The relationship between GLIM-malnutrition, post-operative complications and long-term prognosis in elderly patients undergoing colorectal cancer surgery

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Background: Elderly people and patients with colorectal cancer (CRC) are both at high risk of malnutrition. Therefore, it is of great significance to explore suitable malnutrition screening and diagnostic indicators for elderly patients with CRC. Recently, the Global Leadership Initiative on Malnutrition (GLIM) proposed new diagnostic criteria for malnutrition. The aim of this article was to evaluate the diagnostic value of GLIM criteria for malnutrition in elderly colorectal patients. We explored the relationship between GLIM-malnutrition, post-operative complications and the long-term prognosis of elderly colorectal patients.

Methods: Elderly patients (aged ≥65 years) who underwent CRC surgery from January 2015 to December 2018 were included. Malnutrition was diagnosed based on the GLIM criteria. The relationships between GLIM-malnutrition and clinical characteristics were analyzed by *t*-tests, Mann-Whitney *U* tests, and chi-squared tests. The relationships between GLIM-malnutrition and post-operative complications were analyzed by chi-squared tests, and logistic regression analyses. The relationships between GLIM-malnutrition and the long-term prognosis were analyzed by Kaplan-Meier analyses and logistic and Cox regression analyses.

Results: A total of 385 elderly patients were included in this study, and 118 patients (30.65%) were diagnosed with malnutrition according to the GLIM criteria. GLIM-malnutrition was significantly associated with older age, lower body mass index (BMI), lower grip strength, tumor location, higher Nutrition Risk Screening 2002 (NRS-2002), and lower levels of albumin and hemoglobin. GLIM-malnutrition was an independent risk factor [odds ratio (OR): 1.753, 95% confidence interval (CI): 1.100–2.795, P=0.018] for post-operative complications. Cox regression analysis showed that GLIM-malnutrition was an independent risk factor for overall survival in elderly patients with CRC.

Conclusions: The GLIM criteria are feasible diagnostic criteria for malnutrition of elderly patients with CRC. GLIM-malnutrition is significantly associated with post-operative complications and overall survival

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in elderly patients with CRC.

Introduction

Malnutrition is common amongst elderly people and is becoming a global public health problem as populations age. Colorectal cancer (CRC) has the third highest incidence and second highest mortality rate among all malignancies. In 2020, more than 1.93 million people worldwide were diagnosed with CRC, which caused 935,000 deaths (1). A study has shown that the incidence of malnutrition is higher in elderly patients with CRC than in younger patients, and malnutrition affects the clinical outcome of patients (2). Malnutrition in tumor patients will increase the incidence of post-operative complications, affect the efficacy of drug treatment, and even reduce long-term survival (3,4). Therefore, early diagnosis of malnutrition and nutritional intervention are of great significance in improving the short-term and long-term prognosis of cancer patients (5).

There are many screening and diagnostic tools for

malnutrition, including monotypic indicators such as body mass index (BMI) and involuntary weight loss, as well as composite indicators such as Nutrition Risk Screening 2002 (NRS 2002), Malnutrition Universal Screening Tool (MUST), Patient-Generated Subjective Global Assessment (PG-SGA), and Mini Nutritional Assessment-Short Form (MNA-SF). However, the large number of indicators illustrates the lack of a globally consistent consensus on diagnostic criteria for malnutrition (6). Therefore, to establish a globally accepted diagnostic indicator of malnutrition, the Global Leadership Initiative on Malnutrition has introduced a new indicator called the "GLIM criteria" (7). The GLIM criteria utilises a two-step model involving risk screening followed by malnutrition diagnosis assessment. Some studies have shown that, compared with multiple other nutritional diagnostic indicators, the GLIM score is an appropriate index for the diagnosis of malnutrition in cancer patients, such as gastric cancer (8), esophageal cancer (9), and head and neck cancer (10), and is closely related to the patient prognosis (11).

However, there is no study explored the application of GLIM criteria in elderly colorectal patients. Therefore, the purpose of this study was to investigate the effectiveness of GLIM in screening and diagnosing malnutrition in elderly patients who underwent curative CRC surgery. We also analyzed the impact of GLIM-malnutrition on post-operative complications and long-term outcomes of patients. We present this article in accordance with the REMARK reporting checklist (available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-543/rc).

Methods

Patients

Participants in this study were selected from elderly patients who underwent curative CRC surgery at the First Affiliated Hospital of Wenzhou Medical University from January 2015 to December 2018. The inclusion criteria were patients who

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Highlight box

Key findings
- Global Leadership Initiative on Malnutrition (GLIM)-malnutrition is significantly associated with post-operative complications and overall survival in elderly patients with colorectal cancer (CRC).

What is known and what is new?
- The GLIM criteria is a new diagnostic criteria for malnutrition that has been used to assess the nutritional status of patients with various tumors.
- In this study, we evaluated the GLIM criteria for the diagnosing malnutrition in elderly patients with CRC. GLIM-malnutrition is significantly associated with post-operative complications and decreased overall survival in elderly patients with CRC.

What is the implication, and what should change now?
- The GLIM criteria is effective to assess malnutrition of elderly patients with CRC early thereby allowing the initiation of appropriate nutritional interventions to reduce post-operative complications, prolong the survival time of patients, and alleviate the overall burden on patients and society.

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(I) were ≥65 years old; (II) received elective curative surgery for CRC; and (III) agreed to participate in this study and sign a written informed consent. The exclusion criteria were patients who (I) received chemotherapy and radiotherapy before surgery; (II) had cancer metastasis; (III) underwent palliative surgery; and (IV) were unable to complete grip strength measurement. All surgeries were performed by well-experienced surgeons with a high degree of skill according to the Japanese CRC treatment guidelines. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of the First Affiliated Hospital of Wenzhou Medical University (ethical No. 2014063) and informed consent was taken from all the patients.

Data acquisition

The following data were prospectively collected and recorded: (I) baseline characteristics: age, sex, body mass index (BMI), hemoglobin concentration (<120 g/L in males or <110 g/L in females was defined as anemia), serum albumin concentration (<35 g/L was defined as hypoalbuminemia), weight loss, handgrip strength (HGS) and history of previous abdominal surgery; (II) various evaluation indicators: NRS 2002 scores; American Society of Anesthesiologists (ASA) grade, Charlson comorbidity index score (CCI); (III) open or laparoscopic surgery; (IV) pathological characteristics of tumor: differentiation and tumor-node-metastasis (TNM) stage of tumor; and (V) post-operative complications within 30 days after surgery, which were classified according to the Clavien-Dindo classification. Only complications classified as grade II or above were accounted for.

GLIM criteria

According to the diagnostic criteria of GLIM-malnutrition (7), we first used the NRS 2002 score to assess the risk of malnutrition in patients. Patients with NRS scores ≥3 were further evaluated for at least one of the following 3 phenotypic criteria: (I) non-volitional weight loss: weight loss >5% within the past 6 months or >10% beyond 6 months; (II) low BMI: <18.5 if <70 years old or <20 if ≥70 years old; and (III) reduced muscle mass: HGS <26 kg for men and <18 kg for women. According to the diagnostic criteria of GLIM, patients still need to meet at least one etiologic criterion (reduced food intake or assimilation and inflammation or disease burden). However, patients

with CRC already bear a disease burden. Therefore, in this study, patients with NRS 2002 ≥3 who met at least one of the phenotypic criteria above were diagnosed with GLIM-malnutrition.

Follow-up

All patients had follow-up 1 month after surgery, every 3 months for the first 2 years, and every 6 months thereafter. Follow-up programs include blood tests, imaging studies such as CT or MRI, and endoscopy when appropriate. Overall survival (OS) was calculated from the date of surgery to the date of death from any cause or the last follow-up date. Disease-free survival (DFS) was calculated from the date of surgery to the date of any form of cancer recurrence, death from any cause or the last follow-up date. The last follow-up date was November 2020. The median follow-up time was 37 months.

Statistical analysis

Continuous data with a normal distribution were compared using t-tests and are presented as the mean ± standard deviation (SD). Continuous data with skewed distributions were compared using the Mann-Whitney U test and are presented as interquartile ranges (IQRs). Categorical data were analyzed by the chi-squared test or Fisher's exact test. Univariate and multivariate logistic regressions were used to analyze potential independent risk factors for post-operative complications. Survival curves were analyzed by the Kaplan-Meier (K-M) method and compared by log-rank tests. Univariate and multivariate COX regressions were used to analyze potential independent risk factors for OS. Only variables with a P value <0.1 in the univariate regression analysis were included in the multivariate regression analysis. Multivariate regression analysis was performed using forward step-wise elimination. All statistical analyses were performed using EmpowerStats software (Version 2.0). Two-tailed P values <0.05 were regarded as statistically significant.

Results

Characteristics of the study participants

The study was first enrolled 512 elderly patients who underwent curative CRC surgery. According to the exclusion criteria, 385 candidates were eventually included
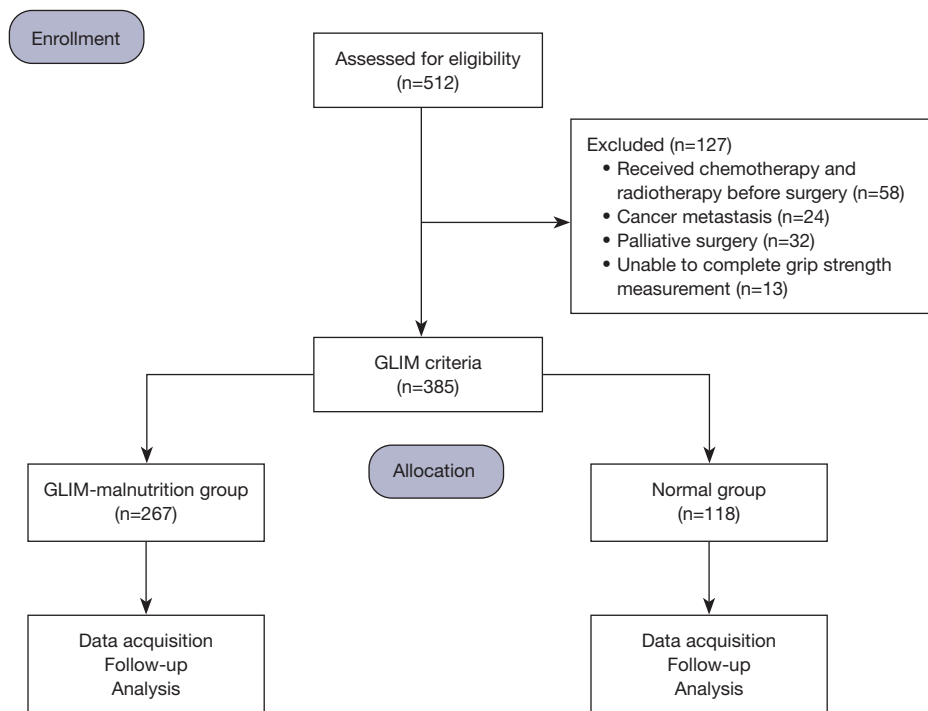
Figure 1 A flow chart for the research. GLIM, Global Leadership Initiative on Malnutrition.

in the study (*Figure 1*). Nutritional risk screening showed that 165 (42.86%) of them were at risk of malnutrition (NRS 2002 ≥3). According to the GLIM diagnostic criteria, 76 patients (19.74%) experienced statistically significant weight loss, 65 patients (16.88%) had a low BMI, and 68 patients (17.66%) had reduced muscle mass. A total of 118 patients (30.65%) were diagnosed with malnutrition according to the GLIM criteria; we called this group the GLIM-malnutrition group.

The Chi-square analysis based on clinical baseline revealed that in elderly patients who underwent curative colorectal resections, GLIM-malnutrition was significantly associated with older age, higher NRS 2002, lower BMI, lower grip strength, tumor location and lower levels of albumin and hemoglobin. However, there were no significant differences between the GLIM-malnutrition group and the non-malnutrition groups in sex, ASA grade, CCI score, previous abdominal surgery, differentiation of tumor, TNM stage, laparoscopic surgery, and hospital stay (*Table 1*).

Relationship between GLIM-malnutrition and post-operative complications

As shown in *Table 2*, a total of 113 (29.4%) patients with

CRC experienced post-operative complications. Compared with the non-malnutrition group (n=68, 25.5%), the incidence of post-operative complications in the GLIM-malnutrition group was significantly higher (n=45, 38.1%), but the incidence of severe complications in the two groups was not significantly different. GLIM-malnutrition is closely related to medical complications (P=0.010), but not to surgical complications. Among specific complications, only the incidence of post-operative venous thrombosis was significantly higher in the GLIM-malnutrition group (P=0.035). Multivariate analyses showed that GLIM-malnutrition [odds ratio (OR): 1.753, 95% confidence interval (CI): 1.100–2.795, P=0.018] and hypoalbuminemia (OR: 2.450, 95% CI: 1.089–5.512, P=0.030) were independent risk factors for post-operative complications (*Table 3*).

Relationship between GLIM-malnutrition and long-term prognosis

K-M survival analysis showed that patients with GLIM-malnutrition had worse OS than patients with non-malnutrition, but there was no significant difference in DFS between the two groups (*Figure 2*). In multivariate Cox regression analyses, GLIM-malnutrition (OR: 2.145,

Table 1 The relationship between GLIM-malnutrition and baseline clinical characteristics

Factors	Total (n=385)	Non-malnutrition (n=267)	GLIM-malnutrition (n=118)	P value
Age, years	73 [11]	71 [10]	76 [10]	<0.001*
Gender				0.391
Female	154 (40.0)	103 (38.6)	51 (43.2)	
Male	231 (60.0)	164 (61.4)	67 (56.8)	
BMI, kg/m^2	22.631±3.145	23.158±2.968	21.439±3.221	<0.001*
HGS, kg	21.80 [13.55]	24.30 [12.90]	17.35 [12.93]	<0.001*
Hemoglobin, g/L	119 [30]	120 [33]	115.5 [31.5]	0.004*
Albumin, g/L	36.90 [5.30]	37.3 [4.5]	35.75 [6.05]	<0.001*
NRS 2002				<0.001*
<3	220 (57.1)	220 (82.4)	0 (0.0)	
≥3	165 (42.9)	47 (17.6)	118 (100.0)	
CCI				0.464
0	165 (42.9)	117 (43.8)	48 (40.7)	
1	146 (37.9)	96 (36.0)	50 (42.4)	
≥2	74 (19.2)	54 (20.2)	20 (16.9)	
ASA grade				0.350
I	95 (24.7)	64 (24.0)	31 (26.3)	
II	228 (59.2)	164 (61.4)	64 (54.2)	
III	62 (16.1)	39 (14.6)	23 (19.5)	
Previous abdominal surgery				0.417
No	240 (62.3)	170 (63.7)	70 (59.3)	
Yes	145 (37.7)	97 (36.3)	48 (40.7)	
Tumor location				0.002*
Colon	243 (63.1)	155 (58.1)	88 (74.6)	
Rectum	142 (36.9)	112 (41.9)	30 (25.4)	
Differentiation of tumor				0.303
Median or high	309 (80.3)	218 (81.7)	91 (77.1)	
Low	76 (19.7)	49 (18.4)	27 (22.9)	
TNM stage				0.597
I	70 (18.2)	52 (19.5)	18 (15.3)	
II	164 (42.6)	111 (41.6)	53 (44.9)	
III	151 (39.2)	104 (39.0)	47 (39.8)	
Laparoscopic surgery				0.090
No	210 (54.5)	138 (51.7)	72 (61.0)	
Yes	175 (45.5)	129 (48.3)	46 (39.0)	
Length of hospital stay (days)	21.300±8.283	21.030±8.275	21.898±8.305	0.344

Data are presented as mean ± SD, median [IQR], and n (%). *, statistically significant. GLIM, Global Leadership Initiative on Malnutrition; BMI, body mass index; HGS, handgrip strength; NRS 2002, the Nutritional Risk Screening 2002; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists; TNM, tumor-node-metastasis; SD, standard deviation; IQR, interquartile range.

Table 2 Details of post-operative complications

Complications	Total (n=385)	Non-malnutrition (n=267)	GLIM-malnutrition (n=118)	P value
Total complications[a]	113 (29.4)	68 (25.5)	45 (38.1)	0.012*
Surgical complications	66 (17.1)	43 (16.1)	23 (19.5)	0.416
Wound infection	17 (4.4)	10 (3.7)	7 (5.9)	0.336
Intra-abdominal infection	16 (4.2)	9 (3.4)	7 (5.9)	0.246
Anastomotic leakage	12 (3.1)	11 (4.1)	1 (0.8)	0.088
Intra-abdominal hemorrhage	6 (1.6)	4 (1.5)	2 (1.7)	0.886
Intestinal obstruction	6 (1.6)	5 (1.9)	1 (0.8)	0.454
Wound rupture	4 (1.0)	3 (1.1)	1 (0.8)	0.805
Gastrointestinal dysfunction	2 (0.5)	0 (0.0)	2 (1.7)	0.033
Seroperitoneum	2 (0.5)	1 (0.4)	1 (0.8)	0.552
Gastroplegia	1 (0.3)	0 (0.0)	1 (0.8)	0.132
Medical complications	47 (12.2)	25 (9.4)	22 (18.6)	0.010*
Pneumonia	17 (4.4)	9 (3.4)	8 (6.8)	0.133
Venous thrombosis	12 (3.1)	5 (1.9)	7 (5.9)	0.035*
Pleural effusion	4 (1.0)	1 (0.4)	3 (2.5)	0.053
Heart failure	4 (1.0)	2 (0.7)	2 (1.7)	0.399
Urinary infection	3 (0.8)	2 (0.7)	1 (0.8)	0.919
Pulmonary embolism	2 (0.5)	2 (0.7)	0 (0.0)	0.346
Sepsis	2 (0.5)	1 (0.4)	1 (0.8)	0.552
Septic shock	1 (0.3)	1 (0.4)	0 (0.0)	0.506
Acute kidney injury	1 (0.3)	1 (0.4)	0 (0.0)	0.506
Death	1 (0.3)	1 (0.4)	0 (0.0)	0.506
Severe complications[b]	30 (7.8)	22 (8.2)	8 (6.8)	0.622

Data are presented as n (%). *, statistically significant. [a], complications classified as grade II and above. [b], complications classified as grade III and above. GLIM, Global Leadership Initiative on Malnutrition.

95% CI: 1.234–3.728, P=0.007), low BMI (OR: 2.218, 95% CI: 1.236–3.980, P=0.008), low HGS (OR: 2.044, 95% CI: 1.122–3.722, P=0.020), hypoalbuminemia (OR: 3.077, 95% CI: 1.408–6.724, P=0.005), and low tumor differentiation (OR: 1.795, 95% CI: 1.029–3.129, P=0.039) and high TNM stage (OR: 3.482, 95% CI: 2.061–5.882, P<0.001) were independent risk factors for OS in elderly patients with CRC, and ASA grade (OR: 0.492, 95% CI: 0.224–1.081, P=0.077) was an independent protective factor (*Table 4*).

Discussion

Patients with CRC often have reduced food intake, increased energy expenditure, vomiting, intestinal obstruction, and anemia. Due to decreased physiological reserve, elderly patients with CRC are at increased risk of malnutrition.

In previous studies, the incidence of malnutrition in elderly cancer patients assessed by various diagnostic indicators was approximately 27–41.9% (12-14). Song *et al.* reported that the incidence of malnutrition in CRC patients of all ages who were assessed by the GLIM criteria was 23.6% (15). Similarly, our study showed that 30.9% of elderly patients who underwent CRC surgery were diagnosed with malnutrition according to the GLIM criteria.

At present, many nutritional assessment indicators have been shown to be closely related to the occurrence

Table 3 Univariate and multivariate analyses of factors associated with post-operative complications

Factors	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P value	OR (95% CI)	P value
GLIM-malnutrition				
Yes *vs.* no	1.804 (1.136, 2.864)	0.012*	1.753 (1.100, 2.795)	0.018*
Age, years				
≥80 *vs.* <80	1.361 (0.808, 2.294)	0.247		
Gender				
Male *vs.* female	1.183 (0.753, 1.859)	0.465		
Low BMI				
Yes *vs.* no	0.907 (0.501, 1.643)	0.748		
Low HGS				
Yes *vs.* no	1.513 (0.872, 2.625)	0.141		
Anemia				
Yes *vs.* no	1.397 (0.898, 2.171)	0.138		
Hypoalbuminemia				
Yes *vs.* no	2.590 (1.161, 5.780)	0.020*	2.450 (1.089, 5.512)	0.030*
CCI				
≥2 *vs.* <2	1.293 (0.753, 2.221)	0.352		
ASA grade				
III *vs.* I, II	1.286 (0.721, 2.294)	0.394		
Previous abdominal surgery				
Yes *vs.* no	1.200 (0.766, 1.880)	0.427		
Tumor location				
Colon *vs.* rectum	0.983 (0.624, 1.548)	0.940		
Differentiation of tumor				
Low *vs.* median or high	1.537 (0.906, 2.608)	0.111		
TNM stage				
III *vs.* I, II	1.092 (0.698, 1.709)	0.700		
Laparoscopic surgery				
Yes *vs.* no	0.723 (0.463, 1.129)	0.153		

*, statistically significant. GLIM, Global Leadership Initiative on Malnutrition; OR, odds ratio; CI, confidence interval; BMI, body mass index; HGS, handgrip strength; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists; TNM, tumor-node-metastasis.

of post-operative complications in tumor patients, such as PG-SGA score (16), Mini-nutrition assessment MNA (17), albumin (18), and sarcopenia (19). As a newer diagnostic indicator of malnutrition, GLIM-malnutrition is also associated with increased post-operative complications in patients with different types of malignancies (20-22). In this study, we found that GLIM-malnutrition (OR: 1.753, 95% CI: 1.100–2.795, P=0.018) was an independent risk
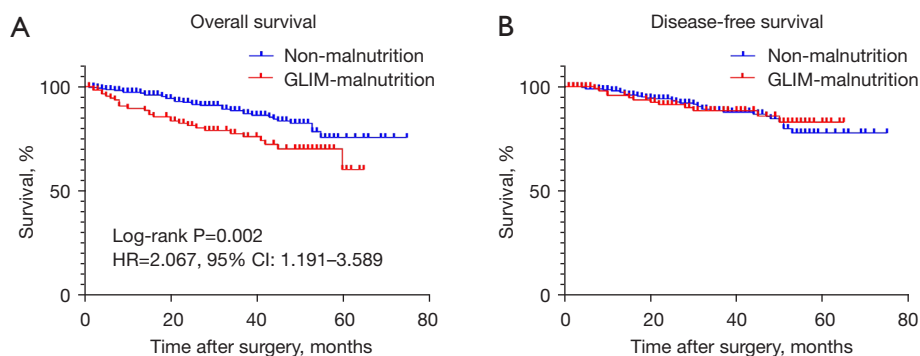
Figure 2 Kaplan-Meier survival analysis for patients stratified by GLIM-malnutrition. (A) Overall survival; (B) disease-free survival. GLIM, Global Leadership Initiative on Malnutrition.

factor for increased post-operative complications in elderly colorectal patients through univariate and multivariate regression analyses. Patients in the GLIM-malnutrition group had a higher incidence of venous thrombosis than those without malnutrition (P=0.035). This finding correlates with Achen *et al.*, who reported that malnutrition is strongly associated with venous thrombosis in patients with malignancy (23). Moreover, the recent PREHAB trial (24) has demonstrated optimized post-operative recovery and fewer severe and medical post-operative complications in patients with CRC that underwent a multimodal prehabilitation program before surgery compared with standard care. The above results suggest that early diagnosis and early intervention of malnutrition are of great significance in reducing post-operative complications in patients with malignancy.

The K-M analysis showed that in older CRC patients, the GLIM-malnutrition group had lower OS than the non-malnutrition group, but there was no significant difference in DFS. Univariate and multivariate COX regression analyses revealed that GLIM-malnutrition (OR: 2.144, 95% CI: 1.234–3.728, P=0.007) was an independent risk factor for OS in older CRC patients. Likewise, GLIM-malnutrition was reported to be an independent risk factor for OS in patients with gastric cancer (25). Orell *et al.* pointed out that among head and neck cancer patients, patients with GLIM-malnutrition had a shorter median survival time than well-nourished patients (57 *vs.* 72 months) (26). However, Song *et al.* showed that GLIM-malnutrition was significantly related to DFS in colorectal patients across all age groups (15). We speculate that this may be related to the different characteristics of the patient populations utilized in the studies. Song *et al.* reported that patients with GLIM-

malnutrition had a higher TNM stage of tumor, a higher proportion of previous abdominal surgery and a lower proportion of laparoscopic surgery than those without malnutrition (15). In contrast, our study showed that malnutrition in elderly CRC patients was not associated with these clinical baseline indicators. In addition, our study shows that hypoalbuminemia is also an independent risk factor for post-operative complications and OS in older CRC patients, which correlates with other data available in the literature (27,28).

Nutritional diagnosis and treatment encompasses nutritional screening, assessment, and intervention. The GLIM criteria integrates nutritional screening and assessment, which sets it apart from other nutritional screening tools. The selection of nutritional risk screening tools and muscle mass assessment tools in the GLIM criteria does not incur significant costs. NRS 2002 is a common choice as a nutritional risk screening tool (11,29). However, the choice of muscle mass assessment tool remains controversial. Different studies have used various methods of assessing muscle mass, such as bioelectrical impedance analysis (30), computed tomography (CT) (13) or hand grip strength (31). A multi-center clinical study showed that hand grip strength is a reasonable surrogate for muscle mass as one of the constituents in the diagnostic criteria of GLIM in patients with gastrointestinal cancer (32). Grip strength was chosen to assess muscle mass in this study as it does not require additional testing equipment and is therefore cost-effective. However, our research still has some limitations. First, this is a single-center retrospective study that included only 385 elderly CRC patients. Second, the measurement of muscle mass in the GLIM criteria remains controversial. In this study, we only used grip strength as a measurement. Further research is needed to compare different methods of

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Table 4 Univariate and multivariate Cox regression analyses of factors associated with overall survival

Factors	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P value	OR (95% CI)	P value
GLIM-malnutrition				
Yes *vs.* no	2.223 (1.277, 3.870)	0.005*	2.145 (1.234, 3.728)	0.007*
Age, years				
≥80 *vs.* <80	2.286 (0.735, 7.105)	0.153		
Gender				
Male *vs.* female	1.436 (0.825, 2.499)	0.201		
Low BMI				
Yes *vs.* no	2.039 (1.056, 3.935)	0.034*	2.218 (1.236, 3.980)	0.008*
Low HGS				
Yes *vs.* no	1.865 (1.010, 3.445)	0.047*	2.044 (1.122, 3.722)	0.020*
Anemia				
Yes *vs.* no	1.039 (0.606, 1.783)	0.888		
Hypoalbuminemia				
Yes *vs.* no	2.872 (1.277, 6.463)	0.011*	3.077 (1.408, 6.724)	0.005*
CCI				
≥2 *vs.* <2	1.268 (0.617, 2.603)	0.518		
ASA grade				
III *vs.* I, II	0.470 (0.200, 1.104)	0.083	0.492 (0.224, 1.081)	0.077
Previous abdominal surgery				
Yes *vs.* no	0.806 (0.467, 1.395)	0.553		
Tumor location				
Colon *vs.* rectum	1.192 (0.701, 2.029)	0.516		
Differentiation of tumor				
Low *vs.* median or high	1.881 (1.0722, 3.2999)	0.028*	1.795 (1.029, 3.129)	0.039*
TNM stage				
III *vs.* I, II	3.379 (1.987, 5.746)	<0.001*	3.482 (2.061, 5.882)	<0.001*
Laparoscopic surgery				
Yes *vs.* no	0.660 (0.380, 1.146)	0.140		

*, statistically significant. GLIM, Global Leadership Initiative on Malnutrition; OR, odds ratio; CI, confidence interval; BMI, body mass index; HGS, handgrip strength; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists; TNM, tumor-node-metastasis.

muscle mass measurement. Third, we assumed that all CRC patients meet the definition for 'disease burden' according to the GLIM criteria, which while reasonable, may not be rigorous enough. This problem remains to be explored by future studies.

Conclusions

Our study shows that the GLIM criteria can accurately evaluate the nutritional status of elderly patients with CRC. GLIM-malnutrition is significantly associated with post-

operative complications in elderly patients with CRC. At the same time, GLIM-malnutrition is an independent risk factor for OS in elderly patients with CRC. Therefore, using the GLIM criteria to provide early assessment of the nutritional status of elderly patients with CRC can allow corresponding nutritional interventions to be implemented, thereby reducing post-operative complications and improving survival outcomes.

Acknowledgments

Footnote

Reporting Checklist: The authors have completed the REMARK reporting checklist. Available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-543/rc

Data Sharing Statement: Available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-543/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-543/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of the First Affiliated Hospital of Wenzhou Medical University (ethical no. 2014063) and informed consent was taken from all the patients.

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