Comparison of different methods for nutrition assessment in patients with tumors

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Abstract. Nutrition screening to identify patients at risk of malnutrition is vital for cancer patients because of the high prevalence of malnutrition in this population. The aim of the present study was to compare different methods of nutrition assessment in patients with tumors. From June 2013 to June 2014, we conducted an observational multicenter study to compare the assessment of nutritional status in patients with tumors by anthropometry, biochemical indicators, nutritional risk screening (NRS-2002) and patient-generated subjective global assessment (PG-SGA). Mann-Whitney test and Kruskal-Wallis H non-parametric test were used for intergroup comparisons. Spearman's rank correlation coefficients were calculated to evaluate the association between different methods of nutritional assessment. The κ statistic was used to evaluate the agreement between two assessment methods. A total of 927 oncology inpatients underwent full nutritional assessment and nutrition screening. The PG-SGA tool determined that 13.7% of patients were well-nourished (PG-SGA from 0-1) and the rest (86.3%) were malnourished. Among the malnourished patients, 57.8% were moderately malnourished (PG-SGA from 2-8) and 28.5% were severely malnourished (PG-SGA ≥9). According to NRS-2002, 30.7% of patients were at nutritional risk (NRS-2002 ≥3). There was a significant positive correlation between PG-SGA scores and NRS-2002 scores in both men and women. Compared to albumin, the PG-SGA had a sensitivity of 93.78% and specificity of 21.80%. In comparison, NRS-2002 had a low sensitivity of 43.13% and relatively higher specificity of 82.16%. In conclusion, the relationship between PG-SGA, NRS-2002 and nutritional status is statistically significant. Compared with NRS-2002, PG-SGA is a suitable screening tool for detecting the risk of malnutrition in patients with cancer.

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Introduction

Accompanied by the continuous industrialization and urbanization in China, the incidence of malignant tumors is increasing annually. Presently, malignant tumors are one of the main diseases that seriously threatens human health. Moreover, because of life style changes and aging, malignant tumors represent a primary cause of death in our country (1). It is also known that cancer patients are prone to malnutrition. Some studies suggested that roughly 50-90% of cancer patients suffer from malnutrition (2). The number of incidences of severe malnutrition in patients with malignant tumors was reported to be about 2,000,000/year (3).

Once a patient is diagnosed with a malignant tumor, nutritional risk screening (NRS-2002) must be carried out in a timely manner (4). Recently, two screening tools have been widely-used the NRS-2002, recommended by the European Society for Clinical Nutrition and Metabolism (ESPEN) (5), and patient-generated subjective global assessment (PG-SGA), developed by Ottery (6) for the oncology population. The PG-SGA was developed based on Subjective Global Assessment (SGA). Clinical studies found that the PG-SGA is the most ideal and widely used tool to evaluate the nutritional status of patients with tumors. Therefore, the PG-SGA has become widely applied and popularization by the American Dietetic Association (ADA) (2,7-9).

The primary aim of this study was to analyze the potential relationship of the PG-SGA with nutritional status assessed by NRS-2002, anthropometry and biochemical indicators to determine its value as a clinical tool for integration in the assessment of patients with cancer. The secondary aim of the study was to compare the similarities and differences between the PG-SGA and NRS-2002 in the evaluation of nutritional status of patients with cancer.

Patients and methods

Patients. In this cross-institutional study, we selected subjects from the First Hospital of Hebei Medical University, the Second Hospital of Hebei Medical University (East court), Hengshui Halison International Peace Hospital, Xingtai People's Hospital and the Affiliated Hospital of Chengde Medical College from June 2013 to June 2014, for a total of 927 patients with malignant tumors. Patients with cancer and aged at least

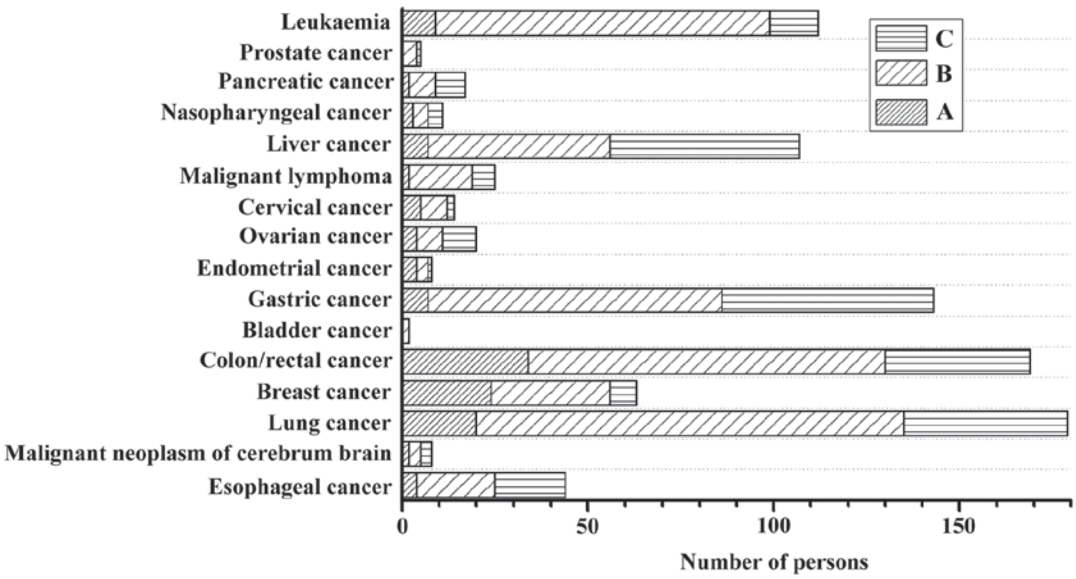

Figure 1. Different types of cancer patients with categorisation of malnutrition by PG-SGA. PG-SGA, patient-generated subjective global assessment.

18 years old were eligible for inclusion in the study. Multiple admission patients were investigated only once. The exclusion criteria included patients who were unwilling to participate in the study, patients aged <18 years or >90 years, patients with physical or cognitive impairment, patients with AIDS and recipients of organ transplants. The design of the study was approved by the Research Ethics Board of the First Hospital of Hebei Medical University (no. 2013205) and written informed consent was obtained from all participants.

Nutritional status. A questionnaire survey was used to investigate the nutritional status of patients with malignant tumors. Patients (n=927) who consented to participate in the study completed the NRS-2002 and PG-SGA. The NRS-2002 ranges from 0-7 points and consists of three parts: part one assesses the severity of disease, part two assesses the nutritional status and part three is an adjustment for patients aged >70 years. Patients with a total score of ≥3 were estimated to be at nutritional risk (10). The PG-SGA ranges from 0 to 50 points, with a score of ≤1 indicating well-nourished (PG-SGA ≤1, PG-SGA-A), a score of 2-8 indicating moderately malnourished (2≤ PG-SGA <9, PG-SGA-B), and a score of ≥9 indicating severely malnourished (PG-SGA ≥9, PG-SGA-C) (10).

Anthropometry. Body weight (BW; nearest 0.1 kg) and height (nearest cm) were measured while the patient was standing without shoes and wearing light clothes. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared (kg/m^2). Mid-arm circumference (MAC), mid-arm muscle circumference (MAMC), and triceps skinfold thickness (TSF) were measured on the dominant arm according to Heymsfield *et al* (11). MAMC was calculated according to the following formula: MAMC (cm) = MAC (cm) - [TSF (mm) x 0.314] (12). Non-dominant hand grip was performed using a standardized position recommended by the American Society of Hand Therapists. All anthropometric measurements were made at least 3 times by the same investigator and the reported values were averaged.

Biochemistry. Blood samples from a cubital vein were collected on admission for analysis of total protein, albumin, and hemoglobin. Because the diagnostic criteria for nutritional risk were different in each hospital, they were made by referring to the protocol of each hospital.

Statistical analysis. Statistical analyses were carried out using SPSS version 13 (SPSS, Inc., Chicago, IL, USA). All data were not normally distributed. Baseline characteristics are presented as frequencies with percentages or median with interquartile range. The Mann-Whitney test and Kruskal-Wallis H non-parametric test were used for intergroup comparisons. Because the data were not normally distributed, the relation was assessed by Spearman's rank correlation analysis. The κ statistic was used to evaluate the agreement between two assessment methods. The range of values for κ was from 0-1. A value of κ below 0.4 indicated that chance alone could account for the observed agreement, and a value of 1 represented a perfect concordance. A probability value <0.05 was considered to indicate a statistically significant difference.

Results

The baseline characteristics of patients are summarized in Table I. The study population consisted of 510 (55%) men with a median age of 62 years (interquartile range, 55-70 years) and 417 (45%) women with a median age of 59 years (interquartile range: 48-66 years). According to the PG-SGA, 13.7% of patients were well-nourished (PG-SGA from 0-1) and 86.3% were malnourished, among whom, 57.8% were moderately malnourished (PG-SGA from 2-8) and 28.5% of patients were severely malnourished (PG-SGA ≥9). The nutritional status of patients according to tumor type is shown in Fig. 1. According to NRS-2002, 30.7% of patients were at nutritional risk (NRS-2002 ≥3). The median weight, BMI, TSF, MAMC, and non-dominant hand grip were higher in men than in women (P<0.05). Lung cancer was the most prevalent tumor, accounting for 19.3% of patients. The biochemical variables

Table I. Clinical characteristics of the patients.

Clinical characteristics	Total (n=927)	Men (n=510)	Women (n=417)
Age, median (IQR)	61 (52-78)	62 (55-70)	59 (48-66)
Nutritional parameters, median (IQR)			
Weight, kg	61 (52-68)	65 (59-70)	58 (52-64.63)[a]
BMI, kg/m^2	22.3 (20.3-24.5)	22.10 (20.3-23.93)	22.7 (20.6-25.2)[a]
TSF, mm	12.0 (8.1-15)	10.05 (8-13.63)	13.0 (9-16)[a]
MAC, cm	27.0 (23.5-30.0)	27.0 (24-30.0)	26.25 (23-30.0)
MAMC, cm	22.72 (20.29-25.45)	23.13 (21.17-25.92)	22.08 (18.73-24.56)[a]
Non-dominant hand grip, kg	16.7 (10-24)	20 (12-27.93)	14.05 (10-20)[a]
Total protein, g/l	65 (59.2-71)	64.75 (59.18-70.93)	66.80 (60.15-71.75)
Albumin, g/l	38.2 (34.1-42)	38 (34.00-42.00)	39 (35.45-41.80)
Hemoglobin, mg/l	117.0 (102-129)	118.0 (102-132)	115.0 (101-127)[b]
Tumor location, n (%)			
Esophageal cancer	44 (4.7)	31 (6.1)	13 (3.1)
Malignant neoplasm of cerebrum brain	8 (9)	5 (1.0)	3 (7.0)
Lung cancer	179 (19.3)	112 (22.0)	67 (16.1)
Breast cancer	63 (6.8)	2 (0.4)	61 (14.6)
Colon/rectal cancer	169 (18.2)	90 (17.6)	79 (18.9)
Bladder cancer	2 (0.2)	1 (0.2)	1 (0.2)
Gastric cancer	143 (15.4)	107 (21.0)	36 (8.6)
Endometrial cancer	8 (0.9)	0 (0)	8 (1.9)
Ovarian cancer	20 (2.2)	0 (0)	20 (4.8)
Cervical cancer	14 (1.5)	0 (0)	14 (3.4)
Malignant lymphoma	25 (2.7)	11 (2.2)	14 (3.4)
Liver cancer	107 (11.5)	64 (12.5)	43 (10.3)
Nasopharyngeal cancer	11 (1.2)	10 (2.0)	1 (0.2)
Pancreatic cancer	17 (1.8)	7 (1.4)	10 (2.4)
Prostate cancer	5 (0.5)	5 (1.0)	0 (0)
Leukemia	112 (12.1)	65 (12.7)	47 (11.3)

[a]$P<0.001$; [b]$P<0.05$ by Mann-Whitney test. IQR, interquartile range; BMI, body mass index; TSF, triceps skinfold thickness; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference.

mentioned above did not differ significantly according to sex, except for hemoglobin.

Anthropometrics, biochemical parameters, and NRS-2002 score for each of the PG-SGA classifications are shown in Table II. All variables were statistically significant between the PG-SGA groups ($P<0.05$).

Correlations of the PG-SGA and NRS-2002 scores with anthropometrics, muscle function, and biochemical parameters stratified by sex are shown in Table III. For patients with malignant tumors, there was a significant positive correlation between the PG-SGA scores and NRS-2002 scores in both men and women. In men, BMI, non-dominant hand grip, and total protein had moderate negative correlations with PG-SGA, whereas in women, such correlations were found between weight, BMI, TSF, non-dominant hand grip, MAC, MAMC, total protein and albumin. Both men and women had a weak negative correlation of PG-SGA with hemoglobin. In addition, the relationship between nutritional status and NRS-2002 was similar to the relationship between nutritional status and PG-SGA.

Concordance between albumin and NRS-2002 was observed in 577 of 927 (62.2%) patients, and concordance between albumin and PG-SGA was observed in 551 of 927 (59.4%) patients. Sensitivity was 93.78% with PG-SGA and 43.13% with NRS-2002. Specificity was 21.8 and 82.16% with PG-SGA and NRS-2002, respectively. Agreement was higher between albumin and NRS-2002 ($\kappa=0.251$, $P=0.0007$) than between albumin and the PG-SGA ($\kappa=0.160$, $P=0.0006$; Table IV).

Discussion

Previous studies (13-15) showed that malnutrition can reduce the immune function of patients with tumors and increase the

Table II. Comparison of nutritional indicators (median, IQR) according to PG-SGA.

	PG-SGA		
Nutritional parameters	A[a]	B[b]	C[c]
Weight, kg	65 (60-72)	63 (56-70)	58 (50-62)[d]
BMI, kg/m^2	24 (22-26)	22.6 (20.8-24.8)	21.1 (19.03-22.98)[d]
MAC, cm	28.5 (26.5-31.25)	27.5 (24.3-30)	24 (20.4-27.00)[d]
TSF, mm	14.1 (10-20.5)	12.5 (8.4-15)	9.05 (8-12.33)[d]
Non-dominant hand grip, kg	21.1 (16.4-29.75)	17 (10-24)	14 (9-20)[d]
MAMC, cm	23.87 (22.14-25.76)	23.2 (20.72-25.89)	21.3 (17.75-23.23)[d]
Total protein, g/l	68.6 (65.0-73.5)	66.2 (60.0-72.1)	60.2 (57.67-66.2)[d]
Albumin, g/l	41 (38.2-43.25)	38.8 (34.7-42.7)	35.8 (32.43-40.0)[d]
Hemoglobin, mg/l	124.0 (114.0-134.5)	116.0 (100.0-128.0)	115.0 (101.0-134.5)[d]

[a]A, PG-SGA rating in well-nourished patients. [b]B, PG-SGA rating in moderately undernourished patients. [c]C, PG-SGA rating in severely undernourished patients. [d]$P<0.001$, $P<0.05$ by Mann-Whitney test. IQR, interquartile range; PG-SGA, patient-generated subjective global assessment; BMI, body mass index; MAC, mid-arm circumference; TSF, triceps skinfold thickness; MAMC, mid-arm muscle circumference.

Table III. Correlation coefficients and P-values for patient data and nutritional assessment techniques according to sex.

	PG-SGA				NRS-2002			
	Men		Women		Men		Women	
Nutritional parameters	Correlation	P-value	Correlation	P-value	Correlation	P-value	Correlation	P-value
Weight, kg	-0.296	<0.001	-0.350	<0.001	-0.341	<0.001	-0.418	<0.001
BMI, kg/m^2	-0.305	<0.001	-0.355	<0.001	-0.336	<0.001	-0.417	<0.001
TSF, mm	-0.224	<0.001	-0.343	<0.001	-0.207	<0.001	-0.332	<0.001
MAC, cm	-0.294	<0.001	-0.417	<0.001	-0.266	<0.001	-0.395	<0.001
MAMC, cm	-0.237	<0.001	-0.321	<0.001	-0.222	<0.001	-0.295	<0.001
Non-dominant hand grip, kg	-0.333	<0.001	-0.219	<0.001	-0.324	<0.001	-0.239	<0.001
Total protein, g/l	-0.323	<0.001	-0.333	<0.001	-0.319	<0.001	-0.313	<0.001
Albumin, g/l	-0.271	<0.001	-0.376	<0.001	-0.297	<0.001	-0.264	<0.001
Hemoglobin, mg/l	-0.214	<0.001	-0.165	0.001	-0.266	<0.001	-0.255	0.001
NRS-2002 score	0.543	<0.001	0.575	<0.001				

All P-values were determined with the use of Spearman's correlation coefficient. PG-SGA, patient-generated subjective global assessment; NRS-2002, nutritional risk screening; BMI, body mass index; TSF, triceps skinfold thickness; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference.

risk of infection, the incidence of postoperative complications and mortality. With the correct nutritional evaluation, malnutrition or the risk of malnutrition can be detected. The process of recovery in patients may benefit from timely nutritional screening and nutritional support. Commonly used anthropometric indicators such as BMI, TSF and MAC, have limitations including the lack of specific normal reference values and large measurement error. In addition, all of the individual nutritional indexes emphasize specific aspects and should therefore not be used alone for nutritional evaluation. The use of a comprehensive nutritional assessment tool should be recommended for patients with malignancy. Numerous nutritional evaluation tools have been applied clinically, such as NRS-2002, Mini Nutritional Assessment (MNA), SGA and PG-SGA. NRS-2002 is mainly used to screen for malnutrition risk in patients to provide guidance for clinical nutrition intervention. The PG-SGA is an effective tool for the assessment of nutritional status of patients with tumors and has been widely promoted and applied by the ADA and other organizations. However, the relationship between the PG-SGA, NRS-2002, and individual anthropometric and biochemical parameters remains unclear. Therefore, the objective of this study was to explore the association between the PG-SGA, NRS-2002 and other nutritional parameters.

The PG-SGA scores have been shown to be accurate for distinguishing well-nourished patients from malnourished

Table IV. Statistical comparison of albumin and screening tool values at hospital admission: PG-SGA and NRS-2002 vs. albumin.

	PG-SGA			NRS-2002		
Items	At risk (B+C)	No risk (A)	Total	At risk (NRS-2002 ≥3)	No risk (NRS-2002 <3)	Total
At risk (albumin <35g/l)	452	30	482	204	269	473
No risk (albumin ≥35g/l)	348	97	445	81	373	454
Total	800	127	927	285	642	927
Sensitivity		93.78% (454/482)			43.13% (204/473)	
Specificity		21.80% (97/445)			82.16% (373/454)	
		κ=0.160, P=0.0006			κ=0.251, P=0.0007	

PG-SGA, patient-generated subjective global assessment; NRS-2002, nutritional risk screening.

patients with a score of ≥9 (16). Our study found that according to PG-SGA, the incidence rate of malnutrition in cancer patients was 86.3%. Using the PG-SGA as a method of nutritional evaluation, Bauer *et al* (8) found that the incidence of malnutrition in ambulant cancer patients receiving radiation therapy was 75%. Shaw *et al* (4), reported that the prevalence of malnutrition in cancer outpatients was 71%. The prevalence of malnutrition in cancer is often quoted as 40-80% (17,18), and this may depend largely on the method of assessment and screening, the clinical setting and diagnostic group studied. Regarding the parameters of this study, there was no limit on cancer stage, and whether patients received treatment or not was not taken into consideration for analysis. Therefore, these may have been causes of the high incidence of malnutrition in this study. However, the study showed that compared with those who were classified as malnourished according to the PG-SGA (86.3%), NRS-2002 underestimated the incidence of patients at risk (30.7%). This may have been because of differences between NRS-2002 and the PG-SGA. The PG-SGA was designed in such a way that the components of the medical history can be completed by the patient using a checkbox format. Physical examination is then performed by a health professional. In comparison, PG-SGA contains more anthropometric parameters. Although the assessment process is cumbersome, it is a comprehensive and effective evaluation tool.

In our study, the values of all variables were significantly lower in the PG-SGA-C group than in the PG-SGA-A group, and all variables except for hemoglobin in the PG-SGA-C group were lower than in the PG-SGA-B group. Only non-dominant hand grip and hemoglobin in the PG-SGA-B group were lower than in the PG-SGA-A group. This was consistent with the results from other studies regarding nutritional evaluation using NRS-2002, in which the nutritional parameters of the high-risk group with NRS ≥3 were significantly lower than those of other groups (19).

We studied the relationship between PG-SGA and NRS-2002 scores and parameters in patients with malignant tumors and found that there was a significant positive correlation between the PG-SGA scores and NRS-2002 scores in either men or women. Our results suggest that there was a negative and moderate correlation between PG-SGA scores and BMI, and between PG-SGA scores and total protein in both men and women. In contrast, studies with similar methodology found poor agreement between nutritional assessment parameters and PG-SGA scores (20). This variation may have been because each method reveals a different aspect of malnutrition. Furthermore, our results indicated that the relationship between nutritional status and NRS-2002 is similar to the relationship between nutritional status and the PG-SGA. The association between nutritional status and the NRS-2002 score of patients with head and neck cancer was well described in a study by Orell-Kotikangas *et al* (19). The study showed that in men, BMI, MAC and mid-arm muscle area (MAMA) had moderate negative correlation with NRS-2002, whereas in women, such correlation was not observed. This finding is not concordant with our results. The difference may be because of the fact that our study included 417 female patients (45%) with cancer compared with 15 women (23%) with head and neck squamous-cell carcinoma (HNSCC) (17), in which their proportion of female participants was far below our study.

Albumin is commonly considered as a good marker of nutritional status. We compared the accordance between albumin and screening tool parameters upon hospital admission, i.e., PG-SGA and NRS-2002 vs. albumin. The agreement of both methods was low, indicating poor consistency of malnutrition identification in individual patients. When comparing PG-SGA score with albumin, a higher sensitivity and lower specificity compared with NRS-2002 are seen in patients with tumors. The sensitivity and specificity of the NRS-2002 were poor in comparison at 43.13 and 82.16%, respectively, which were lower than previous studies undertaken in patients with HNSCC (19). Therefore, we find that the PG-SGA is more suitable than NRS-2002 to screen for the risk of malnutrition in patients with tumors.

Several limitations were associated with the present study. First of all, the design was not prospective. Although the sample size was large, some types of cancer had a limited number of patients. In addition, the values of the PG-SGA and NRS-2002 are difficult to analyze from the perspective of different tumor types. Although many studies have been performed to associate PG-SGA, NRS-2002 and nutritional parameters, this study is still meaningful because it involved a variety of tumors. As the sample population included 927 patients, it was comparatively large. In this study, the number of patients with lung cancer was the highest, followed by colorectal cancer, and gastric cancer. This trend was consistent with data (21) on malignant tumors in China. The results of this study indicate that for patients with cancer, the relationship between the PG-SGA, NRS-2002 and nutritional status is statistically significant. Compared with NRS-2002, PG-SGA is a suitable screening tool for detecting the risk of malnutrition in patients with cancer.

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