Association of Sarcopenia and Low Nutritional Status with Unplanned Hospital Readmission after Radical Gastrectomy in Patients with Gastric Cancer: A Case-Control Study

Yiqi Cai,1 Shan Chen,2 Xiaodong Chen,1 Wenjing Chen,1 Pengfei Wang,1 Guanbao Zhu,1 and Jinji Jin1

1Department of Gastrointestinal Surgery, The First Affiliated Hospital of Wenzhou Medical University, Wenzhou, China
2First Clinical College of Wenzhou Medical University, Wenzhou, China

Correspondence should be addressed to Jinji Jin; wyyjij201314@sina.com

Received 21 January 2022; Revised 9 March 2022; Accepted 10 March 2022; Published 15 April 2022

Objectives. Sarcopenia is one of the influencing factors of poor prognosis in patients with gastric cancer but the association with readmission are unknown. We aimed to explore factors associated with readmission after gastrectomy and to determine whether preoperative sarcopenia is a common outcome in readmitted patients.

Methods. In this case-control study, patients who underwent gastric resection in the First Affiliated Hospital of Wenzhou Medical University between April 2016 and September 2017 were included. The reasons of readmission patients were described. The readmission patients and non-readmission patients were matched by propensity score matching (PSM). The univariate analysis was applied for the baseline characteristics, operative details, postoperative prognosis and discharge disposition, and multiple logistic regression analysis for the independent risk factors of readmission.

Results. The unplanned readmission rate within 30 days of radical gastrectomy for gastric cancer was 6.5% (43/657). The average time interval from discharge to readmission was 13 days. Delayed gastric evacuation was the main cause of readmission (18.6%, 8/43). Body mass index (BMI), nutritional risk screening (NRS) 2002 score, history of abdominal surgery, sarcopenia, and preoperative albumin were included in the multivariate logistic regression analysis. NRS 2002 (OR = 3.43, 95% CI: 1.10–10.72, \( P = 0.034 \)) and sarcopenia (OR = 4.25, 95% CI: 1.13–16.02, \( P = 0.033 \)) were found to be independently associated with unplanned readmission within 30 days of radical gastrectomy for cancer. Other factors such as age, sex, BMI, American Society of Anesthesiologists grade, surgical method, operation and reconstruction type, TNM stage, surgical duration, previous abdominal surgery, and preoperative albumin and hemoglobin level were not associated with unplanned readmission after radical gastrectomy for cancer.

Conclusions. Sarcopenia and low nutritional status are independently associated with unplanned readmission within 30 days of radical gastrectomy for cancer.

1. Introduction

Unplanned readmission refers to readmission of patients in a short duration due to the same or related illness after discharge. Unplanned readmission exacerbates the patient’s physical and mental stress, prolongs the hospitalization time, increases the treatment cost, and overburdens medical resources, so has been receiving increasing attention [1, 2]. In 2004, readmission-related medical expenses in the United States reached $17.4 billion [1]. Moreover, unplanned readmission has become an important indicator for evaluating the quality of medical care worldwide [1].

According to GLOBOCAN 2018 [3], based on the incidence, gastric cancer is the fourth most common malignant tumor; while based on the mortality, gastric cancer ranks third. In China, approximately 410,000 new cases of gastric cancer are reported every year [4, 5], accounting for 42% of cases worldwide [3]. Gastrectomy remains the gold-standard treatment for gastric carcinoma [6, 7]. However, the patients who have undergone gastrectomy often develop postoperative complications, and unplanned readmissions have become common in the patients [8, 9]. Previous studies have examined the incidence rate and related factors of readmission after surgeries for colorectal and hepat-
pancreato-biliary cancers [10–17]; however, those have not been studied in the case of gastric cancer.

Gastric resection is a complicated surgery associated with high postsurgical morbidity and mortality [18]. A study reported that unplanned readmission is associated with increased mortality of patients who undergo radical gastrectomy [19]. However, the factors associated with readmission after radical gastrectomy have not been studied. Identification of the influencing factors for readmission after radical gastrectomy can help prevent readmission and improve the management of patients with gastric cancer.

Sarcopenia refers to progressive age-related loss of skeletal muscles and their function, resulting in weakness [20]. Sarcopenia can be prevented by regular physical activity, healthy diet including adequate intake of carbohydrates and proteins, and the maintenance of body weight in the normal range [21]. Sarcopenia is not only associated with falls, physical frailty, functional disability/loss of independence, and increased risk of mortality [20], but also correlated with the risk of poor outcomes after major surgeries [22–26]. At present, many current studies have shown that preoperative sarcopenia is associated with the postoperative risks for the complications, mortality, and length of hospital stay after gastrointestinal tumor surgery [27–29]. However, the correlation between sarcopenia and postoperative readmission in patients with gastric cancer has not been reported.

Therefore, the objective of this study was to explore factors associated with readmission after gastrectomy, and to determine whether preoperative sarcopenia is a common outcome in readmitted patients.

2. Materials and Methods

2.1. Study Design and Samples. This study was a retrospective case-control study that included the patients who underwent elective gastric resection for p-stages I-III primary gastric cancer in the Department of Gastrointestinal Surgery of The First Affiliated Hospital of Wenzhou Medical University between April 2016 and September 2017. The patients were managed according to the Japanese gastric cancer treatment guidelines 2014 [30].

The inclusion criteria were shown as follows: (1) age ≥ 18 years; (2) diagnosis of gastric cancer; and (3) discharge from the hospital after successful elective gastrectomy and reconstruction surgery. The exclusion criteria were displayed as follows: (1) death within 30 days after discharge from the hospital; (2) palliative surgery; (3) patients with residual gastric cancer or concomitant tumor in another organ or system; (4) patients who received neoadjuvant chemotherapy; and (5) patients without sufficient data.

The ethics committee of the First Affiliated Hospital of Wenzhou Medical University approved this study (approval number: 2014 No. 063) and informed consent was obtained from all study participants.

2.2. Data Collection. The data were obtained from medical charts and the hospital information system (The data included inpatient number, age, sex, body mass index (BMI), sarcopenia, previous abdominal surgery, preoperative hemoglobin, preoperative albumin, nutritional risk screening (NRS), American Society of Anesthesiology score, surgical approach, type of resection, type of reconstruction, duration of surgery, TNM stage, and major postoperative complications). Based on the Clavien–Dindo grading system, major postoperative complications were defined as grade III or IV [31], including anastomotic leakage, bleeding, failure of conservative drug treatment, adhesive intestinal obstruction, and internal hernia. Unplanned readmission was defined as any emergent hospitalization within 30 days after discharge from the hospital, according to past readmission-related trials [32, 33]. Elective hospital admission for adjuvant therapy was not considered as unplanned readmission in this study. In the case of patients who were hospitalized for multiple physical signs, the most prominent sign was considered as the reason for readmission.

All patients were routinely followed up every 10 days by telephone or outpatient visit for 30 days. Nutritional risk assessment was performed prior to surgery was carried out 24 h after admission according to the NRS 2002 guidelines; the assessment of individuals ≥ 3 points were considered to be at nutritional risk [33, 34].

2.3. Assessment of Sarcopenia

(1) Assessment of muscle: Routine preoperative abdominal computed tomography scan was performed in all patients. Lumbar vertebra (L3) imaging was selected for measurement from the Picture Archiving and Communication System (PACS). According to EWGSOP2, muscle area and mean muscle attenuation were utilized to represent muscle quantity and muscle quality, respectively. Muscle was analyzed at computed tomography (CT) workstation (GE ADW 4.5) using specific Hounsfield units (HU) thresholds of -29 to 150, and tissue boundaries were manually outlined as needed. And L3 cross-sectional muscle area was normalized with the square of stature and reported as skeletal muscle index (SMI, cm²/m²). Cutoff values of SMI were 34.9 cm²/m² for females and 40.8 cm²/m² for males [35]. The sex-specific cutoff values for mean muscle attenuation in HU of the cross-sectional muscle area were 28.6 HU for females and 38.5 HU for males [35].

(2) Muscle strength and physical performance. Grip strength and 6 m usual gait speed were tested routinely prior to surgery for the diagnosis of sarcopenia [36, 37]. Myodynamia and physical performance were recorded using an electronic handgrip dynamometer (EH101; Zhongshan Camry Electronic Co., Ltd., Guangdong Province, China). Each subject was allowed to use a dominant hand for all the tests. The 6-m usual gait speed was determined as follows: the patient was allowed to walk over 6 m, and the time from the first footfall to the last one was recorded. The two examinations were completed within 7 days prior to surgery. Additionally, each test was
3. Results

3.1. Patient Characteristics. Among 710 included patients admitted between April 2016 and December 2017, 697 individuals were eligible for this study. Of the 683 study participants, 7 were excluded because of death within 30 days of discharge, 11 patients because of palliative surgery, 8 patients because of residual gastric cancer or concomitant tumor in another organ or system. In addition, 5 individuals were excluded for receiving neoadjuvant chemotherapy and 9 for insufficient data. Eventually, 657 patients were enrolled in this study (Figure 1) who underwent gastrectomy for cancer, without loss to follow-up. The demographic data and clinical features of the patients were presented in Table 2. Average patient age was 64.5 years, and maximum of the cases (494, and 75.2%) were males. Overall, 43 patients (6.54%) were readmitted within 30 days of discharge. The average time interval from discharge to readmission was 13 days, which was the same as the time interval from readmission to the second discharge. There was no second readmission within 30 days of surgery.

Before PSM, the readmission group had higher NRS (P = 0.001) and increased rate of major complications (P < 0.001) and sarcopenia (P = 0.001) compared with the patients who were not readmitted.

After PSM, the readmission group had higher NRS (P = 0.001) and rate of sarcopenia (P = 0.001), and lower albumin level (P = 0.010) than the patients who were not readmitted (Table 2).

3.2. Reasons for Readmission. Table 3 presents the reasons for readmission. Delayed gastric evacuation was the main reason, accounting for 18.6% of all readmitted patients (8/43). Of the 43 readmitted individuals, 41 received conservative therapy, and two required reoperation, including one each for abdominal internal hemorrhage and gastrointestinal hemorrhage. Besides, two patients diagnosed with anastomotic stricture underwent endoscopic balloon dilatation. One of the patients died during readmission because of multiple organ dysfunction syndrome.

3.3. Factors Associated with Readmission. The factors associated with readmission were analyzed using the univariate analysis (Table 4). BMI, NRS 2002 score, history of abdominal surgery, sarcopenia, and preoperative albumin were included in the multivariate logistic regression analysis (Table 4). NRS 2002 (OR = 3.43, 95% CI: 1.10–10.72, P = 0.034) and sarcopenia (OR = 4.25, 95% CI: 1.13–16.02, P = 0.033) were independently associated with 30-day readmission after radical gastrectomy for cancer.

4. Discussion

Unplanned readmission after radical gastrectomy for cancer indicates the threat to patient health because of the high mortality rate in those patients [19, 39]. Sarcopenia is a common condition associated with a high surgical risk [22–26]. Therefore, the identification of factors associated with unplanned readmission after gastric cancer resection is important for the prevention and management of the disease like sarcopenia. For one thing, the frequency of unplanned readmission within 30 days was found to be 6.5%. For another, regression analysis displayed the correlation of sarcopenia and a preoperative NRS 2002 score of ≥3 with readmission within 30 days of radical gastrectomy. These findings showed that sarcopenia and increased NRS score could be considered as indicators of preoperative examination.

Sarcopenia, determined by both muscle quality and quantity, is exacerbated by a poor nutritional status. Age-related sarcopenia is a syndrome associated with progressive and general loss of SMM and myodynamia [36]. Recent

---

**Table 1: EWGSOP2 criteria for the diagnosis of sarcopenia.**

| Diagnostic category | Definition |
|---------------------|------------|
| (1) Low muscle strength | The muscle mass of the rectus femoris muscle is less than 6.6 kg for males and less than 5.0 kg for females. |
| (2) Low muscle quantity or quality | The muscle mass of the rectus femoris muscle is less than 6.6 kg for males and less than 5.0 kg for females. |
| (3) Low physical performance | The performance on the 6-min walk test is less than 400 m for males and less than 300 m for females. |

---

**Table 2: Demographic data and clinical features of patients.**

| Feature | Readmission | No Readmission | P value |
|---------|-------------|----------------|----------|
| Age (years) | 65 ± 12 | 66 ± 13 | 0.24 |
| Gender (M:F) | 381:276 | 345:312 | 0.12 |
| BMI | 24.5 ± 3.2 | 24.7 ± 3.1 | 0.15 |

**Table 3: Reasons for readmission.**

| Reason | Readmission (n=43) |
|--------|-------------------|
| Delayed gastric evacuation | 8/43 |
| Complications | 3/43 |
| Other | 26/43 |

---

3.4. Statistical Analysis. All analyses were performed using SPSS 22.0 (IBM, Armonk, New York, US). Continuous variables were tested for normal distribution by the Kolmogorov–Smirnov test. Moreover, continuous data were presented as means ± standard deviations or as medians and interquartile ranges. Normally distributed continuous data were analyzed through the Student’s t-test. Categorical data were presented as the numbers and percentages and analyzed by the chi-square test. To identify factors associated with readmission within 30 days, the univariate analysis was applied for analyzing baseline characteristics, operative details, postoperative prognosis, and discharge disposition. Multivariate logistic regression analysis was performed with the backward method. Propensity score matching (PSM) was performed for matching readmitted patients with those who were not readmitted. Age and sex were matched for PSM; matching tolerance was set at 0.05. A P value < 0.05 was considered statistically significant.
reports suggest that sarcopenia is associated with postoperative complications, malnutrition, and unfavorable outcomes in patients with gastric cancer [33, 36]. Besides, sarcopenia is also associated with poor outcomes after major surgeries [22–26]. In this study, sarcopenia was found to be correlated with readmission. Among 657 patients, 19.6% had sarcopenia, and the percentage was consistent with the previous literature [40]. According to this study and our previous studies [33], sarcopenia was highly associated with unplanned readmission. Moreover, the association between sarcopenia and unplanned readmission was also observed in patients who had undergone esophagectomy [25] or abdominoperineal resection [41], as well as in elderly patients in acute care wards [42]. Since sarcopenia can be detected conveniently and objectively, preoperative examination and treatment can be performed to avoid unplanned readmission.

Malnutrition occurs in 36%–43% of patients with gastric cancer, representing a common problem in these individuals [43, 44]. Malnutrition is usually considered a risk for postoperative complications in patients undergoing major abdominal surgery [45, 46]. Currently, many researches have indicated that postoperative complications are the risk factors of unplanned readmission [18, 47, 48]. However, in this study, it is found that postoperative complications were not associated with unplanned readmission. In fact, most of patients with gastric cancer treated at our center who develop postoperative complications were cured during hospitalization before discharge. Therefore, the probability of readmission was greatly reduced in patients with postoperative complications. Also, the above may the reason why there was no significant difference for major postoperative complications in the readmission and non-readmission groups. Our previous study reported that the NRS score of >3 could be considered a risk factor for unplanned readmission of patients after radical gastrectomy [33]. Nevertheless, various subjective factors may affect this score.

The correlation between sarcopenia and readmission after gastrectomy for gastric cancer can be explained by the reflection of SSM on the patient’s nutritional status and the association of nutritional risk and postoperative complications as well as readmission [49]. Also, the above explains why sarcopenia is the factor associated with readmission after gastric cancer resection. To a large extent, maintenance of physical function, daily activities, and vitality depends on skeletal muscle strength [49]. Patients with sarcopenia gradually experience weakness and limited mobility, affecting the postoperative recovery process. Therefore, examining the pathogenesis of sarcopenia may help predict the chances in readmission after surgery. Sarcopenia is also associated with postoperative infection and complications [23], which may also explain, at least to some extent, the relationship between sarcopenia and readmission after gastrectomy.

CT is considered as a gold standard for assessing SMM [22]. In clinical practice, patients with gastric cancer routinely receive CT scan for the determination of the size and location of tumors and detection of metastasis. Patients would not incur additional cost or would not be exposed to additional radiation in CT for assessing SSM. The above is
Table 2: Characteristics of the readmission and non-readmission groups before and after propensity score matching.

| Variable                        | Before matching | After matching | P     | Before matching | After matching | P     |
|---------------------------------|-----------------|----------------|-------|-----------------|----------------|-------|
|                                | Readmission     | Non-readmission|       | Readmission     | Non-readmission|       |
|                                | group (n = 43)  | group (n = 614)|       | group (n = 43)  | group (n = 43) |       |
| Age, years, n (%)               |                 |                |       |                 |                |       |
| <65                             | 25 (58.1)       | 287 (46.7)     | 0.148 | 25 (58.1)       | 32 (74.4)      | 0.110 |
| ≥65                             | 18 (41.9)       | 327 (53.3)     |       | 18 (41.9)       | 25 (58.1)      |       |
| Sex, male, n (%)                |                 |                |       |                 |                |       |
|                                | 32 (74.4)       | 462 (75.2)     | 0.904 | 32 (74.42)      | 25 (58.1)      | 0.110 |
|                                | 32 (74.4)       | 462 (75.2)     |       | 32 (74.42)      | 25 (58.1)      |       |
| BMI, kg/m², n (%)               |                 |                |       |                 |                |       |
| <18.5                           | 7 (16.3)        | 48 (7.8)       | 0.086 | 7 (16.3)        | 3 (7.0)        | 0.162 |
| 18.5–23.9                       | 20 (46.5)       | 378 (61.6)     |       | 20 (46.5)       | 16 (37.2)      |       |
| ≥23.9                           | 16 (37.2)       | 188 (30.6)     |       | 16 (37.2)       | 24 (55.8)      |       |
| NRS 2002 score, n (%)           |                 |                |       |                 |                |       |
| <3                              | 15 (34.9)       | 370 (60.3)     |       | 15 (34.9)       | 33 (76.7)      | 0.001 |
| ≥3                              | 28 (62.1)       | 244 (39.7)     |       | 28 (62.1)       | 10 (23.3)      |       |
| ASA grade, n (%)                |                 |                |       |                 |                |       |
| I                               | 7 (16.3)        | 78 (12.7)      | 0.362 | 7 (16.3)        | 7 (16.3)       | 0.059 |
| II                              | 25 (58.1)       | 432 (70.4)     |       | 25 (58.1)       | 33 (76.7)      |       |
| III                             | 11 (25.6)       | 102 (16.6)     |       | 11 (25.6)       | 3 (7.0)        |       |
| IV                              | 0               | 2 (0.3)        |       | 0               | 0              |       |
| Preoperative hemoglobin (g/L)   | 127 ± 21        | 119 ± 21       | 0.435 | 127 ± 21        | 131 ± 14       | 0.251 |
| Preoperative albumin (g/L)      | 38.5 ± 5.7      | 37.9 ± 4.6     | 0.516 | 38.5 ± 5.7      | 41.2 ± 3.6     | 0.010 |
| Surgical approach, n (%)        |                 |                |       |                 |                |       |
| Open surgery                    | 33 (76.7)       | 455 (74.1)     | 0.702 | 33 (76.7)       | 27 (62.8)      | 0.159 |
| Laparoscopy                     | 10 (23.3)       | 159 (25.9)     |       | 10 (23.3)       | 16 (37.2)      |       |
| Type of resection, n (%)        |                 |                |       |                 |                |       |
| Subtotal gastrectomy            | 24 (55.8)       | 401 (65.3)     | 0.208 | 24 (55.8)       | 29 (67.4)      | 0.268 |
| Total gastrectomy               | 19 (44.2)       | 213 (34.7)     |       | 19 (44.2)       | 14 (32.6)      |       |
| Type of reconstruction, n (%)   |                 |                |       |                 |                |       |
| Roux-en-Y                       | 23 (53.5)       | 253 (41.2)     | 0.190 | 23 (53.5)       | 16 (37.2)      | 0.190 |
| Billroth I                      | 8 (18.6)        | 106 (17.3)     |       | 8 (18.6)        | 20 (46.5)      |       |
| Billroth II                     | 12 (27.9)       | 255 (41.5)     |       | 12 (27.9)       | 7 (16.3)       |       |
| TNM stage, n (%)                |                 |                |       |                 |                |       |
| Tis                             | 0               | 6 (1.0)        | 0.735 | 0               | 0              | 0.684 |
| I                               | 15 (34.9)       | 201 (32.7)     |       | 15 (34.9)       | 15 (34.9)      |       |
| II                              | 7 (16.3)        | 135 (22.0)     |       | 7 (16.3)        | 10 (23.3)      |       |
| III                             | 21 (48.8)       | 270 (44.0)     |       | 21 (48.8)       | 18 (41.9)      |       |
| IV                              | 0               | 2 (0.3)        |       | 0               | 0              |       |
| Previous abdominal surgery, n (%)| 9 (20.9)       | 66 (10.8)     | 0.075 | 9 (20.9)       | 3 (7.0)        | 0.062 |
| Duration of surgery, n (%)      |                 |                |       |                 |                |       |
| <3.0 hours                      | 8 (18.6)        | 196 (31.9)     | 0.068 | 8 (18.6)        | 10 (23.3)      | 0.596 |
| ≥3.0 hours                      | 35 (81.4)       | 418 (68.1)     |       | 35 (81.4)       | 33 (76.7)      |       |
| Major postoperative complication, n (%)| 24 (55.8)       | 168 (27.4)     | <0.001| 24 (55.8)       | 28 (65.1)      | 0.051 |
| Sarcopenia, n (%)               | 25 (58.1)       | 118 (19.2)     | 0.001 | 25 (58.1)       | 8 (18.6)       | 0.001 |

BMI: body mass index; NRS: nutritional risk score; ASA: American Society of Anesthesiologists score.
applied widely for assessing skeletal muscle quality in patients with gastrointestinal cancer. Therefore, the pre-assessment of sarcopenia by the surgeon before operation and optimization of the nutritional status of malnourished patients as early as possible are essential.

Gastrointestinal complications such as delayed gastric evacuation, followed by postoperative infectious complications, are the most common causes of readmission, according to previous studies [18, 47]. Majority of patients with sarcopenia face nutritional problems before resection. Specifically, gastrointestinal complications are exacerbated because of lower tolerance to malnutrition. Furthermore, sarcopenia correlates with the high morbidity of infectious complications after operation [45, 46], perhaps contributing to the relationship between sarcopenia and readmission after gastrectomy. In addition, Shi et al. [26] reported that sarcopenia is associated with adverse outcomes after gastrectomy, including longer hospital stay and severe complications. Lieffers et al. [24] reported that sarcopenia is correlated with infection, the need for rehabilitation, and prolonged hospital stay after surgery for colorectal cancer. The management of patients with sarcopenia must focus on the early provision of enteral/parenteral nutrition, nutritional status improvement, and reduction of complications of postoperative intestinal intolerance. All the above can reduce the rate of unplanned readmission.

Combined with the results of our study, we recommended that clinicians not only needed to assess the tumor condition but also needed to evaluate nutritional status and sarcopenia presence of patients. When, interventions were recommended based on specific diseases and nutritional requirements to improve postoperative outcomes. Combined with the progress of others’ studies [28], we recommend treating the application of a high-protein diet or TPN for the treatment of patients with sarcopenia before performing

### Table 3: Causes of readmission in 43 patients after gastrectomy for gastric cancer.

| Causes of readmission                              | n (%)  |
|----------------------------------------------------|--------|
| Delayed gastric emptying                           | 8 (18.60) |
| Small bowel obstruction                            | 5 (11.62) |
| Abdominal pain                                     | 3 (6.98) |
| Wound infection                                    | 5 (11.62) |
| Abdominal infection                                | 2 (4.65) |
| Intra-abdominal hemorrhage                         | 5 (18.10) |
| Intra-abdominal fluid collection                   | 3 (6.98) |
| Cholecystitis                                      | 2 (4.65) |
| Gastrointestinal hemorrhage                        | 2 (4.65) |
| Secondary malignant tumor                          | 2 (4.65) |
| Deep venous thrombosis                             | 2 (4.65) |
| Cerebral infarction                                | 1 (2.32) |
| Pneumonia                                          | 1 (2.32) |
| Appendicitis                                       | 1 (2.32) |
| MODS                                               | 1 (2.32) |
| Total                                              | 43     |

### Table 4: Univariate and multivariate analyses (backward) of factors potentially associated with readmission in patients with gastric cancer.

| Variable                                | Univariate | Multivariate |
|-----------------------------------------|------------|--------------|
|                                        | OR  | 95% CI      | P            | OR  | 95% CI      | P            |
| Age                                     | 2.095 | 0.839–5.227 | 0.113        |      |              |              |
| Sex, male, n (%)                        | 2.095 | 0.839–5.227 | 0.113        |      |              |              |
| BMI, n (%)                              | 0.534 | 0.278–1.028 | 0.060        | 0.540 | 0.252–1.157 | 0.113        |
| NRS 2002 score, n (%)                   | 6.160 | 2.393–15.855 | 0.001        | 3.429 | 1.097–10.724 | 0.034        |
| ASA grade, n (%)                        | 1.800 | 0.831–3.899 | 0.136        |      |              |              |
| Surgical approach, n (%)                | 0.522 | 0.200–1.309 | 0.162        |      |              |              |
| Type of resection, n (%)                | 1.640 | 0.682–3.942 | 0.269        |      |              |              |
| Type of reconstruction, n (%)           | 0.775 | 0.436–1.377 | 0.384        |      |              |              |
| TNM stage, n (%)                        | 1.992 | 0.679–1.757 | 0.716        |      |              |              |
| Comorbidities, n (%)                    | 1.537 | 0.244–9.695 | 0.647        |      |              |              |
| Previous abdominal surgery, n (%)       | 3.529 | 0.884–14.090 | 0.074        | 2.935 | 0.591–14.584 | 0.188        |
| Duration of surgery, n (%)              | 1.326 | 0.467–3.767 | 0.597        |      |              |              |
| Major postoperative complication        | 1.586 | 0.681–3.737 | 0.282        |      |              |              |
| Sarcopenia, n (%)                       | 5.031 | 1.899–13.328 | 0.014        | 4.249 | 1.127–16.015 | 0.033        |
| Preoperative hemoglobin (g/L)            | 0.986 | 0.961–1.010 | 0.250        |      |              |              |
| Preoperative albumin (g/L)              | 0.882 | 0.797–0.975 | 0.014        | 2.935 | 0.591–14.584 | 0.652        |

BMI: body mass index; NRS: nutritional risk score; ASA: American Society of Anesthesiologists score; OR: odds ratio; CI: confidence interval.
surgical resection. But even so, in the current study, sarcopenia remained an important predictor of clinical outcome. Whether prolonged postoperative hospitalization contributes to readmission is a highly debatable topic. Kim et al. [47] reported that longer postoperative hospitalization is a critical predictive factor of readmission. Conversely, Ahmad et al. [18] reported that postoperative hospitalization has no significant effect on readmission. In this study, we analyzed the length of first hospital stay after gastrectomy as a categorical (defining 13 days as a cutoff) and continuous variable; and in both the cases, prolonged hospital stay was not associated with readmission within 30 days.

This study has some limitations. First, this was a single-centered study, and the sample size of the readmission group was small. Stronger scientific evidence supported by multicenter prospective studies was needed to confirm these results. Second, we only concluded correlative factors of readmission following gastrectomy within 30 days. Studying the data over a longer term would provide a correlation between the probability of readmission and mortality. Third, as enhanced recovery after surgery (ERAS) was not universally promoted, these results could not be directly applied for all patients with gastric cancer, especially those receiving ERAS. Hence, further investigation was required. Fourth, we did not quantitatively measure the data about food intake, appetite, weight change, and physical activity level.

In conclusion, this study has shown that the rate of readmission within 30 days of radical gastrectomy is 6.5%. A preoperative NRS 2002 score of ≥3 and the occurrence of sarcopenia are associated with the unplanned readmission of patients who have undergone gastrectomy for cancer. Optimization of nutrition, especially in patients with nutritional risk before surgery, can potentially reduce the rate of readmission.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

The ethics committee of The First Affiliated Hospital of Wenzhou Medical University approved this study (approval number: 2014 No. 063), and the need for individual informed consent was waived.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Authors’ Contributions

Substantial contributions to study conception and design, data acquisition, analysis, and interpretation were made by YC and SC. Drafting the manuscript and revising it critically for important intellectual content was done by XC and WC. Final approval of the version to be published was given by PW and GZ. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of all parts of the study are appropriately investigated and resolved by JJ, YC, SC, and XC contributed equally to this work.

Acknowledgments

The authors would like to thank Editage (https://www.editage.com) for language editing support. This study was funded by the Department of Health of Zhejiang Province, China (grant no. Y2100660 and grant no. 2016DTA006) and the Wenzhou Municipal Science and Technology Bureau (grant no. Y20170104).

References

[1] M. M. Sellers, R. P. Merkow, A. Halverson et al., “Validation of new readmission data in the American college of surgeons national surgical quality improvement program,” Journal of the American College of Surgeons, vol. 216, no. 3, pp. 420–427, 2013.

[2] S. F. Jencks, M. V. Williams, and E. A. Coleman, “Rehospitalizations among patients in the Medicare fee-for-service program,” New England Journal of Medicine, vol. 360, no. 14, pp. 1418–1428, 2009.

[3] F. Bray, J. Ferlay, I. Soerjomataram, R. L. Siegel, L. A. Torre, and A. Jemal, “Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries,” CA: A Cancer Journal for Clinicians, vol. 68, no. 6, pp. 394–424, 2018.

[4] L. Yang, R. Zheng, R. Zheng et al., “Incidence and mortality of stomach cancer in China, 2014,” Chinese Journal of Cancer Research, vol. 30, no. 3, pp. 291–298, 2018.

[5] K. Gao and J. Wu, “National trend of gastric cancer mortality in China (2003-2015): a population-based study,” Cancer Communications, vol. 39, no. 1, p. 24, 2019.

[6] E. K. Bartlett, R. E. Roses, R. R. Kelz, J. A. Drebin, D. L. Fraker, and G. C. Karakousis, “Morbidity and mortality after total gastrectomy for gastric malignancy using the American college of surgeons national surgical quality improvement program database,” Surgery, vol. 156, no. 2, pp. 298–304, 2014.

[7] C. J. H. van de Velde and K. C. M. J. Peeters, “The gastric cancer treatment controversy,” Journal of Clinical Oncology, vol. 21, no. 12, pp. 2234–2236, 2003.

[8] I. Özer, E. B. Bostancı, M. Ulaş, Y. Özoğlu, and M. Akoğlu, “Changing trends in gastric cancer surgery,” Balkan Medical Journal, vol. 34, no. 1, pp. 10–20, 2017.

[9] M. Climent, N. Hidalgo, O. Vidal et al., “Postoperative complications do not impact on recurrence and survival after curative resection of gastric cancer,” European Journal of Surgical Oncology, vol. 42, no. 1, pp. 132–139, 2016.

[10] M. T. Kassin, R. M. Owen, S. D. Perez et al., “Risk factors for 30-day hospital readmission among general surgery patients,” Journal of the American College of Surgeons, vol. 215, no. 3, pp. 322–330, 2012.

[11] T. G. Kerwel, S. W. Leichtle, T. Asgeirsson, S. K. Hendren, R. K. Cleary, and M. A. Luchtefeld, “Risk factors for readmission after elective colectomy postoperative complications are more important than patient and operative factors,” Diseases of the Colon & Rectum, vol. 57, no. 1, pp. 98–104, 2014.

[12] M. R. Kwaan, S. A. Vogler, M. Y. Sun et al., “Readmission after colorectal surgery is related to preoperative clinical conditions and major complications,” Diseases of the Colon & Rectum, vol. 56, no. 9, pp. 1087–1092, 2013.
[13] J. M. Sutton, K. Wima, G. C. Wilson et al., “Factors associated with 30-day readmission after restorative proctocolectomy with IPAA: a national study,” Diseases of the Colon & Rectum, vol. 57, no. 12, pp. 1371–1378, 2014.

[14] A. N. Kulyayt, P. W. Dillon, C. S. Hollenbeak, and D. B. Stewart, “Determinants of 30-d readmission after colectomy,” Journal of Surgical Research, vol. 193, no. 2, pp. 528–535, 2015.

[15] T. L. Whitlock, A. Tignor, E. M. Webster et al., “A scoring system to predict readmission of patients with acute pancreatitis to the hospital within thirty days of discharge,” Clinical Gastroenterology and Hepatology, vol. 9, no. 2, pp. 175–180, 2011.

[16] E. B. Schneider, O. Hyder, C. L. Wolfgang et al., “Patient readmission and mortality after surgery for hepatopancreatobiliary malignancies,” Journal of the American College of Surgeons, vol. 215, no. 5, pp. 607–615, 2012.

[17] D. Emick, T. Riall, J. Cameron et al., “Hospital readmission after pancreaticoduodenectomy,” Journal of Gastrointestinal Surgery, vol. 10, no. 9, pp. 1243–1253, 2006.

[18] R. Ahmad, B. H. Schmidt, D. W. Rattner, and J. T. Mullen, “Factors influencing readmission after curative gastrectomy for gastric cancer,” Journal of the American College of Surgeons, vol. 218, no. 6, pp. 1215–1222, 2014.

[19] A. W. Acher, M. H. Squires, R. C. Fields et al., “Readmission following gastric cancer resection: risk factors and survival,” Journal of Gastrointestinal Surgery, vol. 20, no. 7, pp. 1284–1294, 2016.

[20] E. Marzetti, R Calvani, R Calvani et al., “Sarcopenia: an overview,” Aging Clinical and Experimental Research, vol. 29, no. 1, pp. 11–17, 2017.

[21] A. J. Cruz-Jentoft, G. Bahat, J. Bauer et al., “Sarcopenia: revised European consensus on definition and diagnosis,” Age and Ageing, vol. 48, no. 1, pp. 16–31, 2019.

[22] B. C. Boer, F. de Graaff, M. Brusse-Keizer et al., “Skeletal muscle mass and quality as risk factors for postoperative outcome after open colon resection for cancer,” International Journal of Colorectal Disease, vol. 31, no. 6, pp. 1117–1124, 2016.

[23] D.-D. Huang, C.-J. Zhou, S.-L. Wang et al., “Impact of different sarcopenia stages on the postoperative outcomes after radical gastrectomy for gastric cancer,” Surgery, vol. 161, no. 3, pp. 680–693, 2017.

[24] J. R. Lieffers, O. F. Bathe, K. Fassbender, M. Winget, and V. E. Baracos, “Sarcopenia is associated with postoperative infection and delayed recovery from colorectal cancer resection surgery,” British Journal of Cancer, vol. 107, no. 6, pp. 931–936, 2012.

[25] D. Makiuara, R. Ono, J. Inoue et al., “Impact of sarcopenia on unplanned readmission and survival after esophagectomy in patients with esophageal cancer,” Annals of Surgical Oncology, vol. 25, no. 2, pp. 456–464, 2018.

[26] B. Shi, S. Liu, J. Chen et al., “Sarcopenia is associated with perioperative outcomes in gastric cancer patients undergoing gastrectomy,” Annals of Nutrition and Metabolism, vol. 75, no. 4, pp. 213–222, 2019.

[27] R. Matsui, N. Inaki, and T. Tsuji, “Impact of preoperative muscle quality on postoperative severe complications after radical gastrectomy for gastric cancer patients,” Annals of Gastroenterological Surgery, vol. 5, no. 4, pp. 510–518, 2021.

[28] H. Wang, R. Yang, J. Xu, K. Fang, M. Abdelrahim, and L. Chang, “Sarcopenia as a predictor of postoperative risk of complications, mortality and length of stay following gastrointestinal oncological surgery,” Annals of the Royal College of Surgeons of England, vol. 103, no. 9, pp. 630–637, 2021.

[29] F. Chen, J. Chi, Y. Liu, L. Fan, and K. Hu, “Impact of preoperative sarcopenia on postoperative complications and prognosis of gastric cancer resection: a meta-analysis of cohort studies,” Archives of Gerontology and Geriatrics, vol. 98, Article ID 104534, 2022.

[30] Japanese Gastric Cancer Association, “Japanese gastric cancer treatment guidelines 2014 (ver. 4),” Gastric Cancer, vol. 20, pp. 1–19, 2017.

[31] D. Dindo, N. Demartines, and P.-A. Clavien, “Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey,” Annals of Surgery, vol. 240, no. 2, pp. 205–213, 2004.

[32] R. Asaoka, T. Kawamura, R. Makuchi et al., “Risk factors for 30-day hospital readmission after radical gastrectomy: a single-center retrospective study,” Gastric Cancer, vol. 22, no. 2, pp. 413–420, 2019.

[33] C.-L. Zhuang, S.-L. Wang, D.-D. Huang et al., “Sarcopenia predicts readmission and mortality in elderly patients with gastric cancer after radical gastrectomy: analysis from a large-scale prospective study,” Clinical Nutrition, vol. 39, no. 7, pp. 2301–2310, 2020.

[34] L.-K. Chen, L.-K. Liu, J. Wook et al., “Sarcopenia in Asia: consensus report of the Asian working group for sarcopenia,” Journal of the American Medical Directors Association, vol. 15, no. 2, pp. 95–101, 2014.

[35] A.-H. J. Cruz-Jentoft, J. P. Baeyens, J. M. Bauer et al., “Sarcopenia: European consensus on definition and diagnosis: report of the European working group on sarcopenia in older people,” Age and Ageing, vol. 39, no. 4, pp. 412–423, 2010.

[36] J. Yu, C.-L. Zhuang, S.-J. Shao et al., “Risk factors for postoperative fatigue after gastrointestinal surgery,” Journal of Surgical Research, vol. 194, no. 1, pp. 114–119, 2015.

[37] E. I. Williams and F. Fitton, “Factors affecting early unplanned readmission of elderly patients to hospital,” BMJ, vol. 297, no. 6651, pp. 784–787, 1988.

[38] S. K. Kamarajah, J. Bundred, and B. H. L. Tan, “Body composition assessment and sarcopenia in patients with gastric cancer: a systematic review and meta-analysis,” Gastric Cancer, vol. 22, no. 1, pp. 10–22, 2019.

[39] T. J. Miller, C. C. Skeetcher, L. A. Barnes, A. Y. Li, and A. Momeni, “Sarcopenia is a risk factor for infection for patients undergoing abdominoperineal resection and flap-based reconstruction,” Plastic and Reconstructive Surgery-Global Open, vol. 7, no. 7, Article ID e2343, 2019.

[40] M. Yang, X. Hu, H. Wang, L. Zhang, Q. Hao, and B. Dong, “Sarcopenia predicts readmission and mortality in elderly patients in acute care wards: a prospective study,” Journal of Cachexia, Sarcopenia and Muscle, vol. 8, no. 2, pp. 251–258, 2017.

[41] G. Gavazzi, S. Colatruglio, A. Sironi, V. Mazzaferrro, and R. Miceli, “Importance of early nutritional screening in patients with gastric cancer,” British Journal of Nutrition, vol. 106, no. 12, pp. 1773–1778, 2011.
[44] S. W. Ryu and I. H. Kim, "Comparison of different nutritional assessments in detecting malnutrition among gastric cancer patients," *World Journal of Gastroenterology*, vol. 16, no. 26, pp. 3310–3317, 2010.

[45] B. Jie, Z.-M. Jiang, M. T. Nolan, S.-N. Zhu, K. Yu, and J. Kondrup, "Impact of preoperative nutritional support on clinical outcome in abdominal surgical patients at nutritional risk," *Nutrition*, vol. 28, no. 10, pp. 1022–1027, 2012.

[46] W. Zhou, X. Xu, J. Yan, and Y. Mou, "Nutritional risk is still a clinical predictor of postoperative outcomes in laparoscopic abdominal surgery," *Surgical Endoscopy*, vol. 27, no. 7, pp. 2569–2574, 2013.

[47] M.-C. Kim, K.-H. Kim, and G.-J. Jung, "A 5 year analysis of readmissions after radical subtotal gastrectomy for early gastric cancer," *Annals of Surgical Oncology*, vol. 19, no. 8, pp. 2459–2464, 2012.

[48] S.-L. Wang, C.-L. Zhuang, D.-D. Huang et al., "Sarcopenia adversely impacts postoperative clinical outcomes following gastrectomy in patients with gastric cancer: a prospective study," *Annals of Surgical Oncology*, vol. 23, no. 2, pp. 556–564, 2016.

[49] C. M. M. Prado and S. B. Heymsfeld, "Lean tissue imaging," *Journal of Parenteral and Enteral Nutrition*, vol. 38, no. 8, pp. 940–953, 2014.