. All data were analyzed using SPSS26.0 software (IBM Corporation, Armonk, NY, USA).

RESULTS

STUDY POPULATION CHARACTERISTICS

The hospitalization records of 195 patients with aplastic anemia were collected, including 123 AA patients, 47 SAA patients and 25 VSAA patients. Table I describes the baseline characteristics of 195 patients. In blood routine, WBC ($p < 0.001$), ANC ($p < 0.001$), and RET ($p < 0.001$) decreased with the deepening of disease severity. This phenomenon was consistent with the characteristics of aplastic anemia. In the nutritional screening tools, the NRI and PNI scores of VSAA and SAA patients were significantly lower than those of AA patients ($p < 0.001$), while the CONUT scores were significantly higher than those of AA patients ($p < 0.001$). In addition, the CRP inflammatory index of AA patients was significantly lower than that of SAA and VSAA patients ($p < 0.001$).

Table I. Characteristics of the study population

Characteristics	AA (n = 123)	SAA (n = 47)	VSAA (n = 25)	p
Sex (n[%]) Male Female	 56 (45.5 %) 67 (54.5 %)	 21 (44.7 %) 26 (55.3 %)	 8 (32.0 %) 17 (68.0 %)	0.46
Age (year)	47.08 ± 17.33	47.26 ± 17.34	47.40 ± 18.73	0.99
BMI (n [%])				0.41
BMI < 24 (kg/m^2)	66 (53.7 %)	20 (42.6 %)	8 (32 %)	
BMI ≥ 24 (kg/m^2)	57 (46.3 %)	27 (57.4 %)	17 (68 %)	
WBC (×10^9/l)	2.60 ± 1.04	1.76 ± 0.94	1.05 ± 0.87	< 0.001
ANC (×10^9/l)	1.22 ± 0.77	0.55 ± 0.38	0.08 ± 0.06	< 0.001
LY (×10^9/l)	1.14 ± 0.52	1.09 ± 0.79	0.90 ± 0.83	0.36
RBC (×10^{12}/l)	1.92 ± 0.83	1.80 ± 0.56	2.10 ± 0.41	0.10

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Table I (Cont.). Characteristics of the study population

Characteristics	AA (n = 123)	SAA (n = 47)	VSAA (n = 25)	p
Hb (g/l)	62.31 ± 23.93	59.47 ± 18.88	65.44 ± 12.52	0.52
PLT ($\times 10^9$/l)	25.20 ± 24.40	10.06 ± 13.97	10.72 ± 13.19	< 0.001
RET ($\times 10^9$/l)	0.06 ± 0.04	0.03 ± 0.03	0.01 ± 0.02	< 0.001
CRP (mg/l)	14.57 ± 26.93	24.42 ± 29.01	62.00 ± 63.71	< 0.001
NRI	100.33 ± 10.76	96.70 ± 8.39	90.55 ± 10.07	< 0.001
PNI	42.81 ± 6.19	40.03 ± 6.00	36.73 ± 7.52	< 0.001
CONUT	2.53 ± 1.92	3.13 ± 1.91	4.28 ± 2.73	0.003
INA (n [%]) 1st degree 2nd degree 3rd degree 4th degree	 26 (21.1 %) 59 (48 %) 6 (4.9 %) 32 (26 %)	 3 (6.4 %) 18 (38.3 %) 4 (8.5 %) 22 (46.8 %)	 5 (20 %) 4 (16 %) 1 (4 %) 15 (60 %)	 0.003

AA: aplastic anemia; SAA: severe aplastic anemia; VSAA: very severe aplastic anemia; BMI: body mass index; WBC: white blood cell count; ANC: neutrophil count; LY: lymphocyte count; RBC: red blood cell count; Hb: hemoglobin; PLT: platelet count; RET: reticulocyte count; CRP: C-reactive protein; NRI: Nutritional Risk Index; PNI: Prognostic Nutritional Index; CONUT: Control Nutritional Status; INA: Instant Nutritional Assessment.

NUTRITIONAL STATUS OF PATIENTS WITH APLASTIC ANEMIA

As shown in table II, when using NRI, PNI, CONUT and INA to assess nutritional status, 74.5 %, 31.8 %, 75.5 % and 87.3 % of the patients in the low BMI group had any degree of malnutrition risk, respectively; and 31.8 %, 29.4 %, 67.1 % and 76.5 % of the patients in the high BMI group had any degree of malnutrition risk, respectively. In addition, 60.9 % of patients with low BMI were diagnosed as malnutrition by the combined index, and 38.8 % of patients with high BMI were diagnosed as malnutrition by the combined index. After integrating the data of the two groups, the overall prevalence of malnutrition in patients with aplastic anemia was 51.3 %.

Table II. Distribution of malnutrition risk identified by different nutritional assessment scales and combined index (CX)

Characteristics		BMI < 24 (n = 110)		BMI ≥ 24 (n = 85)		Total (n = 195)	
Risk of malnutrition		n	%	n	%	n	%
NRI	No	28	25.5	58	68.2	86	44.1
	Mild	8	7.2	9	10.6	17	8.7
	Moderate	60	54.5	18	21.2	78	40
	Severe	14	12.7	0	0	14	7.2
PNI	No	75	68.2	60	70.6	135	69.2
	Moderate	17	15.5	9	10.6	26	13.3
	Severe	18	16.4	16	18.8	34	17.4
CONUT	No	27	24.5	28	32.9	55	28.2
	Mild	55	50	35	41.2	90	46.2
	Moderate	28	25.5	21	24.7	49	25.1
	Severe	0	0	1	1.2	1	0.5

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Table II (Cont.). Distribution of malnutrition risk identified by different nutritional assessment scales and combined index (CX)

Characteristics		BMI < 24 (n = 110)		BMI ≥ 24 (n = 85)		Total (n = 195)	
Risk of malnutrition		n	%	n	%	n	%
INA	1st degree	14	12.7	20	23.5	34	17.4
	2nd degree	46	41.8	35	41.2	81	41.5
	3rd degree	8	7.2	3	3.5	11	5.6
	4th degree	42	38.2	27	31.8	69	35.4
CX	Non-malnutrition	43	30.1	52	61.2	95	48.7
	Malnutrition	67	60.9	33	38.8	100	51.3

BMI: body mass index; NRI: Nutritional Risk Index; PNI: Prognostic Nutritional Index; CONUT: Control Nutritional Status; INA: Instant Nutritional Assessment; CX: combined index.

RELATIONSHIP BETWEEN NUTRITIONAL STATUS AND SEVERITY OF DISEASE

As shown in figure 1, in the high BMI group, the prevalence of malnutrition increased significantly with the aggravation of the disease ($p = 0.03$) and in the low BMI group, the prevalence of malnutrition in SAA and VSAA patients was also significantly higher than that in AA patients ($p = 0.01$). After integrating the data of two groups, we found that the more severe the disease, the higher the prevalence of malnutrition ($p < 0.001$).

Table III showed the laboratory data grouped by nutritional status. In the low BMI group, WBC ($p = 0.001$), LY ($p < 0.001$), Hb ($p = 0.02$), RET ($p < 0.001$), and CRP ($p < 0.001$) of patients with non-malnutrition were significantly higher than in malnourished patients. In the high BMI group, WBC ($p = 0.01$), LY ($p < 0.001$), Hb ($p = 0.03$), PLT ($p = 0.04$) and CRP ($p < 0.001$) of patients with non-malnutrition were significantly higher than those of patients with malnutrition. Regardless of BMI, laboratory results of malnourished patients were worse than those of well-nourished patients.

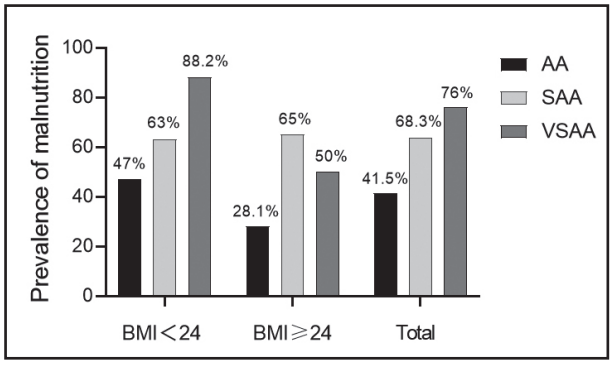

Figure 1.

Prevalence of malnutrition according to severity of the disease (AA: aplastic anemia; SAA: severe aplastic anemia; VSAA: very severe aplastic anemia).

COMPARISON OF DIFFERENT NUTRITIONAL SCREENING TOOLS AND COMBINED INDEX

As shown in table IV, in the low BMI group, the sensitivity of NRI, CONUT and INA was 100 %, and the sensitivity and negative predictive value of PNI were the lowest among the four screening tools. In the high BMI group and total, the highest sensitivity and negative predictive value were found in INA, but its specificity and positive predictive value were the lowest. PNI had the highest specificity and positive predictive value, and NRI had the highest positive likelihood ratio in all groups. Regardless of BMI, NRI had the highest consistency.

The ROC curve was used to measure the diagnostic value of different nutritional screening tools (combined index was the standard). As shown in figure 2, NRI had the highest area under the curve in all groups.

DISCUSSION

Our study was the first to use objective nutritional screening tools to assess nutritional status of patients with aplastic anemia. In our study, 60.9 % of low BMI patients and 38.8 % of high BMI patients were diagnosed as malnutrition by the combined index. Previous researchers compared the differences of nutritional indicators such as serum albumin between AA and SAA patients (23). Combined with previous research, our study enriched the nutritional data of patients with aplastic anemia.

The ESPEN guidelines were considered as the gold standard for malnutrition and were often compared with other nutritional assessment scales when assessing nutritional status in hospitalized patients (24,25). ESPEN defined malnutrition as follows: a) BMI < 18.5 kg/m^2; b) weight loss > 10 % due to non-human factors regardless of time, or weight loss > 5 % within three months and at least one of the following: BMI < 20 kg/m^2 (age < 70) or BMI < 22 kg/m^2 (age > 70) and fat free mass index (FFMI) < 15 kg/m^2 (female) or FFMI < 17 kg/m^2 (male) (26).

Table III. Characteristics of laboratory data according to nutritional status

	BMI < 24 (n = 110)			BMI ≥ 24 (n = 85)			Total (n = 195)		
	No malnutrition	Malnutrition	p	No malnutrition	Malnutrition	p	No malnutrition	Malnutrition	p
WBC ($\times10^9$/l)	2.60 ± 0.86	1.81 ± 1.35	0.001	2.51 ± 0.86	1.87 ± 1.13	0.01	2.57 ± 0.86	1.84 ± 1.23	< 0.001
ANC ($\times10^9$/l)	1.05 ± 0.73	0.74 ± 0.88	0.06	0.97 ± 0.55	0.98 ± 0.87	0.97	1.01 ± 0.64	0.81 ± 0.87	0.07
LY ($\times10^9$/l)	1.37 ± 0.49	0.91 ± 0.61	< 0.001	1.32 ± 0.64	0.70 ± 0.62	< 0.001	1.35 ± 0.58	0.86 ± 0.61	< 0.001
RBC ($\times10^{12}$/l)	2.12 ± 0.80	1.84 ± 0.57	0.05	1.95 ± 0.85	1.67 ± 0.69	0.15	2.07 ± 0.82	1.76 ± 0.62	0.003
Hb (g/l)	69.00 ± 23.61	59.24 ± 16.02	0.02	64.60 ± 25.02	52.75 ± 19.11	0.03	67.85 ± 24.07	56.49 ± 17.38	< 0.001
PLT ($\times10^9$/l)	21.56 ± 20.81	18.72 ± 21.90	0.50	23.00 ± 23.62	12.43 ± 21.47	0.04	23.25 ± 22.60	16.31 ± 21.44	0.03
RET ($\times10^9$/l)	0.07 ± 0.05	0.04 ± 0.04	< 0.001	0.05 ± 0.03	0.04 ± 0.32	0.06	0.06 ± 0.04	0.04 ± 0.04	< 0.001
CRP (mg/l)	12.02 ± 18.89	33.39 ± 41.66	< 0.001	7.08 ± 10.46	47.58 ± 11.03	0.001	8.96 ± 14.96	36.39 ± 46.47	< 0.001

BMI: body mass index; WBC: white blood cell count; ANC: neutrophil count; LY: lymphocyte count; RBC: red blood cell count; Hb: hemoglobin; PLT: platelet count; RET: reticulocyte count; CRP: C-reactive protein.

Table IV. Comparison of different nutritional screening tools and combined index

	BMI < 24				BMI ≥ 24				Total			
	NRI	PNI	CONUT	INA	NRI	PNI	CONUT	INA	NRI	PNI	CONUT	INA
SEN (%)	100	52.3	100	100	78.8	75.8	78.8	100	93	60	93	100
SPE (%)	65.1	100	62.8	32.6	98.1	100	53.8	38.5	83.2	100	57.9	35.8
PPV (%)	81.7	100	80.7	68.9	96.3	100	52	50.8	85.3	100	69.9	62.1
NPV (%)	100	57.3	100	100	87.9	86.7	80 %	100	91.9	70.4	88.7	100
LR (+)	2.87	-	2.69	1.48	41.47	-	1.71	1.63	5.54	-	2.21	1.60
LR (-)	0	0.48	0	0	0.22	0.24	0.39	0	0.08	0.40	0.12	0
Kappa (p)	0.695 < 0.001	0.461 < 0.001	0.673 < 0.001	0.370 < 0.001	0.795 < 0.001	0.793 < 0.001	0.298 0.003	0.327 < 0.001	0.763 < 0.001	0.594 < 0.001	0.513 < 0.001	0.364 < 0.001

SEN: sensitivity; SPE: specificity; PPV: positive predictive value; NPV: negative predictive value; LR(+): positive likelihood ratio; LR(-): negative likelihood ratio; NRI: Nutritional Risk Index; PNI: Prognostic Nutritional Index; CONUT: Control Nutritional Status; INA: Instant Nutritional Assessment.

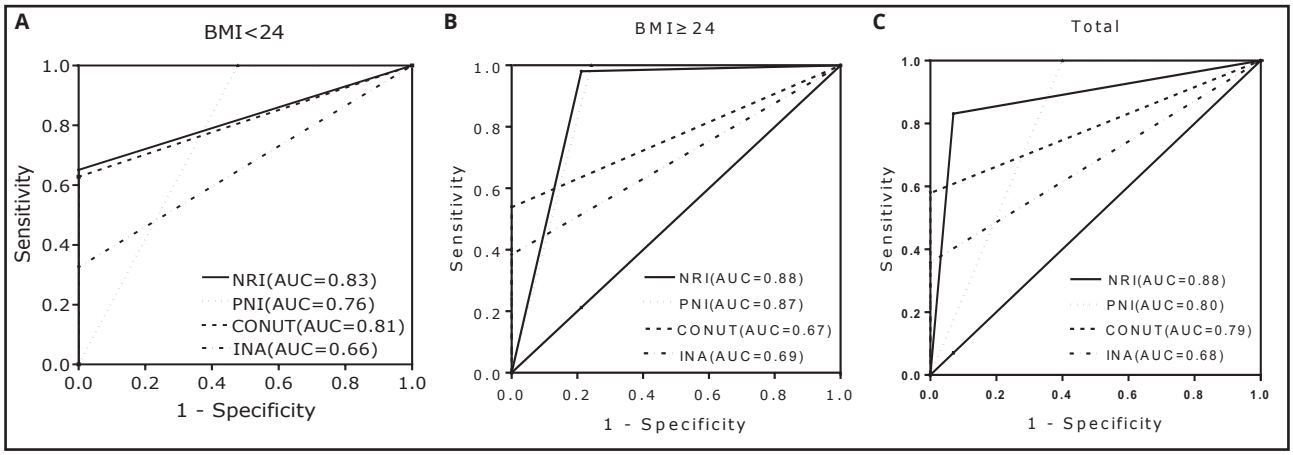

Figure 2.

Receiver operating characteristic curve (ROC) for different nutritional screening tools to diagnose malnutrition (combined index is the gold standard) (NRI: Nutritional Risk Index; PNI: Prognostic Nutritional Index; CONUT: Control Nutritional Status; INA: Instant Nutritional Assessment)

We can clearly see that ESPEN guidelines have also strongly relied on low BMI or weight loss. Since our study included overweight or obese patients, using ESPEN guidelines to diagnose nutritional status in patients with aplastic anemia may reduce the overall prevalence of malnutrition. Therefore, patients were divided into two groups according to BMI and the method of Pablo et al. was used, taking the combined index as the presumed gold standard. This method has been widely verified (27-29).

We tend to pay more attention to the nutritional status of the emaciated population, and it is challenging to recognize that overweight or obese people suffer from malnutrition. On the one hand, there is a lack of a nutritional evaluation scale specially designed for obese or overweight people, while it is difficult to identify muscle wasting in overweight or obese people with standard nutritional physical examination (30). On the other hand, this idea will overturn the normal understanding (obesity or overweight belongs to over-nutrition). At present, no epidemiological study on obesity or overweight in patients with aplastic anemia has been found, but with the rising obesity rate of hospitalized patients (31), the problem of malnutrition in overweight or obese patients with aplastic anemia should not be ignored. In our study, 85 (43.5 %) patients were diagnosed as overweight or obese (the mean BMI of 85 patients was 26.59 [95 % CI: 26.12, 17.06]), of which 33 (38.8 %) suffered from malnutrition (diagnosed by the combined index).

In our study, after integrating the data of the two groups, the overall prevalence of malnutrition calculated by the combined index was 51.3 %. The prevalence of malnutrition varies from disease to disease. For example, the malnutrition rate can reach about 39 % in hepatitis B-related cirrhosis (32), while it is only 17 % in chronic obstructive pulmonary disease (33). Although there were great differences in the results of different nutritional screening tools, the nutritional status of patients with aplastic anemia was still not optimistic. Our study showed that the severity of the disease was related to the nutritional status of patients. The malnutrition rate of SAA and VSAA patients was significantly higher than that of AA patients, which means that the more serious the disease, the worse the nutritional status of patients. In addition, the high level of inflammation in patients with aplastic anemia may be a potential factor leading to poor nutritional status, as Sieske et al. found that inflammation would aggravate the malnutritional risk of patients (34). In this study, we found that the CRP inflammatory index of well-nourished patients was significantly lower than that of malnourished patients in the two groups (low BMI and high BMI).

In order to find the best nutritional screening tool for patients with aplastic anemia, the consistency between different screening tools and combined index was compared. In the low BMI group, CONUT and INA had the highest sensitivity, but their specificity and positive predictive value were significantly lower than those of NRI and PNI, which means that CONUT and INA overestimated the number of malnutrition, resulting in a high misdiagnosis rate. Although PNI had the highest specificity and positive predictive value, its sensitivity and negative predictive value were the lowest among the four screening tools, suggesting that PNI underestimated the number of malnutrition and led to a higher rate of missed diagnosis. In the high BMI group, although CONUT had the same sensitivity as NRI, its specificity and positive predictive value were significantly lower than those of NRI, suggesting that CONUT exaggerated the prevalence of malnutrition. In addition, when assessing the nutritional status of overweight or obese patients with aplastic anemia, PNI can be used as an alternative tool for NRI, because the kappa value of PNI was similar to NRI. Regardless of BMI, NRI is the best tool to assess the nutritional status of patients with aplastic anemia, because the highest consistency and area under curve was found in NRI. In our opinion, this fact was related to the NRI calculation method. The calculation formula of NRI includes nutritional indicators and

body weight. Compared with the other three screening tools, it seems more comprehensive.

Although we emphasized that the accuracy of the traditional comprehensive scale and ESPEN guidelines will be affected when evaluating overweight or obese people, we did not use the combined index to compare and verify. This is the defect of our study, and we will further study it in the future work. The fact of using the combined index generated by four nutritional screening tools to assess nutritional status of patients with aplastic anemia also brings some problems, because the parameters required for nutritional evaluation will be affected by the disease itself. For example, the destruction of the immune system in patients with aplastic anemia will not only lead to lymphopenia (35), but also increase the risk of infection. Albumin, as an acute phase reactive protein, will decline during infection (36). Due to the lack of previous work, we were unable to obtain follow-up data of patients. We only analyzed the relationship between nutritional status and disease severity, and whether nutritional status could significantly affect the clinical outcome of patients remained unknown, therefore, further research is needed to clarify these problems in the future. In addition, the sample size of this study is small, and the data may be biased. For example, in the low BMI group, the small sample size of VSAA patients may lead to falsely high malnutrition rates in patients with VSAA.

CONCLUSIONS

Our data showed that the malnutrition rate of patients with aplastic anemia was 51.3 % and more than 30 % of obese or overweight patients suffered from malnutrition. Therefore, the nutritional status of overweight or obese patients should not be ignored. The nutritional status of patients with aplastic anemia was related to the severity of the disease. NRI is the best tool for assessing the nutritional status of patients with aplastic anemia.

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