ORIGINAL ARTICLE

Observational Study

Predictive value of frailty assessment tools in patients undergoing surgery for gastrointestinal cancer: An observational cohort study

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Abstract

BACKGROUND
Few studies have simultaneously compared the predictive value of various frailty assessment tools for outcome measures in patients undergoing gastrointestinal cancer surgery. Therefore, it is difficult to determine which assessment tool is most relevant to the prognosis of this population.

AIM
To investigate the predictive value of three frailty assessment tools for patient prognosis in patients undergoing gastrointestinal cancer surgery.

METHODS
This single-centre, observational, prospective cohort study was conducted at the Affiliated Lianyungang Hospital of Xuzhou Medical University from August 2021 to July 2022. A total of 229 patients aged ≥ 18 years who underwent surgery for gastrointestinal cancer were included in this study. We collected baseline data on the participants and administered three scales to assess frailty: The comprehensive geriatric assessment (CGA), Fried phenotype and FRAIL scale. The outcome measures were the postoperative severe complications and increased hospital

costs.

RESULTS
The prevalence of frailty when assessed with the CGA was 65.9%, 47.6% when assessed with the Fried phenotype, and 34.9% when assessed with the FRAIL scale. Using the CGA as a reference, kappa coefficients were 0.398 for the Fried phenotype and 0.291 for the FRAIL scale (both $P < 0.001$). Postoperative severe complications and increased hospital costs were observed in 29 (12.7%) and 57 (24.9%) patients, respectively. Multivariate logistic analysis confirmed that the CGA was independently associated with increased hospital costs (odds ratio = 2.298, 95% confidence interval: 1.044-5.057; $P = 0.039$). None of the frailty assessment tools were associated with postoperative severe complications.

CONCLUSION
The CGA was an independent predictor of increased hospital costs in patients undergoing surgery for gastrointestinal cancer.

Key Words: Gastrointestinal cancer; Frailty; Assessment tools; Prognostic; Complication; Hospital costs

Core Tip: Few studies have simultaneously compared the predictive value of various frailty assessment tools for the prognosis in patients undergoing gastrointestinal cancer surgery. Therefore, we investigated the predictive power of the comprehensive geriatric assessment (CGA), Fried phenotype and FRAIL scale for the prognosis of patients undergoing surgery for gastrointestinal cancer. There was a high prevalence of preoperative frailty. Scores on the CGA were positively related to patients' increased hospital costs.

INTRODUCTION

Gastric and colorectal cancers have high morbidity and mortality rates in China and are a heavy burden on China's population health[1]. Surgery is the mainstay of treatment for patients with gastrointestinal cancer; however, surgical stress poses a challenge to patients[2,3]. It is important to identify the factors that affect postoperative adverse outcomes of patients, which can help us recognise the importance of frailty in evaluating patients before surgery. This can also provide a theoretical basis for formulating corresponding intervention measures. As such, frailty has gradually become a concern in recent years. It is considered a group of syndromes caused by a decreased physiological reserve or multisystem disorder resulting in increased vulnerability and weakened stress tolerance[4]. When frail patients attempt to cope with stressors (*e.g.*, surgery), it can easily lead to disability, falls, fractures and other adverse clinical outcomes. McGovern *et al*[5] and Ding *et al*[6] found that patients undergoing colorectal and gastric cancer surgery had a large range of difference in their prevalence of preoperative frailty, but it remained at a high level of 12.0% to 56.0% and 8.5% to 45.9%, respectively. Frailty was found to be an independent predictor of postoperative complications, mortality and overall survival in patients undergoing gastrointestinal cancer surgery[7-11]. It should be noted that frail patients may increase the incidence of severe complications due to their decreased ability to cope with stress, and frailty has the potential to compromise patient recovery following surgery, thereby increasing the cost of associated treatment, care and medications.

Currently, there is no consensus on the best frailty screening tool for surgical patients with gastrointestinal cancer[12]. Clegg *et al*[13] stated that the comprehensive geriatric assessment (CGA) is the gold standard for frailty assessment. The CGA includes multiple dimensions and is widely recommended for clinical use. However, the CGA is time consuming and requires a professionally trained healthcare provider. The Fried phenotype proposed by Fried was endorsed by the American College of Surgeons and the American Geriatrics Society for preoperative frailty assessment[14]. The Fried phenotype assessment is based on both self-assessment and objective measures and is a commonly used frailty assessment tool in clinical practice[15]. However, because the Fried phenotype assessment measures patients' physical activity, it can only be performed by medically stable and ambulatory patients. The FRAIL scale, proposed by the International Association for Nutrition, Health, and Aging, is recommended for frailty screening by the Australian and New Zealand Society for Sarcopenia and Frailty Research[16]. The FRAIL scale is based on patient self-report and is simple and quick to complete, facilitating clinical implementation. However, it does not distinguish between frailty and comorbidities. Interestingly, the FRAIL scale has, to date, not been used for patients undergoing gastrointestinal cancer surgery.

These three scales have their own advantages and disadvantages and differ in terms of items and dimensions. Few studies have simultaneously compared the predictive value of the three frailty assessment tools for patient prognosis. Therefore, it is difficult to determine which assessment tool is most relevant to the prognosis of patients undergoing gastrointestinal cancer surgery[17,18]. Thus, we prospectively analysed whether the three frailty scales were predictive of postoperative severe complications and increased hospital costs of patients undergoing gastrointestinal cancer surgery. We also determined which assessment tool was most associated with the measured outcomes by odds ratio.

MATERIALS AND METHODS

Patients

This single-centre, observational, prospective cohort study was conducted at the Lianyungang Hospital of Xuzhou Medical University from August 2021 to July 2022. The inclusion criteria were as follows: (1) Age ≥ 18 years; (2) Patients whose first pathological diagnosis was gastric, colon or rectal cancer; (3) Patients who underwent elective radical surgery; and (4) Patients who had complete clinical data that could be obtained. The exclusion criteria were as follows: (1) Patients who had cancer combined with other sites of malignant cancers; (2) Patients with a psychiatric history; and (3) Patients who were unable to cooperate with and complete data collection. The study was approved by the Ethics Committee of the Affiliated Lianyungang Hospital of Xuzhou Medical University, Jiangsu, China (ethics approval number: KY-20211029001-01) and was performed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all participants in this study.

Measures

CGA: A CGA typically assesses comorbidities, polypharmacy, functional status, cognition, psychological status and nutritional status[19-21]. In this study, the assessment tools and cut-off values included in the CGA were as follows: Charlson Comorbidity Index (CCI) ≥ 3 was considered multimorbidity[22]; ≥ 5 types of medication prescribed was classified as polypharmacy[22]; Barthel index (BI) < 100 or instrumental activities of daily living < 8 was considered impaired functional status[22,23]; cognition was assessed using the Mini-Mental State Examination, and cognitive impairment was defined according to the patient's education, in which illiteracy was ≤ 17, primary education was ≤ 20 and junior high school education or above was ≤ 24[24]; the Hospital Anxiety and Depression Scale was used to assess anxiety and depression, and anxiety scores or depression scores ≥ 8 were considered an impaired psychological status [25]; a Patient-Generated Subjective Global Assessment score ≤ 4 was considered malnutrition[26]. Based on previous studies, impairment in ≥ 2 domains within the CGA was defined as frailty[19,21].

Fried phenotype: The Fried phenotype includes five items: Weight loss, slowness, exhaustion, low physical activity and weakness. Handgrip strength was measured using an electronic handgrip dynamometer (EH101, Xiangshan, China); activity was assessed using the short form of the International Short Physical Activity Questionnaire[27]; and the criteria for other items were based on the Taiwanese version of the Fried phenotype cut-off[28]. Regarding scoring, there is one point per item according to the assessment criteria of said item. The total score can range from 0-5, with a score of 0 indicating robust, 1-2 indicating pre-frailty, and ≥ 3 indicating frailty[29]. Patients with Fried phenotype scores ≥ 3 were included in the frailty group and those with Fried phenotype scores of 0-2 were included in the non-frailty group[30].

FRAIL scale: The FRAIL scale includes five items: Fatigue, resistance, illness, ambulation and weight loss. The items are based on patients' self-assessment. There is one point for each item. The total score can range from 0-5, with 0 indicating robust, 1-2 indicating pre-frailty, and ≥ 3 indicating frailty[31]. Patients who scored ≥ 3 on the FRAIL scale were included in the frailty group and those who scored 0 to 2 were included in the non-frailty group[32].

Clinical data collection

Data collection was performed one day before surgery and included: (1) Baseline demographic data, including age, sex, body mass index (BMI), smoking history, drinking history, upper arm circumference, waist circumference, hip circumference and calf circumference; (2) Clinical data, including cancer type, CCI score, polypharmacy, neoadjuvant therapy, the American Society of Anesthesiologists (ASA) classification, Karnofsky Performance Scale (KPS) score, operative method, operation time, tumour node metastasis (TNM) stage, histological grade and postoperative length of stay; and (3) Laboratory data, including haemoglobin (HB), white blood cell count, platelets, lymphocyte count, lymphocyte ratio, creatinine, haematocrit, albumin and total protein. The scale can be filled out by the patient themselves, or the researcher can inform the patient of the items and help them fill it out. It was necessary to further confirm whether the patient met the inclusion and exclusion criteria after we collected patient data after surgery because the definite TNM stage of the patient and the possible suspension of surgery could not be determined before surgery.

Outcome measures

The outcome measures were severe complications and increased hospital costs. Only postoperative severe complications that developed during hospital were considered. Based on previous studies, severe complications were considered as Clavien-Dindo classification ≥ 3[33]. Increased hospital costs were defined as costs greater than the 75th percentile of the entire cohort[6]. All outcome measures were obtained using an electronic information system.

Sample size

We calculated the sample size for postoperative severe complications based on a previous study[34], the complication rate was 43% in frail patients and 17% in non-frail patients. We set an *α*-value of 0.05 and a power of 80% to calculate that 96 patients should be included in the study.

Statistical analysis

Taking the CGA as a reference, the kappa coefficient was used to analyse its agreement with the Fried phenotype and the FRAIL scale. The measurement data with a normal distribution were described using mean ± SD, and independent samples *t* tests were used for comparison between groups. The measurement data with a biased distribution were described by median and interquartile ranges, and the Mann-Whitney *U* test was used for comparison between groups. The enumeration data were described by frequency and percentage, and the χ^2 test, continuity correction χ^2 test and Mann-Whitney *U* test were used for comparison between groups. Risk factors for severe complications and increased hospital costs were analysed using the above statistical methods and univariate logistic regression. Factors with $P < 0.10$ in the univariate analysis combined with each of the three frailty assessment tools were included in a multivariate logistic regression model. All tests were two-sided, and $P < 0.05$ was considered statistically significant. SPSS version 25.0 (SPSS Inc., Chicago, IL, United States) was used for all statistical analyses.

RESULTS

Baseline patient characteristics

A total of 229 patients with gastrointestinal cancer who underwent surgery met our inclusion criteria and were enrolled in the study. Severe complications and increased hospital costs were observed in 29 (12.7%) and 57 (24.9%) patients, respectively. There were 13 (5.7%) patients with 3, and 16 (7.0%) patients with 4. The median for hospital costs was 65031 renminbi (RMB), with interquartile ranges of 58125 and 78973 RMB. Among them, 141 (61.6%) were men and 88 (38.4%) were women. Patients were aged 30-88 years, with a mean age of 66.31 years. Patients had a BMI (kg/m^2) ranging from 15.56-33.98 kg/m^2, with a mean of 23.71 kg/m^2. Regarding cancer type, 83 (36.2%) patients had gastric cancer, 81 (35.4%) had colon cancer, and 65 (28.4%) had rectal cancer. Based on the CGA, there were significant differences in age, BMI, CCI score, upper arm circumference, hip circumference, calf circumference, HB, lymphocyte ratio, haematocrit, albumin, ASA classification, KPS score, cancer type, operative method, histological grade, and hospital costs between frail and non-frail patients (all $P < 0.05$). The baseline characteristics of the frail and non-frail patients corresponding to each assessment tool are presented in Table 1.

Frailty assessment

The prevalence of preoperative frailty assessed using the CGA, Fried phenotype and FRAIL scale was 65.9%, 47.6% and 34.9%, respectively. Taking the CGA as a reference, kappa coefficients were 0.398 and 0.291 for the Fried phenotype and the FRAIL scale (both $P < 0.001$). Moreover, it showed poor agreement between scales for frailty assessment.

Univariate analysis of outcome measures

Our results showed that sex, age, smoking history, drinking history, lymphocyte count, albumin, total protein, ASA classification, and operation time were contributing factors of severe complications (Table 2). Smoking history, neoadjuvant therapy, waist circumference, ASA classification, KPS score, cancer type, histological grade, severe complications and postoperative length of stay were factors influencing increased hospital costs.

Association of frailty with outcome measures

The three frailty assessment tools were combined with factors with $P < 0.10$ from the univariate analysis of outcome measures (Table 3). The univariate and multivariate analyses showed that frailty assessed using all assessment tools was not associated with severe complications (all $P < 0.05$). Other independent factors included age, drinking history, albumin and operation time (all $P < 0.05$). Both univariate and multivariate analyses showed that the CGA was associated with increased hospital costs (odds ratio = 2.298, 95% confidence interval: 1.044-5.057; $P = 0.039$). Other independent factors included postoperative length of stay and neoadjuvant therapy (both $P < 0.05$).

DISCUSSION

We prospectively analysed whether the three frailty scales predicted severe complications and increased hospital costs in patients undergoing gastrointestinal cancer surgery. Our study revealed the CGA was an independent predictor of increased hospital costs in this population.

Our results showed a high prevalence of preoperative frailty in patients with gastrointestinal cancer undergoing surgery, ranging from 34.9% (FRAIL) to 65.9% (CGA). A study by Chen *et al*[21] found that the prevalence of frailty using the CGA, Geriatric 8 and the Flemish version of the Triage Risk Screening Tool ranged from 40.9% to 75.0% in newly diagnosed all types of cancer patients aged ≥ 20 years, similar to the results of this study. Zhang *et al*[35] showed that the prevalence of preoperative frailty in older adult patients with gastric and colorectal cancer was 43.8%, which is also

Table 1 Baseline patient characteristics

Variables	Comprehensive geriatric assessment			Fried phenotype			FRAIL scale		
	Non-frail (*n* = 78)	Frail (*n* = 151)	*P* value	Non-frail (*n* = 120)	Frail (*n* = 109)	*P* value	Non-frail (*n* = 149)	Frail (*n* = 80)	*P* value
Male, *n* (%)	53 (67.9)	88 (58.3)	0.154	78 (65.0)	63 (57.8)	0.263	96 (64.4)	45 (56.3)	0.225
Age, yr	66 (57-71)	68 (62-76)	0.020	65 (57-71)	70 (63-76)	< 0.001	66 (58-72)	69 (63-76)	0.012
BMI, kg/m^2	24.45 ± 3.47	23.33 ± 3.39	0.021	24.35 ± 3.12	23.0 ± 3.68	0.003	23.95 ± 3.27	23.27 ± 3.75	0.158
Smoking history, *n* (%)	35 (44.9)	71 (47.0)	0.757	62 (51.7)	44 (40.4)	0.087	76 (51.0)	30 (37.5)	0.051
Drinking history, *n* (%)	32 (41.0)	68 (45.0)	0.562	61 (50.8)	39 (35.8)	0.022	70 (47.0)	30 (37.5)	0.168
Neoadjuvant therapy, *n* (%)	2 (2.6)	10 (6.6)	0.321	4 (3.3)	8 (7.3)	0.174	5 (3.4)	7 (8.8)	0.151
CCI score, *n* (%)	78 (100)		0.001			0.091			0.003
0-2	0 (0)	133 (88.1)		114 (95.0)	97 (89.0)		143 (96.0)	68 (85.0)	
≥ 3	0 (0)	18 (11.9)		6 (5.0)	12 (11.0)		6 (4.0)	12 (15.0)	
Polypharmacy, *n* (%)		6 (4.0)	0.178	1 (0.8)	5 (4.6)	0.173	0 (0)	6 (7.5)	0.003
Upper arm circumference, cm	29.5 ± 2.5	28.2 ± 2.9	0.001	29.3 ± 2.4	27.8 ± 3.1	< 0.001	29.1 ± 2.6	27.8 ± 3.1	0.001
Waist circumference, cm	89.8 ± 9.8	87.5 ± 9.7	0.091	89 ± 39.4	87.1 ± 10.0	0.099	88.7 ± 9.8	87.3 ± 9.6	0.303
Hip circumference, cm	96.4 ± 6.3	93.6 ± 7.4	0.006	96.0 ± 6.0	92.9 ± 7.9	0.001	95.1 ± 6.7	93.7 ± 7.9	0.157
Calf circumference, cm	34.8 ± 3.2	33.0 ± 3.4	< 0.001	34.8 ± 3.0	32.3 ± 3.5	< 0.001	34.2 ± 3.2	32.5 ± 3.6	0.001
HB, g/L	130 (109-137)	116 (97-133)	0.003	130 (114-141)	108 (92-128)	< 0.001	127 (111-138)	106 (87-128)	< 0.001
WBC, 10^9/L	5.75 (4.50-6.84)	6.00 (4.70-7.22)	0.184	5.85 (4.52-6.97)	5.93 (4.72-6.90)	0.598	5.80 (4.53-6.81)	6.00 (4.76-7.54)	0.186
Platelet, 10^{12}/L	209 (178-244)	228 (186-270)	0.171	212 (181-249)	228 (186-274)	0.255	219 (179-254)	227 (190-278)	0.265
Lymphocyte count, 10^9/L	1.56 (1.17-1.97)	1.39 (1.07-1.77)	0.070	1.47 (1.17-1.96)	1.40 (1.04-1.74)	0.046	1.44 (1.16-1.94)	1.40 (0.92-1.74)	0.067
Lymphocyte ratio, %	28.6 (23.0-33.0)	23.5 (18.4-31.3)	0.002	28.2 (21.8-33.3)	23.4 (17.3-29.1)	0.003	27.6 ± 9.2	23.5 ± 9.7	0.013
Creatinine, μmmol/L	63.4 (53.8-71.0)	58.2 (48.5-72.3)	0.127	63.6 (54.4-73.2)	55.3 (47.0-67.5)	0.001	62.5 (52.6-72.5)	56.7 (47.3-69.5)	0.074
Haematocrit, %	39.3 (34.1-41.9)	35.4 (31.3-40.5)	0.003	39.3 (34.9-42.8)	33.5 (29.4-39.0)	< 0.001	38.8 (34.1-41.5)	32.7 (28.0-39.1)	< 0.001
Albumin, g/L	38. ± 13.7	36.4 ± 4.0	0.002	38.4 ± 3.5	35.4 ± 3.9	< 0.001	37.8 ± 3.7	35.4 ± 4.0	< 0.001
Total protein, g/L	62.7 ± 5.8	61.2 ± 5.9	0.059	62.8 ± 5.6	60.5 ± 6.0	0.003	62.4 ± 5.4	60.4 ± 6.6	0.011
ASA classification, *n* (%)			0.036			0.009			0.011
I-II	55 (70.5)	85 (56.3)		83 (69.2)	57 (52.3)		100 (67.1)	40 (50.0)	
III-IV	23 (29.5)	66 (43.7)		37 (30.8)	52 (47.7)		49 (32.9)	40 (50.0)	
KPS score, *n* (%)			< 0.001			< 0.001			< 0.001
≥ 70	76 (97.4)	118 (78.1)		119 (99.2)	75 (68.8)		144 (96.6)	50 (62.5)	
< 70	2 (2.6)	33 (21.9)		1 (0.8)	34 (31.2)		5 (3.4)	30 (37.5)	
Cancer type, *n* (%)			0.011			0.216			0.104
Stomach	18 (23.1)	65 (43.0)		40 (33.3)	43 (39.4)		49 (32.9)	34 (42.5)	
Colon	32 (41.0)	49 (32.5)		40 (33.3)	41 (37.6)		51 (34.2)	30 (37.5)	
Rectum	28 (35.9)	37 (24.5)		40 (33.3)	25 (22.9)		49 (32.9)	16 (20.0)	
Operative method, *n* (%)			0.005			0.008			0.187
Open surgery	13 (16.7)	52 (34.4)		25 (20.8)	40 (36.7)		38 (25.5)	27 (33.8)	

Laparoscopic surgery	65 (83.3)	99 (65.6)		95 (79.2)	69 (63.3)		111 (74.5)	53 (66.3)	
Operative time, min	156 (123-202)	169 (120-210)	0.578	165 (120-217)	163 (121-195)	0.486	165 (125-210)	160 (119-200)	0.412
TNM stage, *n* (%)			0.057			0.328			0.911
I-II	55 (70.5)	87 (57.6)		78 (65.0)	64 (58.7)		92 (61.7)	50 (62.5)	
III	23 (29.5)	64 (42.4)		42 (35.0)	45 (41.3)		57 (38.3)	30 (37.5)	
Histological grade, *n* (%)			0.012			0.545			0.374
Poorly differentiated	28 (35.9)	78 (51.7)		55 (45.8)	51 (46.8)		67 (45.0)	39 (48.8)	
Moderately differentiated	33 (42.3)	55 (36.4)		43 (35.8)	45 (41.3)		56 (37.6)	32 (40.0)	
Highly differentiated	17 (21.8)	18 (11.9)		22 (18.3)	13 (11.9)		26 (17.4)	9 (11.3)	
Postoperative length of stay, d	14 (12, 16)	14 (12, 19)	0.184	14 (12, 18)	15 (13, 18)	0.162	14 (12, 17)	15 (13, 19)	0.029
Hospital costs, RMB	62341 (58067, 71180)	67697 (59097, 81720)	0.006	63148 (57893, 74841)	67764 (59156, 82804)	0.047	63477 (57719, 76170)	69031 (59596, 82043)	0.023
Severe complications, *n* (%)	6 (7.7)	23 (15.2)	0.104	13 (10.8)	16 (14.7)	0.382	16 (10.7)	13 (16.3)	0.232

Data are presented as means ± SD, medians (interquartile ranges) or *n* (%).

CCI: Charlson Comorbidity Index; BMI: Body mass index; HB: Haemoglobin; WBC: White blood cell; ASA: American Society of Anesthesiologists; KPS: Karnofsky Performance Scale; TNM: Tumour node metastasis.

within the range of our findings. Conversely, Yin *et al*[36] assessed frailty using the 54-item Frailty Index, 9-item Clinical Frailty Scale and FRAIL scale and found that the prevalence of preoperative frailty in older adult patients undergoing elective abdominal surgery was 32.5%, 36.6%, and 43.8%, respectively, which is slightly lower than our findings. This may be related to the fact that our study population included only patients with gastrointestinal cancer. Due to the inherent and therapeutic factors of gastrointestinal cancer, their physiological and psychological reserve abilities are more susceptible to stress, leading to adverse outcomes[35], which likely contribute to the high prevalence of frailty in this population. The poor agreement between the CGA and the Fried phenotype and FRAIL scale showed that there were large differences between assessment tools for the diagnosis of frailty. In addition, the CGA was more sensitive at identifying frailty than the other two scales, possibly because the CGA includes more comprehensive dimensions, these being the physical and psychological dimensions. Psychological problems such as anxiety and depression are more common in cancer patients[37]; thus, the CGA is more sensitive at identifying frailty. The Fried phenotype and the FRAIL scale focus only on the physical dimensions and thus assess the prevalence of frailty as lower than what the CGA would assess[38].

Our study revealed that the CGA, Fried phenotype and FRAIL scale did not independently predict severe complications in patients with gastrointestinal cancer. Reisinger *et al*[39] and Richards *et al*[7] showed that frailty is not an independent influencing factor for severe complications in patients undergoing colorectal cancer surgery ($P = 0.19$ and $P = 0.62$), consistent with our study results. Conversely, the results of Lo *et al*[40] showed that frailty increases the risk of postoperative severe complications. This may be due to differences in the assessment tools used, study populations and geography. Additionally, none of the frailty assessment instruments in our study included a social dimension. Since the global coronavirus disease 2019 pandemic in 2020, social distancing has become an important public health initiative. Social frailty may also have an impact on adverse short-term outcomes in patients. Thus, social frailty items can be used as part of frailty assessment in the future to further explore the elements of frailty assessment tools that can predict postoperative complications in patients undergoing gastrointestinal cancer surgery. This will lead to the creation of more comprehensive assessment tools.

In addition, our study revealed that the CGA scores were positively related to patients' increased hospital costs. In a cohort study of 52012 adult patients undergoing surgery, Shaw *et al*[41] showed that patients' frailty led to an increase in healthcare costs by $6048. Lee *et al*[42] stated that hospital costs were higher in frail patients (adjusted odds ratio = 1.46, 95% confidence interval: 1.46-1.46, $P < 0.001$), possibly because of longer hospital stays and more expenditures for rescues and the intensive care unit. Considering that most of the patients in this study made a living through farming and had poor family financial situations, increased hospital costs may have aggravated their psychological and economic burden, thus affecting their attitude towards treatment. Therefore, it is of great significance for us to use the CGA to evaluate patients' frailty before surgery and provide psychological counselling for them.

Our study has certain strengths. First, this is the first study to use the FRAIL scale to assess frailty in patients with gastrointestinal cancer undergoing surgery. Second, most severe complications occur in hospitals and need to be highly valued, while there are few reports on our population. Third, we used prospective research methods to investigate the predictive value of various frailty assessment tools on patient outcomes, which has not been much reported in previous studies.

Variables	Severe complications (-) (*n* = 200)	Severe complications (+) (*n* = 29)	*P* value	OR (95%CI)	*P* value	increased hospital costs (-) (*n* = 172)	increased hospital costs (+) (*n* = 57)	*P* value	OR (95%CI)	*P* value
Table 2 Predictors of severe complications and increased hospital costs (univariate analysis)										
Male, *n* (%)	119 (59.5)	22 (79.5)	0.090	0.467 (0.191, 1.145)	0.096	101 (58.7)	40 (70.2)	0.123	0.605 (0.318, 1.151)	0.125
Age, yr	66 (58-73)	70 (65-77)	0.004	1.070 (1.022, 1.120)	0.004	67 (58, 73)	68 (64, 74)	0.212	1.024 (0.993, 1.056)	0.124
BMI, kg/m^2	23.52 (21.22-25.72)	23.73 (21.22-26.64)	0.588	1.024 (0.916, 1.146)	0.671	23.52 (21.28, 25.53)	23.59 (20.83, 26.30)	0.876	0.993 (0.911, 1.084)	0.883
Smoking history, *n* (%)	87 (43.5)	19 (65.5)	0.026	2.468 (1.092, 5.576)	0.030	73 (42.4)	33 (57.9)	0.043	1.865 (1.017, 3.420)	0.044
Drinking history, *n* (%)	81 (40.5)	19 (65.5)	0.011	2.791 (1.234, 6.313)	0.014	70 (40.7)	30 (52.6)	0.115	1.619 (0.886, 2.957)	0.117
Neoadjuvant therapy, *n* (%)	12 (6.0)	0 (0)	0.363	NA[1]		5 (2.9)	7 (12.3)		4.676 (1.422, 15.376)	0.016
CCI score, *n* (%)										
0-2	184 (92.0)	27 (93.1)	1.000	0.852 (0.185, 3.912)	0.837	158 (91.9)	53 (93.0)	1.000	0.852 (0.269, 2.701)	0.785
≥ 3	16 (8.0)	2 (6.9)	1.000	1.393 (0.157, 12.362)	0.766	14 (8.1)	4 (7.0)	0.336	3.130 (0.614, 15.963)	0.170
Polypharmacy, *n* (%)	5 (2.5)	1 (3.4)				3 (1.7)	3 (5.3)			
Upper arm circumference, cm	28.7 ± 2.8	28.3 ± 3.3	0.453	0.949 (0.827, 1.088)	0.452	28.6 ± 2.8	28.8 ± 2.9	0.633	1.026 (0.923, 1.140)	0.632
Waist circumference, cm	87.9 ± 9.4	90.3 ± 11.9	0.318	1.025 (0.985, 1.067)	0.226	87.6 ± 9.7	90.1 ± 9.7	0.094	1.027 (0.995, 1.059)	0.095
Hip circumference, cm	94.0 (90.7-98.8)	96.0 (89.5-101.3)	0.454	0.998 (0.945, 1.054)	0.938	94.5 ± 7.0	94.9 ± 7.6	0.663	1.009 (0.968, 1.053)	0.661
Calf circumference, cm	33.8 (31.5-35.9)	34.6 (31.8-37.5)	0.719	0.989 (0.883, 1.107)	0.843	33.6 ± 3.4	33.7 ± 3.5	0.768	1.013 (0.928, 1.106)	0.766
HB, g/L	121 (103-135)	119 (100-135)	0.872	0.998 (0.982, 1.015)	0.836	124 (104, 135)	112 (97, 134)	0.208	0.992 (0.979, 1.005)	0.206
WBC, 10^9/L	5.91 (4.71-6.99)	5.93 (4.20-6.68)	0.441	0.952 (0.782, 1.158)	0.621	5.85 (4.52, 7.03)	5.96 (5.14, 6.85)	0.557	1.008 (0.874, 1.162)	0.917
Platelet, 10^{12}/L	221 (182-263)	204 (168-247)	0.279	0.996 (0.990, 1.001)	0.147	220 (183, 260)	227 (168, 270)	0.809	0.999 (0.995, 1.003)	0.652
Lymphocyte count, 10^9/L	1.47 (1.16-1.88)	1.22 (1.03-1.77)	0.057	0.483 (0.218, 1.067)	0.072	1.42 (1.10, 1.84)	1.46 (1.20, 1.87)	0.509	1.043 (0.620, 1.756)	0.873
Lymphocyte ratio, %	26.4 ± 9.5	24.0 ± 9.8	0.198	0.972 (0.931, 1.015)	0.198	25.3 (20.4, 32.5)	23.6 (18.6, 31.3)	0.581	0.999 (0.968, 1.031)	0.962
Creatinine, μmmol/L	59.8 (49.8-71.4)	65.7 (55.1-71.3)	0.244	1.008 (0.992,	0.342	59.8 (50.5, 71.4)	61.1 (49.9, 71.0)	0.896	0.993 (0.977,	0.408

				1.023)					1.010)	
Haematocrit, %	37.2 (32.1-41.0)	35.9 (30.3-41.5)	0.981	0.994 (0.935, 1.058)	0.859	37.8 (32.5, 41.1)	35.0 (31.2, 41.1)	0.294	0.973 (0.928, 1.021)	0.262
Albumin, g/L	37.3 ± 3.9	34.9 ± 4.1	0.002	0.856 (0.772, 0.948)	0.003	37.2 ± 3.8	36.4 ± 4.3	0.236	0.955 (0.885, 1.030)	0.236
Total protein, g/L	61.8 (58.3-65.8)	58.9 (56.6-62.4)	0.012	0.921 (0.857, 0.989)	0.023	61.6 (58.0, 65.3)	60.5 (57.6, 64.7)	0.977	1.015 (0.965, 1.068)	0.567
ASA classification, *n* (%)										
I-II	127 (63.5)	13 (44.8)	0.054	2.141 (0.975, 4.701)	0.058	112 (65.1)	28 (49.1)	0.032	1.933 (1.054, 3.546)	0.033
III-IV	73 (36.5)	16 (55.2)				60 (34.9)	29 (50.9)			
KPS score, *n* (%)										
≥ 70	170 (85.0)	24 (82.8)	0.970	1.181 (0.418, 3.336)	0.754	150 (87.2)	44 (77.2)	0.069	2.014 (0.939, 4.323)	0.072
< 70	30 (15.0)	5 (17.2)				22 (12.8)	13 (22.8)			
Cancer type, *n* (%)										
Stomach	74 (37.0)	9 (31.0)	0.743	Reference		56 (32.6)	27 (47.4)	0.114	Reference	
Colon	69 (34.5)	12 (41.4)		1.430 (0.567, 3.604)	0.448	63 (36.6)	18 (31.6)		0.593 (0.295, 1.189)	0.141
Rectum	57 (28.5)	8 (27.6)		1.154 (0.419, 3.178)	0.782	53 (30.8)	12 (21.1)		0.470 (0.216, 1.021)	0.057
Operative method, *n* (%)										
Open surgery	58 (29.0)	7 (24.1)	0.587	1.284 (0.520, 3.169)	0.588	52 (30.2)	13 (22.8)	0.281	1.467 (0.729, 2.951)	0.283
Laparoscopic surgery	142 (71.0)	22 (75.9)				120 (69.8)	44 (77.2)			
Operative time, min	159 (120-202)	180 (135-225)	0.097	1.006 (1.000, 1.012)	0.053	157 (120, 196)	170 (131, 220)	0.157	1.004 (0.999, 1.009)	0.112
TNM stage, *n* (%)										
I-II	124 (62.0)	18 (62.1)	0.994	0.997 (0.447, 2.225)	0.994	111 (64.5)	31 (54.4)	0.171	1.526 (0.831, 2.802)	0.173
III	76 (38.0)	11 (37.9)				61 (35.5)	26 (45.6)			
Histological grade, *n* (%)										
Poorly differentiated	91 (45.5)	15 (51.7)	0.322	0.725 (0.408, 1.287)	0.272	74 (43.0)	32 (56.1)	0.073	0.674 (0.434, 1.048)	0.080
Moderately differentiated	76 (38.0)	12 (41.4)				69 (40.1)	19 (33.3)			
Highly differentiated	33 (16.5)	2 (6.9)				29 (16.9)	6 (10.5)			
Severe complications, *n* (%)	-	-	-	-	-	14 (8.1)	15 (26.3)	< 0.001	4.031 (1.804, 9.005)	0.001
Postoperative	-	-	-	-	-	14 (12, 16)	17 (14, 24)	<	1.160	<

length of stay, d				0.001	(1.094, 1.229)	0.001

[1]NA: Low number of observations.

Data are presented as means ± SD, medians (interquartile ranges) or *n* (%). CCI: Charlson Comorbidity Index; BMI: Body mass index; HB: Haemoglobin; WBC: White blood cell; ASA: American Society of Anesthesiologists; KPS: Karnofsky Performance Scale; TNM: Tumour node metastasis; OR: Odds ratio; CI: Confidence interval.

Table 3 Impact of frailty on severe complications and increased hospital costs by the multivariate logistic regression

	Frail group	Non-frail group	Univariate		Multivariate		
			Frailty: OR (95%CI)	*P* value	Frailty: OR (95%CI)	*P* value	Other significant predictors, OR (95%CI), *P* value
Severe complications							
Comprehensive geriatric assessment, N = 151, n = 78	23 (15.2)	6 (7.7)	2.156 (0.839, 5.541)	0.111	-	-	Age: 1.064 (1.010, 1.122); *P* = 0.019. Drinking history: 3.649 (1.504, 8.855); *P* = 0.004. Albumin: 0.880 (0.783, 0.989); *P* = 0.032. Operative time: 1.008 (1.001, 1.015); *P* = 0.022
Fried phenotype, N = 109, n = 120	16 (14.7)	13 (10.8)	1.416 (0.647, 3.098)	0.384	-	-	Age: 1.064 (1.010, 1.122); *P* = 0.019. Drinking history: 3.649 (1.504, 8.855); *P* = 0.004. Albumin: 0.880 (0.783, 0.989); *P* = 0.032. Operative time: 1.008 (1.001, 1.015); *P* = 0.022
FRAIL scale, N = 80, n = 149	13 (16.3)	16 (10.7)	1.112 (0.866, 1.428)	0.406	-	-	Age: 1.064 (1.010, 1.122); *P* = 0.019. Drinking history: 3.649 (1.504, 8.855); *P* = 0.004. Albumin: 0.880 (0.783, 0.989); *P* = 0.032. Operative time: 1.008 (1.001, 1.015); *P* = 0.022
Increased hospital costs							
Comprehensive geriatric assessment, N = 151, n = 78	46 (30.5)	11 (14.1)	2.668 (1.291, 5.513)	0.008	2.298 (1.044, 5.057)	0.039	Postoperative length of stay: 1.167 (1.098, 1.241); *P* < 0.001. Neoadjuvant therapy: 5.778 (1.601, 20.860); *P* = 0.007
Fried phenotype, N = 109, n = 120	33 (30.3)	24 (20.0)	1.737 (0.948, 3.183)	0.074	-	-	Postoperative length of stay: 1.168 (1.100, 1.241); *P* < 0.001. Neoadjuvant therapy: 6.348 (1.792, 22.484); *P* = 0.004
FRAIL scale, N = 80, n = 149	25 (31.3)	32 (21.5)	1.662 (0.900, 3.069)	0.105	-	-	Postoperative length of stay: 1.168 (1.100, 1.241); *P* < 0.001. Neoadjuvant therapy: 6.348 (1.792, 22.484); *P* = 0.004

N: Number in frailty group; n: Number in non-frailty group; OR: Odds ratio; CI: Confidence interval.

Our study had several limitations that need to be noted. First, this was a small, single-centre study, and the conclusions obtained need to be validated in patients from other regions and hospitals. Second, our study population included only patients with gastrointestinal cancer who underwent elective radical surgery. Patients who underwent emergency admission and palliative surgery were not included. Third, we did not analyse the different diseases in gastrointestinal cancer separately.

Finally, based on our study, more long-term outcome measures (including relapse-free survival time and overall survival) should be of interest. In addition, we hope to form a multidisciplinary team including nutritionists, psychologists, rehabilitation therapists, gastrointestinal surgeons, and nurses to help patients develop personalized pre-rehabilitation measures, which can be implemented at home, in the hospital or a combination of both. We should improve the frail state of patients before operation with as little expenditure as possible to reduce the hospitalization expenses of patients. A pre-rehabilitation program suitable for China's national conditions is urgently needed.

CONCLUSION

The prevalence of preoperative frailty was high in patients undergoing gastrointestinal cancer surgery, as assessed by different frailty scales. The CGA is an independent predictor of increased hospital costs in patients undergoing gastrointestinal cancer surgery. It is hoped that our study will arouse the attention of health care providers and the CGA should be included as part of routine preoperative risk assessment in patients undergoing surgery for gastrointestinal cancer.

ARTICLE HIGHLIGHTS

Research background

Few studies have simultaneously compared the predictive value of various frailty assessment tools for the prognosis in patients undergoing gastrointestinal cancer surgery. Therefore, it is difficult to determine which assessment tool is most relevant to the prognosis of this population.

Research motivation

We used three commonly used frailty assessment tools to investigate the status of preoperative frailty and to analyse their predictive value for prognosis in patients undergoing surgery for gastrointestinal cancer.

Research objectives

To investigate the predictive value of different frailty assessment tools for postoperative severe complications and increased hospital costs in patients undergoing surgery for gastrointestinal cancer.

Research methods

A single-centre, observational, prospective cohort study was conducted at the Affiliated Lianyungang Hospital of Xuzhou Medical University from August 2021 to July 2022. A total of 229 patients aged ≥ 18 years who underwent surgery for gastrointestinal cancer were included in this study. We collected baseline data on the participants and administered three scales to assess frailty: The comprehensive geriatric assessment (CGA), Fried phenotype and FRAIL scale. The outcome measures were postoperative severe complications and increased hospital costs.

Research results

The prevalence of frailty when assessed with the CGA was 65.9%, 47.6% when assessed with the Fried phenotype and 34.9% when assessed with the FRAIL scale. Using the CGA as a reference, kappa coefficients were 0.398 for the Fried phenotype and 0.291 for the FRAIL scale (both $P < 0.001$). Postoperative severe complications and increased hospital costs were observed in 29 (12.7%) and 57 (24.9%) patients, respectively. Multivariate logistic analysis confirmed that the CGA was independently associated with increased hospital costs (odds ratio = 2.298, 95% confidence interval: 1.044-5.057; $P = 0.039$). None of the frailty assessment tools were associated with postoperative severe complications.

Research conclusions

The CGA has a significant effect on increased hospital costs for patients undergoing gastrointestinal cancer surgery, and should be included as part of routine preoperative risk assessment in this population.

Research perspectives

More long-term outcome measures (including relapse-free survival time and overall survival) should be of interest. In addition, there is an urgent need for a pre-rehabilitation program which is suitable for China's national conditions to improve preoperative frailty in patients undergoing gastrointestinal cancer surgery.

FOOTNOTES

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