ORIGINAL ARTICLE

# MORTALITY PREDICTORS AFTER MAJOR ABDOMINAL SURGERY IN PATIENTS AGED 80 AND OVER: THE ROLE OF FRAILTY AND PHYSIOLOGICAL RESERVE

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## Abstract

**Introduction:** Patients aged 80 years or older undergoing major abdominal surgery represent a high-risk group with substantial postoperative mortality. Frailty and reduced physiological reserve are key determinants of adverse outcomes; however, data focusing specifically on this population are limited. This study aimed to identify predictors of 30-day mortality, with emphasis on frailty and physiological reserve.

**Materials and Method:** This retrospective single-center cohort study included patients aged 80 years or older who underwent major abdominal surgery between 2021 and 2025. Frailty was assessed using the five-item modified frailty index. Physiological reserve was evaluated using preoperative albumin, hemoglobin, and creatinine levels. The primary outcome was 30-day mortality. Multivariable logistic regression analysis was performed.

**Results:** A total of 92 patients were included, with a 30-day mortality rate of 18.5%. Emergency surgery was more frequent among non-survivors (70.6% vs. 12.0%, p<0.001), as was preoperative sepsis (33.3% vs. 4.0%, p=0.003). Severe frailty was present in 50.0% of non-survivors compared to 14.9% of survivors (p=0.025). Non-survivors had lower albumin levels (28.4 vs. 37.0 g/L, p=0.001). In the multivariable analysis, frailty was an independent predictor of mortality (odds ratio 2.71, 95% confidence interval 1.03–7.16, p=0.044). Albumin showed a trend toward significance (odds ratio 0.87 per unit increase, p=0.069). The model demonstrated high discriminative ability (area under the curve 0.899).

**Conclusion:** Frailty is an independent predictor of 30-day mortality in patients aged 80 years or older undergoing major abdominal surgery. Incorporating frailty assessment into routine preoperative evaluation may improve risk stratification and clinical decision-making.

***Keywords:*** Frailty; Octogenarians; Nonagenarians; Mortality; Surgical Oncology; General Surgery.

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## INTRODUCTION

The global population of the 'oldest-old' (aged ≥80 years) is projected to triple by 2050. This rapid demographic shift brings significant challenges to healthcare systems; as frailty—a state of increased vulnerability and clinical decline across multiple systems—is exceptionally prevalent in this age group, reaching rates as high as 83.4% in community-dwelling octogenarians (1).

In patients aged 80 years and above, major surgical procedures are accompanied by a substantial burden of early postoperative morbidity and mortality. Reports on non-cardiac surgery in this "oldest-old" group describe frequent cardiopulmonary complications, prolonged hospitalization, functional decline and a higher probability of discharge to nursing or rehabilitation facilities when compared with younger adults (2,3). These findings indicate that chronological age alone does not fully account for the excess risk observed, and that an underlying vulnerability state must contribute importantly to poor surgical outcomes in the very old (2).

Frailty has been proposed as the key construct capturing this vulnerability, reflecting a multidimensional decline in physiological reserve and a reduced capacity to tolerate stress. Frail older adults are more likely than robust peers to experience falls, disability, unplanned hospital admissions, institutionalization and death, even after adjusting for age and comorbidities (4,5). Within surgical populations, the presence of frailty has been consistently linked to higher rates of postoperative complications, longer length of stay and discharge to institutional care, often outperforming conventional risk tools that rely primarily on age and comorbidity counts (6). A systematic synthesis of the literature confirms that across diverse operations, frail older patients have significantly worse postoperative trajectories than non-frail patients (7).

Because comprehensive geriatric assessments and detailed frailty phenotyping are difficult to implement at scale in routine practice, several pragmatic frailty instruments have been developed. The modified frailty index (mFI) and its abbreviated derivative, the mFI 5, incorporate a limited set of comorbidity and functional items that can usually be retrieved from existing records, and both have shown associations with postoperative morbidity and mortality in multiple surgical cohorts (7–9). At the same time, laboratory parameters such as hypoalbuminemia, anemia and reduced renal function have been recognized as biological correlates of diminished physiological reserve and adverse prognosis in older adults, although they are often reported separately from formal frailty constructs (4,5).

Despite this growing body of evidence, there are relatively few data specifically targeting patients aged 80 years and above undergoing major abdominal surgery, particularly in tertiary referral settings where case-mix may differ substantially from general surgical cohorts. Many existing studies include broader age ranges, heterogeneous procedure types, or do not simultaneously evaluate pragmatic frailty tools together with objective markers of physiological reserve in a unified preoperative model (2,7). Importantly, this study evaluates frailty within a high-risk, mixed elective–emergency surgical population, where decision-making is often time-critical and risk stratification tools are most needed.

The present single-center retrospective study therefore aimed to investigate 30-day mortality after major abdominal surgery in patients aged 80 years or older by focusing exclusively on the oldest-old population and examining frailty status, measured by the mFI-5, alongside selected indicators of physiological reserve including serum albumin, hemoglobin, and creatinine levels.

## MATERIALS AND METHOD

### Study design and ethical approval

This study is a single-center, retrospective observational cohort conducted at a tertiary oncology center in Ankara, Türkiye. The protocol was approved by the institutional ethics committee (IRB number: 2026-02/31), and the study was registered at ClinicalTrials.gov (NCT07440095). The research was designed and reported in accordance with the Declaration of Helsinki and local regulations for non-interventional clinical studies. Because the study used anonymized data obtained from hospital records without direct patient contact, the requirement for individual informed consent was waived by the ethics committee.

### Study population

All patients aged 80 years or older who underwent major abdominal surgery between 1 January 2021 and 31 December 2025 in the departments of general surgery, surgical oncology, gynecologic oncology and urology were screened for eligibility. Major abdominal surgery was defined as open or laparoscopic procedures involving the stomach, small bowel, colon–rectum, hepatobiliary system, pancreas, urological tract (including nephrectomy and cystectomy) or pelvic organs, requiring at least one overnight hospital stay. Both elective and emergency operations were included.

Patient identification was performed through the institutional electronic hospital database. The number of 50,051 represents the total surgical procedures performed during the study period across all surgical departments. Eligible patients were identified by sequential electronic filtering based on age (≥80 years) and procedure type consistent with major abdominal surgery definitions, followed by detailed chart review for eligibility confirmation.

Inclusion criteria were: (1) age ≥80 years at the time of surgery, (2) major abdominal surgery performed between 2021 and 2025, and (3) availability of at least 30-day postoperative follow-up data. Exclusion criteria were: (1) age <80 years at the time of surgery, (2) procedures not meeting the definition of major abdominal surgery, (3) missing key peri-operative or outcome data, and (4) insufficient information to assess frailty or physiological reserve according to predefined variables.

### Data collection and variables

Data were obtained retrospectively from the hospital electronic medical record and anesthesia–surgery information systems using a standardized case report form (CRF) specifically developed for this study. Each eligible case was assigned to a unique study code, and all identifiers were removed prior to analysis.

Baseline demographic variables included age, sex, body mass index (BMI), smoking status, and source of admission. Preoperative clinical status was characterized by the American Society of Anesthesiologists (ASA) physical class, indication for surgery, and the presence of malignancy. Information regarding clinical history—specifically history of metastasis and exposure to chemotherapy or radiotherapy within the previous year—was also collected. Preoperative infection status was categorized as no sepsis or sepsis. To maintain focus on the primary prognostic model, only the core variables of interest and those demonstrating clinical or statistical significance were presented in the primary tables; however, all collected baseline parameters were evaluated during initial comparative analyses.

Frailty and functional status were evaluated using the 5-item modified frailty index. Components included: (1) functional dependence (partial or total), (2) diabetes requiring oral antidiabetic drugs or insulin, (3) history of chronic obstructive pulmonary disease or pneumonia, (4) congestive heart failure, and (5) hypertension requiring medication. Each item was scored as present or absent, yielding a



total score from 0 to 5. Based on their total score, patients were categorized into three groups: non-frail (score = 0), intermediate frailty (score = 1–2), and severe frailty (score ≥ 3). Global functional status was also separately recorded as independent, partially dependent, or dependent.

Physiological reserve was characterized by using pre-operative laboratory parameters obtained within 24 hours before surgery, or the closest available value when this window was not possible. The following variables were recorded: serum albumin, hemoglobin, creatinine, white blood cell count, C-reactive protein and lactate. Laboratory and clinical variables such as ASA status and pre-operative sepsis category were used together as objective indicators of physiological reserve.

Given the limited number of mortality events (n=17), the multivariable model was intentionally restricted to a small number of prespecified variables to reduce overfitting. Variable selection was based on clinical relevance, strength of univariable association, missingness profile, and avoidance of conceptual overlap or collinearity. To handle missing data in the multivariable analysis, a complete-case approach was adopted for the variables retained in the final model. Consequently, 76 patients with complete data for all model covariates were included in the final regression analysis.

### Peri-operative and postoperative data

Surgical details collected included surgical approach (open or laparoscopic), specific procedure name and anatomical region, and procedure group (colorectal, gastric, hepatobiliary, pancreatic, small bowel, gynecologic, urologic or other). Intraoperative vasopressor requirements were also documented.

Postoperative course within the first 30 days was evaluated using predefined binary outcomes on the CRF. The following early postoperative events were recorded: admission to the intensive care unit (ICU) and length of ICU stay (days), invasive mechanical ventilation >24 hours, postoperative vasopressor use, pneumonia or respiratory failure, cardiac complications (myocardial infarction, arrhythmia or decompensated heart failure), acute kidney injury, need for renal replacement therapy, clinically significant bleeding, anastomotic leakage, surgical site infection and unplanned reoperation within 30 days. Preoperative infection status was initially recorded in detailed categories but dichotomized for analysis as sepsis present versus absent because of small subgroup sizes. Hospital length of stay and 30-day readmission were also collected.

### Outcomes

The primary outcome was all-cause 30-day mortality after major abdominal surgery. Mortality status, date and place of death (in-hospital, after discharge or unknown) were recorded using hospital records and, when necessary, telephone follow-up for cases with incomplete early postoperative data. Secondary outcomes included ICU admission and ICU length of stay, postoperative complications within 30 days (as listed above), hospital length of stay and 30-day readmission.

The main exposures of interest were frailty status, quantified by the mFI-5, and indicators of physiological reserve, including serum albumin, hemoglobin and creatinine, in addition to ASA class and pre-operative sepsis status. The study was designed to explore the association between these pre-operative factors and 30-day mortality, and to identify independent predictors of early death in very old patients undergoing major abdominal surgery.

### Statistical analysis

All analyses were performed using Statistical Package for the Social Sciences (SPSS) 24.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for distributional properties using visual

inspection (histograms and Q–Q plots) and the Shapiro–Wilk test. Normally distributed variables are presented as mean ± standard deviation (SD) and non-normally distributed variables as median (interquartile range, IQR). Categorical variables are presented as counts and percentages.

Patients were stratified by the primary outcome (30-day mortality: survivors vs. non-survivors). Between-group comparisons were performed using the Student's t test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test as appropriate.

To identify predictors of 30-day mortality, univariable logistic regression analyses were first conducted for clinically relevant candidate variables, including age, sex, urgency (elective vs. emergency), ASA class, preoperative sepsis category, frailty status (mFI-5 categories: 0, 1–2, ≥3), and selected physiological reserve markers (albumin, hemoglobin, creatinine; and additionally white blood cell, C-reactive protein, lactate when available). Variables with $p < 0.10$ in univariable analyses and variables deemed clinically important a priori were considered for multivariable logistic regression. To minimize the risk of overfitting due to the limited number of mortality events, the multivariable model was restricted to a parsimonious set of clinical predictors (mFI-5, albumin, surgical urgency, and ASA class). Although preoperative sepsis was significant in univariable analysis, it was excluded from the final model to minimize conceptual overlap with urgency and to preserve model stability. Variables with substantial missingness, particularly CRP, were not retained in the final model in order to avoid further reduction in analyzable sample size.

Results are reported as odds ratios (OR) with 95% confidence intervals (CI). Model discrimination was assessed using the area under the receiver operating characteristic curve (AUC). Multivariable regression was performed using complete-case analysis for variables included in the final model.

A two-sided p-value $< 0.05$ was considered statistically significant.

## RESULTS

During the study period, 50,051 surgical procedures were recorded in the institutional database across all surgical specialties. After sequential electronic filtering and detailed chart review for eligibility assessment, 92 patients aged ≥80 years undergoing major abdominal surgery were included in the final analysis (Figure 1). Thirty-day mortality occurred in 17 patients (18.5%). Emergency surgery (n=12, 70.6% vs. n=9, 12.0% $p<0.001$), higher ASA class ($p<0.001$), and preoperative sepsis ($p=0.003$) were significantly more frequent among non-survivors (Table 1).

Admission via the emergency department was also strongly associated with mortality ($p<0.001$). Other baseline factors, including smoking, metastasis, and prior oncology treatments, showed no significant association (all $p>0.05$). Consequently, non-significant parameters were omitted from the

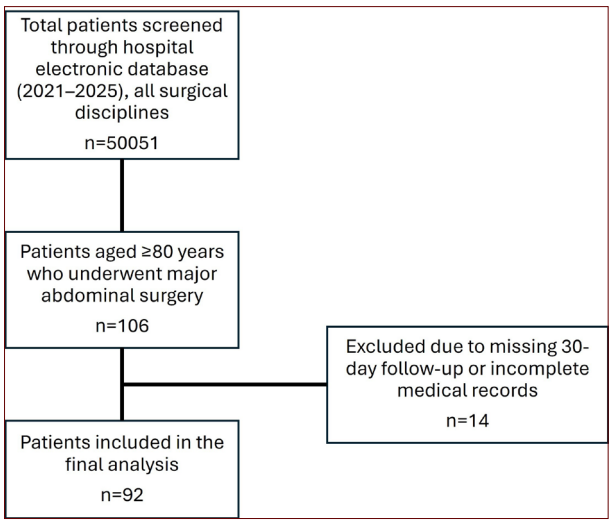



**Figure 1.** Flow chart of patient selection and study methodology

**Table 1.** Baseline and perioperative characteristics and laboratory findings of patients aged ≥80 years by 30-day mortality status (n=92)

| Variable | Survivors (n=75) | Non-survivors (n=17) | p-value |
|---|---|---|---|
| **Demographics** | | | |
| Age (years), median [IQR] | 82 [81–84] | 84 [82–87] | 0.086 |
| Sex, n (%) | | | 0.114 |
| Female | 32 (42.7) | 11 (64.7) | |
| Male | 43 (57.3) | 6 (35.3) | |
| **BMI (kg/m²), median [IQR]†** | 24.47 [22.30–27.64] | 27.20 [23.78–29.85] | 0.111 |
| **Clinical / Perioperative Status** | | | |
| Urgency, n (%) | | | <0.001 |
| Elective | 66 (88.0) | 5 (29.4) | |
| Emergency | 9 (12.0) | 12 (70.6) | |
| ASA class, n (%) | | | <0.001 |
| II | 6 (8.0) | 2 (11.8) | |
| III | 56 (74.7) | 4 (23.5) | |
| IV | 13 (17.3) | 10 (58.8) | |
| V | 0 (0.0) | 1 (5.9) | |
| Preoperative sepsis, n (%)‡ | 3 (4.0) | 5 (33.3) | 0.003 |
| Intra-operative vasopressor requirement, n (%) | 8 (10.7) | 10 (58.8) | <0.001 |
| Surgical approach, n (%) | | | 0.005 |
| Open | 51 (68.0) | 17 (100.0) | |
| Laparoscopic | 24 (32.0) | 0 (0.0) | |
| Admission source, n (%) | | | <0.001 |
| Emergency Department | 11 (14.7) | 12 (70.6) | |
| Other (Home/Referral) | 64 (85.3) | 5 (29.4) | |
| **Malignancy (yes), n (%)** | 68 (90.7) | 10 (58.8) | 0.003 |
| **Frailty Status** | | | |
| mFI-5 category, n (%)§ | | | 0.025 |
| 0 (Non-frail) | 8 (11.9) | 0 (0.0) | |
| 1–2 (Intermediate) | 49 (73.1) | 5 (50.0) | |
| ≥3 (Severe) | 10 (14.9) | 5 (50.0) | |
| **Laboratory Findings** | | | |
| Albumin (g/L), median [IQR]¶ | 37.0 [31.0–40.0] | 28.4 [24.5–32.5] | 0.001 |
| Hemoglobin (g/dL), median [IQR] | 11.3 [10.2–13.1] | 9.8 [9.3–11.6] | 0.025 |
| Creatinine (mg/dL), median [IQR] | 0.84 [0.70–1.05] | 1.10 [0.71–1.40] | 0.099 |
| WBC (×10³/μL), median [IQR] | 6.9 [5.7–8.9] | 8.3 [4.6–14.0] | 0.300 |
| CRP (mg/L), median [IQR]†† | 15.0 [3.8–31.0] | 108.0 [37.0–213.0] | <0.001 |
| Lactate (mmol/L), median [IQR]‡‡ | 0.99 [0.80–1.20] | 1.07 [0.80–1.90] | 0.685 |

Notes: Continuous variables are presented as median [interquartile range] and compared using the Mann–Whitney U test. Categorical variables are presented as n (%) and compared using the Chi-square test or Fisher's exact test as appropriate. † BMI available in n=88 (4 missing): Survivors n=74 (1 missing), Non-survivors n=14 (3 missing). ‡ Preoperative sepsis: n=90 (2 missing). § mFI-5: n=77 (15 missing). ¶ Albumin: n=88 (4 missing). †† CRP: n=65 (27 missing). ‡‡ Lactate: n=80 (12 missing). ASA: American Society of Anesthesiologists, mFI-5: modified Frailty Index-5, WBC: white blood cell count, CRP: C-reactive protein, BMI; Body Mass Index, IQR; interquartile range

primary tables to maintain focus on the prognostic model.

Frailty (mFI-5) was significantly associated with mortality (p=0.025), with severe frailty (mFI-5 ≥3) present in 50.0% of non-survivors compared to 14.9% of survivors. Among laboratory markers, non-survivors had significantly lower albumin (p=0.001) and hemoglobin (p=0.025), and higher CRP levels (p<0.001); whereas age, BMI, creatinine, and lactate levels showed no significant differences. Intraoperative vasopressor requirement was markedly higher among non-survivors (p<0.001).

Malignancy was more prevalent in survivors (p=0.003), but this was driven by surgical urgency: malignancy was present in 92.8% of elective vs. 44.4% of emergency cases (p<0.001). When stratified by urgency, malignancy showed no independent association with mortality.

Procedure group distribution (e.g., colorectal, gastric, hepatobiliary, pancreatic, and urologic procedures) did not differ significantly between survivors and non-survivors (p=0.663); however, comparisons across less frequent categories were limited by small cell counts.

Intraoperative vasopressor requirement was significantly more frequent among non-survivors than survivors (n=10, 58.8% vs. n=8, 10.7%, p<0.001). However, the need for intraoperative vasopressors was not significantly associated with surgical urgency (33.3% in emergency cases vs. 15.5% in elective cases, p=0.113), indicating that hemodynamic instability occurred across both urgency categories.

Postoperative outcomes and complication rates differed markedly between survivors and non-survivors (Table 2). Non-survivors had a significantly

**Table 2.** Postoperative outcomes and complications by 30-day mortality status (N=92)

| Variable | Survivors (n=75) | Non-survivors (n=17) | p-value |
|---|---|---|---|
| **Intensive Care** | | | |
| ICU admission, n (%) | 67 (89.3) | 17 (100.0) | 0.343* |
| ICU stay (days), median [IQR] | 1 [1–1] | 7 [2–15] | <0.001 |
| Mechanical ventilation >24h, n (%) | 5 (6.7) | 14 (82.4) | <0.001* |
| Vasopressor use, n (%) | 3 (4.0) | 14 (82.4) | <0.001* |
| **Postoperative Complications** | | | |
| Pulmonary complication, n (%) | 14 (18.7) | 12 (70.6) | <0.001* |
| Cardiac complication, n (%) | 9 (12.0) | 9 (52.9) | <0.001* |
| Acute kidney injury, n (%) | 17 (22.7) | 11 (64.7) | 0.001* |
| Renal replacement therapy, n (%) | 1 (1.3) | 3 (17.6) | 0.019 |
| Postoperative sepsis, n (%) | 4 (5.3) | 13 (76.5) | <0.001* |
| Anastomotic leak, n (%) | 4 (5.3) | 2 (11.8) | 0.306* |
| Surgical site infection, n (%) | 8 (10.7) | 5 (29.4) | 0.060* |
| Bleeding complication, n (%) | 0 (0.0) | 0 (0.0) | — |
| **30-Day Events** | | | |
| Reoperation within 30 days, n (%) | 7 (9.3) | 2 (11.8) | 0.670* |
| Readmission within 30 days, n (%) | 6 (8.0) | 1 (5.9) | 1.000* |
| **Hospital Stay** | | | |
| Hospital LOS (days), median [IQR] | 14 [10–22.5] | 14 [8–30] | 0.968 |

*Fisher's exact test; all others Chi-square or Mann-Whitney U as appropriate. IQR: Interquartile range, ICU: Intensive care unit, LOS: Length of stay.



longer ICU stay compared to survivors (median 7 [2–15] vs. 1 [1–1] days, p<0.001), although ICU admission rates were similar between groups (n=17, 100% vs. n=67, 89.3%, p=0.343). The need for prolonged mechanical ventilation (>24 hours) was substantially higher among non-survivors (n=14, 82.4% vs. n=5, 6.7%, p<0.001), as was postoperative vasopressor requirement ( n=14, 82.4% vs. n=3, 4.0%, p<0.001).

Postoperative complications, particularly pulmonary, cardiac, renal, and septic events, were significantly more frequent in non-survivors (all p<0.001; Table 2). Renal replacement therapy was also more common in this group (p=0.019).

In contrast, anastomotic leak, surgical site infection, reoperation, and readmission rates did not differ significantly between groups. Notably, overall hospital length of stay was similar between survivors and non-survivors (median 14 days in both groups, p=0.968).

A clear dose–response relationship was observed between the mFI-5 score and 30-day mortality (linear-by-linear association, p=0.010). Mortality rates increased progressively with higher frailty scores: 0% in patients with a score of 0, 7.4% for a score of 1, 11.1% for a score of 2, 30.8% for a score of 3, and 50.0% in patients with a score of 4. No patients in the cohort had an mFI-5 score of 5.

To determine the independent predictors of 30-day mortality, a multivariable logistic regression model was performed (Table 3). The model demonstrated excellent fit (Hosmer-Lemeshow p=0.973) and explained 42.7% of the variance (Nagelkerke $R^2$).

The mFI-5 score was identified as a significant independent predictor of mortality (p=0.044). Each one-point increase in the mFI-5 score was associated with a 2.71-fold increase in the odds of 30-day mortality (OR: 2.71, 95% CI: 1.03–7.16). Preoperative albumin levels showed a strong trend toward significance, with each 1 g/L increase associated with a 13% reduction in mortality risk (OR: 0.87, 95% CI: 0.75–1.01, p=0.069). Surgical urgency was included in the multivariable model because of its strong univariable association; however, it did not reach independent statistical significance after adjustment for mFI-5 and albumin (Table 3).

In a sensitivity analysis using mFI-5 as a binary variable, frail patients (score ≥3) had 4.0 times higher odds of 30-day mortality compared to non-frail patients (score <3), although this trend did not reach independent statistical significance (OR: 4.00, 95% CI: 0.77–20.83, p=0.097).

The predictive performance of the multivariable model was evaluated using the Receiver Operating Characteristic (ROC) curve analysis. The model demonstrated excellent discriminative ability, with an AUC of 0.899 (95% CI: 0.822–0.977, p<0.001) (Figure 2). This indicates that the multivariable

**Table 3.** Multivariable Logistic Regression Analysis for Predictors of 30-Day Mortality (n=76)

| Variable | B | S.E. | Wald | p-value | OR (95% CI) |
|---|---|---|---|---|---|
| mFI-5 Score (per point) | 0.999 | 0.495 | 4.067 | 0.044 | 2.71 (1.03–7.16) |
| Albumin (g/L) | -0.139 | 0.076 | 3.311 | 0.069 | 0.87 (0.75–1.01) |
| Urgency (Emergency) | 1.488 | 0.971 | 2.347 | 0.126 | 4.43 (0.66–29.73) |
| ASA Class (IV-V) | 0.523 | 0.940 | 0.310 | 0.578 | 1.69 (0.27–10.64) |
| Constant | -0.067 | 2.574 | 0.001 | 0.979 | 0.93 |

Model fit: Hosmer-Lemeshow test p=0.973; Nagelkerke $R^2$ = 0.427.OR: Odds Ratio, CI: Confidence Interval, mFI-5: modified Frailty Index-5, ASA: American Society of Anesthesiologists.

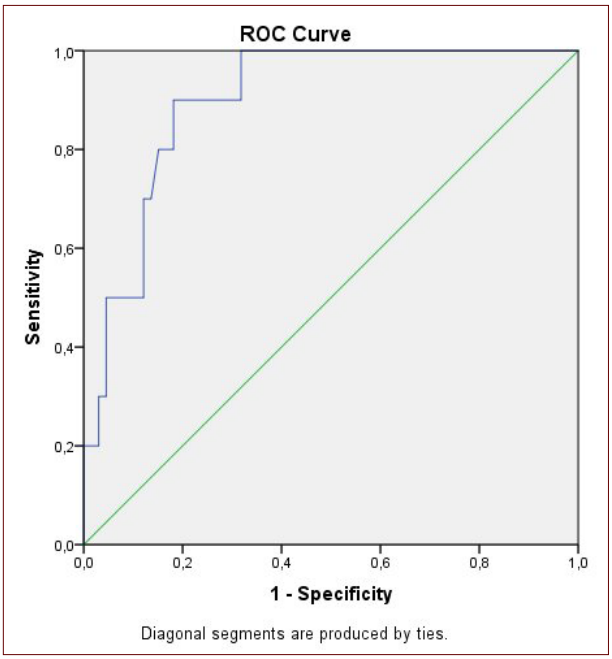



**Figure 2.** ROC curve analysis of the multivariable model for predicting 30-day mortality

ROC; Receiver Operating Characteristic

model incorporating mFI-5, albumin, urgency, and ASA class demonstrates strong discriminative ability for predicting 30-day mortality in patients aged ≥80 years undergoing major abdominal surgery.

Admission source was not entered into the primary multivariable model because of conceptual overlap with surgical urgency, and intraoperative vasopressor requirement was analyzed separately as a perioperative marker rather than a preoperative predictor.

## DISCUSSION

Our study demonstrates that in patients aged 80 years or older undergoing major abdominal surgery, frailty—as measured by the mFI-5—provides stronger prognostic information for postoperative mortality than traditional risk markers such as ASA physical status or the urgency of the procedure. While emergency surgery and a higher ASA class were associated with mortality in univariable analyses, their associations were attenuated after adjustment, whereas the mFI-5 score remained independently associated with mortality in the multivariable model. Taken together, these findings suggest that, within this advanced-age cohort, biological reserve and frailty may be more informative than procedural timing alone in determining postoperative outcomes.

Importantly, our study differs from many previous reports by focusing exclusively on patients aged ≥80 years undergoing major abdominal surgery and by evaluating frailty together with laboratory-based indicators of physiological reserve within the same preoperative framework.

Traditional risk assessment tools, such as the ASA classification, have long been central to perioperative risk estimation (10). However, in octogenarians, the ASA score may not fully capture the multidimensional vulnerability that contributes to adverse outcomes. Similarly, Matsuo et al. and Hikage et al. showed that postoperative outcomes in very old patients are influenced not only by chronological age but also by functional status, ASA class, performance status, and serum albumin levels (11,12). Our findings support the clinical utility of the mFI-5 as a concise 5-item tool that can identify high-risk older patients who may benefit from intensified perioperative planning and optimization.

Beyond frailty, our study also underscores the potential importance of physiological reserve reflected by preoperative serum albumin levels. Although albumin did not reach conventional statistical significance in the multivariable model ($p=0.069$), the direction and magnitude of its association were clinically meaningful, with each 1 g/L increase corresponding to an estimated 13% lower odds of 30-day mortality. This is consistent with Stovell and Jenkinson, who highlighted hypoalbuminemia as an indicator of reduced resilience and diminished capacity to tolerate surgical stress (13). In addition, prior evidence



suggests that frailty and poor nutritional status may coexist and jointly contribute to postoperative vulnerability, potentially amplifying adverse outcomes in older surgical patients (7).

Furthermore, our study highlights the prognostic value of intraoperative hemodynamic stability. Intraoperative vasopressor requirement was a strong predictor of 30-day mortality ($p<0.001$). Interestingly, while emergency surgery was a major risk factor, the need for vasopressors did not significantly correlate with surgical urgency ($p=0.113$). This suggests that intraoperative hemodynamic instability may serve as a real-time indicator of diminished physiological reserve and underlying frailty, rather than being solely a consequence of procedural urgency or acute surgical stress. This finding reinforces the concept that frail oldest-old patients have a narrower 'hemodynamic safety margin' regardless of the elective or emergency nature of the surgery.

The analysis of postoperative outcomes revealed marked differences between survivors and non-survivors. Non-survivors experienced substantially higher rates of severe complications, including postoperative sepsis (76.5%), prolonged mechanical ventilation (82.4%), and postoperative vasopressor requirement (82.4%). These findings suggest that mortality in this population may frequently follow a trajectory of severe systemic complications and limited physiological tolerance to further insults. As discussed in Frailty as a Predictor of Surgical Outcomes, frail patients may have reduced "buffer capacity," increasing susceptibility to a cascade of organ dysfunction once a major complication occurs (7). The higher incidence of acute kidney injury and cardiac complications among non-survivors in our cohort further supports the concept of multisystem vulnerability in the frail oldest-old.

Consequently, our findings have important implications for perioperative management in the oldest-old. The multivariable model incorporating mFI-5, albumin, urgency, and ASA demonstrated excellent discrimination (AUC 0.899). Within this model, mFI-5 remained independently associated with 30-day mortality in major abdominal surgery. Importantly, we observed a clear dose–response relationship between frailty severity and 30-day mortality ($p=0.010$). This stepwise increase from 0% to 50% mortality reinforces the mFI-5 as a progressive risk marker rather than a simple binary indicator, allowing for more nuanced preoperative risk stratification. In elective cases, early recognition of frailty may support individualized planning, including nutritional optimization and targeted "prehabilitation" approaches where feasible. In emergency settings, where time for optimization is limited, an mFI-5–informed assessment may facilitate structured team communication and shared decision-making by providing a clearer estimate of short-term mortality risk and the likelihood of postoperative multi-organ dysfunction.

Our findings align with studies demonstrating the superiority of mFI-5 over traditional markers in diverse surgical cohorts (14,15). Specifically, the sharp mortality increase at an mFI-5 threshold of ≥3 mirrors results observed in geriatric fracture patients (16). Furthermore, the inclusion of comorbidities like COPD in the mFI-5 remains critical, as respiratory dysfunction is a key correlate of frailty and diminished reserve in octogenarians (1).

Finally, the remarkably high prevalence of frailty reported in oldest-old populations underscores the importance of routine frailty screening within geriatric care pathways. Sharma et al. reported frailty prevalence exceeding 80% in community-dwelling adults aged ≥80 years using the Fried phenotype and emphasized the need for structured protocols incorporating frailty screening and multidisciplinary interventions (1). In the perioperative setting, this supports the rationale for integrating frailty assessment into routine evaluation, particularly for high-stress procedures such as major abdominal surgery in advanced-age patients.

The lower malignancy prevalence among non-survivors was likely related to the case-mix

characteristics of our tertiary oncology center. Malignancy was predominantly observed in elective surgical patients who underwent preoperative evaluation and optimization, whereas non-malignant cases more frequently represented emergency admissions with greater acute physiological instability. When stratified by urgency, malignancy was not independently associated with 30-day mortality.

Our univariable analysis showed that all mortality events occurred in the open surgery group. However, this likely reflects a selection bias where higher-risk emergency cases or more complex oncological resections were more frequently managed via an open approach.

### Limitations

Several limitations exist. First, the retrospective, single-center design may limit generalizability and introduce selection bias regarding surgical candidacy in the oldest-old. Second, the sample size was modest, and the number of mortality events was limited (n=17), which may reduce the stability of the multivariable model and increase the risk of overfitting despite the parsimonious modeling strategy. Third, the multivariable analysis was based on a complete-case approach (n=76), which may have introduced selection bias because patients with missing data for model covariates were excluded. Fourth, the mFI-5 is a comorbidity-based tool and may not fully capture physical performance domains like gait speed; retrospective functional status assessment also risks misclassification. Fifth, residual confounding from unmeasured factors—such as goals-of-care decisions and perioperative triage practices—may influence short-term mortality. Sixth, while the model showed strong discrimination (AUC 0.899), external validation is needed to confirm transportability and clinical thresholds. Finally, the oncology-center setting and heterogeneous procedure types may not reflect general surgical populations. Despite these limitations, the observed dose–response relationship suggests that the mFI-5 may still provide clinically meaningful risk stratification for major abdominal surgery in patients aged ≥80 years.

Prospective multicenter studies are warranted to validate these findings and evaluate the impact of frailty screening on clinical outcomes.

## CONCLUSION

In patients aged 80 years or older undergoing major abdominal surgery, the mFI-5 appears to be a practical tool for identifying patients at increased risk of postoperative mortality. The mFI-5 score remained an independent predictor of 30-day mortality after adjustment for confounding factors. Incorporating frailty assessment into routine preoperative evaluation may enhance risk stratification and support perioperative decision-making in this high-risk population. These findings support the integration of frailty assessment into routine preoperative workflows, particularly in time-sensitive surgical settings involving the oldest-old.

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