Impact of Body Composition and Physical Function on Quality of Life After Gastrectomy for Gastric Cancer

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Purpose: Patients with gastric cancer after gastrectomy often suffer from a decline in their quality of life (QoL), but the relationship between body composition (BC) and physical function on QoL has rarely been studied. This study aims to evaluate and determine the changes in QoL after gastrectomy and the impact of BC and physical function on QoL.

Methods: A total of 311 gastric cancer patients completed EORTC QLQ-C30 and EORTC QLQ-STO22 questionnaires before and 1, 3, 6 months post-surgery. Data including BC, handgrip strength (HGS) and 6-m gait speed (GS) were collected prospectively. Multiple linear regression analysis was used to determine the correlation between QoL and BC, HGS and GS.

Results: Patients had significantly worse scores after surgery on most function and symptom scales ($p < 0.001$), but most of these scales recovered within 6 months after surgery. A higher subcutaneous fat area (SFA) was associated with increased symptom scores 1 month after surgery. A higher GS is associated with a better global health status symptom.

Conclusion: Patients suffer from a decline in their QoL after gastrectomy for gastric cancer. Intervention strategies aiming at reducing SFA and improving GS may improve the QoL in patients underwent gastrectomy for gastric cancer.

Keywords: handgrip strength (HGS), gait speed, subcutaneous fat area (SFA), visceral fat area (VFA), skeletal muscle density (SMD)

INTRODUCTION

Gastric cancer is the fifth most common malignant tumor and the fourth leading cause of cancer death in the world [1]. The incidence of gastric cancer is highest in East Asia [2]. Although the treatment of tumor has made great progress, the main treatment for resectable gastric tumor is surgical resection with or without adjuvant chemotherapy [3]. However, gastrectomy has a negative impact on the quality of life (QoL) [4–6]. Dissatisfaction with life of patients after gastrectomy is mostly diet-related symptoms, including reflux, early satiety, nausea and pain [7]. Therefore, medical workers and researchers are paying more and more attention to improving the QoL of survivors [8]. So far, many studies on QoL after gastrectomy have been reported, most of which focused on the relationship between gender, age, type of reconstruction, the extent of gastric resection, surgical approach, and complications and QoL [9–16]. Weight loss and changes in body

composition (BC) are very common after gastrectomy, and these changes will affect the QoL (17). Nutritional assessment based on BC measurement can reflect BC, metabolic characteristics and physiological reserves, and is a factor that determines prognosis (18). The patient's 6-meter gait speed (GS) has always been used as an indicator of poor prognosis (19–21). However, few studies have reported the correlation between BC, physical function and QoL after gastrectomy.

The purpose of this study is to describe the changes in the patient's QoL within 6 months after gastrectomy, and to clarify the relationship between preoperative handgrip strength (HGS), GS, BC and QoL at 1, 3, and 6 months after surgery.

MATERIALS AND METHODS

Patients

This study included patients who underwent gastric cancer surgery in the First Affiliated Hospital of Wenzhou Medical University from 2014 to 2020. The research protocol has been approved by the Ethical Review Committee of the First Affiliated Hospital of Wenzhou Medical University. This project has been registered in the China Clinical Trial Registration Center (NO. ChiCTR1800019717). Inclusion criteria: (1) Age ≥18 years; (2) American Society of Anesthesiologists (ASA) score ≤3; (3) Preoperative gastroscopy pathology suggests gastric adenocarcinoma; (4) CT examination of the abdomen in our hospital within 1 month before the operation; (5) have complete questionnaire on the QoL before and within 6 months after surgery; (6) Agreed to participate in this study and signed an informed consent.

Exclusion criteria: (1) Incurable tumor; (2) The patient who cannot cooperate with the measurement of HGS or GS; (3) The patient has received radiotherapy or chemotherapy before surgery.

Data Collection

The following data were prospectively collected (1) Preoperative patient demographic and disease characteristics, including gender, age, body mass index (BMI), ASA score grade, previous history of abdominal surgery. (2) Surgical details: including laparoscopic assisted surgery, type of gastrectomy, type of reconstruction. (3) Pathological data: the surgical specimens are tested by the pathology department to obtain the pathological type, tumor location, degree of differentiation, and tumor-node-metastasis (TNM) staging (according to the TNM staging of the 8th edition of American Joint Committee on Cancer (AJCC) (22).

Hand Grip Strength and Physical Function

When the patient was admitted to the hospital, the patients were taught to use the maximum strength of the dominant hand to grasp the electronic grip (model: EH101; CAMRY, Guangdong, China) and take the average of two measurements (23–26).

The GS of 6 meters test is often used to evaluate as a physical function. The patients were taught to walk 6 meters at a normal speed without assistance, we record the required time and take the average of 2 measurements.

Quality of Life Assessment

Patients complete the QoL questionnaire after admission of hospital and during the routine follow-up after surgery. Postoperative follow-up was completed in three time periods: 1, 3, and 6 months after surgery. The main purpose of this follow-up is to assess the recovery of the QoL after gastrectomy over time, so only those patients who completed all preoperative and postoperative follow-ups were included in the analysis.

QLQ-C30 and QLQ-STO22 are adopted in QoL assessment. The EORTC QLQ-C30 questionnaire is used to assess the QoL of patients with cancer in general (27). EORTC QLQ-STO22 is specially developed to evaluate the HRQL of gastric cancer patients (28). According to the conversion formula provided by EORTC, the questionnaire score can be linearly converted into 0 to 100 points.

The EORTC QLQ-C30 scale can be divided into 1 global QoL scale, 5 functional scales (physical function, role function, emotional function, cognitive function, social function) and 9 symptom subscales (fatigue, nausea and vomiting, pain, dyspnea, insomnia, appetite loss, constipation, diarrhea, financial difficulties). QLQ-STO22 can be divided into 9 symptom subscales (dysphagia, pain, reflux, eating restriction, anxiety, dry mouth, body image, hair loss, taste loss). The functional scale and the general health status scale are positive score scales, the higher the score, the better the QoL; the symptom scale are negative score scales, the higher the score, the worse the QoL.

Measurement Body Composition Parameters

By analyzing CT images at the level of the third lumbar vertebra (L3), using image processing system (GE ADW 4.5), BC parameters were measured to determine skeletal muscle and abdominal adipose tissue area [subcutaneous fat area (SFA) and visceral fat area (VFA)]. Tissue Hounsfield Unit (HU) thresholds were as follows: skeletal muscle −29 to +150 HU, SFA −190 to −0 HU, VFA −150 to −50 HU (29). Skeletal muscle was normalized for height in meters squared to calculate the skeletal muscle index (SMI). Skeletal muscle density (SMD) was identified by the average value of HU in the muscle area. In order to explore the distribution of abdominal fat tissue, we also calculated the visceral fat area to subcutaneous fat area ratio (VSR).

Statistical Analysis

K-S test is used for normality test, The continuity data of the normal distribution is expressed as: mean and standard deviation (SD), and the non-normal distribution continuity data was expressed as: the median and the interquartile range (IQR). QoL 1, 3, 6 months after surgery were compared with preoperative QoL by using the paired Wilcoxon test. Finally, multivariable

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Abbreviations: SD, standard deviation; IQR, interquartile range; BMI, body mass index; HGS, handgrip strength; GS: gait speed; ASA, American Society of Anesthesiologists; SMD, skeletal muscle density; SMI, skeletal muscle index; SFA, subcutaneous fat area; VFA, visceral fat area; VSR, VFA to SFA ratio; TNM, tumor-node-metastasis; QoL: quality of life; BC: body composition; BCMS: BC measurement; AJCC: American Joint Committee on Cancer HU: Tissue Hounsfield Unit.

linear regression analysis with stepwise backward elimination was performed to evaluate the association between QoL scales and HGS, GS, BC paramenters, demographic characteristics variables. A P-value <0.05 is considered statistically significant. All statistical analyses were performed using IBM SPSS version 22.

RESULTS

Patient Characteristics

A total of 311 patients were included in the final analysis in this study. Human body baselines are shown in **Table 1**. Of the 311 individuals included, 227(73.0%) were men. The average HGS and GS of all patients were 27.6 ± 9.1 kg and 1.0 ± 0.2 m/s. The average body mass index (BMI) was 22.6 ±3.0 kg/m². The median of SMD and SMI are 37.2 HU and 43.7 cm²/m², respectively. The median of SFA and VFA are 0.9 and 0.9 dm², respectively. The median age at diagnosis was 64 years. One hundred and fifteen (37.0%) patients underwent total gastrectomy, 101 (32.5%) patients underwent laparoscopy-assisted operation. Among all patients, 119 (38.3%) patients used Billroth I for gastrointestinal reconstruction, 40 (12.9%) patients used Billroth II method, and the remaining 152 (48.9%) used Roux-en-Y method. The majority of patients ($n = 204$, 65.6%) had an advanced tumor stage ($\geq$II).

Postoperative QoL vs. Preoperative QoL

The average QoL score and standard deviation of the study population were shown in **Table 2**. In the first month after the operation, all functional scales except for the emotional function decreased compared to before surgery, and then gradually increased within 6 months after surgery. At 6 months after the operation, the scores of role function, emotional function and cognitive function returned to the preoperative level, while the scores of physical function and social function have not yet recovered to the preoperative level. The score of global health status continued to improve after surgery, and was significantly higher than before surgery at 6 months after surgery.

On General symptom scales, most symptoms become worse after surgery. In addition, pain, appetite loss, and dysphagia symptom scale scores were not statistically different before and 1 month after surgery, indicating that these symptoms did not change after surgery at this point in time. At 6 months after surgery, nausea and vomiting, diarrhea, eating restrictions, hair loss symptom scales scores were still higher than those before surgery. The scores of the rest of the symptom scales all showed a gradual decline and improved significantly.

Predictive Factors for QoL 1, 3, 6 Months After Surgery

Table 3 shows that SFA is associated with poor QoL at 1 month after surgery, such as nausea and vomiting [4.2 (2.7; 5.6), $p <$ 0.001], appetite loss [4.8 (2.4; 7.3), $p < 0.001$], constipation [4.1 (2.9; 5.3), $p < 0.001$], dysphagia [2.3 (0.7; 3.8), $p = 0.004$], global health status [−2.5 (−4.4; −0.5), $p = 0.014$]. VFA is negatively correlated with role function [−5.1 (−9.6; −0.6), $p = 0.028$] and cognitive function [−2.7 (−4.9; −0.6), $p = 0.013$], but it is

positively correlated with anxiety [−4.5 (−8.0; −1.0), $p = 0.012$]. GS is positively correlated with insomnia [−12.1 (−22.2; −2.0), $p = 0.02$], global health status [12.7 (2.6; 22.9), $p = 0.014$] and hair

TABLE 1 | Baseline characteristics of the patients.

Factor	$n = 311$ (%)
Age, median (IQR), years	64.0(15.0)
BMI, mean (SD),kg/m²	22.6(3.0)
HGS, mean (SD), kg	27.6(9.1)
GS, mean (SD), m/s	1.0(0.2)
L3 SMD, median (IQR), HU	37.2(10.6)
L3 SMI, median (IQR), cm²/m²	43.7(10.3)
SFA, median (IQR), dm²	0.9(0.7)
VFA, median (IQR), dm²	0.9(0.9)
VSR, median (IQR)	0.98(0.81)
Gender	
Male	227(73.0)
Female	84(27.0)
ASA	
I	102(32.8)
II	156(50.2)
III	53(17.0)
Type of gastrectomy	
Distal gastrectomy	196(63.0)
Total gastrectomy	115(37.0)
Laparoscopy-assisted operation	
Yes	101(32.5)
No	210(67.5)
TNM stage	
0	0(0)
I	107(34.4)
II	80(25.7)
III	124(39.9)
Type of reconstruction	
Billroth I	119(38.3)
Billroth II	40(12.9)
Roux-en-Y	152(48.9)
Pathological type	
Differentiated	92(29.6)
Undifferentiated	219(70.4)
Tumor location	
Proximal	43(13.8)
Middle	65(20.9)
Distal	200(64.3)
Linitis plastica	3(1)
Previous abdominal surgery	
Yes	36(11.6)
No	275(88.4)

SD, standard deviation; IQR, interquartile range; BMI, body mass index; HGS, handgrip strength; GS: gait speed; ASA, American Society of Anesthesiologists; SMD, skeletal muscle density; SMI, skeletal muscle index; SFA, subcutaneous fat area; VFA, visceral fat area; VSR, VFA to SFA ratio; TNM, tumor-node-metastasis.
The values in the table were number of patients unless indicated otherwise.

TABLE 2 | Mean scores of EORTC QLQ-C30 and QLQ-STO22 scales.

	Preoperative QoL	P-value[c]	1 month after surgery QoL	P-value[d]	3 months after surgery QoL	P-value[e]	6 months after surgery QoL
Functional scales[a]							
Physical	92.6(6.0)	**<0.001**	77.4(13.7)	**<0.001**	82.4(12.6)	**<0.001**	87.5(11.8)
Role	88.8(9.0)	**<0.001**	76.1(19.4)	**0.013**	86.4(18.4)	0.116	91.0(14.8)
Emotional	92.1(5.1)	**<0.001**	93.8(11.6)	**<0.001**	96.4(9.3)	**<0.001**	97.8(6.6)
Cognitive	98.2(3.5)	**0.004**	96.0(8.7)	**<0.001**	97.7(7.6)	**<0.001**	99.2(3.5)
Social	92.6(8.8)	**<0.001**	78.7(18.8)	**<0.001**	79.0(18.7)	**<0.001**	84.7(16.9)
General symptom scales[b]							
Fatigue	13.0(8.4)	**<0.001**	26.1(18.1)	**<0.001**	21.5(18.9)	0.241	15.8(16.9)
Nausea and vomiting	3.5(6.6)	**<0.001**	5.0(14.2)	0.080	10.8(18.2)	**<0.001**	6.1(14.2)
Pain	8.3(6.3)	0.369	8.9(12.3)	**<0.001**	5.5(10.2)	**<0.001**	3.5(8.5)
Dyspnoea	3.9(6.2)	**<0.001**	4.1(12.7)	**<0.001**	1.4(6.7)	**<0.001**	1.0(5.6)
Insomnia	10.9(10.9)	**0.008**	9.5(17.7)	**<0.001**	6.8(15.6)	**0.010**	4.3(11.8)
Appetite loss	11.5(12.2)	0.266	15.2(22.8)	**<0.001**	16.4(21.0)	0.799	12.4(19.4)
Constipation	3.2(6.8)	**<0.001**	2.2(11.6)	**<0.001**	2.7(10.9)	**<0.001**	1.0(6.8)
Diarrhea	1.6(4.1)	**<0.001**	5.2(13.0)	**<0.001**	3.9(10.7)	**<0.001**	3.7(10.9)
Financial difficulties	2.6(5.1)	**<0.001**	3.6(11.0)	**<0.001**	1.6(7.6)	**<0.001**	1.1(5.9)
Global health status[a]	62.5(7.6)	**0.041**	63.7(16.3)	**<0.001**	71.5(17.1)	**<0.001**	78.7(17.3)
QLQ-STO22							
General symptom scales[b]							
Dysphagia	10.2(6.1)	0.922	13.8(14.5)	**<0.001**	9.6(7.1)	**<0.001**	6.6(6.2)
Pain	13.2(7.3)	**<0.001**	8.5(10.9)	**<0.001**	8.0(11.8)	**<0.001**	3.4(8.3)
Reflux	7.2(8.1)	**0.001**	6.2(10.7)	**<0.001**	6.2(11.7)	**<0.001**	4.2(9.4)
Eating restrictions	1.6(2.7)	**0.001**	4.3(10.7)	**<0.001**	2.9(7.5)	**<0.001**	2.0(5.7)
Anxiety	12.4(8.5)	**<0.001**	10.3(14.6)	**<0.001**	5.8(13.0)	**<0.001**	2.5(6.6)
Dry mouth	22.8(9.8)	**<0.001**	12.6(18.7)	**<0.001**	8.2(15.1)	**<0.001**	4.7(11.9)
Taste	4.8(7.3)	**<0.001**	8.7(20.9)	**<0.001**	7.0(17.7)	**<0.001**	4.8(14.0)
Body image	1.3(3.7)	**<0.001**	3.0(9.9)	**<0.001**	1.2(8.2)	**<0.001**	0.4(3.8)
Hair loss	1.1(3.1)	**<0.001**	0.6(3.6)	**<0.001**	2.4(8.2)	**<0.001**	1.7(7.1)

Scores are presented as mean [± SD].

[a] *Score range 0–100: higher scores represent a better quality of life or level of functioning.*

[b] *Score range 0–100: higher scores represent more severe symptoms.*

[c] *Preoperative QoL compared with 1 month after surgery QoL.*

[d] *Preoperative QoL compared with 3 months after surgery QoL.*

[e] *Preoperative QoL compared with 6 months after surgery QoL.*

Bold values indicate significant variables (p < 0.05).

TABLE 3 | Multivariable linear regression model on quality of life, symptom scales, and functional scales from EORTC QLQ-C30 and QLQ-STO22 for 1 month after surgery.

	Physical functioning[a]	Role functioning[a]	Emotional functioning[a]	Cognitive functioning[a]	Social functioning[a]	Fatigue[b]	Nausea and vomiting[b]	Pain[b]	Dyspnea[b]	Insomnia[b]	Appetite loss[b]	Constipation[b]	Diarrhea[b]	Financial problems[b]	Global health status[a]
Quality of life from the EORTC QLQ-C30 questionnaire															
Gender	–	–	–	–	–	–	–	–	–	–	–	–	5.0 (0.4;9.6)	–	–
Age	–	–	–	–	–	–	−0.2 (−0.3;0.0)	–	–	–	–	–	–	–	–
BMI	–	1.3(0.2;2.4)	–	0.6(0.0;1.1)	–	–	–	–	−0.9 (−1.5;−0.3)	–	–	–	−0.9 (−1.4;−0.5)	–	–
ASA	−3.8 (−6.2;−1.3)	−5.0 (−8.4;−1.6)	–	–	–	–	–	2.7 (0.6;4.9)	3.6 (1.2;5.9)	3.3 (0.2;6.4)	–	–	3.4 (1.1;5.8)	–	–
SFA	–	–	–	–	–	–	4.2 (2.7;5.6)	–	–	–	4.8 (2.4;7.3)	4.1(2.9;5.3)	–	–	−2.5 (−4.4;−0.5)
VFA	–	−5.1 (−9.6;−0.6)	–	−2.7 (−4.9;−0.6)	–	–	–	–	–	–	–	–	–	–	–
VSR	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
SMD	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
SMI	–	–	–	–	–	–	–	–	–	0.3 (0.0;0.5)	–	–	–	–	–
HGS	–	–	–	–	–	−0.3 (−0.6;0.0)	–	–	–	–	–	–	−0.3 (−0.5;0.0)	–	−0.3 (−0.5;−0.1)
GS	–	–	–	–	−18.3 (−28.9;−7.8)	–	–	–	–	−12.1 (−22.2;−2.0)	–	–	–	–	12.7 (2.6;22.9)
Tumor location	–	–	–	–	–	4.0 (1.0;7.0)	–	−2.8 (−5.4;−0.3)	−2.9 (−5.6;−0.1)	–	–	–	–	–	–
Pathological type	–	–	–	–	–	–	–	–	–	–	–	–	3.8(0.4;7.3)	–	–
TNM stage	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Type of reconstruction	–	–	−1.9 (−3.6;−0.1)	–	–	–	–	–	–	–	–	−1.6 (−3.1;−0.2)	–	–	−2.3 (−4.3;−0.3)
Laparoscopy-assisted operation	–	–	–	−2.4 (−4.7;−0.1)	–	–	–	–	–	–	–	–	–	–	–
Type of gastrectomy	–	–	–	–	–	–	–	−4.0 (−7.9;−0.1)	−6.1 (−10.2;−1.9)	–	–	–	–	−3.3 (−6.1;−0.5)	–
Previous abdominal surgery	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.5 (0.5;12.5)

	Dysphagia[b]	Pain[b]	Reflux[b]	Eating restrictions[b]	Anxiety[b]	Dry mouth[b]	Taste[b]	Body image[b]	Hair loss[b]
Quality of life from the EORTC QLQ-STO22 questionnaire									
Gender	–	–	–	–	–	–	–	–	–
Age	–	–	–	–	–	–	–	0.1(0.0;0.2)	–
BMI	–	–	–	–	–	−1.2(−2.1;−0.2)	–	–	–
ASA	–	–	–	–	3.0(0.5;5.6)	4.5(1.1;7.9)	–	–	–

(Continued)

TABLE 3 | Continued

	Dysphagia[b]	Pain[b]	Reflux[b]	Eating restrictions[b]	Anxiety[b]	Dry mouth[b]	Taste[b]	Body image[b]	Hair loss[b]
SFA	2.3(0.7;3.8)	–	–	–	–	–	–	–	–
VFA	–	–	–	–	–4.5(-8.0;-1.0)	–	–	–	–
VSR	–	–	–	–	–	–	–	–	–
SMD	0.3(0.0;0.5)	–	–0.2(-0.4;0.0)	–	–0.4(-0.7;-0.2)	–0.5(-0.8;-0.1)	–	–	–
SMI	–	–	–	–	–	–	–	–	–
HGS	–	–0.2(-0.3;0.0)	–	–	–	–	–	–	–
GS	–2.3(-4.6;0.0)	–	–	–	–	–	–	–1.7(-3.4;0.0)	–2.4(-4.6;-0.2)
Tumor location	–	–	–	–	–	–	–	–	–0.8(-1.5;-0.1)
Pathological type	–	–	–	–	–	–	–	–	–
TNM stage	–	–	–	–	–	5.0(0.1;9.8)	–	–	–
Type of reconstruction	–	–	–	–	–	–	–	–1.5(-2.9;-0.1)	–0.8(-1.4;-0.2)
Laparoscopy-assisted operation	–	3.9(1.2;6.7)	–	–	–	–	–	–	–
Type of gastrectomy	–	–	–	–	–	–	–	–	–
Previous abdominal surgery	7.3(1.9;12.6)	–	–	–	–	–	–	–	–

Scores are presented as linear regression coefficients, with 95% confidence intervals between brackets. During stepwise backward linear regression, the weakest associated variables and Insignificant variables (p > 0.05) are excluded from the model (–); [a]Higher scores represent better quality of life or functioning; [b]Higher scores represent more symptoms.

loss [−2.4 (−4.6; −0.2), $p = 0.032$], but it is also a poor social function [−18.3 (−28.9; −7.8), $p = 0.001$] significant predictor.

It can be seen from **Table 4** that VFA is a predictor of good QoL at 3 months after surgery. It is positively correlated with cognitive functioning [1.4 (0.0; 2.7), $p = 0.045$], dyspnea [−2.3 (−3.9; −0.7), $p = 0.005$], global health status [3.1 (0.4; 5.8), $p = 0.027$] and eating restrictions [−1.8 (−3.5; −0.1), $p = 0.042$]. VSR is positively correlated with social functioning [3.3 (0.2; 6.5), $p = 0.039$], but patients with high VSR have symptoms of dyspnea [1.9 (0.2; 3.6), $p = 0.028$], eating restrictions [2.2 (0.3; 4.1), $p = 0.021$]. High GS is an independent predictor of better QoL scores for cognitive functioning [6.3 (1.2; 11.3), $p = 0.016$], financial problems [−5.6 (−10.6; −0.5), $p = 0.032$], reflux [−7.6 (−14.2; −1.0), $p = 0.023$]. At the same time, it is also a predictor of hair loss [7.1 (1.9; 12.3), $p = 0.007$]. SMI is associated with higher nausea and vomiting [0.4 (0.1; 0.8), $p = 0.014$], pain [0.3 (0.1; 0.6), $p = 0.004$] and anxiety [0.4 (0.1; 0.7), $p = 0.009$] scores.

The multiple linear regression model at 6 months after surgery was shown in **Table 5**. VSR is an independent predictor of better global health status [3.1 (0.1; 6.1), $p = 0.04$]. SFA and insomnia [2.2 (0.9;3.4), $p = 0.001$] are negatively correlated. A higher VFA is negatively correlated with nausea and vomiting [3.0 (0.7; 5.3), $p = 0.01$]. GS is positively correlated with emotional functioning [5.6 (0.9; 10.4), $p = 0.02$], cognitive functioning [2.8 (0.6; 5.0), $p = 0.014$], reflux [−5.5 (−11.0; −0.1), $p = 0.046$]. However it is negatively correlated with social functioning [−14.3 (−24.8; −3.7), $p = 0.008$]. SMD is a good predictor for fatigue [−0.4 (−0.7; −0.2), $p = 0.002$], appetite loss [−0.4 (−0.7; −0.1), $p = 0.011$], anxiety [−0.2 (−0.3; −0.1), $p = 0.001$] and dry mouth [−0.2 (−0.4;0.0), $p = 0.037$]. At the same time, it is also a predictor of higher dyspnea [0.1 (0.0;0.2), $p = 0.017$] QoL score.

DISCUSSION

In the present study, we investigated the relationship between CT-based BC parameters, physical function and QoL 1, 3, 6 months after surgery in patients with gastric cancer. To the best of our knowledge, this is the first prospective study to investigate these correlations in gastric cancer. Our study showed that gastrectomy had a significant negative impact on QoL (5). However, most functional and symptomatic damages recovered within 6 months. These findings were similar to the results of another study by Hu et al. (5, 30). The results of multiple linear regression showed that patients with higher GS at the time of diagnosis had better global health status scores 1 month after surgery. In addition, higher pace is associated with lower symptom score. In the first month after surgery, patients with a higher SFA at diagnosis usually had a poorer QoL, mainly manifested by a higher score on the symptom scale. Three and six months after surgery, SFA has no significant relationship with QoL. At 1 month after surgery, higher VFA content is associated with deterioration of role functioning and cognitive functioning, and it is associated with the reduction of appetite loss and anxiety symptoms. At 3 months after surgery, VFA has a protective effect on some functions, symptom scales and

TABLE 4 | Multivariable linear regression model on quality of life, symptom scales, and functional scales from EORTC QLQ-C30 and QLQ-STO22 for 3 months after surgery.

	Physical functioning[a]	Role functioning[a]	Emotional functioning[a]	Cognitive functioning[a]	Social functioning[a]	Fatigue[b]	Nausea and vomiting[b]	Pain[b]	Dyspnea[b]	Insomnia[b]	Appetite loss[b]	Constipation[b]	Diarrhea[b]	Financial problems[b]	Global health status[a]
Quality of life from the EORTC QLQ-C30 questionnaire															
Gender	4.9 (1.6;8.2)	–	–	3.1 (0.4;5.8)	–	–	−9.5 (−15.5;−3.5)	–	−4.1 (−6.6;−1.7)	–	−6.8 (−12.4;−1.2)	−4.0 (−7.6;−0.4)	–	–	–
Age	–	–	–	–	–	–	–	–	–	–	–	−0.1 (−0.3;0.0)	−0.2 (−0.3;0.0)	−0.1 (−0.2;0.0)	−0.3 (−0.5;−0.1)
BMI	–	–	–	–	–	–	−0.5 (−1.0;0.0)	–	–	−0.7 (−1.3;0.0)	–	−1.0 (1.7;−0.2)–	–	−0.4 (−0.7;−0.1)	–
ASA	–	–	–	–	–	–	3.9 (2.0;5.7)	1.6 (0.3;2.9)	–	–	–	–	2.2 (0.2;4.1)	3.0 (1.5;4.4)	–
SFA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
VFA	–	–	–	1.4 (0.0;2.7)	–	–	–	–	−2.3 (−3.9;−0.7)	–	–	–	–	–	3.1 (0.4;5.8)
VSR	–	–	–	–	3.3 (0.2;6.5)	–	–	–	1.9 (0.2;3.6)	–	–	–	–	–	–
SMD	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
SMI	–	–	–	–	–	–	0.4 (0.1;0.8)	0.3 (0.1;0.6)	–	–	–	–	–	–	–
HGS	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
GS	–	–	–	6.3 (1.2;11.3)	–	–	–	–	–	–	–	–	–	−5.6 (−10.6;−0.5)	–
Tumor location	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pathological type	–	–	–	–	–	–	–	–	–	4.3 (0.1;8.5)	–	–	–	–	–
TNM stage	–	−3.2 (−5.7;−0.7)	–	–	–	–	3.3 (0.8;5.9)	–	–	–	–	–	–	–	–
Type of reconstruction	–	–	–	–	–	–	–	–	–	–	–	2.7 (0.0;5.4)	–	–	–
Laparoscopy–assisted operation	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Type of gastrectomy	–	–	–	–	−6.9 (−12.8;−1.0)	4.8 (0.3;9.4)	–	–	−5.1 (−8.8;−1.3)	–	–	–	–	–	–
Previous abdominal surgery	–	–	–	–	–	–	7.2 (0.1;14.3)	–	–	–	–	–	–	–	–

	Dysphagia[b]	Pain[b]	Reflux[b]	Eating restrictions[b]	Anxiety[b]	Dry mouth[b]	Taste[b]	Body image[b]	Hair loss[b]
Quality of life from the EORTC QLQ-STO22 questionnaire									
Gender	–	–	–	−3.2 (−5.5;−0.8)	−7.3 (−11.5;−3.1)	−5.5 (−10.5;−0.5)	–	–	–
Age	–	0.2 (0.0;0.3)	–	–	–	–	–	–	–
BMI	–	–	–	–	−1.0 (−1.7;−0.4)	−0.9 (−1.7;−0.1)	–	–	–
ASA	–	–	–	–	–	4.1 (1.3;6.9)	–	1.6 (0.1;3.1)	–

(Continued)

TABLE 4 | Continued

	Dysphagia[b]	Pain[b]	Reflux[b]	Eating restrictions[b]	Anxiety[b]	Dry mouth[b]	Taste[b]	Body image[b]	Hair loss[b]
SFA	–	–	–	–	–	–	–	–	–
VFA	–	–	–	−1.8 (−3.5;−0.1)	–	–	–	–	–
VSR	–	–	–	2.2 (0.3;4.1)	–	–	–	–	–
SMD	–	–	–	–	–	–	0.3 (0.0;0.6)	–	–
SMI	–	–	–	–	0.4 (0.1;0.7)	–	–	–	–
HGS	–	–	–	–	–	–	–	–	−0.2 (−0.3;0.0)
GS	–	–	−7.6 (−14.2;−1.0)	–	–	–	–	–	7.1 (1.9;12.3)
Tumor location	–	–	–	–	–	–	–	–	–
Pathological type	–	−3.3 (−6.2;−0.4)	−4.2 (−7.2;−1.2)	–	–	–	–	–	–
TNM stage	–	–	–	–	–	–	2.9(0.4;5.4)	–	–
Type of reconstruction	–	–	–	–	–	–	–	–	–
Laparoscopy-assisted operation	–	–	–	–	–	–	–	–	–
Type of gastrectomy	–	–	–	2.0(0.1;3.9)	–	–	–	–	–
Previous abdominal surgery	–	–	–	–	–	–	–	–	–

Scores are presented as linear regression coefficients, with 95% confidence intervals between brackets. During stepwise backward linear regression, the weakest associated variables and Insignificant variables (p>0.05) are excluded from the model (−); [a]Higher scores represent better quality of life or functioning; [b]Higher scores represent more symptoms.

global health status. At 6 months after surgery, VSR is positively correlated with global health status. HGS, SMI and SMD showed minimal correlation with postoperative QoL. In addition, on some scales, males and lower ASA scores are predictors of better QoL [11].

Similar findings regarding the importance of BC on the QoL after surgery have also been demonstrated in several previous studies. The study by Biljana Gigic et al. concluded that for patients after colorectal cancer surgery, VFA was negatively correlated with social function and pain scores at a 6-month follow-up. At 12 months after surgery, VFA was negatively correlated with body function [31]. In addition, Sheean's research showed that compared with non-obese women, abdominal obese women with estrogen receptor-positive metastatic breast cancer had significantly higher levels of serum inflammation biomarkers, more severe symptoms, and lower QoL [32]. Different from the conclusion of Biljana Gigic et al., our results show that high visceral fat is beneficial to the QoL at 3 months after surgery. The possible explanation is that visceral fat has a physiological role of providing energy during stress, which promotes the repair of the body [33]. According to our team's previous research results, VFA is a double-edged sword for gastric cancer patients. In patients with normal BMI, the positive effect of VFA on nutritional status may exceed its negative effect [34]. Therefore, for patients with normal BMI, the protective effect of VFA on QoL may be more obvious.

The studies by Swisher et al. and Gudmundsson et al. show that higher SFA has an adverse effect on postoperative QoL. In view of these studies, we can recommend cancer patients with higher SFA to actively exercise and control their diet, which can reduce their body fat rate and improve their QoL [35, 36].

In the present study, GS showed a strongest predictive effect on QoL compared with other confounding factors. For example, 1 month after surgery, GS is the strongest predictor of global health. GS, as one of the measurement methods of physical performance, is used to diagnose sarcopenia. According to the European Working Group on Sarcopenia in Older People (EWGSOP) diagnostic criteria for sarcopenia, a single cut-off speed $\leq$ 0.8 m/s is used as an indicator of severe sarcopenia [26]. In recent years, Charlotte Beaudart and his colleagues had invented a QoL questionnaire for patients with sarcopenia and found that there was a decline in the QoL in patients with sarcopenia [37]. The research of our colleagues also found that patients with sarcopenia have a lower QoL after surgery [38]. Decreased GS should be regarded as a sign of poor QoL after surgery.

In clinical studies, GS has been used as an effective tool to assess the elderly who are at high risk of adverse outcomes [19–21]. There is a lot of evidence that poor physical functioning is associated with readmission rates [39], disability [40, 41], mortality [19], falls and depression [19, 42]. These findings indicate that low GS at diagnosis is a powerful predictor of poor QoL and adverse outcomes in patients after gastrectomy.

GS as a safe, fast and simple tool is not commonly used clinically, even though International Academy on Nutrition and

TABLE 5 | Multivariable linear regression model on quality of life, symptom scales, and functional scales from EORTC QLQ-C30 and QLQ-STO22 for 6 months after surgery.

	Physical functioning[a]	Role functioning[a]	Emotional functioning[a]	Cognitive functioning[a]	Social functioning[a]	Fatigue[b]	Nausea and vomiting[b]	Pain[b]	Dyspnea[b]	Insomnia[b]	Appetite loss[b]	Constipation[b]	Diarrhea[b]	Financial problems[b]	Global health status[a]
Quality of life from the EORTC QLQ-C30 questionnaire															
Gender	3.7 (0.5;6.8)	–	−2.8 (−5.3;−0.4)	–	–	–	–	–	−2.1 (−3.6;−0.5)	–	−5.4 (−10.7;−0.1)	–	–	–	–
Age	−0.1 (−0.3;0.0)	−0.2 (−0.3;0.0)	0.1 (0.0;0.2)	0.1 (0.0;0.1)	–	–	–	–	–	–	–	–	–	–	–
BMI	–	–	−0.3 (−0.6;0.0)	–	–	–	–	–	–	–	–	–	–	−0.3 (−0.5;0.0)	–
ASA	–	–	–	–	–	–	–	2.1 (0.6;3.6)	–	–	–	–	–	–	–
SFA	–	–	–	–	–	–	–	–	–	2.2 (0.9;3.4)	–	–	–	–	–
VFA	–	–	–	–	–	–	3.0 (0.7;5.3)	–	–	–	–	–	–	–	–
VSR	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.1 (0.1;6.1)
SMD	–	–	–	–	–	−0.4 (−0.7;−0.2)	–	–	0.1 (0.0;0.2)	–	−0.4 (−0.7;−0.1)	–	–	–	–
SMI	–	0.3 (0.0;0.5)	–	–	–	–	–	–	–	–	–	–	–	–	–
HGS	–	–	–	–	–	–	−0.2 (−0.4;−0.1)	–	–	–	–	–	–	–	–
GS	–	–	5.6 (0.9;10.4)	2.8 (0.6;5.0)	−14.3 (−24.8;−3.7)	–	–	–	–	–	–	–	–	–	–
Tumor location	–	–	−1.3 (−2.4;−0.2)	–	–	–	3.2 (0.3;6.1)	–	–	–	–	–	4.0 (1.7;6.3)	–	–
Pathological type	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7 (0.1;3.3)	–
TNM stage	–	–	–	–	–	–	–	1.4 (0.1;2.7)	–	–	–	–	–	–	–
Type of reconstruction	–	–	–	0.7 (0.2;1.1)	–	–	–	–	–	–	–	–	–	–	–
Laparoscopy-assisted operation	–	–	–	–	–	4.6 (0.4;8.9)	–	–	–	–	–	–	–	–	–
Type of gastrectomy	–	–	–	–	–	–	–	−4.0 (−6.8;−1.1)	–	–	–	–	–	–	–
Previous abdominal surgery	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

	Dysphagia[b]	Pain[b]	Reflux[b]	Eating restrictions[b]	Anxiety[b]	Dry mouth[b]	Taste[b]	Body image[b]	Hair loss[b]
Quality of life from the EORTC QLQ-STO22 questionnaire									
Gender	–	–	–	–	–	–	–	–	–
Age	0.1 (0.0;0.1)	–	–	–	–	–	0.2 (0.0;0.3)	–	–
BMI	0.3 (0.1;0.6)	–	–	–	–	–	–	–	–

(Continued)

TABLE 5 | Continued

	Dysphagia[b]	Pain[b]	Reflux[b]	Eating restrictions[b]	Anxiety[b]	Dry mouth[b]	Taste[b]	Body image[b]	Hair loss[b]
ASA	–	–	–	1.1 (0.1;2.1)	–	–	–	–	–
SFA	–	–	–	–	–	–	–	–	–
VFA	–	–	–	–	–	–	–	–	–
VSR	–	–	–	–	–	–	–	–	–
SMD	–	–	–	–	−0.2 (−0.3;−0.1)	−0.2 (−0.4;0.0)	–	–	–
SMI	–	–	–	–	–	–	–	–	–
HGS	–	–	–	–	–	–	–	–	–
GS	–	–	−5.5 (−11.0;−0.1)	–	–	–	–	–	–
Tumor location	–	–	−2.5 (−4.5;−0.4)	–	–	–	–	–	–
Pathological type	–	–	−2.7 (−5.2;−0.2)	–	–	–	–	–	−2.2 (−3.8;−0.6)
TNM stage	−0.9 (−1.8;0.0)	–	–	–	–	–	–	–	–
Type of reconstruction	–	–	–	–	–	–	–	–	–
Laparoscopy-assisted operation	–	–	−2.8 (−5.3;−0.4)	–	–	–	–	–	–
Type of gastrectomy	1.9 (0.3;3.5)	–	–	–	–	–	–	–	–
Previous abdominal surgery	–	–	–	–	–	–	–	–	–

Scores are presented as linear regression coefficients, with 95% confidence intervals between brackets. During stepwise backward linear regression, the weakest associated variables and Insignificant variables (p > 0.05) are excluded from the model (–); [a]Higher scores represent better quality of life or functioning; [b]Higher scores represent more symptoms.

Aging (IANA) research shows that the usual gait as a single item tool is as sensitive as comprehensive tools in predicting adverse outcomes (19). We can use the GS test as a routine preoperative examination like abdominal CT. In this way, the characteristics that determine the patient's short-term QoL can be identified as early as possible. Our findings indicate that patients with high SFA or low GS at diagnosis have a lower QoL after gastrectomy. Therefore, these patients may need a customized plan to reduce SFA and improve physical function. For example, in the process of tumor treatment, moderate- or vigorous-intensity exercise (43), reasonable diet, and strengthening of nutritional support will help to improve their QoL.

The advantage of our research is the use of CT to define the composition of BC, which allows us to accurately define the fat and muscle tissue of patients with gastric cancer. Secondly, CT is used as a routine preoperative examination for patients with gastric cancer, which means that there is no need for another exposure to radiation. Our main innovation is to comprehensively analyze the effects of various components of human BC and physical functions on the QoL, and conduct a multi-factor analysis on them.

This study has several limitations. First of all, this is a single-center study, and the results of the study may not be representative of the general population. Secondly, the postoperative follow-up time for patients is short, and because postoperative abdominal CT examinations are not frequent performed, postoperative BC data are missing. The long-term BC and QoL after surgery still need to be verified in future studies.

CONCLUSIONS

This research found that patients with gastric cancer suffer from a decline in their QoL after gastrectomy. Besides, a lower gait speed or a higher subcutaneous fat area before surgery is associated with a worse quality of life after surgery. Therefore, based on current research, exercise and diet control may improve the quality of life in patients with gastric cancer after gastrectomy.

Code availability: SPSS software (version 22.0 IBM, Armonk, NY, USA).

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethical Review Committee of the First Affiliated Hospital of Wenzhou Medical University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

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