

## Comparative Study on the Application Effectiveness of Different Frailty Assessment Tools in Preoperative Frailty Screening for Older Adults: Postprint

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### Abstract

**Background:** Internationally, a wide variety of frailty assessment tools exist, with inconsistent application choices for perioperative frailty assessment tools in older adults. It remains unclear which frailty assessment tool is most suitable for the perioperative population in China.

**Objective:** To compare the application effectiveness of the FRAIL scale, Clinical Frailty Scale (CFS), Perioperative Frailty Index, and 5-item Modified Frailty Index (mFI-5) in preoperative frailty assessment among elderly surgical patients, aiming to provide a reference for healthcare professionals in selecting appropriate frailty assessment tools.

**Methods:** Using convenience sampling, 329 hospitalized elderly patients undergoing elective surgery at Guangdong Provincial Hospital of Chinese Medicine from February to May 2023 were selected as study subjects. Frailty assessment was conducted using the 11-item Modified Frailty Index (mFI-11), FRAIL scale, CFS, mFI-5, and Perioperative Frailty Index. The kappa test was used to evaluate consistency among the five frailty assessment tools; using mFI-11 assessment results as the reference standard, the diagnostic value of the other four tools for preoperative frailty incidence in elderly patients was analyzed through Receiver Operating Characteristic (ROC) curve and Decision Curve Analysis (DCA), with Area Under the Curve (AUC) calculated; optimal cutoff values for each frailty assessment tool were determined according to the principle of maximum Youden's Index (YI), and assessment performance indicators at both original and optimal cutoff values were calculated.

**Results:** CFS and Perioperative Frailty Index demonstrated the highest agreement in assessing preoperative frailty in elderly patients (Kappa=0.655,

$P < 0.001$ ), while FRAIL scale showed the lowest agreement with mFI-5 and mFI-11 (Kappa=0.182, 0.262). ROC curve analysis revealed that the AUCs for mFI-5, Perioperative Frailty Index, CFS, and FRAIL scale in screening preoperative frailty in elderly patients were 0.920, 0.888, 0.823, and 0.799, respectively; the AUC of mFI-5 was significantly greater than that of FRAIL scale and CFS ( $Z=3.188, 3.215, P=0.001$ ); the AUC of Perioperative Frailty Index was significantly greater than that of FRAIL scale ( $Z=2.561, P=0.001$ ); at optimal cutoff values, mFI-5 exhibited high sensitivity (91.18%) and specificity (84.41%) in screening preoperative frailty, while Perioperative Frailty Index demonstrated high sensitivity (94.12%) and specificity (71.86%). DCA results indicated that within the relevant risk threshold range, mFI-5 yielded the highest net benefit, followed by Perioperative Frailty Index.

**Conclusion:** mFI-5 demonstrated the highest screening accuracy, with high sensitivity and specificity at optimal cutoff values; Perioperative Frailty Index showed the second highest screening accuracy but relatively better comprehensive predictive performance. Both tools are suitable for early frailty risk screening in elderly surgical patients.

## Full Text

### Abstract

**Background:** A wide variety of frailty assessment tools exist internationally, with varying application choices for the geriatric perioperative population. It remains unclear which frailty assessment tool is most suitable for the perioperative population in China. **Objective:** To compare the application effects of the FRAIL scale, Clinical Frailty Scale (CFS), Perioperative Frailty Index, and 5-item modified frailty index (mFI-5) in preoperative frailty assessment among elderly surgical patients, providing a reference for healthcare professionals to select appropriate assessment tools. **Methods:** Using convenience sampling, 329 hospitalized elderly patients undergoing elective surgery at Guangdong Hospital of Traditional Chinese Medicine from February to May 2023 were selected as study subjects. Frailty assessments were conducted using the 11-item modified frailty index (mFI-11), FRAIL scale, CFS, mFI-5, and Perioperative Frailty Index. The kappa test was used to evaluate consistency among the five tools. Using mFI-11 results as the reference standard, receiver operating characteristic (ROC) curve and decision curve analysis (DCA) were employed to analyze the diagnostic value of the other four tools for preoperative frailty in elderly patients, with area under the ROC curve (AUC) calculated. Optimal cut-off values were determined based on the maximum Youden index (YI), and performance indicators at both original and optimal cut-off values were calculated. **Results:** CFS and the Perioperative Frailty Index showed the highest consistency in assessing preoperative frailty in the elderly (Kappa=0.655,  $P < 0.001$ ), while FRAIL scale demonstrated the lowest consistency with mFI-5 and mFI-11 (Kappa=0.182, 0.262). ROC analysis revealed AUCs of 0.920, 0.888, 0.823, and

0.799 for mFI-5, Perioperative Frailty Index, CFS, and FRAIL scale, respectively. The AUC of mFI-5 was significantly greater than that of FRAIL scale and CFS ( $Z=3.188, 3.215; P=0.001$ ). The AUC of Perioperative Frailty Index was significantly greater than that of FRAIL scale ( $Z=2.561, P=0.001$ ). At optimal cut-off values, mFI-5 showed high sensitivity (91.18%) and specificity (84.41%), while Perioperative Frailty Index showed sensitivity of 94.12% and specificity of 71.86% (Table 3). DCA results indicated that mFI-5 provided the highest net benefit within relevant risk threshold ranges, followed by Perioperative Frailty Index. **Conclusion:** mFI-5 demonstrated the highest screening accuracy with high sensitivity and specificity at optimal cut-off values. While Perioperative Frailty Index had slightly lower screening accuracy, its overall predictive performance was relatively good. Both tools are suitable for early frailty risk screening in elderly surgical patients.

**Keywords:** Frailty; Preoperative frailty; Screening; Frailty assessment tools; Aged; Evaluation research

## Introduction

Frailty is a non-specific state characterized by declining physiological reserve, increased vulnerability, and reduced stress resistance [1]. Studies have reported that the prevalence of preoperative frailty in elderly patients ranges from 16.8% to 50.5% [2-7]. Multiple studies have identified preoperative frailty as an independent risk factor for postoperative complications, length of hospital stay, and mortality, increasing the risk of adverse postoperative outcomes and prolonging hospitalization [8-10].

Currently, numerous frailty assessment tools exist internationally, with inconsistent application choices for the geriatric perioperative population. The 11-item modified frailty index (mFI-11) is one commonly used method for preoperative frailty assessment in the elderly. Developed based on the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database and validated for surgical populations [11], mFI-11 has been widely applied in perioperative frailty assessment among elderly surgical patients both domestically and internationally. Multiple systematic reviews abroad have demonstrated that mFI-11 effectively assesses preoperative frailty and predicts adverse postoperative outcomes in orthopedic, urologic, head and neck oncology, and general surgery patients [12-14]. However, since 2012, data for 5 of its 11 composite variables have been completely missing, which may limit its assessment utility [15]. Nevertheless, foreign surgeons and researchers continue to widely use mFI-11 to evaluate frailty in surgical populations with relatively good predictive performance [16-21].

Furthermore, the reported prevalence of preoperative frailty in the elderly varies across different assessment tools. For instance, ARTEAGA et al. [22] used the FRAIL scale, CFS, Triage Risk Screening Tool (TRST), and Survey of Health, Ageing and Retirement in Europe-Frailty Instrument (Share-FI) to screen el-

derly general surgery emergency patients, finding frailty prevalence rates of 14.1%, 25%, 29.2%, and 30.4%, respectively. MCISAAC et al. [23] employed CFS and the Frailty Phenotype (FP) for preoperative frailty assessment in elderly non-cardiac surgery patients, with prevalence rates of 42.4% and 36.7%, respectively. Overall, no international consensus has been reached regarding the selection of perioperative frailty assessment tools for the elderly, and no recognized “gold standard” for frailty diagnosis has been established. It remains unclear which frailty assessment tool is most suitable for China’s perioperative population.

Based on this, our research team previously developed the Perioperative Frailty Index according to international principles for creating frailty index items [24], selecting 32 variables as health deficit items based on domestic Hospital Information Systems (HIS), literature review, and expert opinion. To further compare the effectiveness of the Perioperative Frailty Index with commonly used assessment tools and identify suitable options for Chinese populations, this study used mFI-11 as the reference standard to compare the application effects of FRAIL scale, CFS, mFI-5, and Perioperative Frailty Index in preoperative frailty assessment among elderly surgical patients. The aim is to provide healthcare professionals with evidence-based guidance for selecting appropriate frailty assessment tools to identify high-risk elderly patients preoperatively.

## Methods

### 1.1 Study Subjects

Using convenience sampling, 329 hospitalized elderly patients scheduled for elective surgery at Guangdong Hospital of Traditional Chinese Medicine from February to May 2023 were selected as study subjects. Inclusion criteria were: (1) age  $\geq 60$  years, regardless of gender; (2) scheduled for elective surgery; (3) American Society of Anesthesiologists (ASA) classification grade 1-3; (4) able to complete questionnaires independently or with researcher assistance; (5) informed consent and voluntary participation. Exclusion criteria included: (1) severe mental, visual, auditory, or cognitive impairment preventing communication; (2) severe illness or other reasons preventing surgery; (3) inability to cooperate with questionnaire completion due to severe language or hearing impairment. This study was approved by the Ethics Committee of Guangdong Hospital of Traditional Chinese Medicine (BE2022-165).

### 1.2 Sample Size Calculation

The sample size was calculated using the formula for estimating population rates:  $N = [(Z\alpha/2)^2 p(1-p)]/\delta^2$ , with allowable error  $\delta$  set at 5%,  $\alpha = 0.05$ ,  $Z\alpha/2 = 1.96$ , and  $P$  as the preoperative frailty incidence rate of 24.1% in elderly perioperative patients [3]. The calculated sample size was 281 cases. Considering a 10% invalid response rate, the final required sample size was 309 cases.

### 1.3 Data Collection

A unified questionnaire was used to collect data, including demographic information such as age, gender, marital status, education level, smoking history, alcohol consumption history, and polypharmacy (\$ \$5 medications). For self-reported items, researchers used standardized instructions to ask patients each question individually without leading prompts, completing the forms based on patient responses and checking for completeness on-site. Non-self-reported items or objective indicators (such as comorbidities, test results, BMI) were collected through electronic medical record review and clinical assessment. Data were entered independently by two researchers using a double-entry method for verification and analysis.

### 1.4 Frailty Assessment

**1.4.1 mFI-11:** The mFI-11 includes 11 items: preoperative functional dependence, diabetes history, chronic obstructive pulmonary disease (COPD) history, congestive heart failure history, myocardial infarction history, among others. Each item is scored as 0 (absent) or 1 (present), with total scores ranging from 0-11. The mFI-11 score is calculated as the number of deficits present divided by the number of applicable items, with \$ \$0.27 indicating frailty [25].

**1.4.2 FRAIL Scale:** Developed by international experts in nutrition, health, and aging in 2008, the FRAIL scale includes five items: fatigue, resistance, ambulation, illness, and loss of weight. Each item scores 1 point, with a total score \$ \$3 indicating frailty [26].

**1.4.3 mFI-5:** Modified from mFI-11 by SUBRAMANIAM et al. [27], mFI-5 includes five variables: functional dependence, diabetes, congestive heart failure, COPD, and hypertension requiring medication. The frailty score is calculated as the number of deficits present divided by the number of applicable items, with \$ \$0.27 indicating frailty.

**1.4.4 CFS:** The CFS covers domains of mobility, energy, physical activity, and function, with nine levels (1-9). Level 1 represents very fit, level 2 well, level 3 managing well, level 4 vulnerable, levels 5-8 indicate mild, moderate, severe, and very severe frailty, respectively, and level 9 represents terminally ill [28]. A CFS grade \$ \$5 indicates frailty.

**1.4.5 Perioperative Frailty Index:** Based on international principles for frailty index creation [24] and domestic HIS data, literature review, and expert opinion, this study selected 32 items as health deficit variables to construct the Perioperative Frailty Index. Each selected item was assigned a value ranging from 0-1 point. The Frailty Index (FI) was calculated as:  $FI = \text{cumulative health deficit score} / \text{total health variable score (32 points)}$ . According to SEARLE et al.' s definition [24], FI \$ \$0.25, corresponding to a Perioperative Frailty Index score \$ \$8, was defined as frailty.

### 1.5 Quality Control

Researchers first explained the study purpose and significance to participants, obtained informed consent, and for self-reported questionnaire content, used standardized instructions to ask each item individually without leading prompts. Forms were completed based on patient responses and checked for completeness on-site. Objective indicators were collected through electronic medical record review and clinical assessment. Data were analyzed using a double-entry method by two independent researchers.

### 1.6 Statistical Methods

SPSS 26.0, MedCalc 22.0, and R software packages were used for statistical analysis. Non-normally distributed continuous data were expressed as M (P25, P75), and categorical data as frequencies or percentages. The Kappa test was used to evaluate consistency among the five frailty assessment tools. Using mFI-11 results as the reference standard, decision curve analysis (DCA) and receiver operating characteristic (ROC) curve analysis were employed to assess the diagnostic value of the other four tools for preoperative frailty in elderly patients, with area under the ROC curve (AUC) calculated. DeLong's test was used to compare AUC differences among assessment tools. Optimal cut-off values were determined based on the maximum Youden index (YI), and performance indicators including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated at both original and optimal cut-off values.  $P < 0.05$  was considered statistically significant.

## Results

### 2.1 General Information and Frailty Assessment

Among the 329 elderly surgical patients, 133 (40.4%) were male and 196 (59.6%) were female, with a median age of 69 (65, 73) years. The number of patients identified as preoperatively frail according to mFI-11, FRAIL scale, CFS, Perioperative Frailty Index, and mFI-5 were 34 (10.3%), 46 (14.0%), 69 (21.0%), 51 (15.5%), and 77 (23.4%), respectively (Table 1).

### 2.2 Consistency Among Five Assessment Tools for Preoperative Frailty Screening

Consistency analysis revealed that CFS and Perioperative Frailty Index showed the highest agreement in assessing preoperative frailty in the elderly (Kappa=0.655,  $P < 0.001$ ), followed by mFI-11 with mFI-5 and mFI-11 with Perioperative Frailty Index (Kappa=0.485, 0.449). FRAIL scale demonstrated the lowest consistency with mFI-5 and mFI-11 (Kappa=0.182, 0.262) (Table 2).

### 2.3 Performance Comparison of Four Frailty Assessment Tools

Using mFI-11 assessment results as the reference standard, ROC curves (Figure 1 [Figure 1: see original paper]) and DCA curves (Figure 2 [Figure 2: see original paper]) were plotted for the four assessment tools. ROC analysis showed AUCs of 0.799, 0.823, 0.888, and 0.920 for FRAIL scale, CFS, Perioperative Frailty Index, and mFI-5, respectively. The AUC of mFI-5 was significantly greater than that of FRAIL scale and CFS ( $Z=3.188, 3.215; P=0.001$ ). The AUC of Perioperative Frailty Index was significantly greater than that of FRAIL scale ( $Z=2.561, P=0.001$ ). At optimal cut-off values, mFI-5 showed high sensitivity (91.18%) and specificity (84.41%), while Perioperative Frailty Index showed sensitivity of 94.12% and specificity of 71.86% (Table 3). The optimal cut-off values for CFS and mFI-5 were consistent with their original cut-off values.

DCA results demonstrated that when threshold probability ranged from \$ 5% to \$ 40%, all four assessment tools had diagnostic significance for preoperative frailty occurrence, with mFI-5 providing the highest net benefit, followed by Perioperative Frailty Index (Figure 2). When threshold probability exceeded 40%, FRAIL scale and CFS showed negative effects or net benefit approaching zero.

## Discussion

Frailty is a common clinical syndrome in older adults [29]. Against the backdrop of population aging, elderly surgical patients are increasing, with over 50% of older patients experiencing frailty during surgical treatment [30]. Previous studies have reported preoperative frailty prevalence rates of 16.8%-50.5% in elderly patients [2-7], showing considerable variation. This study found preoperative frailty prevalence rates of 10.3%, 14.0%, 21.0%, 15.5%, and 23.4% according to mFI-11, FRAIL scale, CFS, Perioperative Frailty Index, and mFI-5, respectively. Kappa consistency tests revealed moderate agreement between mFI-11 and Perioperative Frailty Index and between mFI-11 and mFI-5, but poor agreement between mFI-11 and FRAIL scale and between mFI-11 and CFS, possibly due to lack of standardized screening criteria across different frailty assessment tools.

### 3.1 Performance of Four Frailty Assessment Tools in Screening Preoperative Frailty

This study found that mFI-5, Perioperative Frailty Index, CFS, and FRAIL scale all showed good diagnostic accuracy for mFI-11-diagnosed preoperative frailty (all AUCs  $>0.7$ ), with mFI-5 demonstrating the highest screening accuracy, consistent with previous findings [31]. ROC analysis showed that mFI-5's optimal cut-off value was consistent with its original cut-off value, with relatively stable specificity. At the original cut-off value, mFI-5 showed higher sensitivity than the other three tools but exhibited characteristics of high negative predictive value (NPV) and low positive predictive value (PPV), consistent with previous

research [32-33]. DCA results indicated that when threshold probability ranged from \$ 5% to \$ 90%, mFI-5 was more effective than the other three tools in screening preoperative frailty. This may be because mFI-5 was simplified from mFI-11 while retaining relevant assessment variables, thus maintaining high diagnostic similarity for mFI-11-diagnosed preoperative frailty, aligning with previous results [34].

At the original cut-off value, Perioperative Frailty Index showed relatively balanced specificity and NPV, sensitivity and PPV, suggesting relatively good consistency between screening and diagnostic results. At the optimal cut-off value, its sensitivity and specificity were 94.12% and 71.86%, respectively, but with relatively low PPV, indicating only moderate consistency between screening and diagnostic results. This may be because the frailty index was modified and constructed based on domestic HIS systems, and differences in lifestyle, cultural habits, and healthcare systems between East and West may result in variations in item expression. Meanwhile, DCA analysis showed that compared with CFS and FRAIL scale, Perioperative Frailty Index provided higher clinical net benefit and a broader relevant risk threshold range when predicted preoperative frailty risk was \$ 5%.

This study found that CFS' s original and optimal cut-off values were consistent, with sensitivity at the optimal cut-off value lower than that of mFI-5 and Perioperative Frailty Index, showing characteristics of low PPV and high NPV. CFS' s AUC was significantly smaller than those of mFI-5 and Perioperative Frailty Index ( $P < 0.05$ ), while no significant difference was found compared with FRAIL scale ( $P > 0.05$ ), suggesting CFS' s accuracy in screening preoperative frailty was similar to FRAIL scale. DCA results showed overlapping risk thresholds between CFS and FRAIL, with CFS being more effective than FRAIL only when threshold probability ranged from \$ 15% to \$ 40%, inconsistent with previous research [35]. This discrepancy may be related to the inclusion of multiple surgery types in this study, whereas previous studies [35] included more homogeneous surgical populations. Different surgical populations may have varying baseline conditions and activity tolerance, leading to different predictive performance of the same assessment tool across different surgical types.

Additionally, at the original cut-off value, FRAIL scale showed high specificity but low sensitivity, indicating weak ability to identify preoperative frailty patients and high missed diagnosis rates. The optimal cut-off value for FRAIL scale was  $>1$  point, at which sensitivity increased and specificity relatively decreased, improving screening performance for preoperative frailty. DCA results showed that within relevant risk threshold ranges, FRAIL scale provided lower clinical net benefit than the other three tools for preoperative frailty screening. AUC comparison results showed no significant difference between CFS and FRAIL scale in screening accuracy ( $P > 0.05$ ), inconsistent with XING et al. [35] but consistent with THIAM et al. [36], possibly also related to different surgery types included across studies.

### 3.2 mFI-5 and Perioperative Frailty Index Demonstrated Good Assessment Performance

Through AUC comparison and DCA analysis, this study found that mFI-5 showed higher screening accuracy than FRAIL scale and CFS ( $P < 0.05$ ), with relatively high sensitivity and specificity. Additionally, Perioperative Frailty Index showed higher screening accuracy than FRAIL scale ( $P < 0.05$ ), with no significant difference compared with mFI-5 ( $Z = 1.059$ ,  $P = 0.289$ ), suggesting both tools have relatively good application effects in screening for mFI-11-diagnosed preoperative frailty.

Frailty is a multidimensional state influenced by physiological, psychological, and social factors [37]. Clinically, mFI-5 has fewer assessment items and is simple and quick to use, but its content focuses primarily on disease variables, with certain limitations in screening cognitive and psychosocial dimensions. In contrast, Perioperative Frailty Index includes comorbidities, activities of daily living, physical function, nutrition, and laboratory tests, providing relatively good comprehensive predictive performance. Moreover, Perioperative Frailty Index was modified and constructed based on domestic HIS systems for Chinese surgical populations, with all item variables retrievable from HIS systems and capable of automatic generation through system settings, greatly saving clinical assessment time.

In summary, among the four frailty assessment tools examined, mFI-5 has fewer assessment items, higher screening accuracy, and high sensitivity and specificity at optimal cut-off values. Perioperative Frailty Index has the second-highest screening accuracy but relatively good comprehensive predictive performance and greater clinical convenience for promotion and application, followed by CFS and FRAIL scale. Therefore, in clinical practice, healthcare professionals should select appropriate frailty assessment tools based on specific circumstances, shifting focus from postoperative to preoperative frailty and moving surgical risk management forward to address existing frailty risk factors and guide individualized surgical planning. When clinical conditions permit, selecting multidimensional, multi-domain frailty assessment tools for preoperative evaluation can help healthcare professionals understand patients' preoperative physiological, psychological, and social conditions, enabling multidisciplinary collaborative approaches to address existing problems and provide appropriate perioperative interventions for effective preoperative frailty management, optimizing clinical outcomes and promoting rapid patient recovery.

**Limitations:** (1) This single-center study may lack representativeness and generalizability; (2) The study did not conduct stratified screening by surgical type to further analyze each tool's performance in different surgical populations; (3) As a cross-sectional study, it could not observe the impact of assessment results on postoperative outcomes. Future longitudinal studies are needed to explore the predictive ability of frailty assessment tools for preoperative frailty occurrence and related adverse outcomes in elderly patients, providing comprehensive

evaluation of these tools' application effects.

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