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Original Article

Preoperative prediction of adverse outcome after elective gastrointestinal surgery in older patients: three leading frailty instruments and the American Society of Anesthesiologists physical status

Yahui Xing[1,2*], Ziqing He[1*], Lei Wang[1], Hao Zhang[1], Yang Gao[1], Erwei Gu[1], Lei Zhang[1], Lijian Chen[1]

[1]*Department of Anesthesiology, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, P. R. China;* [2]*Anhui Province Taihe County People's Hospital, Taihe, Anhui, P. R. China.* [*]*Equal contributors.*

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Abstract: Objective: This study aimed to compare the ability of three frailty assessments to predict adverse outcomes after elective gastrointestinal surgery and analyze how frailty assessments impact the American Society of Anesthesiologists (ASA) risk prediction model. Methods: Frailty was measured using the FRAIL scale, Fried Phenotype (FP), and Clinical Frailty Scale (CFS), alongside ASA assessments before surgery. Univariate and logistic regression analyses were used to determine the predictive value of each method. The predictive abilities of the tools were assessed by the area under the receiver operating characteristic curves (AUCs) and their 95% confidence intervals (CIs). Results: After adjusting for age and other risk factors, logistic regression analysis revealed significant positive associations between preoperative frailty and postoperative total adverse systemic complications (odds ratios [ORs] [95% CIs]: FRAIL, 1.297 [0.943-1.785]; FP, 1.317 [0.965-1.798]; CFS, 2.046 [1.413-3.015]; $P < 0.001$). The CFS was the best predictor of any adverse systemic complications (AUC, 0.696; 95% CI, 0.640-0.748). The predictive abilities of the FRAIL scale (AUC, 0.613; 95% CI, 0.555-0.669) and FP (AUC, 0.615; 95% CI, 0.557-0.671) were similar. The CFS and ASA assessment combined (AUC, 0.697; 95% CI, 0.641-0.749) had a statistically improved AUC compared to the ASA assessment alone (AUC, 0.636; 95% CI, 0.578-0.691), illustrating their value for predicting any adverse systemic complications. Conclusion: Frailty instruments enhance the accuracy of predicting postoperative outcome in older adults. Clinicians should add frailty assessments before preoperative ASA, particularly the CFS, given its ease of use and clinical feasibility.

Keywords: Frailty, older adults, preoperative assessment, adverse outcomes, clinical frailty scale

Introduction

As the general population ages, there is an increasing need for surgery among older adults, especially as a result of some diseases, such as gastrointestinal tumors. Surgery and anesthesia are associated with increased physiologic and psychologic stress, which this population may not tolerate well [1]. Eighty-five percent of colorectal patients are over 60 years of age, and a lack of muscle strength and poor physical condition, which are increasingly common in older patients, are risk factors for postoperative complication [2]. Consequently, it is necessary to predict and prevent complications for patients undergoing surgery and reduce modifiable risk factors [3]. These steps will, in turn, reduce surgical delays, cancellations, and costs, and increase patient and staff satisfaction [4-7]. Numerous follow-up studies have demonstrated that the American Society of Anesthesiologists (ASA) physical status classifications are strongly associated with patient outcome, either independently or combined with other information [8-11]. However, despite its common use in surgical settings, there is considerable variability in the ASA physical status scores that anesthesiologists assign to specific patients [12, 13]. Misclassification can have several negative consequences, especially in emergencies, and tends to underestimate the number of predicted deaths [14, 15].

In recent years, the aging global population has drawn a considerable amount of attention to frailty, a syndrome associated with the accumulation of age- and disease-related deficits that increase the risk of adverse health outcome, including morbidity and mortality [16-20]. Various scales are currently available to measure frailty before surgery, and at least 27 frailty measures and/or definitions aiming to diagnose this syndrome have been published since 2001 [21, 22]. The Fried phenotype (FP) [16] is used to diagnose frailty [22] based on five measures of physical and physiological vulnerability: shrinking, weakness, exhaustion, slowness, and low physical activity level [16]. The FRAIL scale, a hybrid measure comprising components of both the FP and the Frailty Index (FI), consists of a five-item screening questionnaire with simple "yes" or "no" answers [23-25]. The Clinical Frailty Scale (CFS) is a clinical assessment-based tool developed by the Canadian Study of Health and Aging [17] that evaluates specific health domains, including comorbidity, function, and cognition, to generate a frailty score ranging from 1 (very fit) to 9 (terminally ill).

Previous studies have demonstrated that all three of these frailty assessments (the FP, FRAIL scale, and CFS) can predict adverse outcome following surgery [16, 17, 25-28]. However, it is unclear which frailty assessment paradigm is best for assessing perioperative risk. Moreover, previous studies have failed to compare frailty and ASA status and to determine whether frailty measures could improve the predictive value of ASA status for adverse postoperative outcome. Because there is no gold-standard method for validating the FP, FRAIL scale, and CFS, our primary objectives were to compare the abilities of these frailty instruments to predict adverse postoperative outcomes and to analyze the impact of frailty measures on the ASA risk prediction model. We hypothesized that each instrument would significantly improve the ASA classification's predictive accuracy and that a combination of frailty instruments and ASA classification would be statistically significantly superior to the ASA classification alone.

Methods

Study design and ethics

This study was designed as a prospective observational trial to evaluate the predictive power of different frailty tools for postoperative adverse outcomes and their impact on the ASA risk model. The trial protocol was approved by the Clinical Research Ethics Committee of the First Affiliated Hospital of Anhui Medical University Institutional Review Board (approval No. PJ2020-13-09). The study was registered with the Chinese Clinical Trial Registry (identifier ChiCTR2000039864) on November 12, 2020. All participants and/or their family members were informed of the study's purpose, and written informed consent was obtained before requesting any data. The ethics committee approved the practice of telephone follow-ups after surgery and access to medical records without additional written consent.

Study population

The study population consisted of patients aged 60 years or older who underwent gastrointestinal surgery between December 2020 and January 2022 and were in a stable disease stage. For feasibility reasons, we excluded patients undergoing urgent procedures or conservative treatment, cerebral apoplexy patients, patients with severe cognitive disorders or mental illness, patients who were unable to understand or provide consent, and patients who only underwent explorative laparoscopy/laparotomy. Patients who fulfilled the eligibility criteria were contacted by phone or in person and were subsequently interviewed for frailty assessment after they provided informed consent. **Figure 1** presents the number of patients who met the inclusion and exclusion criteria. A total of 294 patients completed the study.

Preoperative assessment

A research clinician was trained to conduct the screening and performed all frailty assessments 1 day before surgery. **Table 1** presents the definitions and calculation methods of the frailty assessments. The FP measured involuntary weight loss, tiredness, decreased activity, slowed step speed, and weakened grip strength, and frailty was then determined by calculating the total score. The FRAIL scale assessment consisted of five simple questions to identify fatigue, sense of resistance on a staircase, inability to walk one block without help (reduced free movement), coexistence of five or more diseases, and greater than 5% weight loss within 1 year. One point was assigned for the presence of each feature, resulting in a score from 0 (lowest) to 5 (highest). The CFS divided frailty into nine grades -

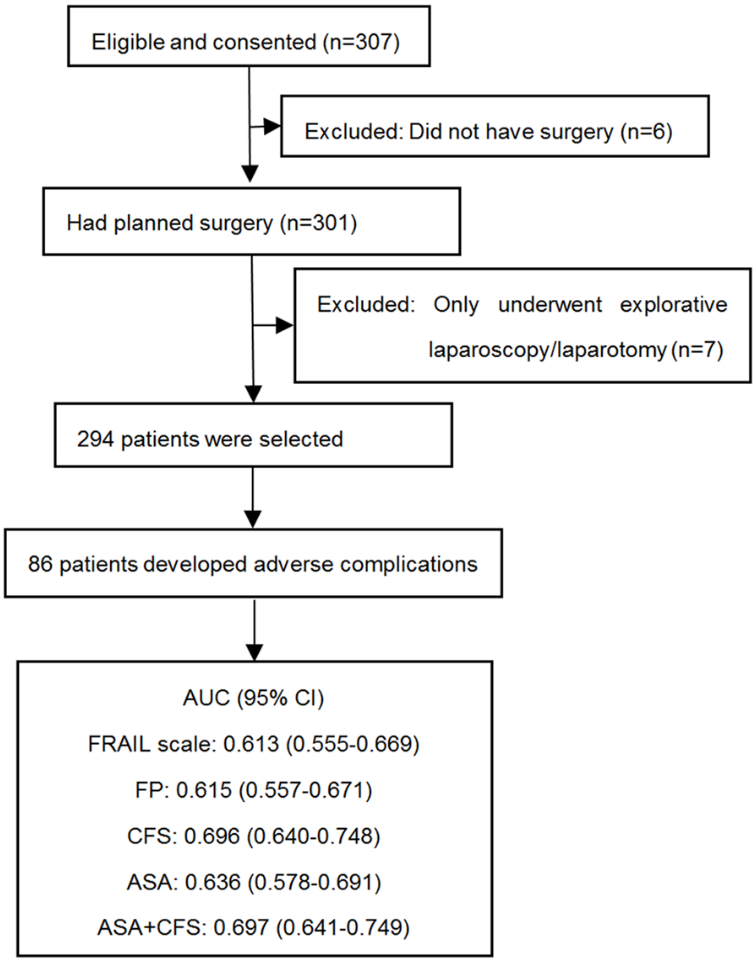

Figure 1. Flow diagram of included patients. During the study period, a total of 307 consecutive patients presenting with gastrointestinal surgery were screened. We excluded 6 patients who dd not have surgery and 7 patients who only underwent exploratory laparoscopic/laparotomy surgery only. Finally, 294 patients were enrolled and completed the study.

very healthy, healthy, good health, vulnerable to injury, mild frailty, moderate frailty, severe frailty, very severe frailty, and terminal illness - by measuring mobility, energy, physical activity, and function. The ASA physical status classification system has been employed to measure the physiologic reserve of patients when considering surgery, regardless of its type [29], and is currently a common method for preoperative risk assessment in the perioperative period. Each patient underwent a routine ASA assessment before surgery.

Outcome

By comparing the ability of three frailty instruments (FP, FRAIL scale, and CFS) we predicted adverse postoperative outcome, and analyzed the influence of FRAIL on the ASA risk prediction model. Main outcomes recorded included postoperative adverse outcome. Each patient was followed up within 30 days after surgery. The primary outcomes were adverse systemic complications within 30 days after surgery, divided into respiratory complications, cardiovascular complications, neurological complications, gastrointestinal complications, postoperative non-infectious fever, and other complications (**Table 2**) [30-37]. The incidence of postoperative complications was evaluated according to imaging examination, laboratory examination, and clinical symptoms. The secondary outcomes included extended hospital length of stay (LOS) (defined as the number of days in the hospital exceeding the 75th percentile of the sample), extended post-anesthesia care unit (PACU) LOS (defined as the time in the PACU beyond the 75th percentile of the sample), 30-day mortality, and unplanned intensive care unit (ICU) admissions.

Statistical analysis

Continuous variables were evaluated for normality using the Shapiro-Wilk test. Data with a normal distribution were expressed as mean ± standard deviation (SD), and those with a non-normal distribution were expressed as median (interquartile range [IQR]). Categorical data were presented as absolute numbers (percentages). The percentages of missing information per collected data/variable, including perioperative complications, 1-month mortality, extended PACU LOS, mortality, unplanned ICU admissions, and extended hospital LOS, were then calculated. For univariate analysis, we employed the Mann-Whitney U test for non-normal distributions, the independent samples

Table 1. Composition of frailty instruments

Fried Phenotype (FP)	The Frail Scale	Clinical Frailty Scale (CFS)
Weight loss: > 10 lbs unintentionally in previous year	Fatigue: feeling tired most or all of the time in the past 4 weeks	1. Very fit: people who are robust, very active, and motivated. These people commonly exercise regularly. They are among the fittest of their age.
Grip strength: lowest 20% (by gender and body mass index)	Resistance: sense of resistance, on a staircase is difficult	2. Well: people who have no active disease symptoms but are less fit than category 1. Often, they exercise or are very active occasionally.
Exhaustion: self-report	Aerobic: reduced free movement, unable to walk 1 block	3. Managing well: people whose medical problems are well controlled, but they are rarely active beyond walking.
Slowness: 15-foot walking speed (by gender and height)	Illness: coexistence of multiple diseases 5	4. Vulnerable: while not dependent on others for daily help, often symptoms limit activities. A common complaint is being "slowed up" and/or being tired during the day.
Low activity: kilocalories per week (males < 383, females < 270)	Weight loss: weight loss in 1 year > 5%	5. Mildly frail: these people often have more evident slowing and need help in high-order IADLs. Typically, this impairs shopping and walking outside alone, meal preparation, and housework.
		6. Moderately frail: people need help with all outside activities and with keeping house. Inside, they often have problems with stairs and need help with bathing, and they might need minimal help with dressing.
		7. Severely frail: completely dependent for all personal care from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ≈ 6 months).
		8. Very severely frail: completely dependent, approaching the end of life. Typically, they could not recover from even a minor illness.
		9. Terminally ill: approaching the end of life. This category applies to people with a life expectancy < 6 mo, who are not evidently frail.
One point is assigned for the presence of each feature of the phenotype, resulting in a score from 0 to 5, 3-5 are frail	One point is assigned for the presence of each feature of the scale, resulting in a score from 0 to 5, 3-5 are frail	After assessment, an individual is assigned a score on the scale, ≥ 4 is considered as frail.

IADLs, instrumental activities of daily living.

Table 2. Complications

Type	Items
Respiratory complications [30]	1. Pulmonary infection: patient has received antibiotics for a suspected respiratory infection and met one or more of the following criteria: new or changed sputum, new or changed lung opacities, fever, white blood cell count > 12 * 10^9 L^{-1}
	2. Respiratory failure: postoperative PaO_2 < 8 kPa (60 mmHg) on room air, a PaO_2:FiO_2 ratio < 40 kPa (300 mmHg) or arterial oxyhaemoglobin saturation measured with pulse oximetry < 90% and requiring oxygen therapy
Cardiovascular complications [30-33]	1. New arrhythmias
	2. Myocardial ischemia: ECG changes; radiological or echocardiographic evidence
	3. Ischaemia or hypotension: requiring drug therapy or fluid therapy of more than 200 ml/h
	4. Heart failure: it is a clinical syndrome characterised by a constellation of symptoms (dyspnoea, orthopnoea, lower limb swelling) and signs (elevated jugular venous pressure, pulmonary congestion) often caused by a structural and/or functional cardiac abnormality resulting in reduced cardiac output and/or elevated intracardiac pressures
Neurological complications [30]	1. Confusion or delirium: Confusion Assessment Method
	2. Stroke
Gastrointestinal complications [30, 36]	1. Anastomotic breakdown
	2. Intestinal bleeding
	3. Intestinal obstruction
	4. Delayed gastric emptying
Postoperative non-infectious fever [34]	The negative bacterial culture of blood, urine, sputum and joint cavity puncture fluid accompanied by fever symptoms
Other complications [30, 35, 37]	1. Nutritional/metabolic complications: consisted of stress hyperglycemia, electrolyte disorder, and metabolic or endocrine disturbances
	2. Liver and kidney dysfunction: elevation of various enzymes and/or bilirubin in the liver, a rapid increase in serum creatinine, decrease in urine output, or both, KDIGO criteria
	3. Incisional inflammatory exudation
	4. Urinary tract infections
	5. Urinary retention

t-test for normally distributed continuous variables, and the chi-square test for categorical variables to compare the potential differences between the groups of patients with and without systemic complications. For multivariate analysis, all covariates with $P \leq 0.3$ in the univariate analysis (age, BMI, Hb, hypertension, cardiovascular disease, pulmonary disease, type of operation, duration of surgery, and ASA physical status) were entered into a backward stepwise logistic regression model for the prediction of the primary outcome, i.e., the postoperative incidence of systemic complications. The three frailty scores (FP, FRAIL scale, and CFS) were included three main regression models, separately, were constructed with the postoperative prognostic outcome as the outcome variable. The Hosmer-Lemeshow goodness-of-fit test was conducted to evaluate the model-fitting of the logistic multivariable models. To assess the predictive power of the three frailty instruments in all patients, receiver operating characteristic (ROC) curves were constructed, and the regression models were compared based on the area under the ROC (AUC) and its 95% confidence interval (CI). The AUC is a summary measure ranging from 0 to 1; the closer the AUC is to 1, the better the prediction ability. To evaluate the estimation precision, we computed DeLong's 95% CIs around each AUC. After estimating the AUC for each frailty score, we selected the frailty score with the greatest discerning ability, compared it to the ASA classification to evaluate its combinational predictability, and calculated the AUC and 95% CI again.

Results

Demographic and health characteristics of the study population

During the study period, we screened 307 consecutive patients presenting for gastrointestinal surgery. Finally, 294 patients who met the study's eligibility criteria and had complete data underwent gastrointestinal surgery (**Figure 1**).

Table 3 summarizes the cohort's demographics, health characteristics, and scores on the different risk adjustment indices. Seven patients were transferred directly to the ward after removal of the endotracheal tube in the operating room. The median (IQR; range) age recorded upon admission was 69 (66, 74; 60-88) years. The mean ± SD (range) BMI of all participants was 21.96 ± 3.06 (13.96-29.41) kg/m^2. The median (IQR; range) Hb recorded upon admission was 128 (111, 140; 59-167) g/L. The majority of patients were male. Of the 294 study participants, 43.9% received general anesthesia combined with regional anesthesia and 71.1% underwent transabdominal surgery.

Comparison of adverse outcomes

Table 4 presents the adverse outcomes, including perioperative complications, unplanned ICU admissions, 1-month mortality, extended PACU LOS, and extended LOS. Adverse systemic complications were noted in 29.3% of patients, and cardiovascular complications (7.8%) were the most common. The mortality rate was 0.7% at 1 month, and the unplanned ICU admission rate was 2.7%. The median PACU LOS was 45 min (IQR, 35-60 min), and the median hospital LOS was 14 days (IQR, 12-16 days); 23.0% of the cohort had an extended PACU LOS, and 24.8% had an extended hospital LOS.

Univariate analysis showed that BMI, cardiovascular disease, pulmonary disease, ASA status, duration of surgery, and frailty were positively associated with systemic complications (**Table 5**). In the multivariable model, frailty was a strong independent predictor of systemic complications (odds ratio [OR] [95% CI]: FRAIL, 1.297 [0.943-1.785]; FP, 1.317 [0.965-1.798]; CFS, 2.046 [1.413-3.015]) (**Table 6**).

Discriminative ability

To assess the predictive power of the FRAIL scale, FP, and CFS in all patients, ROCs were constructed, and the regression models were compared based on the AUCs and their 95% CIs. Our results indicate that of the three frailty assessments, the CFS was the best predictor of any adverse systemic complications (AUC, 0.696; 95% CI, 0.640-0.748; $P < 0.001$), whereas the predictive ability of the FRAIL score (AUC, 0.613; 95% CI, 0.555-0.669; $P=0.001$) was similar to that of the FP (AUC, 0.615; 95% CI, 0.557-0.671; $P=0.001$). The CFS was also the best predictor of 1-month mortality (AUC, 0.848; 95% CI, 0.802-0.887). The discriminative abilities of the three frailty assessments were statistically similar in terms of predicting extended PACU LOS and extended hospital LOS (**Figure 2A**; **Table 7**). The CFS was statistically superior to the ASA assessment for predicting the occurrence of any adverse systemic complications. The combination of the CFS and ASA assessment (AUC, 0.697; 95% CI, 0.641-0.749) had a statistically improved AUC compared with that of the ASA assessment or CFS alone (**Figure 2B**). The combination also resulted in incremental improvements in the discriminative ability compared with the individual components for all systemic complications, unplanned ICU admissions, extended PACU LOS, extended hospital LOS, and 1-month mortality (**Table 8**).

Discussion

In this prospective observational study, univariate analysis revealed that BMI, ASA status, and operative time were independently associated with adverse postoperative systemic complications. After adjusting for demographic factors, such as sex, age, and BMI, logistic regression analysis found a significant positive association between preoperative frailty and adverse postoperative systemic complications. In comparing the addition of the FP, FRAIL scale, or CFS to a baseline risk model, the addition of the CFS was found to most consistently improve the accuracy. Combined with previous findings demonstrating that the CFS is easier and faster to use than other frailty assessments [19], this study suggests that clinicians should strongly consider including CFS in their preoperative frailty assessments. Our results further indicate that the diagnostic value of the ASA assessment combined with the CFS is higher than that of the ASA assessment alone; therefore, the CFS can improve the predictive value of the ASA physical status assessment for adverse postoperative outcome.

This study also demonstrated that frailty is associated with poor postoperative outcomes in older patients undergoing elective gastrointestinal surgery, which is consistent with the findings of previous studies in this population [38-40]. Recent studies have increasingly tended to predict postoperative outcomes using frailty measures. However, to date, there has been no agreement on the optimal tools for assessing frailty; thus, there is little consistency in the criteria and tools used for this pur-

Table 3. Patient characteristics

Characteristic	N or mean ± standard deviation or median (interquartile range)	% or range
Gender		
Male	196	66.7
Female	98	33.3
Age, years	69 (66, 74)	60-88
Age group		
60-69 years	155	52.7
70-79 years	112	38.1
80-89 years	27	9.2
≥ 90 years	0	0
BMI (kg/m^2)	21.96 ± 3.06	13.96-29.41
BMI group		
< 18.5 (kg/m^2)	36	12.2
18.5-23.9 (kg/m^2)	180	61.2
23.9-27.9 (kg/m^2)	69	23.5
≥ 28 (kg/m^2)	9	3.1
Hb record upon admission (g/L)	128 (111, 140)	59-167
Hb group		
< 30 g/L	0	0
30-60 g/L	1	0.3
60-90 g/L	38	12.9
90-120 g/L	68	23.2
≥ 120 g/L	187	63.6
Hypertension	133	45.2
Cardiovascular disease	45	15.3
Diabetes	26	8.8
Cerebrovascular disease	38	12.9
Pulmonary disease	37	12.6
Anesthesia type		
General anesthesia	165	56.1
General anesthesia combined with regional anesthesia	129	43.9
Type of operation		
Laparotomy surgery	209	71.1
Laparoscopic surgery	85	28.9
Duration of surgery (min)	136 (105, 177)	60-360
PACU length of stay (min)	45 (35, 60)	15-162
Hospital length of stay (day)	14 (12, 16)	4-89
ASA		
I-II	185	62.9
III-V	109	37.1
FRAIL scale		
0-2 (non-frai)	276	93.9
3-5 (frail)	18	6.1
FP		
0-2 (non-frai)	272	92.5
3-5 (frail)	22	7.5

CFS		
1-3 (non-frai)	179	60.9
≥ 4 (frail)	115	39.1

BMI, body mass index; Hb, hemoglobin; ASA, American Society of Anesthesiologists; FP, Fried Phenotype; CFS, Clinical Frailty Scale; PACU, post-anesthesia Care Unit.

Table 4. Incidence of postoperative adverse events

Outcome	Yes, n (%)	No, n (%)
All adverse systemic complications (total)*	86 (29.3)	208 (70.7)
Respiratory complications	10 (3.4)	284 (96.6)
Cardiovascular complications	23 (7.8)	271 (92.2)
Neurological complications	17 (5.8)	277 (94.2)
Gastrointestinal complications	20 (6.8)	274 (93.2)
Postoperative non-infectious fever	21 (7.1)	273 (92.9)
Other systemic complications	14 (4.8)	280 (95.2)
Unplanned ICU admission	8 (2.7)	286 (97.3)
1-month mortality	2 (0.7)	292 (99.3)
Extended PACU LOS	66 (23.0)	221 (77.0)
Extended hospital LOS	73 (24.8)	221 (75.2)

*Fifteen patients had multiple concurrent complications. ICU, intensive Care Unit; PACU, post-anesthesia Care Unit; LOS, length of stay.

Table 5. Univariate associations with systemic complications

Variable	*P* value
Gender	0.319†
Age	0.077*
BMI	< 0.001‡
Hb	0.139*
Hypertension	0.292†
Cardiovascular disease	0.005†
Diabetes	0.785†
Cerebrovascular disease	0.471†
Pulmonary disease	0.006†
Anesthesia type	0.654†
Type of operation	0.267†
Duration of surgery	0.018*
ASA	< 0.001†
FRAIL scale	< 0.001†
FP	< 0.001†
CFS	< 0.001†

*Mann-Whitney U test. †chi-square test. ‡Independent samples t test. BMI, body mass index; Hb, hemoglobin; ASA, American Society of Anesthesiologists; FP, Fried Phenotype; CFS, Clinical Frailty Scale.

pose. In the present study, we compared three commonly used frailty instruments (the FP, FRAIL scale, and CFS). The results were consistent with those of previous studies. For example, in a multicenter prospective cohort study published in 2018 that included 702 patients undergoing elective noncardiac surgery, Daniel et al. found that the CFS was more predictive of poor postoperative outcome than a modified FI [19]. A 2020 meta-analysis of 70 studies and five different frailty instruments [41] found that the FP was used in the largest number of studies, the CFS was most closely related to mortality and poor discharge, and delirium was associated with the FP [41]. Although our study suggests that the CFS should be included in preoperative frailty assessments to predict postoperative complications, it was not superior to the FP or FRAIL scales for predicting unplanned ICU admissions and prolonged hospital LOS.

Moreover, our study mainly examined patients undergoing gastrointestinal surgery, and we recognize that inconsistencies in age and type of surgery could lead to different conclusions. Therefore, to achieve higher overall accuracy, multivariate risk models specific to older age groups may need to be developed to most effectively predict high-priority outcomes for the increasing number of older adults undergoing major surgery. A 2020 review noted inconsistent results among studies that compared the abilities of the CFS and FP to determine death or the development of new disabilities among older adults following elective noncardiac surgery. In fact, no evidence of differences in sensitivity, specificity, or ORs was observed in this review [42]. Although other studies have found that FP and FI are associated with an increased risk of death in the older Chinese community [43], Cooper et al. found no difference between FP and FI in terms of predicting prolonged hospital LOS, complications, or discharge following orthopedic surgery [44]. The FRAIL scale is also a valid predictor of mortality [45] and has been used to preoperatively screen for frailty and cognitive impairment in

Table 6. Multivariate analysis of frailty variables associated with systemic complications

Variable	Odds ratio (95% CI)	*P* value
FRAIL scale	1.297 (0.943, 1.785)	< 0.001
FP	1.317 (0.965, 1.798)	< 0.001
CFS	2.064 (1.413, 3.015)	< 0.001

CI, confidence interval; FP, Fried Phenotype; CFS, Clinical Frailty Scale.

older patients undergoing elective spinal surgery and identify patients at high risk for postoperative delirium [27]. Recent studies have also demonstrated that preoperative ultrasound measurement of the quadriceps shows a promising role in identifying frail patients before surgery [46]. This method has been associated with skilled nursing facility admissions and postoperative delirium and provides new directions for researchers and clinicians to more efficiently assess vulnerability in the future. Therefore, by including frailty assessments in preoperative patient assessments, clinicians can provide older patients with more accurate information about potential risks that they may encounter during major elective surgery, as recommended by best practice guidelines. This approach can even help clinicians develop personalized treatment plans for frail patients to improve patient outcomes. Furthermore, as time is a primary consideration for clinicians, this study demonstrated that CFS assessments take only 5-10 min in clinical practice and are therefore feasible in busy surgical environments.

The ASA physical status assessment is currently the most commonly used scale for evaluating patients before surgery, and a high ASA status is associated with increased mortality [47]; however, several studies have demonstrated that ASA status does not effectively predict individual patient outcomes (57% positive predictive value vs. 80% negative predictive value) [48]. To fill this gap, frailty is becoming an important variable for evaluating the health status of older adults [49]. Our search for the optimal frailty assessment method for predicting any adverse systemic complication showed that the CFS was statistically superior to the ASA assessment, whereas the ASA assessment had some similarities with frailty in preoperative assessment and overlaps in discrimination, such as the function of certain vital organs. Our results suggest that combining the CFS with the ASA assessment for preoperative evaluation may be statistically more valuable than including either tool alone, but the difference is very small. However, we may find that the advantage is greater if we study more of the older adult population. Moreover, in our study, all three frailty assessment tools performed reasonably well in predicting both ICU admission and mortality. This further supports the notion that adding frailty measures to preoperative assessments will add value to postoperative prognosis prediction. Makary et al. assessed the discrimination of ASA status, Lee and Eagle risk scores, and each of these two scores plus the FP for predicting surgical complications and adverse discharge disposition and consistently found that frailty improved discrimination [50]. Similar to our study, Reichart et al. found that the CFS in cardiac surgery increased discrimination, appropriately reclassified patient risk, and explained the variance in predicting mortality compared with the European System for Risk Assessment in Cardiac Surgery (EuroSCORE) II model [51]. In 2018, the American Society for Perioperative Evaluation and Quality Improvement released recommendations for the management of preoperative frailty, including guidance for older adults who require surgery [52]. Therefore, we assert that frailty should become a standard part of comprehensive preoperative evaluation and could be incorporated into future amendments to the ASA physical status system.

Preoperative evaluation of older adults for the prediction of poor postoperative outcome is an essential tool to help clinicians do cost-benefit analysis of surgery. However, due to energy and time limitations, among other reasons, the follow-up time of this study was only 1 month, and the patients' quality of life and long-term results following surgery were not evaluated, which may introduce some bias to the research results. A long-term follow-up of these patients is required to better validate the tools studied. Furthermore, this single-center study had a small sample size and considered only elective gastrointestinal surgery. Future follow-up studies should expand the sample size and types of surgery to verify the influencing factors and develop an effective vulnerability assessment tool for older adults.

Conclusions

Frailty may independently predict the risk of adverse outcome, and frailty assessment may

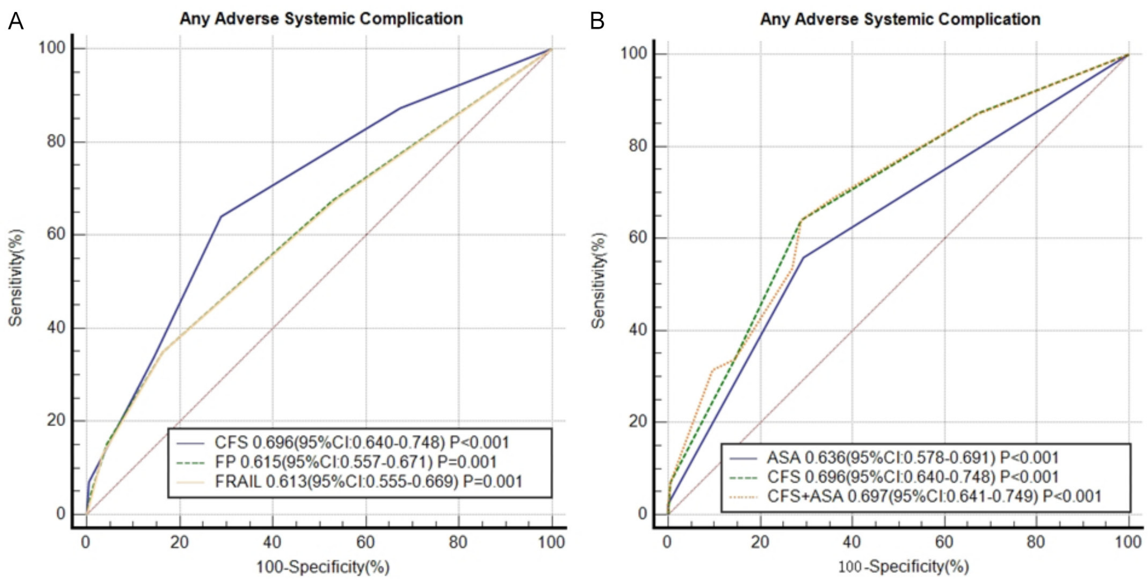

Figure 2. Receiver Operator Characteristic Curves for Predicting any Adverse Systemic Complication Using (A) Frailty Instruments, (B) CFS and ASA. To assess the predictive power of FRAIL, and FP, CFS in all patients, ROC curves were constructed, and the regression models were compared based on the AUC and its 95% CI. CFS was a better predictor of any adverse systemic complications (AUC, 0.696; 95% CI, 0.640, 0.748) compared to the other two frailty assessments, whereas the predictive ability of the FRAIL score (AUC, 0.613; 95% CI, 0.555, 0.669) was similar to that of FP (AUC, 0.615; 95% CI, 0.557, 0.671) (A). A comparison between CFS and ASA in terms of the best frailty score for the occurrence of any adverse systemic complications revealed that CFS was statistically superior. The combination of CFS and ASA (AUC, 0.697; 95% CI, 0.641, 0.749) had a statistically improved AUC in comparison to ASA and CFS alone (B).

Table 7. Comparison of the differential abilities of FRAIL, FP, and CFS to predict postoperative outcome

Outcome	FRAIL scale	FP	CFS
Systemic complications	0.613 (0.555-0.669)	0.615 (0.557-0.671)	0.696 (0.640-0.748)
Unplanned ICU admission	0.801 (0.751-0.845)	0.733 (0.679-0.783)	0.796 (0.745-0.840)
Extended PACU LOS	0.528 (0.468-0.587)	0.532 (0.472-0.591)	0.576 (0.517-0.634)
Extended hospital LOS	0.587 (0.529-0.644)	0.587 (0.528-0.644)	0.581 (0.522-0.638)
1-month mortality	0.587 (0.529-0.644)	0.603 (0.544-0.659)	0.848 (0.802-0.887)

Data are expressed as AUC (95% CI); FP, Fried Phenotype; CFS, Clinical Frailty Scale; ICU, intensive Care Unit; PACU, post-anesthesia Care Unit; LOS, length of stay.

Table 8. Comparison of the differential abilities of CFS, ASA, and ASA combined with CFS score to predict postoperative outcome

Outcome	ASA	CFS	ASA+CFS
Systemic complications	0.636 (0.578-0.691)	0.696 (0.640-0.748)	0.697 (0.641-0.749)
Unplanned ICU admission	0.804 (0.754-0.848)	0.796 (0.745-0.840)	0,823 (0.775-0.865)
Extended PACU LOS	0.548 (0.488-0.607)	0.576 (0.517-0.634)	0.572 (0.512-0.630)
Extended hospital LOS	0.574 (0.515-0.631)	0.581 (0.522-0.638)	0.587 (0.529-0.644)
1-month mortality	0.907 (0.867-0.937)	0.848 (0.802-0.887)	0.929 (0.893-0.956)

Data are expressed as AUC (95% CI); ASA, American Society of Anesthesiologists; CFS, Clinical Frailty Scale; ICU, intensive Care Unit; PACU, post-anesthesia Care Unit; LOS, length of stay.

improve the predictive value of the ASA assessment for adverse outcome in elective abdominal surgery. The CFS is simple and feasible to implement, and its clinical application is practical. Therefore, we recommend that clinical staff perform preoperative frailty assessments in older patients along with other routine risk assessments to improve surgical safety.

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Disclosure of conflict of interest

None.

Address correspondence to: Lei Zhang and Lijian Chen, Department of Anesthesiology, The First Affiliated Hospital of Anhui Medical University, No. 218 Jixi Road, Hefei 230022, Anhui, P. R. China. E-mail: zhlanesth@yeah.net (LZ); chenlijian77@126.com (LJC)

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