Meta-Analysis and Systematic Review

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Preoperative frailty and postoperative complications after non-cardiac surgery: a systematic review

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Abstract

Objective: Many tools have been used to assess frailty in the perioperative setting. However, no single scale has been shown to be the most effective in predicting postoperative complications. We evaluated the relationship between several frailty scales and the occurrence of complications following different non-cardiac surgeries.

Methods: This systematic review was registered in PROSPERO (CRD42023473401). The search strategy included PubMed, Google Scholar, and Embase, covering manuscripts published from January 2000 to July 2023. We included prospective and retrospective studies that evaluated frailty using specific scales and tracked patients postoperatively. Studies on cardiac, neurosurgical, and thoracic surgery were excluded because of the impact of underlying diseases on patients' functional status. Narrative reviews, conference abstracts, and articles lacking a comprehensive definition of frailty were excluded.

Results: Of the 2204 articles identified, 145 were included in the review: 7 on non-cardiac surgery, 36 on general and digestive surgery, 19 on urology, 22 on vascular surgery, 36 on spinal surgery, and 25 on orthopedic/trauma surgery. The reviewed manuscripts confirmed that various frailty scales had been used to predict postoperative complications, mortality, and hospital stay across these surgical disciplines.

Conclusion: Despite differences among surgical populations, preoperative frailty assessment consistently predicts postoperative outcomes in non-cardiac surgeries.

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Introduction

To enhance patient safety, it is essential to identify the factors that influence postoperative outcomes.[1,2] Preoperative evaluation of frailty, which reflects a decrease in physiological reserves, can predict poorer outcomes.[1,3–5]

Frailty is a state of vulnerability caused by physiological derangement due to the deterioration of various systems.[1,6] Patients with frailty experience a decline in muscular strength and endurance along with a reduction in physiological balance, increasing the risk of postoperative dependency or death.[4] Key characteristics of frailty include decreased physical activity, malnutrition, sarcopenia, over-medication, depression, cognitive disorders, and lack of social support.[7] Frailty is a dynamic syndrome[6] that can be modified.[8] Theoretically, optimizing a patient's condition preoperatively can reduce their frailty and secondary complications. In addition, personalized anesthesia management and vigilant monitoring can help detect intraoperative and postoperative fluctuations that might influence outcomes.

The management of patients with frailty should prioritize achieving favorable surgical outcomes, preventing complications, and optimizing postoperative recovery. Identifying and utilizing frailty screening tools can delay dependency, promote health, and support the well-being of elderly populations.[5] However, commonly used frailty scales may not be suitable in all situations because of limited resources, clinical context, the quality of instruments, and cultural considerations.[5] In certain populations, identifying the most appropriate scale can be challenging because of physical limitations that may lead to misinterpretation of measurements.[5] Various tools have been used to assess frailty in the perioperative setting, but which scale is the most effective in predicting postoperative complications remains unclear. Therefore, we evaluated the relationship between different frailty scales and the occurrence of complications in different non-cardiac surgeries. Given the extensive research on this topic in recent years, the main objective of this systematic review was to consolidate the literature on the application of several frailty scales in predicting postoperative complications in different non-cardiac surgeries.

Methods

This systematic review was conducted according to current guidelines, and its protocol was prospectively registered in PROSPERO (CRD42023473401). This article adheres to the applicable PRISMA statement.[9]

Eligibility criteria

For this systematic review on preoperative frailty and the appearance of postoperative complications, we selected studies published from 1 January 2000 to 31 July 2023. We included the following manuscripts: systematic reviews as well as retrospective and prospective observational studies involving patients with preoperative frailty who were followed postoperatively for complications, differences in hospital stay, readmission rates, and short-term survival. Only studies in which preoperative frailty had been assessed using scales were included. Studies involving patients who had undergone cardiac surgery, neurosurgery, or thoracic surgery were excluded because the patients' functional status could be affected by their underlying disease. This restriction was intended to homogenize the included studies. In addition, we excluded manuscripts that assessed frailty solely through sarcopenia or comorbidities. Although sarcopenia may be a component of frailty, it is not exclusively representative of the syndrome. Similarly, comorbidity scales are generally not effective indicators of frailty.

Search strategy

Manuscripts were identified in PubMed and Google Scholar using the following search strategy:

- PubMed: ("preoperative frailty") AND ("postoperative complications") AND ("2000/01/01"[Date-Publication]: "2023/07/31"[Date-Publication]) NOT ("cardiac surgery") NOT ("neurosurgery") NOT ("thoracic surgery")
- Google Scholar: "preoperative frailty" AND "postoperative complications" NOT "cardiac surgery" NOT "neurosurgery" NOT "thoracic surgery"
- Excerpta Medica Data Base (Embase): "preoperative frailty" AND "postoperative complications" NOT "cardiac surgery" NOT "neurosurgery" NOT "thoracic surgery"

Study selection

The titles and abstracts of the articles were evaluated according to their pertinence and relevance. Articles published in Spanish, English, or German up to July 2023 were selected using predefined criteria. Studies were excluded if they focused on frailty in patients who did not undergo surgery or if they did not evaluate postoperative outcomes such as complications, the hospital stay duration, readmission rates, or survival. To focus on specific data, only the most relevant systematic reviews were included and summarized, whereas narrative reviews and conference abstracts were excluded. In addition, studies were excluded if frailty was not clearly defined or if it was assessed solely through sarcopenia or the presence of comorbidities. Figure 1 shows a flow chart of the article selection process.

Data extraction

A predefined data collection form was used, extracting the following data from each article: study type, population included, frailty scale used, incidence of frailty in the sample, rate of postoperative complications, and relationship between the frailty scale and postoperative complications, including the length of stay, discharge, and mortality. Two authors (A. B.-B. and A. R.-P.) independently evaluated the quality of the observational studies. Given the nature of the topic, randomized clinical trials were not expected to be included in this systematic review. Any discrepancies between the authors were discussed until an agreement was reached. If discrepancies persisted, the third author (Y. H.-A.) was consulted to reach a conclusion. Data obtained from observational studies and conclusions from systematic reviews were summarized, and the odds ratio (OR), relative risk (RR), 95% confidence interval (95% CI), and area under the curve (AUC) were compared.

Results

Our search yielded 2204 articles. After excluding duplicates, 2102 articles were evaluated. Studies focused on cardiac surgery (1104 articles), neurosurgery (771 articles), and thoracic surgery (82 articles) were excluded. The final review included 145 articles (Figure 1).

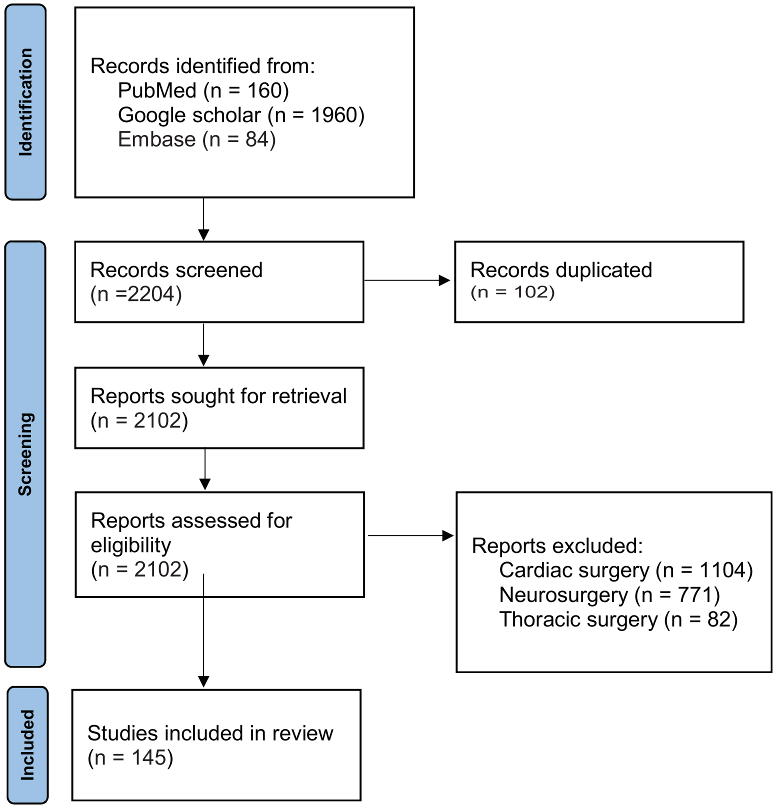

Figure 1. Flow chart of article selection.

Non-cardiac surgery

In non-cardiac surgery, patients classified as frail according to Fried criteria had twice the likelihood of developing cardiac, renal, and infectious complications.[10] The Risk Analysis Index (RAI) can also predict mortality independently of the Operative Stress Score of the procedure.[11] Deterioration of function as measured by the 11-item modified Frailty Index (mFI-11) was associated with a higher rate of early re-admission after orthopedic, digestive, and vascular surgeries.[12] Declining cognitive function as assessed by the Sloan-Kettering Memorial Frailty Index was also confirmed as a significant risk factor for delirium ($OR = 15.29$, 95% $CI = 7.18–32.56$, $p < 0.001$).[13]

Prospective studies have confirmed that frailty as determined by the Edmonton Frail Scale (EFS) is associated with postoperative cardiac complications and a longer hospital stay.[14] In a study of 705 patients aged >65 years with a considerably mortality rate (10.2%), the Clinical Frailty Scale (CFS) showed a sensitivity of 60% and a specificity of 59% in predicting postoperative mortality or disability, while the 5-item modified Frailty Index (mFI-5) had a sensitivity of 56% and a specificity of 65%.[15] Another prospective study compared three frailty assessment scales: FRAIL (a questionnaire containing 5 factors), the Frailty Index (FI) (a 70-item scale derived through parameters from the Comprehensive Geriatric Assessment (CGA)), and the CFS.[16] Among 194 patients with a complication rate of 29.9%, frailty was associated with the occurrence of postoperative complications across all three tools, with similar ORs among the three scales (4.02, 5.87, and 5.93, respectively).[16]

General and digestive surgery

In patients aged >65 years, a higher FI was associated with greater risk of postoperative complications (OR = 2.54, 95% CI = 1.12–5.77), longer hospital stays, and a greater likelihood of discharge to a care facility (OR = 20.48, 95% CI = 5.54–75.68).[17] An FI of >0.12 was accompanied by an increased risk of developing any type of complication (OR = 2.71, 95% CI = 1.08–6.78, p = 0.03) after complex abdominal surgery.[18] After cytoreductive surgery with hyperthermic intraperitoneal chemotherapy, frailty assessed by the mFI-11 was the only factor associated with postoperative mortality (OR = 29.1, 95% CI = 4.00–210.87, p = 0.01),[19] and patients with an mFI-11 score of ≥0.27 had a higher rate of serious complications (OR = 2.93, 95% CI = 1.22–7.03, p = 0.02) after retroperitoneal sarcoma resection.[20] The populations included in these studies were relatively young (mean age, 55 and 59 years), implying that frailty influences postoperative outcomes not only in elderly patients but also in younger ones.[19,20] Although the mFI-11 failed to predict 30-day mortality after retroperitoneal sarcoma resection,[20] frailty according to the scale extracted from the Canadian Study of Health and Aging (CSHA) was associated with postoperative mortality (OR = 4.84, 95% CI = 1.38–16.98, p < 0.01) after general surgery.[21]

Regarding urgent abdominal surgeries, a retrospective study involving patients aged >80 years showed that as the mFI-11 score increased from 0.00 to 0.64, the percentage of patients experiencing serious complications increased from 9.1% to 77.1%.[22] Moreover, two prospective studies involving patients aged >65 years showed that frailty according to the Johns Hopkins Adjusted Clinical Groups (JHACG) frailty scale,[23] Vulnerable Elderly Scale,[23] and CFS[24] was associated with mortality. The risk of postoperative complications also increased in direct proportion to the CFS score (OR = 4.56–3.92).[24]

In patients who undergo surgery for colorectal cancer, frailty increases the probability of requiring colostomy.[25] A prospective study determined that male sex, sarcopenia, age, and history of abdominal surgery were independent predictors of mortality, anastomotic leakage, and sepsis. The interaction of these variables with the presence of frailty according to the Groningen Frailty Indicator (GFI) did not increase the predictive value of sarcopenia.[26] In a subsequent retrospective study of 53,652 patients aged >65 years, frailty evaluated according to a proposed Colon Cancer Frailty Index defined by nine preoperative variables was associated with hospital complications (OR = 1.8, 95% CI = 1.1–2.9, p = 0.001) and transfer to a care facility after hospitalization (OR = 1.3, 95% CI = 1.1–3.5, p = 0.01).[25] However, frailty was not an independent predictor of mortality.[25] Despite this, another retrospective study of 41,455 patients with cancer who had undergone resection of the liver, colon, rectum, pancreas, esophagus, or stomach showed that frailty as evaluated by the mFI-11 was associated with a higher rate of major complications (OR = 1.88, 95% CI = 1.75–2.02, p < 0.0001) and 30-day mortality (OR = 2.35, 95% CI = 2.03–2.72, p < 0.0001).[27] Another prospective study involving only 144 patients undergoing scheduled abdominal surgery (68% oncological) revealed a greater proportion of patients with frailty according to Fried's Frailty Phenotype (FFP) among those with complications and readmissions.[28] Among patients aged >75 years, patients with frailty had a four-fold increased risk of developing major complications after elective colorectal surgery,[29] and frailty assessed using the mFI-5 was associated with decreased overall survival.[30]

Frailty has also been studied as a predictor of postoperative complications in patients undergoing surgery for gastric cancer. A retrospective study showed an association between an increase in the GFI and inpatient mortality (OR = 1.35, 95% CI = 1.01–1.80, p = 0.04) as well as serious complications (OR = 3.62, 95% CI = 1.53–8.58, p = 0.04) regardless of age, surgery type, tumor stage, American Society of Anesthesiologists (ASA) classification, and neoadjuvant chemotherapy.[31] Other retrospective studies showed that mFI-11 was an independent predictive indicator of higher mortality 1 year postoperatively (OR = 4.43, 95% CI = 2.59–6.34, p = 0.003), anastomotic fistula (OR = 2.85, 95% CI = 1.36–5.99, p = 0.006), and admission to the intensive care unit (ICU) (OR = 2.06, 95% CI = 1.19–3.56, p = 0.01),[32] whereas frailty as assessed by the Study of Osteoporotic Fractures index was a risk factor for readmission in the first postoperative year (OR = 5.74, 95% CI = 1.78–18.48, p = 0.003).[33] The rate of systemic complications after gastrectomy increased in direct proportion to the CFS score,[34] although it did not demonstrate statistical significance in terms of surgical complications or mortality.[34]

The presence of frailty assessed using the FFP has also been found to be associated with major complications (OR = 4.06, p = 0.01) and ICU admission (OR = 4.30, p = 0.01) after pancreaticoduodenectomy.[35] A retrospective study involving 9986 patients who had undergone Whipple surgery showed that a higher mFI-11 score was associated with a higher incidence of any type of complication and short-term mortality.[36] The CFS score has also been shown to be a useful predictor of postoperative complications after pancreatectomy.[37] However, frailty determined by the RAI could not predict whether postoperative complications would occur after hepatobiliary surgery. Nevertheless, the RAI could predict the number and severity of complications, hospital stay, and the need for intensive care in patients with at least one complication.[38] The Kihon Checklist (25 questions covering seven domains) also showed that the relevance of the domain corresponding to mood was greater in patients who later developed postoperative delirium.[39]

Among patients undergoing laparoscopic cholecystectomy, frailty measured by the CGA was related to postoperative complications (OR = 6.0, 95% CI = 1.20–30.40, p = 0.026), longer hospital stays, and greater pain on the first postoperative day.[40] Moreover, a higher mFI-5 score was associated with a greater probability of any kind of complication (OR = 3.12, 95% CI = 1.78–5.47), surgical wound infection (OR = 3.41, 95% CI = 1.58–7.34), and adverse events after discharge (OR = 1.70, 95% CI = 1.24–2.33) despite the low incidence of complications (3%) and the low mean age of the included patients (55 years).[41] Among patients undergoing outpatient major surgery (breast, hernia, thyroid, and parathyroid surgery), high mFI-11 scores were associated with an increase in the occurrence of complications (OR = 3.35, 95% CI = 2.52–4.46, $p < 0.001$) and severe complications (OR = 3.95, 95% CI = 2.65–5.87, $p < 0.001$).[42]

Only four studies of patients undergoing abdominal surgery used more than one frailty scale.[43–46] A prospective study involving patients aged >60 years with a high rate of complications (26%) showed that the EFS, mFI-11, and CFS were unable to predict the occurrence of inpatient complications.[43] Another prospective study of patients undergoing gastrointestinal surgery with a complication rate similar to the previous study (29%) showed that the FRAIL scale score, FFP, and CFS score were independent predictors of systemic complications. Among these measures, the CFS score was the best predictor of mortality 1 month after surgery and was statistically superior to the ASA classification in predicting complications.[44] In a retrospective study of 1132 patients aged >65 years who had undergone high-risk abdominal surgery, both an mFI-11 score of ≥0.27 and a Revised RAI score of ≥45 predicted increased morbidity and mortality (OR = 2.06 and 1.86, respectively).[45] Among geriatric patients undergoing general surgery, although the FFP was associated with postoperative complications (OR = 2.3, 95% CI = 1.4–3.8, $p < 0.01$), the CGA score did not reach statistical significance.[46] However, frailty according to both scales was associated with a longer postoperative hospital stay.[46] In emergency general surgery, adding the FI, HFRS, RAI, and CGA scores to typical risk factors was found to accurately predict perioperative outcomes.[47]

Urological surgery

A retrospective study of 36,682 patients who had undergone radical nephrectomy analyzed the association of postoperative morbidity and mortality using the sFI-5, a scale based on five comorbidities.[48] Patients with an sFI-5 score of 1 and those with an sFI-5 score of ≥2 were more likely to develop postoperative complications (OR = 1.62 and 2.54, respectively) and mortality (OR = 1.77 and 3.52, respectively).[48] This abbreviated scale has also demonstrated greater use of health resources as well as more numerous and severe complications after major urological surgery.[49] Likewise, after radical cystectomy in patients aged >65 years, an sFI-5 score of ≥3 was associated with major complications (OR = 3.22, 95% CI = 2.01–5.17).[50]

Frailty is associated with higher postoperative mortality rates after radical cystectomy.[51] Patients with an mFI-11 score of ≥0.18 showed higher rates of respiratory, cardiovascular, and renal complications as well as higher mortality rates after radical cystectomy.[52] In another retrospective study, however, the discriminative ability of the mFI-11, ASA classification, and Charlson Comorbidity Index was similar (AUC of approximately 0.50–0.51) for any adverse events after radical cystectomy.[53,54]

A retrospective analysis of 41,681 patients undergoing surgery for urologic cancer (58% had undergone prostate surgery) also revealed that higher scores in a validated a 15-item scale (mFI-15) were associated with higher rates of Clavien–Dindo type IV complications (OR = 3.70, 95% CI = 2.86–4.79, $p < 0.0005$) and mortality (OR = 5.95, 95% CI = 3.72–9.51, $p < 0.0005$).[55] Receiver operating characteristic data showed that the mFI-15 had a better sensitivity–specificity balance for predicting 30-day mortality after robotic radical prostatectomy than the Charlson Comorbidity Index or ASA classification,[56] and a higher mFI-5 score was an independent predictor of adverse outcomes, an extended length of stay, and 30-day mortality after radical prostatectomy.[57]

The JHACG frailty score was also found to be an independent predictor of general complications (OR = 1.95), major complications (OR = 1.76), and a prolonged stay (RR = 1.19) after radical prostatectomy.[58] This scale was also confirmed to be an independent predictor of general complications (OR = 1.46, 95% CI = 1.31–1.63, $p < 0.001$), in-hospital mortality (OR = 1.52, 95% CI = 1.02–2.33, $p = 0.04$), and transfer to a care center after hospital discharge (OR = 1.36, 95% CI = 1.17–1.60, $p < 0.001$) following nephroureterectomy.[59] A prospective study involving patients who underwent minimally invasive surgery (79% urologic surgery, 79% malignancy surgery) confirmed the FFP as a predictor of 30-day postoperative complications (OR = 5.91, 95% CI = 1.25–27.96, p = 0.025).[60]

Frailty has also been evaluated in patients with benign urological pathologies. In endoscopic prostate surgery for benign prostate obstruction, patients with an sFI-5 score of ≥2 were more likely to develop a major complication (OR = 1.63, 95% CI = 1.42–1.85, p < 0.01) and to require readmission (OR = 1.65, 95% CI = 1.48–1.85, p < 0.01).[61] In addition, frailty according to the Modified Hopkins Frailty Score was related to a longer postoperative length of stay (p < 0.001) and higher rates of postoperative complications (p = 0.005) or postoperative readmission (p = 0.03) after holmium laser enucleation of the prostate.[62] In another study, an mFI-11 score of ≥0.27 was a significant predictor of major complications (OR = 3.5, 95% CI = 1.2–9.9, p = 0.02) but not of minor complications (OR = 1.0, 95% CI = 0.2–6.5) after artificial urinary sphincter implantation/removal.[63] After penile prosthesis surgery, the distribution of complications was similar among different mFI-11 levels.[64]

Vascular surgery

A retrospective study of 67,308 patients who had undergone vascular surgery at a mean age of 68 years showed a relationship between the mFI-11 score and postoperative mortality (2.1% in patients with an mFI-11 score of 0.00 vs. 24.3% in patients with an mFI-11 score of 0.73, p < 0.001) as well as with complications (11.3% in those with an mFI-11 score of 0.00 vs. 47.2% in patients with an mFI-11 score of 0.73, p < 0.001).[65] A subsequent similar study among patients with a 37.3% incidence of frailty showed that frailty measured by the mFI-11 increased the risk of postoperative complications (OR = 1.6, 95% CI = 1.5–1.7, p < 0.05).[66] In the absence of complications, the risk of discharge to a nursing home was higher in patients with frailty (OR = 2.1, 95% CI = 1.7–2.5, p < 0.01).[66] Frailty assessed using the CFS in independent patients undergoing major vascular surgery has also been shown to be an indicator of postoperative major adverse cardiac events (p < 0.01), reintubation (p < 0.01), and a longer hospital stay (p = 0.03).[67] However, frailty was not an indicator of other postoperative complications, cerebral ischemic events, or 30-day readmission.[67]

Two prospective studies have shown that the GFI score is related to an increase in postoperative complications (OR = 3.7, 95% CI = 1.1–6.3, p = 0.005)[68] and postoperative delirium after vascular surgery, with a sensitivity of 50% and a specificity of 78% (p = 0.03).[69] Addenbrooke's Vascular Frailty Score (AVFS) has also been shown to be related to a decrease in survival rates free of readmission at 12 months (from 68% in patients with an AVFS of 0 to 0% in those with an AVFS of 6, p < 0.001).[70]

Because of the complexities among different vascular procedures, it seems reasonable to study the impact of frailty in detail for each. The mFI-11 demonstrated better discrimination in predicting 30-day mortality than the Lee cardiac risk index and the ASA classification in patients undergoing carotid thromboendarterectomy (TEA) (p < 0.01) and in those undergoing open abdominal aortic aneurysm (AAA) repair (p = 0.02). However, in patients undergoing lower extremity bypass, the mFI-11 was comparable to the ASA classification, with a trend toward better discrimination than the Lee index. No differences were detected in the discrimination of mortality among the three risk indices in endovascular aortic repair (EVAR) and endovascular peripheral vascular interventions.[71]

In patients undergoing carotid TEA and carotid stenting (27.3% with frailty according to the mFI-11), the combined risk of stroke/transient ischemic attack was 11.1% and 5.1% in patients with and without frailty, respectively. Furthermore, patients with frailty had higher rates of complications at 30 days (OR = 3.2, 95% CI = 2.1–4.8, $p = 0.01$), mortality (OR = 2.1, 95% CI = 1.6–3.7, $p = 0.01$), failed rescue after a complication (OR = 2.9, 95% CI = 2.2–4.9, $p = 0.01$), and readmission (OR = 1.9, 95% CI = 1.6–3.9, $p = 0.01$).[72] Two studies involving patients who had undergone carotid TEA evaluated frailty using the RAI, and they obtained contradictory results despite both including similarly high numbers of patients.[73,74] In a 2015 study by Melin et al.,[73] a linear correlation was detected between an increase in the RAI score and the risk of stroke ($p < 0.0001$), death ($p < 0.0001$), and myocardial infarction ($p < 0.0001$). However, Rothenberg et al.[74] concluded that the frequency of stroke was similar in all patients regardless of their RAI score. In asymptomatic patients undergoing carotid stenting, frailty evaluated according to the Cardiovascular Health Study criteria was not associated with postoperative complications.[75]

Because patients undergoing AAA repair are especially vulnerable to postoperative complications, establishing the prognosis is relevant. After elective open repair or EVAR of AAA, the mFI-11 score was associated with postoperative complications, showing a 10-fold increase in the risk of any complication (from 0.36 to 0.45) after EVAR (2.4% to 20.1%) and after open surgery (4.8% to 47.3%) ($p < 0.0001$).[76] The ORs comparing mortality in the highest frailty tertile (mFI-11 scores of 0.45–0.73) with that in the lowest tertile were 3.3 (95% CI = 2.1–5.0, $p < 0.0001$) for open surgery and 2.6 (95% CI = 1.7–3.9, $p < 0.0001$) for EVAR.[76] In patients undergoing ruptured AAA repair, the Ruptured Aneurysm Frailty Score (generated from the AVFS) was shown to have an AUC of 0.81 as a predictor of mortality, higher than that given by the AAA score (AUC = 0.65) or the AVFS (AUC = 0.66).[77] A prospective study of patients undergoing aortic or vascular surgery of the lower limbs (45% of patients could not perform Timed Up and Go Test) showed that an EFS score of ≥ 6.5 was associated with a longer hospital stay ($p = 0.011$), higher complication rates ($p = 0.022$), and adverse functional outcomes such as falls ($p = 0.032$) or fecal incontinence ($p = 0.005$).[78] After lower limb revascularization, a higher mFI-11 score was associated with higher mortality ($p < 0.0001$), minor complications ($p < 0.0001$), and Clavien–Dindo grade IV complications ($p < 0.0001$).[79,80] In addition, one study demonstrated a relationship between frailty and postoperative sensory impairment ($p < 0.001$), morbidity (OR = 3.2, 95% CI = 1.4–7.3, $p = 0.004$), and mortality (OR = 6.3, 95% CI = 1.4–43.7, $p = 0.01$) after infrapopliteal revascularization.[81] Moreover, after transtibial or transfemoral amputation, a higher mFI-5 score was also associated with increased 30-day readmissions,[82] and patients with an mFI-5 score of >2 showed lower survival in the survival curves ($p = 0.004$).[82]

Spinal surgery

Several retrospective studies have investigated the relationship between the mFI-11 score and postoperative complications in spinal surgery. In patients aged >18 years, higher mFI-11 scores were associated with higher rates of mortality, blood transfusion, deep venous thrombosis/pulmonary embolism, and other postoperative complications, with a higher risk of reintervention in patients with an mFI-11 score of >0.18 than in those with an mFI-11 score of 0.09 (OR = 2.3, 95% CI = 1.2–4.5).[83] Another study involving 6094 patients aged >70 years undergoing posterior lumbar fusion showed a significant positive correlation between the mFI-11 score and the grading of complications.[84] An mFI-11 score of

≥0.36 was an independent predictor of any type of complication (OR = 2.2, 95% CI = 1.3–3.7, p = 0.014), sepsis (OR = 6.3, 95% CI = 1.8–21.0, p = 0.01), wound complications (OR = 3, 95% CI = 1.1–8.2, p = 0.05), a prolonged hospital stay (OR = 2.3, 95% CI = 1.4–3.7, p = 0.01), and readmission (OR = 4.3, 95% CI = 1.5–12.7, p = 0.005).[85]

In patients undergoing neurosurgical spinal surgery, an mFI-11 score of ≥0.27 was also associated with at least one infection (p < 0.001), higher mortality (p < 0.001), wound infection (p < 0.001), and Clavien–Dindo grade IV complications (p < 0.001).[86] After spinal surgery for degenerative pathology, the mFI-11 score was associated with major complications (OR = 1.58 for each 0.10-point increase on this scale, p < 0.0005), surgical site infection (OR = 1.1, 95% CI = 1.0–1.3, p = 0.04), and in-hospital mortality (OR = 1.44 for every 0.10-point increase).[87] Patients with frailty showed a postoperative complication rate of 33.3% after spinal decompression and arthrodesis surgery, whereas those without frailty showed a complication rate of 4.2%.[88] In addition, among patients who underwent anterior lumbar arthrodesis, as the mFI-11 score increased from 0.00 to 0.27, the incidence of any kind of complication increased from 10.8% to 32.7%, with pulmonary complications especially relevant (OR = 7.5, 95% CI = 2.5–22.9, p = 0.0001).[89] In adults with deformities, surgical outcomes and complications worsened as the mFI-11 score increased, but acceptable surgical outcomes and complication rates were obtained regardless of frailty in patients with degenerative spondylolisthesis and lumbar canal stenosis.[90] In elective lumbar spinal surgery, no relationship was found between the mFI-11 score and postoperative complications, hospital stay, or discharge to a care facility,[91] but a 0.10-point increase in the mFI-11 score was associated with a higher risk of death (OR = 3.12, 95% CI = 1.21–8.03, p = 0.0006).[91]

A retrospective study of patients undergoing T9–S1 instrumentation detected that an increase in the mFI-11 score was associated with a higher incidence of sepsis (p = 0.023).[92] Another study involving patients aged >55 years undergoing spinal surgery showed that a greater proportion of patients with than without frailty developed adverse events (70% vs. 0%, respectively; p < 0.0001).[93] A study of patients aged >65 years undergoing spinal surgery showed that as the mFI-11 score increased, the incidence of medical complications increased (p = 0.004) and the surgical site infection rate tripled from 4.2% (mFI-11 score of 0.00) to 19.0% (mFI-11 score of ≥0.45) (p = 0.027).[94] Another study involving patients aged >80 years undergoing spinal surgery revealed an increased risk of complications (p = 0.032), major complications (p = 0.014), and surgical wound infection (p = 0.007) as well as a longer hospital stay (p = 0.019) as the mFI-11 score increased from 0.00 to ≥0.36.[95] After posterior cervical fusion, an mFI-11 score of 0.36 was the only independent predictor of Clavien–Dindo grade IV complications (OR = 41.26, 95% CI = 6.62–257.15, p < 0.001).[96]

In oncology patients, the mFI-11 score was associated with mortality (OR = 15.6, 95% CI = 1.31–184.9, p = 0.003) and a prolonged hospital stay (OR = 14.9, 95% CI = 3.45–64.47, p < 0.001), but not with postoperative complications after spinal tumor resection.[97] However, the mFI-11 score showed a low correlation with survival after resection of spinal metastases,[98] and another retrospective study also found no relationship between the mFI-11 score and adverse events.[99] The Metastatic Spinal Tumor Frailty Index (MSTFI) was also unassociated with adverse events or survival but was higher in patients who died 3 months postoperatively (2.04 ± 0.99 vs. 1.47 ± 1.00, $p = 0.012$).[99] This scale was also used in 4583 patients with spinal metastases, and the results showed an OR of 1.88 (95% CI = 1.33–2.66, $p < 0.001$) and 6.97 (95% CI = 4.98–9.74, $p < 0.001$) for complications in patients with mild and severe frailty, respectively.[100] Another study involving patients who had undergone spinal decompression and arthrodesis for primary spinal tumors showed that postoperative complications were present in 5.7% of patients without frailty, 18.8% of those with mild frailty, 29.2% of those with moderate frailty, and 44.1% of those with severe frailty according to the MSTFI ($p < 0.001$).[101]

In patients undergoing degenerative spinal surgery, the predictive effect of the Hospital Frailty Risk Score (HFRS) confirmed that frailty was related to a higher risk of complications, ICU admission, and 30-day readmission.[102] Compared with patients without frailty, patients with an HFRS of >16 had a higher risk of postoperative complications (OR = 28.4, 95% CI = 11.9–67.0, $p < 0.0001$) than those with an HFRS of 5 to 15 (OR = 3.9, 95% CI = 3.4–4.5, $p < 0.0001$).[102] A retrospective analysis of a prospective database (191 patients undergoing treatment of adult spinal deformity) revealed no association between complications and frailty as assessed by the Adult Spinal Deformity Frailty Index.[103] However, a multicenter prospective study confirmed that this index was associated with major complications (OR = 2.9, 95% CI = 1.7–4.9), and this probability was even higher in patients with severe frailty (OR = 3.5, 95% CI = 1.9–6.3).[104] In patients undergoing surgery involving more than five vertebral spaces for treatment of adult deformation, as the mFI-5 score increased from 0 to >2, the rate of postoperative complications increased from 17% to 63%, with an RR of 2.2 ($p < 0.01$).[105] This short scale also showed that among patients with frailty, the risk of complications was twice as high in patients aged >65 years undergoing kyphoplasty.[106] In patients undergoing anterior cervical discectomy, a higher mFI-5 score was shown to be associated with complications such as pneumonia ($p < 0.001$), urinary tract infection ($p = 0.019$), cardiac arrest ($p = 0.013$), acute myocardial infarction ($p < 0.001$), acute renal failure ($p < 0.001$), sepsis ($p < 0.001$), or unplanned orotracheal intubation ($p < 0.001$).[107] Although the mFI-5 could predict complications in patients aged >65 years undergoing one- or two-level posterior lumbar fusion, this ability was not demonstrated in patients undergoing lumbar fusion of more than three levels or combined posterior and anterior surgery.[108] Another scale used in patients undergoing single-level lumbar fusion is the JHACG frailty-defining diagnosis indicator. A retrospective study comparing 5950 patients with frailty versus 5895 patients without frailty of similar age showed that frailty was associated with a higher probability of postoperative infection (OR = 6.87, 95% CI = 4.5–10.9, $p < 0.0001$) or anemia (OR = 1.94, 95% CI = 1.7–2.2, $p < 0.0001$).[109] In addition, frailty according to the modified Cervical Deformity Frailty Index has been shown to be associated with major postoperative complications in patients undergoing surgery for cervical deformity,[110] whereas a study involving only 26 patients undergoing surgery for tuberculous spondylodiscitis showed that the 19-item modified frailty score was significantly higher in patients who died after 30 days.[111] However, a prospective study of 668 patients aged >18 years failed to show an association between frailty measured according to the RAI and postoperative infections, thromboembolism, readmission, or mortality at 30 days.[112] Finally, among elderly patients, those with frailty and pre-frailty according to the FRAIL scale recovered their functional status more slowly after surgery than those without frailty after elective spinal surgery.[113]

Orthopedic and trauma surgery

A prospective study of patients aged >70 years undergoing scheduled orthopedic surgery showed that patients classified as having frailty or pre-frailty using both the adapted FFP or the FI had a greater risk of at least one adverse outcome, a longer hospital stay, and a need for post-acute care.[114] The risk of medical complications in patients classified as having pre-frailty according to the FFP was 1.6 (95% CI = 1.1–2.1), while that in patients classified as having frailty was 1.7 (95% CI = 1.1–2.1).[114] However, the risk of postoperative complications was not significantly higher in either patients with pre-frailty (RR = 1.1, 95% CI = 0.8–1.5) or patients with frailty (RR = 1.2, 95% CI = 0.9–1.6) when using the FI.[114] Another prospective study in Thai patients aged >60 years showed a 2.38 higher risk of postoperative complications in patients with frailty using the Thai version of the reported EFS, showing that it was a good predictor of postoperative delirium (AUC = 0.81, 95% CI = 0.72–0.90).[115]

In shoulder arthroplasty, patients with an mFI-5 score of ≥2 had a higher risk of any type of complication ($p < 0.001$), especially pulmonary ($p = 0.002$), renal ($p = 0.003$), and Clavien–Dindo grade IV complications ($p = 0.023$), as well as a higher risk of postoperative complications (OR = 2.4, 95% CI = 1.9–3.1).[116]

In hip arthroplasty, the mFI-11 score was more effective than age or the ASA classification in predicting any type of complication (OR = 3.6, 95% CI = 1.6–8.0, $p = 0.002$) and reintervention (OR = 8.8, 95% CI = 3.7–20.9, $p < 0.001$).[117] The Rockwood Frailty Deficit Index was also an effective predictor of wound-related complications (OR = 2.0, 95% CI = 1.2–3.0, $p = 0.004$), 90-day mortality (HR = 5.6, 95% CI = 2.2–12.0, $p < 0.001$), and mortality 1 year postoperatively (HR = 5.6, 95% CI = 3.3–9.7, $p < 0.001$).[118]

In knee arthroplasty, a retrospective study of patients aged >60 years showed a relationship between an increase in the mFI-11 score and cardiac (OR = 2.15, 95% CI = 1.89–2.44), pulmonary (OR = 1.79, 95% CI = 1.58–2.02), or renal complications (OR = 2.30, 95% CI = 1.78–2.98).[119] The Frailty Deficit Index was also associated with a higher probability of reintervention and wound complications in patients aged >50 years; specifically, patients with frailty had a 4-fold higher risk of periprosthetic fracture and a 9-fold higher risk of 90-day mortality than patients without frailty.[120]

Some studies have simultaneously evaluated patients undergoing total hip replacement and those undergoing total knee replacement. A retrospective study of 14,583 patients who had undergone total hip replacement and 25,223 patients who had undergone total knee replacement concluded that as the mFI-11 score increased from 0.00 to ≥0.45, the complication rates increased from 2.8% to 20.8% after hip surgery and from 4.1% to 21.3% after knee surgery.[121] The HFRS has also been shown to be associated with surgical and medical complications, readmission, and reintervention after primary total hip and knee arthroplasty[122] as well as with reoperation.[123] Another study involving patients aged >65 years, including 140,158 patients who had undergone total hip replacement and 226,398 patients who had undergone total knee replacement, showed that the risk of any complication increased by 25.4% ($p < 0.001$) after hip surgery and by 17.5% ($p < 0.001$) after knee surgery for each additional point on the mFI-5.[124] The electronic frailty index, which comprises 36 age-related deficits, was also associated with an increased risk of mortality at 30, 60, and 90 days after total hip and knee replacement for osteoarthritis.[125]

In patients undergoing total hip replacement for hip fractures and osteoarthritis, the HFRS was associated with higher rates of reintervention and surgical and medical complications.[126] A retrospective analysis after fixation of intertrochanteric fractures showed higher mFI-11 scores in patients with than without postoperative complications (0.24 vs. 0.14, $p < 0.001$).[127] A study of patients with a mean age of 80 years determined that the Hip-Multidimensional Frailty Score (Hip-MFS) was more accurate than chronological age or the ASA classification in predicting all-cause mortality at 6 months (AUC for Hip-MFS = 0.784, 95% CI = 0.780–0.787; AUC for age = 0.586, 95% CI = 0.572–0.590; AUC for ASA classification = 0.661, 95% CI = 0.657–0.664).[128] A prospective study in Taiwan involving patients aged >50 years who underwent surgical treatment of hip fracture and in whom frailty was evaluated by the phenotypic Chinese-Canadian Study of Health and Aging Clinical Frailty Scale (CSHA-CFS) showed that the cumulative survival rates for patients with frailty and pre-frailty were significantly lower than those for healthy patients 6 months after hospital discharge.[129] After surgery for hip fracture, 67% of patients with frailty developed any complication compared with only 29% of patients without frailty ($p = 0.038$) according to the five criteria of the Fried Frailty Index modified for patients with fracture.[130] In addition, the FI was shown to be associated with postoperative outcomes ($p = 0.012$).[131] However, in a prospective study of 100 patients aged >60 years, neither the modified Fried Criteria nor the Reported-EFS could predict any early postoperative complications, although the Reported-EFS was able to predict basic activities of daily living at 6 months ($p = 0.01$).[132] When different scales (frailty vs. comorbidity) were compared, the Elixhauser Comorbidity Index showed a higher AUC than the mFI-5 in predicting any adverse events (Elixhauser Comorbidity Index AUC = 0.62, 95% CI = 0.62–0.63; mFI-5 AUC = 0.59, 95% CI = 0.58–0.59).[133] However, when different frailty scores were compared, similar results were detected between the GFI and the Velligheids Management System Frailty Score, showing worse survival in patients with than without frailty as classified by the Velligheids score.[134]

In one study, the FRAIL scale was used to predict short-term outcomes in patients aged >70 years who had undergone surgery after a fracture (91.8% lower limb fractures). Complications were detected in 3.4% of healthy patients, 26.0% of patients with pre-frailty, and 39.7% of patients with frailty ($p = 0.03$).[135] After distal radius fracture, the mFI-5 score was associated with the complication rate, increasing from 1.7% in patients with an mFI-5 score of 0 to 7.4% in those with an mFI-5 score of ≥ 2 ($p < 0.05$).[136]

Discussion

This systematic review has confirmed that several preoperative frailty tools are useful in predicting postoperative complications in several non-cardiac surgeries.

Patients with frailty experience worse outcomes after general surgery,[2,137] including higher complication rates from any cause and higher 30-day mortality.[2,137–139] This increase in adverse effects is seen in both elective and urgent surgery.[138] Detecting preoperative frailty creates an opportunity to improve outcomes by modifying variables in three main prognostic areas: patient-related factors, nutrition, and functionality.[140] However, relying on the “eyeball test” to evaluate frailty is inconsistent, highlighting the need to incorporate specific frailty assessments into routine preoperative evaluations.[141]

Urologic oncology surgery is associated with a high risk of postoperative complications, especially in patients of advanced age and patients with frailty. Preoperative determination of frailty can help clinicians optimize specific factors to ensure patients can safely undergo invasive treatments with curative intent.[7] In radical cystectomy with urinary diversion surgery, identifying patients at higher risk for poor outcomes and complications is crucial. However, neither sarcopenia, the Charlson comorbidity index, nor the NSQIP surgical risk calculator are appropriate frailty assessment methods.[142] The lack of specific, validated frailty indices necessitates the use of a combination of tools to effectively identify patients with frailty and prevent associated complications.[7,142]

The prevalence of preoperative frailty in patients undergoing vascular surgery is 20% to 60%, higher than the 10% to 37% found in the general surgical population.[143] This increased prevalence is associated with a greater likelihood of postoperative complications and mortality in patients undergoing highly complex surgeries. Furthermore, frailty and vascular disease are pathophysiologically interrelated,[144] making frailty assessment valuable for counseling patients about surgical risks and helping anesthesiologists personalize perioperative management.[145] However, there is still insufficient evidence to justify rejecting an intervention solely based on frailty.[146]

Spinal surgery is also associated with postoperative complications, and frailty has been shown to predict postoperative recovery and complications.[8] The relationship between frailty and outcomes after spine surgery varies depending on the measurement tool used, patient population, and magnitude of surgery.[147] The properties of frailty scales in patients with spinal disease have yet to be validated,[148,149] but their predictive value for outcomes of several spinal surgeries has been demonstrated.

The clinical context is crucial when measuring frailty. Given the limited evidence of superiority of one tool over another, the appropriateness of a tool likely depends on the specific aspect of frailty being assessed (physical, functional, or cognitive).[150] Table 1 summarizes the main findings from the most relevant systematic reviews. The unique characteristics of orthopedic patients have necessitated modifications of existing frailty instruments.[5] Musculoskeletal pathologies pose significant health challenges in elderly patients,[5] and frailty in this population has been associated with increased postoperative complications, adverse events, reintervention, readmission, hospital stays, and mortality.[5] However, there is inconsistency regarding the appropriate cut-off points of certain scales to define frailty in this population.[4] The main difficulty lies in the musculoskeletal phenotype and clinical symptoms, which can interfere with the accuracy of frailty assessments and highlight the overlap between frailty and disability.[5]

This systematic review has highlighted the significance of frailty in predicting postoperative complications, drawing on a substantial body of published literature. However, it has several limitations. First, studies involving cardiac surgery, neurosurgery, and thoracic surgery were excluded to homogenize the population and prevent baseline diseases from influencing the functional assessment of patients. Consequently, the findings cannot be extrapolated to these surgeries, limiting the generalizability of the results. Second, most of the included studies are retrospective, with few prospective observational studies, few multicenter studies, and no randomized clinical trials. Thus, scientific evidence in this field is still limited. Finally,

Table 1. Summarized information from the most relevant systematic reviews and/or meta-analyses.

Specialty	Authors	Year of publication	Number of studies	Sample size	Age of patients	Surgery/surgical population	Frailty scales evaluated	Outcomes associated with frailty
General and digestive surgery	Hewitt et al.[137]	2018	9	2281	>65 years	Abdominal surgery	GFI, Phenotype model, Deficit-based model, Assessment of frailty traits	• Hospital length of stay • 30-day mortality • Surgical complications (high heterogeneity)
	Ding et al.[151]	2021	29	112,548	>65 years	Digestive system tumors: pancreas, gastric, colorectal, liver, and esophagus	mFI, GFI, CFS, EFS, CGA, Phenotype model	• Postoperative complications (RR = 1.4, 95% CI = 1.4–1.5) • Major complications (RR = 1.7, 95% CI = 1.5–1.9) • Non-home discharge • 30-day mortality (RR = 2.4, 95% CI = 2.1–2.7)
Urological surgery	Campi et al.[152]	2022	18	88,069	>50 years	Partial / radical nephrectomy or tumor ablation	mFI-5, mFI-11, mFI-15, GFI, CFS, JHACG, CGA	• Postop. complications • Hospital length of stay • Readmission • Recurrence-free survival • 30-day mortality
	Liu and Sun[153]	2022	5	171,929	>60 years	Radical prostatectomy	mFI-5, mFI-15, JHACG	• Severe postoperative complications (RR = 1.9, 95% CI = 1.7–2.1) • All-cause mortality (RR = 2.9, 95% CI = 1.9–4.5)
Vascular surgery	Wang et al.[145]	2018	25	168,521	>60 years	Abdominal aortic aneurysm repair, lower extremity revascularization	mFI, GFI, EFS, AVFS, RAFS, CLI-FI, Barthel Index	• 30-day mortality (RR = 3.8, 95% CI = 3.1–4.8)

(continued)

Table 1. Continued.

Specialty	Authors	Year of publication	Number of studies	Sample size	Age of patients	Surgery/surgical population	Frailty scales evaluated	Outcomes associated with frailty
	Houghton et al.[146]	2020	18	62,976	>50 years	Vascular surgery	mFI, GFI, CFS, EFS, FRAIL scale, AVFS, RAFS, RAI, Fried criteria, Katz Index, MPI, CLI-FI, mEFT	• Postoperative complications (OR = 2.2, 95% CI = 1.5–3.0) • Non-home discharge • Hospital length of stay • 30-day mortality (OR = 2.8, 95% CI = 2.0–3.8)
	Banning et al.[143]	2021	8	258,573	>65 years	Carotid endarterectomy	mFI, CFS, RAI	• Postoperative complications • Hospital length of stay • Non-home discharge (OR = 2.8, 95% CI = 2.0–3.9) • Short- and long-term mortality ($p < 0.001$)
	Koh et al.[154]	2022	16	181,416	>50 years	Open and endovascular surgery	FI, mFI, CFS, EFS, AVFS, RAFS, grip strength measurement	• Postoperative morbidity • Failure-to-rescue rate • Hospital length of stay • Non-home discharge • 2-year amputation-free survival • Short- and long-term mortality
Spinal surgery	Chan et al.[149]	2021	32	127,813	Not limited	Various spinal pathologies	mFI-5, mFI-11, FRAIL scale, HFRS, ASD-FI, CD-FI, MSTFI	• Reoperation • Intensive care unit admission • Hospital length of stay • Readmission • Cost of hospitalization • 30-day mortality

(continued)

Table 1. Continued.

Specialty	Authors	Year of publication	Number of studies	Sample size	Age of patients	Surgery/surgical population	Frailty scales evaluated	Outcomes associated with frailty
	Kitamura et al.[148]	2022	92	985,389	≥18 years	Adult spinal deformity	mFI-5, mFI-11, mFI-19, GFI, CFS, EFS, JHACG, CGA, RAI, HFRS, Fried criteria, NHFS, ASD-FI, CD-FI, MSTFI, FBS, TFI	• 30-day adverse events • Complication grades • Hospital length of stay • Discharge to higher-level care • 30-day mortality • 1-year mortality
Orthopedic and trauma surgery	Ma et al.[155]	2022	19	62,132	53–97 years	Hip fracture	FI, mFI, CFS, FRAIL scale, HFRS, CSHA-CFS, rEDS, VMS	• Postoperative complications (RR = 1.8, 95% CI = 1.5–2.1) • In-hospital mortality (RR = 2.9, 95% CI = 2.6–3.3) • 30-day mortality (RR = 2.9, 95% CI = 1.7–4.8)
	Wen et al.[4]	2023	7	350,971	Unspecified	Hip arthroplasty	FI, HFRS	• Postoperative complications (RR = 3.1, 95% CI = 1.9–4.7) • Reoperation (RR = 1.9, 95% CI = 1.7–2.3) • Readmission (RR = 2.0, 95% CI = 1.9–2.2) • 30-day mortality (RR = 2.6, 95% CI = 1.2–5.8)
Various specialties	Panayi et al.[139]	2019	16	683,487	Unspecified	Gastrointestinal, vascular, and orthopedic surgery	mFI-11	• Postoperative complications (RR = 1.5, 95% CI = 1.3–1.6) • Reoperation • Readmission (RR = 1.6, 95% CI = 1.4–1.8) • Non-home discharge (RR = 2.1, 95% CI = 1.9–2.4)

(continued)

Table 1. Continued.

Specialty	Authors	Year of publication	Number of studies	Sample size	Age of patients	Surgery/surgical population	Frailty scales evaluated	Outcomes associated with frailty
	Alkadri et al.[156]	2021	90	4,698,454	46–82 years	General surgery, urology, vascular, orthopedics, and mixed surgical procedures	FI, mFI-5, mFI-11, JHACG, RAI	• Mortality (RR = 4.2, 95% CI = 2.9–5.9) • Non-home discharge (OR = 2.4, 95% CI = 1.9–2.9) • Cost of care (RR = 1.5, 95% CI = 1.5–1.6) • Mortality (OR = 3.6, 95% CI = 2.7–4.7)
	Shaw et al.[157]	2022	71	468,776	49–84 years	Cancer surgery: gastrointestinal, bladder, spine, colorectal, urologic, mixed	FI, mFI-5, mFI-11, sFI, GFI, CFS, JHACG, CGA, Fried criteria, MSTFI, MFS, CCFI, J-CHS, Kihon Checklist	• Postoperative complications (OR = 2.4, 95% CI = 1.6–3.5) • Hospital length of stay (mean difference = 2.3, 95% CI = 1.1–3.5) • Non-home discharge (OR = 2.1, 95% CI = 1.5–3.0) • 30-day mortality (OR = 3.0, 95% CI = 1.8–5.1)

JHACG: Johns Hopkins Adjusted Clinical Groups; ASD-FI: Adult Spinal Deformity Frailty Index; AVFS: Addenbrooke's Vascular Frailty Score; CSHA-CFS: Chinese-Canadian Study of Health and Aging Clinical Frailty Scale; CCFI: Colon Cancer Frailty Index; CD-FI: Cervical Deformity Frailty Index; CFS: Clinical Frailty Scale; CGA: Comprehensive Geriatric Assessment; CLI-FI: Critical Limb Ischaemia Frailty Index; EFS: Edmonton Frail Scale; FBS: Frailty Based Score; FI: Frailty Index; GFI: Groningen Frailty Indicator; HFRS: Hospital Frailty Risk Score; J-CHS: Japanese Cardiovascular Health Study; mEFT: Modified Essential Frailty Toolset; mFI: modified Frailty Index; MFS: Multidimensional Frailty Score; MPI: Multidimensional Prognostic Index; MSTFI: Metastatic Spinal Tumor Frailty Index; NFHS: Nottingham Hip Fracture Score; RAFS: Ruptured Aneurysm Frailty Score; RAI: Risk Analysis Index; rEDS: reported Edmonton Deal Scale; sFI: simplified Frailty Index; TFI: Tilburg Frailty Indicator; VMS: Veiligheids Management System; RR: relative risk; OR: odds ratio; CI: confidence interval.

although the objective of this review was to unify different types of patients and surgeries, the wide variability in patient characteristics and assessment tools has hindered the ability to draw more specific conclusions about the applicability of frailty scales across different surgical settings.

Conclusion

Despite the unique characteristics of the surgical populations reviewed, preoperative frailty assessment reliably predicts the likelihood of complications and the postoperative course of patients. With the importance of frailty in the perioperative setting now established, it is time to put this knowledge into practice. Different frailty scales can effectively predict postoperative outcomes across most surgical specialties examined. The complexity of a scale and the use of complementary frailty tests do not appear to enhanced its predictive value. The finding that "short" scales have the same prognostic capacity as more complex scales suggests the potential for developing a single, simple scale that could be universally applied across all surgeries: a "one scale to rule them all" approach.

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Author contributions

A. B.-B. and A. R.-P. contributed to the conception and design of the study. A. B.-B. and A. R.-P. performed the literature search and assessed the eligibility of studies for inclusion. All authors extracted and organized the data from the selected studies. All authors drafted the manuscript. All authors contributed to revision of the manuscript. All authors read and approved the final manuscript.

Data availability

The data presented in this study are available on request from the corresponding author.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Ethics

This systematic review did not require prior approval by the ethics committee because it was carried out using information provided by previously published articles, without affecting the clinical management of patients, putting their health at risk, or disclosing their personal information.

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Registration

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