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ORIGINAL ARTICLE

The role of the Patient-Generated Subjective Global Assessment (PG-SGA) and biochemical markers in predicting anemia patients with cancer

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Abstract

Purpose The causes of anemia and the common side effects of cancer are multifactorial. Malnutrition is one of the alleged components of the aforementioned complications. This study planned to investigate the relationship among biochemical markers, Patient-Generated Subjective Global Assessment (PG-SGA), and anemia in cancer patients.

Methods This analysis consisted of 234 patients who were enlisted in the Department of Oncology of the First Hospital of Shanxi Medical University between December 2016 and October 2017. The groups were divided into anemic and non-anemic patients. The gathered data primarily discussed the patients' basic information, specifically the age, gender, smoking, alcohol consumption, and nutritional status based on levels of serum biochemical markers and PG-SGA scores.

Results Among the participants, 31.2% of the cancer patients were diagnosed with anemia whereas, according to the scores of PG.SGA, 65.0% of patients experienced malnourishment. The anemia was significantly associated with biochemical markers, expecting a transferrin in univariable analyses. Binary logistic regression analysis between anemic cancer patients and non-anemic cancer patients suggested that high PG-SGA score (odds ratio 1.082; 95% CI 1.027–1.141) implied the risk factor for anemia, and high PG-SGA scores could potentially increase the risk of anemia. The multiple regression analysis showed that hemoglobin concentration (OR 0.575; 95% CI 0.450–0.736) and PG-SGA score (OR 1.231; 95% CI 1.013–1.496) were linked to anemia. However, total protein, albumin, prealbumin, serum iron, transferrin, and transferrin saturation lacked a strong relationship with anemia.

Conclusion Anemia prevailed in cancer patients, as nutritionally assessed by PG-SGA, while hemoglobin established a linkage with anemia as they could provide extra predictive information about anemia in patients diagnosed with cancer.

Keywords Anemia · Malnutrition · Nutritional assessment · Patient-generated subjective global assessment

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Introduction

Anemia is present in patients with cancer, both at diagnosis and during therapy [1]. According to previous studies, the prevalence may vary between 30 and 90% among cancer patients [2]. It is notable from the presented evidences that anemia is a negative prognostic indicator of survival, disease-free recurrence, and local relapse. Subsequently, it bears an important effect on the quality of life [3, 4]. The related studies on anemia have indicated its association with increased mortality and illness in cancer patients [3].

Malnutrition is acknowledged to be a common problem in patients with cancer [5]. Poor nutritional status may be due to the impact of the tumor on the metabolism of host [6, 7]. In addition to this, antineoplastic treatments (e.g., chemotherapy, drug, surgery, radiotherapy) can eradicate or reduce tumor size. Conversely, they may lead to several side effects such as nausea, vomiting, malabsorption, anorexia, and fatigue, which in turn can worsen malnutrition in cancer patients [8]. As of the present studies, a systematic review found that nutritional status had a profound effect on anemia [9] and nutrition deficiency was one of the causes of anemia [10]. Unfortunately, the importance of the relationship between malnutrition and anemia is overlooked and under-treated in patients with cancer [11, 12].

The Patient-Generated Subjective Global Assessment (PG-SGA) which developed by Ottery in 1996 [13] is broadly used in both the studies and clinical practice as the valid nutritional assessment tool for cancer patients [14]. PG-SGA allows for quick identification and prioritization of malnutrition in cancer patients [15]. In addition to this, diagnosing anemia is always based on biochemical markers. However, there is a limited resource on the subjective assessments that could detect anemia and the role of PG-SGA combined with biochemical markers for assessing and predicting anemia in cancer patients does not occur often in current medical studies in China.

Therefore, the aims of this study were to investigate the nutritional state and to evaluate the potential positive correlation between anemia and nutritional status, as well as biochemical markers in cancer patients, through the model assessed by PG-SGA.

Subjects and methods

Patients

The cross-sectional study was performed in the Department of Oncology of the First Hospital of Shanxi Medical University from December 2016 to October 2017. The selection criteria included the cancer patients aged ≥ 18 years and had an expected survival rate of at least 6 months. This study did not comprise the following diagnosis on selected patients: (1) hematological cancer; (2) bone marrow or chronic renal disease; (3) uncooperative patients or psychiatric disease or mental disorder who were unable to complete the questionnaire.

Before the initiation of this study, consent forms were both distributed and obtained to and from the participating cancer patients. This study was approved by the Ethics Committee of the First Hospital of Shanxi Medical University.

Anthropometric measurements

Anthropometric values were measured on the admission time to the participating cancer patients to the hospital. The assessment on the weight and height was performed using an electronic scale (DST-600, Beijing, China), rounded off to the nearest 0.1 kg and 0.1 cm while the subjects wore light clothes in the morning and underwent an overnight fast. The weight and height were used to calculate body mass index (BMI = weight [kg]/height $[m]^2$).

Blood sample collection

"Total protein, albumin, prealbumin, hemoglobin, total cholesterol, triglycerides, HDL-C, LDL-C, iron, transferrin and transferrin saturation were examined through the use of standard clinical chemistry techniques laboratory of the First Hospital of Shanxi Medical University (DXC800, Beckman Coulter, Inc. USA and ABX120, Allocated Bullion Exchange, Inc. France)." The diagnosis of anemia resulted to hemoglobin level < 120 g/L for male and < 110 g/L for female [16].

PG-SGA

All participants were asked to complete the PG-SGA questionnaire on the day of admission to the hospital. Three trained medical professionals assessed the nutritional status of all patients by using the PG-SGA [17]. The PG-SGA is divided into two sections: the first section includes weight history, changes of food, gastrointestinal symptoms (e.g., nausea, vomiting and diarrhea, etc.) and functional capacity; on the other hand, the second section includes information on physical assessment, metabolic demand, and decision regarding disease-related nutrient demands. The participating cancer patients answered the first section while the professional medical personnel accomplished the second section [18, 19]. On the basis of the score, the patients can be classified into four global assessment categories: well-nourished (PG-SGA score, 0–1), suspected of being malnourished (PG-SGA score, 2–3); moderately malnourished (PG-SGA score, 4–8); and severely malnourished (PG-SGA score, ≥ 9) [20].

Statistical analysis

Descriptive statistics were applied to analyze cancer patient's demographic characteristics and biochemical markers. Quantitative variables consider mean ± standard deviation (SD) and qualitative variables were presented as frequency (%). Independent Student's test for normally distributed parameters and Mann-Whitney *U* test for non-normally distributed parameters indicate the assessment method processed on the differences between group of means for continuous variables and chi-square tests for categorical variables. To identify the potential of PG-SGA and parts of biochemical markers to predict anemia in cancer patients, simple and multiple logistic regression analysis was pursued. Statistical significance was considered 0.05 by using two-tailed analysis. All statistics were conducted though the SPSS software (version 20.0 SPSS, Inc).

Results

Object characteristics and the distribution of cancer and nutritional status

The detailed baseline characteristics of enrolled patients were depicted in Table 1. A total of 234 cancer patients participated in this study, out of which 73 subjects had anemia, totaling to 31.2% and 161 did not carry anemia. There were no significant differences between anemic and non-anemic groups in baseline characteristics, except for the higher mean PG-SGA scores in anemic group than in non-anemic group (8.34 ± 6.05 vs. 6.11 ± 4.70, $P = 0.04$).

Comparison of nutritional status in anemic patients and non-anemic patients

The frequency of malnutrition in these patients follows: 20.5% of the participants were malnourished (PG-SGA score, 2–3); 33.8% were moderately malnourished (PG-SGA score, 4–8); 31.2% were severely malnourished (PG-SGA score, ≥ 9) (Table 2). In the anemic group, 75.3% ($n = 73$) of patients were malnourished (PG-SGA score ≥ 4) whereas 60.2% ($n = 161$) of patients were malnourished in non-anemic group. Data collected from box 3 of PG-SGA indicated that the most common nutritional symptom is "No appetite (23.1%)", followed by "Constipation (20.5%)" and "Nausea (15.8%)." There were significant differences in "No appetite" between anemic and non-anemic groups (Table 3).

The relationship between anemia and nutritional status

There was a strong association between anemia and PG-SGA; the binary logistic regression analysis between anemic group and non-anemic group suggested that PG-SGA score (OR 1.082; 95% CI 1.027–1.141) was the risk factor for anemia, of which a higher PG-SGA score defined a higher risk of anemia. The anemia that was significantly associated with biochemical markers in univariate analyses was total protein (OR 0.0942; 95% CI 0.904–0.981), albumin (OR 0.874; 95% CI 0.796–0.901), prealbumin (OR 0.994; 95% CI 0.989–0.999), hemoglobin (OR 0.691; 95% CI 0.606–0.787), serum iron (OR 0.896; 95% CI 0.845–0.950), and transferrin saturation (OR 0.972; 95% CI 0.949–0.996); however, no significant relationship has taken place between transferrin (OR 0.915; 95% CI 0.610–1.373) and anemia. Multiple regression analysis furthered the test of the abilities of biochemical markers and PG-SGA to predict anemia. The multiple regression analysis showed that Hb concentration (OR 0.575; 95% CI 0.450–0.736) and PG-SGA score (OR 1.231; 95% CI 1.013–1.496) interrelated with anemia. On the other hand, the following parameters were not associated with anemia in the multiple regression analysis: total protein, albumin, prealbumin, serum iron, transferrin, transferrin saturation (Tables 4 and 5).

Discussion

Anemia might be well-observed, but it poses as a rarely recognized problem in cancer patients. Gao et al. found that in unclassified cancers, the occurrence of anemia in the diagnosis of cancer patients was at 18.98% [16]. The European Cancer Anemia Survey study of 15,367 patients at 748 sites in 24 countries reported a 39% rate of anemia in cancer patients [21]. In our study, the existence of anemia in cancer patients was observed at 31.2%, a higher percentage compared with Gao et al., but still similar to the result of 39%. Numerous screening tools are currently receiving interest as approaches for detection of malnutrition in cancer patients, especially PG-SGA. From all the gathered results in present studies, anemia was strongly associated with malnutrition. Nevertheless, there are no appropriate subjective measures to evaluate anemia in cancer patients. In this study, we reported the relationship between PG-SGA combine with biochemical markers and anemia. From our knowledge and evidences, this study is the first to use PG-SGA to test the link between nutritional status and anemia.

PG-SGA and biochemical markers are both the means to identify and evaluate nutritional status. They have been widely used in hospitalized patients with cancer. A large number of clinic practitioners and laboratory personnel prefer serum biochemical markers as they can offer objective and quantitative results [22, 23]. Furthermore, they could diagnose the disease by objective values. For instance, a meta-analysis by Zhang et al. showed that the levels of protein markers and total cholesterol were useful biochemical markers for malnutrition

Table 1 Baseline characteristics and nutritional status of 234 cancer patients

Index	Total ($n = 234$)	Anemia ($n = 73$)	Non-anemia ($n = 161$)	*P* value
Age, y	62.43 ± 11.34	63.12 ± 12.04	62.11 ± 11.04	0.521
Height, m	1.65 ± 0.08	1.64 ± 0.08	1.65 ± 0.08	0.148
Weight, kg	60.80 ± 10.90	58.08 ± 10.81	62.03 ± 10.76	0.882
BMI, kg/m^2	22.34 ± 3.44	21.57 ± 3.57	22.69 ± 3.19	0.382
Smoking, *n* (%)				0.230
Yes	60 (25.6)	15 (20.5)	45 (28.0)	
Alcohol consumption, *n* (%)				0.201
Yes	25 (10. 7)	5 (6.8)	20 (12.4)	
PG-SGA	6.18 ± 5.25	8.34 ± 6.05	6.11 ± 4.70	0.04

All values were *n*(%) or mean ± SDs. *BMI* body mass index. *PG-SGA* the Patient-Generated Subjective Global Assessment. *Hb* hemoglobin

[24]. As usual, biochemical markers can keep relatively stable status, but several preanalytical factors may influence these markers such as age, sex, the methods of blood drawing and confounding conditions affecting the distribution or rates of synthesis and catabolism [22]. Contrary to this, we used comprehensive tools to assess anemia rather than using single biochemical markers in cancer patients. This study demonstrated the use of PG-SGA scores and biochemical markers, especially how it correlated hemoglobin to anemia. Moreover, the nutritional status assessed by PG-SGA showed that poor nutritional status presents itself as a risk factor of anemia. According to PG-SGA scores, 14.5% were well-nourished and 65.0% were malnourished in cancer patients. Du et al. reported that the rate of malnutrition in cancer patients retained 86.3% [25]. Barao et al. reported that 39.6% colorectal cancer patients were moderately or severely malnourished based on PG-SGA scores [26]. The discrepancy may depend on the clinical setting, the distributions of cancer and the antineoplastic treatments. Early nutritional assessment combined with biochemical markers will not only present the nutritional status, but also predict the risk for anemia, which may be beneficial in adopting treatments for cancer patients in early time.

There were significant association between nutritional status and anemia in univariate analysis. Arrieta et al. [27] and Frangos et al. [28] described the relationship between the two aforementioned study terms as hypoalbuminemia-associated on malnourished patients with anemia while albumin levels were strongly associated with anemia found in the aged persons. In this study, we found that biochemical markers in univariate analysis had a significant relationship with anemia except transferrin. Multivariate analysis promoted the link between nutritional status and anemia; however, only hemoglobin concentration and PG-SGA found its linkage to anemia. One possible cause was the effects of inflammation on serum ferritin. Antineoplastic treatment could aggravate inflammatory reactions in cancer patients. Ferritin is an acute-phase reactant and recommended as the primary measure of iron status, but it is impacted by inflammation [29]. Second, the PG-SGA and biochemical markers are closely correlated, with the effect of biochemical markers (such as total protein, albumin and prealbumin, etc.) on anemia influenced or masked by others in multivariate analysis. Thus, PG-SGA and biochemical markers (e.g., Hb) appear to be useful predictors of anemia in cancer patients. Another possibility explaining the results in our study is the type of cancer. Previous studies identified that

Table 2 Different nutritional status assessed by PG-SGA between anemic group and non-anemic group

Category	Total, *n* (%)	Anemia, *n* (%)	Non-anemia, *n* (%)	*P* value[a]
0–1	34 (14.5)	9 (12.3)	25 (15.5)	0.007
2–3	48 (20.5)	9 (12.3)	39 (24.2)	
4–8	79 (33.8)	23 (31.5)	56 (34.8)	
≥ 9	73 (31.2)	32 (43.8)	41 (25.5)	

[a] Significance was calculated by Mann-Whitney *U* test. *PG-SGA* the Patient-Generated Subjective Global Assessment

Table 3 Impediments that negatively influence food intake (box 3 of PG-SGA) and anemia

Symptoms[a]	Total	Anemia	Non-anemia	*P* value[b]
No appetite	54 (23.1)	23 (31.5)	31 (19.3)	0.039
Vomiting	29 (12.4)	12 (16.4)	17 (10.6)	0.206
Nausea	37 (15.8)	15 (20.5)	22 (13.7)	0.181
Diarrhea	6 (2.6)	3 (4.1)	3 (1.9)	0.575[c]
Constipation	48 (20.5)	14 (19.2)	34 (21.1)	0.733
Pain	15 (6.4)	6 (8.2)	9 (5.6)	0.636[c]
Dry mouth	31 (13.2)	8 (11.0)	23 (14.3)	0.487

All values were *n*

[a] Patients can indicate more than one symptom; [b] Pearson chi; [c] continuity correction

Table 4 Univariate logistic regression analyses of nutritional status to predict the anemia in cancer patients

Parameters	Univariate OR (95% CI)	*P* value
Nutritional status		
Total protein, (g/L)	0.942 (0.904–0.981)	0.004
Albumin, (g/L)	0.874 (0.796–0.901)	< 0.001
Prealbumin, (mg/L)	0.994 (0.989–0.999)	0.014
Hb, g/L	0.691 (0.606–0.787)	< 0.001
PG-SGA	1.082 (1.027–1.141)	0.003
Serum iron,(μmol/L)	0.896 (0.845–0.950)	< 0.001
Transferrin, (g/L)	0.915 (0.610–1.373)	0.668
Transferrin saturation, (%)	0.972 (0.949–0.996)	0.020

Hb hemoglobin, *PG-SGA* the Patient-Generated Subjective Global Assessment

the prevalence of anemia was high in lung cancer and gynecological malignancy [30]. In this study, however, there is a lack of limitation in the type of malignancy, which may likely increase the heterogeneity.

Nutritional-related symptoms not only reflect nutritional status, but also associate itself with anemia; thus, this study observed the relationship between anemia and the symptoms assessed by PG-SGA to investigate the possible cause of anemia. Hébuterne et al. indicated that 55% of patients were starting to eat less that what they were used to [31]. Kalantar-Zadeh et al. highlighted that poor appetite was associated with anemia, even after adjusting for hemoglobin levels [26]. Abbott J et al. showed that 59% cancer patients had difficulties in eating. The terms "No appetite," "Feeling full quickly," and "Taste changes" were the commonly reported as nutrition impact symptoms [32]. However, in the present study, it was noted that only the symptom of "No appetite" was the considered difference between the two groups. The disparate results were likely due to a section of PG-SGA conducted to the patients, leading to cancer patients not being accurately assessed on the symptoms. High appetite level occurs more frequently in patients with cancer, representing the intake of food. On the other hand, poor appetite could lead to anorexia; oncologists should pay attention to the patients who experience this specific symptom.

Table 5 Multiple logistic regression model of nutritional status to predict the anemia in cancer patients

Parameters	OR (95% CI)	*P* value
Nutritional status		
Total protein, (g/L)	0.954 (0.827–1.101)	0.519
Albumin, (g/L)	0.935 (0.729–1.198)	0.593
Prealbumin, (mg/L)	0.993 (0.968–1.019)	0.616
Hb, g/L	0.575 (0.450–0.736)	< 0.001
PG-SGA	1.231 (1.013–1.496)	0.036
Serum iron,(μmol/L)	1.247 (0.775–2.007)	0.362
Transferrin, (g/L)	0.684 (0.060–7.811)	0.760
Transferrin saturation, (%)	0.970 (0.796–1.183)	0.766

Hb hemoglobin, *PG-SGA* the Patient-Generated Subjective Global Assessment

Obviously, clinical practitioners often neglect the prevalence of malnutrition and anemia. There are no specific nutrition protocols designed for these patients. As dieticians, we hope adequate and proper nutrition can be part of regular therapy of cancer in the future.

The major drawback of the study (which we suggest to be tackled in future similar studies) is the heterogeneity of the participants both in respect to the distribution of cancer and various anti-treatments, as the distribution of cancer may influence the nutritional state of patients. There is also a limitation on the sample size of this study and observation period. In addition to that, the participants in our study were from department of oncology, which may evoke a selection bias in our study, and majority of the participants come from the non-gastrointestinal cancer patients who bear lung cancers. Acknowledging this situation, it could not represent the whole cancer patients. Longitudinal studies and randomized controlled trials performed among cancer patients are warranted to prove the problem.

In conclusion, nutritional status was associated with anemia. PG-SGA and hemoglobin are strongly linked to anemia and they could provide extra predictive information about anemia in patients with cancer. Moreover, additional studies are warranted to demonstrate the effects of these indices and to utilize appropriate interventions for improving the prognosis of anemic patients with cancer.

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Author contributions Ping Sun, Wen-Ting Cao, and Jun-Mei Jia were responsible for the design and conception of the study. Na Yan, Yan-Mei Xin, and Zeng-Rong Liu performed the experiments. Hua-Yan Li and Zhi-Fang Fan participated in clearing the data. Meng Wu and Xiao-Jiao Lian contributed to manage the data and performed the statistical analyses. Meng Wu wrote the draft.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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