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Preoperative Evaluation of the Frail Patient

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Abstract

Perioperative management of older adults is a complex field that is heavily influenced by the clinical heterogeneity of older adults. Frailty—a geriatric syndrome in which a patient is more vulnerable to stressors due to decreases in physical function and reserve—has been indicative of adverse postoperative outcomes. Many tools have been developed to measure frailty that incorporate a variety of factors including physical and cognitive function, comorbidities, self-reported measures of health, and clinical judgment. Most of these frailty assessment tools are able to identify a subset of patients at risk of adverse outcomes including postoperative complications, longer hospital length of stay, discharge to a higher level of care, and mortality. Frailty assessment before surgical interventions can also guide discussions among patients, their families, anesthesiologists, and surgeons to tailor operative plans for patients to mitigate this increased risk. Studies are ongoing to identify interventions in frail patients that can improve postoperative outcomes, but high-quality data in the form of randomized controlled trials are lacking at this time.

In the United States, approximately one-third of all operating room–based procedures are performed on adults ≥65 years.[1] Rates of surgical complications increase with age; in 1

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study of adults >80 years, 20% developed postoperative complications including pneumonia, prolonged (>48 hours) ventilator support, and cardiac arrest.[2] This has implications on the practice of anesthesia as the geriatric population has a unique physiology that affects their surgical outcomes. One such challenge is frailty. Frailty is a biologic syndrome characterized by decreased homeostatic reserve and diminished resistance to stressors due to cumulative declines across multiple physiologic systems that result in vulnerability to adverse outcomes.[3]

Approximately 1 in 6 community-dwelling individuals >60 years may be frail, representing a significant portion of older individuals presenting for surgery.[4] A prospective cohort study comparing 2 frailty assessment tools demonstrated that between 35% and 41% of patients were frail, and these frail patients were more likely to have adverse outcomes including more postoperative complications, increased length of stay (LOS), and higher 30-day readmission rates.[5] Other studies showed that higher frailty scores were associated with higher risk of postoperative 30-day mortality after adjusting for age and American Society of Anesthesiology (ASA) classification.[6,7] These studies demonstrate the importance of identifying frail older individuals who are planned for elective and emergent surgeries.

This narrative review will discuss different frailty assessment tools that have been validated in surgical populations and examine the association of preoperative frailty with postoperative outcomes. Although there are younger adults who are frail, this review will focus on older adults because frailty is strongly associated with increasing age and most of the validated tools have been extensively studied in older populations.[8]

METHODS

Electronic databases including PubMed, Embase, and the Cochrane Library were searched with date restrictions of January 1, 2001 to August 22, 2019. We started our search in 2001 due to the publication of the Physical Frailty Phenotype (PFP) and the Deficit Accumulation Index (DAI) frailty assessments in 2001.[3,9] A combination of controlled vocabulary and keyword terms was used for the concepts of frail elderly, preoperative care, assessment, complications or outcomes, and survey instruments. A total of 1869 records were identified. Duplicate records were removed, and 1510 titles and abstracts were identified. Inclusion criteria are as follows: surgical population, age ≥65, frailty assessed by a validated tool, and reporting on postoperative complications and other clinical outcomes. Exclusion criteria are as follows: oncological surgeries or procedures, age <65, studies assessing different surgical techniques or approaches, studies focusing on the economic and financial impact of frailty, and conference abstracts. In addition, studies that did not utilize all components of previously validated frailty tools (eg, only using gait speed or handgrip strength) were excluded. We also reviewed reference lists in relevant review articles to identify additional studies. Articles were reviewed by L.S.N. and A.L.E., and consensus was reached for final inclusion of eligible studies. Of the 1869 articles initially identified, 32 articles met all inclusion and exclusion criteria (Supplemental Digital Content, Figure, http://links.lww.com/AA/D38).

RESULTS

Frailty Assessment Tools

Conceptual Frameworks Behind Frailty Assessment Tools.—There are 2 major conceptual frameworks behind the most commonly used frailty measurement tools.[10] The first is the concept of frailty as a biological syndrome characterized by energy depletion as exemplified by the PFP (Table 1). The PFP takes into account physical measurements of grip strength and walking speed and raises questions about exhaustion, physical activity, and unintentional weight loss as key clinical presentations of decreased physiologic reserve.[3] The 5 components of the PFP are considered to be proxy measurements of dysregulation in stress response and energy metabolism.[10]

The second framework for defining frailty is considering frailty as an accumulation of deficits across functional, physical, cognitive, and social measures.[10] Instruments that define frailty as "deficit accumulation" include the DAI, the Johns Hopkins Adjusted Clinical Groups (JHACG) frailty assessment, and the modified Frailty Index 11 (mFI 11).[9,21,22] These tools measure factors including nutrition, comorbidities, functional status, disability, and mental health, and a cumulative score is derived. Similarly, the Brief Frailty Instrument by Rockwood[15] incorporates an operational definition of frailty beyond measuring activities of daily living by including cognitive impairment and incontinence components to their tool. The JHACG frailty assessment and DAI utilize specific diagnosis codes or the presence/absence of specific comorbidities to define a frail subset of patients (Table 1).[9,21] Both the PFP and deficit accumulation models, such as the DAI and mFI 11, are more predictive of a patient's cumulative risk of adverse outcomes than age alone.[10]

Measurement Issues in Frailty Assessment Tools.—Although there is a range of factors that comprise different frailty assessment tools, 2 domains (ie, physical and cognitive function) that may require active measurement are discussed below.

Physical Measures.: The 2 physical measurements in the PFP—gait speed and handgrip strength—require training to standardize measurements. A comprehensive review of handgrip strength measurement demonstrates that factors—model of dynamometer, posture and arm position of patient, and handle position—can influence results and make it challenging to compare results when different protocols are used.[25] Gait speed measurement and Timed Up and Go (TUG) testing requires a dedicated location where 4- and 3-m markings can be placed on the floor for the respective tests.[24,26] This requirement for specialized equipment and space may be challenging for some outpatient preoperative clinics or in the home of a patient. In addition, patients with limited mobility due to pain may find their preoperative gait speed and TUG measurements to be an inaccurate assessment of their premorbid functioning.

Cognitive Assessments.: Underlying cognitive impairment is a well-known risk factor for many different postoperative complications including delirium. In 1 recent study of over 7800 patients undergoing hip fracture repair, dementia diagnosis was one of the strongest risk factors for postoperative delirium.[27] Patients identified as having mild cognitive impairment (MCI) before surgery were also at higher risk of developing postoperative

delirium, and demonstrated increased risk of adverse outcomes, specifically higher rates of discharge to a postacute facility and new impairment in cognitive instrumental activities of daily living (IADL) 1 month later.[28] A study of cognitively impaired patients undergoing vascular surgery demonstrated significantly higher rates of wound infections and longer LOS (>10 days) compared to cognitively normal patients.[29] Furthermore, patients with dementia are at higher risk of mortality after surgery compared to patients with normal cognition (hazard ratio [HR] = 1.84; 95% confidence interval [CI], 1.10–3.07).[30]

Despite the strong association of underlying cognitive function with poor postoperative outcomes, not all frailty assessment tools incorporate cognitive assessment. The PFP; Vulnerable Elders Survey (VES); Fatigue, Resistance, Ambulation, Illnesses, Weight Loss (FRAIL) Scale; and mFI 11 do not have an explicit component of preoperative cognitive assessment built into their assessment tools. The DAI and JHACG rely on self-report of cognitive impairment, and the Edmonton Frail Scale (EFS) has a limited active cognitive screening component (eg, clock draw). Active measurement of cognitive function is important as these measures may be used to determine a patient's response to perioperative stressors and could allow monitoring of longitudinal cognitive trajectory.[31]

With respect to the feasibility of incorporating cognitive assessment into an outpatient preoperative visit, the Montreal Cognitive Assessment (MoCA)—a well-validated study with high reliability—can be completed in approximately 10 minutes.[29] A review by Long et al[32] details several other short (≤2.5 minutes) cognitive assessments that can be completed preoperatively including the Mini-Cog, which consists of a 3-word recall and clock drawing test. Incorporating cognitive testing in a preoperative clinic has been shown to be feasible and not burdensome to either practitioners or patients.[33] Due to the lack of active cognitive screening component in most frailty assessment tools, it would be important to incorporate an additional cognitive screening measure into the peri-operative workflow.

Time to Complete Frailty Assessments.—One of the challenges of preoperative evaluation for frailty is the length of time to perform such assessments in a busy outpatient clinic.[10] In general, newer frailty assessment tools are designed to be shorter in duration and more conveniently performed in an outpatient preoperative clinic (Table 1). At this time, tools such as the PFP require patient participation, specialized equipment, staff training for standardized assessment, and additional time to perform the physical measurements. Simpler versions of existing frailty tools continue to be developed (eg, the modified Frailty Index 5 [mFI 5]). MFI 5 uses a subset of measures from the mFI 11 and has also been shown to have good sensitivity for identifying frail older adults preoperatively.[22,34] Frailty assessment tools, such as mFI 11 and JHACG, are further streamlined by relying on data from electronic medical records or the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. Relevant medical comorbidities, changes in weight, and baseline physical and cognitive function can be identified and used in these frailty assessment tools without relying solely on patient self-report.

Postoperative Outcomes Associated With Frailty

Frail patients overall have worse health care outcomes (eg, postoperative complications, LOS, mortality) compared to nonfrail counterparts in both elective and emergent surgical procedures (Table 2). Frail and nonfrail patients had similar surgical procedures in these studies, with exception of vascular procedures, in which frail patients primarily underwent peripheral vascular interventions and were less likely to have major elective vascular surgery than nonfrail patients.[47] A study examining general, vascular, cardiac, thoracic, and orthopedic surgeries in a large population showed that the most robust patients (Risk Analysis Index [RAI] ≤ 10) comprised 80% of the surgical population, while frail patients (RAI ≥ 21) comprised only 7% of the population.[11] As frail patients constitute approximately 15% of community-based individuals who are over 65 years of age,[62] there may be a selection bias where poor operative candidates are excluded from undergoing surgery.[63] This discor-dance between the percentage of frail patients in the overall population compared to the percentage of frail patients undergoing major surgical procedures suggests that surgical studies are likely to underestimate postoperative risk in frail patients.

Postoperative Complications.—Overall, higher postoperative complication rates were associated with frailty status (Table 2). A study examining emergency general surgeries by Joseph et al[36] showed that major complication (eg, sepsis, pneumonia, deep venous thrombosis) rates in frail patients were >3 times more likely than in robust patients (odds ratio [OR] = 3.87; 95% CI, 1.69–8.84). All 4 studies examining patients undergoing orthopedic surgeries (elective and hip fracture repairs) demonstrated higher rates of complications for patients categorized as frail as well.[5,46,49,55] Although many of the studies did not examine delirium as one of the main postoperative complications, 1 study by Gleason et al[49] demonstrated that postoperative delirium rates were higher in frail compared to nonfrail patients undergoing orthopedic procedures (28% vs 3.4%, $P = .01$).

In terms of frailty tool–specific findings, frailty status as defined by the DAI, Groningen Frailty Indicator (GFI), VES, and Clinical Frailty Scale (CFS) was associated with higher rates of postoperative complications in patients undergoing emergency surgery[35,36,43,44]; however, this was not observed with the Brief Frailty Instrument.[35] Interestingly, the VES and GFI were used alongside the Brief Frailty Instrument in the same surgical population to categorize frailty status. Frailty identified by VES and GFI was associated with higher rates of complications in frail patients suggesting that the Brief Frailty Instrument may underestimate risk of postoperative complication in this population.[35] A meta-analysis examining mFI 11 use across various surgical settings showed higher risk of all complications (relative risk [RR] = 1.48; 95% CI, 1.35–1.61), Clavien-Dindo Class IV complications (requiring critical care management) (RR = 2.03; 95% CI, 1.26–3.29), and wound complications (RR = 1.52; 95% CI, 1.47–1.57) for frail patients compared to robust patients.[54]

A large retrospective study by Shah et al[54] using data from ACS-NSQIP demonstrated that frailty is associated with higher complication rates even in low-risk procedures (average 30-day mortality rate ≤1%). In this study, the proportion of individuals with any complication

was higher in the most frail group (Clinical Risk Analysis Index [RAI-C] >40) compared to the robust group (RAI-C ≤10) undergoing low-risk procedures (42.9% vs 4.4%, $P < .001$). Findings were similar for major complications in the same population and with higher proportion of individuals with major complication in the most frail group (RAI-C >40) compared to the robust group (RAI-C ≤10) (36.4% vs 3.2%, $P < .001$). Both of these findings suggest a dose– response association between the degree of frailty and the number of postoperative complications.[11]

Length of Stay.—Frailty was significantly associated with LOS in 20 of 22 studies (Table 2). Two studies that did not show significant association of frailty with LOS examined elective general surgery and vascular procedures and, in general, had smaller samples compared to the studies that showed significant associations.[12,38] One study using 2 different frailty assessment tools in elective total joint replacement patients showed that the frailty status categorized by the CFS was significantly associated with LOS while those categorized by FRAIL scale was not.[42] The CFS is based on the deficit accumulation model,[18] and the FRAIL scale is based more on Fried's phenotypic model.[20,42] The authors postulated that their study population, which consisted of elective orthopedic surgery patients, may have excluded more frail patients (eg, the hip fracture population).[42]

Factors that could be contributing to increased LOS for frail patients are increased postoperative complication rate and additional time required to arrange discharge to skilled facility. Among the orthopedic surgeries that examined LOS as an outcome, 7 of 8 studies demonstrated significantly increased LOS in frail patients. Frailty assessment tools used in these studies ranged from DAI, PFP, CFS, FRAIL scale, and mFI. In general, most studies examined LOS as a continuous variable. Gleason et al[49] examined LOS as both a binary (> or ≤6 days) and a continuous variable and found statistically significant associations of higher frailty score with longer LOS in both analyses.

The study by Drudi et al[38] demonstrated association of frailty with mortality and worsening disability after interventions for peripheral arterial disease (PAD) but not with LOS. The study by Vernon et al[12] using the VES in patients undergoing elective surgical procedures examined LOS as a binary variable to primarily observe whether patients required noninvasive positive pressure ventilation following their procedure or an unanticipated hospital stay. However, the authors state that their study was significantly limited by missing data, with only 48 of 103 patients having complete surveys from which the researchers could calculate frailty score. Smaller sample size may have contributed to the nonsignificant findings between frailty status and LOS in this study.[12]

Postoperative Mortality.—Twenty-five studies specifically examined associations between frailty status and 30-day mortality. One study by McIsaac et al[50] examining independent, community-dwelling patients demonstrated that mortality was particularly high among frail patients in the immediate postoperative period. In this study, frail patients undergoing emergency surgical procedures were 23 times as likely as nonfrail patients to die on postoperative day 1 (HR = 23.1; 95% CI, 22.3–24.1).[50] Among patients undergoing major elective noncardiac surgery, 1-year mortality remained increased for frail versus nonfrail patients even after adjusting for demographics, procedure types, and 19 different

medical comorbidities (HR = 1.36, 95% CI, 1.26–1.46).[51] Other studies of patients undergoing emergency procedures demonstrated similar increases in rates of postoperative mortality for frail patients.[35,36,43,44] Four of the 25 studies did not show statistically significant associations between frailty and postoperative mortality.[37,38,46,49] These studies had smaller sample sizes and included patients undergoing hip fracture repair, general orthopedic surgeries, and vascular surgery.[38,46] One study by Hall et al[23] examining elective surgery patients showed, for those determined to be frail, that mortality 1 year following surgery remained elevated compared to the overall 1-year mortality for the group (26.8% vs 3.5%).

Postoperative Discharge Disposition and 30-Day Readmission Rates.—A majority of the results from Table 2 demonstrate that, depending on the type of surgery, frail patients are at higher risk of functional impairment from prolonged LOS or complications than a nonfrail patient. These adverse outcomes can lead to patients requiring discharge to subacute nursing facilities for continued care. One study found that frail vascular surgery patients were 1.6 times as likely as robust patients to be discharged to a postacute care facility instead of their homes (OR = 1.6; 95% CI, 1.4–1.8).[56] Orthopedic surgery studies examining discharge disposition demonstrated that the PFP, DAI, CFS, and mFI,[5,42,55] but not the FRAIL scale, were associated with increased rates of discharge to skilled facilities in this population.[42] Among community-dwelling older adults undergoing emergency surgery, frail patients were 5.8 times as likely as robust patients to be discharged to a postacute care facility (OR = 5.8; 95% CI, 5.53–6.12).[50] A meta-analysis looking at the use of mFI 11 in surgical patients similarly showed increased relative risk of discharge to postacute care following surgery for frail patients compared to robust patients.[54] The frailty assessment tools that demonstrate positive associations between frailty and 30-day readmission are the mFI and RAI-C, examining general surgery, total hip arthroplasty, and general urological procedures[54,55,60] (Table 2).

Comparison of Frailty Tools to Other Surgical Risk-Stratifying Tools.—Frailty assessment tools have been compared to other tools assessing surgical risk (eg, ASA classification and comorbidity index). One study looking at mFI 11 in total hip arthroplasty population showed that mFI 11 was a stronger predictor of readmission rates (OR = 14.72; 95% CI, 6.95–31.18) than the ASA classification or age.[55] MFI 11 was also a better predictor of any complication (OR = 3.63; 95% CI, 1.64–8.05) and reoperation (OR = 6.52; 95% CI, 2.48–17.13), while ASA classification and age did not show statistically significant association with these outcomes.[55] Other studies showed that frailty was predictive of higher risk for 30-day mortality and discharge to a skilled facility, while age and ASA score were not associated with these outcomes.[36,47] However, 1 study found that addition of frailty measurement to ASA class improved the ability to predict postoperative complications and discharge to a skilled nursing facility.[39]

DISCUSSION

Preoperative assessment of frailty using tools validated for surgical populations is one of the first steps in identifying patients who are at high risk for poor postoperative outcomes. Across different surgical populations, frailty is associated with greater overall postoperative

complications, longer hospital LOS, and higher mortality. Therefore, preoperative knowledge of frailty can help guide discussions with the patient's care team to optimize perioperative care.

There is no gold standard assessment for frailty, particularly among older individuals undergoing surgery. Assessment tools vary in the domains assessed (ie, cognition, comorbidities, and physical function), source of information (ie, direct assessment, self-report, and electronic health records), time required, and location of evaluation (ie, outpatient, inpatient, and by telephone). In considering the data presented in Tables 1 and 2, frailty assessment tools most predictive of postoperative complications, longer LOS, and higher mortality include the mFI, CFS, PFP, and RAI-C. The mFI and RAI-C, in particular, can pull in the relevant information needed to assess frailty from a patient's electronic medical records. The PFP can also be a useful frailty assessment tool in a preoperative clinic, particularly once staff is trained on standardized measurement of grip strength and gait speed. In addition, the PFP also has a well-characterized biologic framework and animal models in which proposed interventions for frailty can be tested for efficacy.[64,65]

The feasibility of implementing frailty assessment in a preoperative clinic visit is an important consideration. Recently developed tools (mFI 11, CFS, RAI-C, and the FRAIL scale) can be completed in approximately 10 minutes without requiring physical measures (eg, hand grip or timed walk).[13] The VES has also been successfully administered over the telephone.[12] With the right tools and appropriate training, both PFP and DAI can be performed in a clinic setting.[5,66]

It is less clear what should be done once a patient is identified as frail and is scheduled to undergo an elective or emergent surgical procedure. Some strategies that can be implemented for both frail and nonfrail patients include preoperative optimization of comorbidities such as diabetes, hypertension and congestive heart failure, nutritional assessment, and closer postoperative monitoring in a stepdown unit.[67] Geriatrics comanagement and consultation can also be implemented early on in a frail patient's hospital course. In the preoperative setting, identifying a frail patient should initiate further discussions of goals of care, and more comprehensive geriatric assessment (CGA) can be performed to identify medical, physical, or socio-economic vulnerabilities that contribute to a patient's frail status that can be targeted for intervention.

Several recent editorials describe a role for rapid frailty assessment tools with high negative predictive values to rule out frailty in surgical candidates, while allowing for patients who screen positive for frailty to undergo more rigorous preoperative assessments.[31,68] These assessments may include a CGA, an interdisciplinary approach that systematically evaluates physical, functional, cognitive, environmental, and social domains for an older adult.[69] An individualized treatment plan resulting from concerted interdisciplinary effort is the goal of a successful CGA.[70]

An example of what can be done for individuals who are identified as frail is highlighted in study by Hall et al[58] using the RAI-C and measuring the effectiveness of a "frailty screening initiative." This initiative consisted of clarifying goals of care and postoperative expectations

for patients as well as informing the patient's surgeons, anesthesiologists, and critical care physicians of the patient's frailty status.[58] Overall 30-day mortality for all subjects in the frailty screening initiative arm, regardless of frailty status, decreased from 1.6% preinitiative to 0.7% following the initiative, and frail subjects had the greatest reduction in 30-day mortality compared to robust patients, decreasing from 12.2% to 3.8%.[58]

One intervention for frail surgical patients that is receiving more attention is prehabilitation. Prehabilitation is a multimodal intervention that aims to reduce vulnerability and increase resilience of patients to stressors such as surgery or nonsurgical interventions.[67] Previous literature has considered prehabilitation as an intervention to reduce disability and restore function among frail patients before development of acute illness, injury, or surgery.[71] However, there is no consensus for the optimal type of prehabilitation for frail patients, likely from the lack of robust randomized control trials at this time.

The strengths of this narrative review include a comprehensive evaluation of frailty assessment tools that were specifically validated in surgical populations as well as postoperative outcomes that have been examined among individuals who were identified as frail using these tools. Limitations of this review include focus on adults over age 65. There are studies examining frail patients who are <65, particularly in cancer, cardiac surgery, and transplant medicine fields that were excluded based on our criteria. An additional limitation is that studies looking at oncologic surgeries and those with concurrent or pre-ceding chemotherapy were also excluded. The presence of cancer and chemotherapy can be an additional stressor to older adults, and patients with a history of cancer have significantly higher rates of frailty and vulnerability.[72] A comprehensive review focusing on frailty in the oncologic setting has been recently published.[73] We also excluded studies that focused only on preoperative sarcopenia, but a review on the topic of sarcopenia and surgical outcomes has also been published recently.[74]

Determining a patient's preoperative frailty status is critical to assessing a patient's overall perioperative risk including postoperative complications, increased mortality, longer hospital LOS, and higher level of care on discharge. Preoperative knowledge of frailty status can guide discussions among patients, their families, anesthesiologists, and surgeons to tailor perioperative care for patients to mitigate this increased risk. All the frailty assessment tools identified in this review demonstrated the ability to identify frail individuals who were at higher risk of worse postoperative outcomes compared to nonfrail individuals in different surgical settings. These assessment tools incorporate different measurements that can be done in the outpatient setting or in the hospital before surgery, demonstrating feasibility. Ongoing studies on the efficacy of preoperative interventions targeting frail patients will be instructive in providing more information about how to best improve postoperative outcomes for frail older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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GLOSSARY

ACS-NSQIP	American College of Surgeons National Surgical Quality Improvement Program
ADL	activities of daily living
ASA	American Society of Anesthesiology
CFS	Clinical Frailty Scale
CGA	comprehensive geriatrics assessment
CI	confidence interval
COPD	chronic obstructive pulmonary disease
DAI	Deficit Accumulation Index
EFS	Edmonton Frail Scale
FRAIL	Fatigue, Resistance, Ambulation, Illnesses, Weight Loss
GFI	Groningen Frailty Indicator
HR	hazard ratio
IADL	instrumental activities of daily living
ICU	intensive care unit
JHACG	Johns Hopkins Adjusted Clinical Groups
LOS	length of stay
MCI	mild cognitive impairment
mFI 5	modified Frailty Index 5
mFI 11	modified Frailty Index 11
MI	myocardial infarction
MoCA	Montreal Cognitive Assessment
NS	not significant
OR	odds ratio

PAD	peripheral arterial disease
PFP	Physical Frailty Phenotype
RAI	Risk Analysis Index
RAI-C	Clinical Risk Analysis Index
RR	relative risk
TIA	transient ischemic attack
TUG	Timed Up and Go
VES	Vulnerable Elders Survey

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Table 1.

Frailty Assessment Tools Used in Surgical Populations

Assessment Tool	Time to Complete Assessment (min)[11–14]	Number of Items	Measurements/Items	Scoring
Brief Frailty Instrument (Rockwood[15] 1999)	10	4	ADLs Cognition Continence Mobility	Scale: 0–3, increasing frailty with increasing score.
Deficit Accumulation Index/Frailty Index (Mitnitski et al[9] 2001)	20–30	21–70	Burden of chronic disease Cognition Exhaustion Measure mobility Mood Nutritional status Physical function Social vulnerability	Quantify deficits in an individual, divide by the total number of deficits taken into consideration. Higher level of frailty with higher proportion of deficits.
Groningen Frailty Indicator (Steverink[16] 2001)	15	15	Cognition Hearing impairment Mobility Nourishment Physical fitness Polypharmacy Psychosocial Vision impairment	Scale: 0–15. Moderately to severely frail ≥4.
Physical Frailty Phenotype (Fried et al[3] 2001)	5–10	5	Exhaustion Grip strength[a] Physical activity Unintentional weight Loss Walking speed[b]	Scale: 0–5. Frail ≥3; Prefrail =11–2; Robust =0.
Vulnerable Elders Survey (Saliba et al[17] 2001)	<5	13	ADL/IADL disability Age Physical function Self-rated health	Scale: 0–10. Frail = score 3+.
Clinical Frailty Scale (Rockwood et al[18] 2005)	<5	1	Physician assigns score based on clinical judgment, comorbidity, and function A multidisciplinary team performs a secondary review and scoring	1 = Very fit; 2 = Well; 3 = Well, with treated comorbid disease; 4 = Apparently vulnerable; 5 = Mildly frail; 6 = Moderately frail; 7 = Severely frail.
Edmonton Frail Scale (Rolfson et al[19] 2006)	10–15	10	Balance Burden of medical illness Cognition Continence Functional independence Gait Health attitudes Medication use Mood Nutrition Quality of life Social support	Scale: 0–17. Not frail ≤5; Apparently vulnerable 6–11; Severe frailty ≥12.

Assessment Tool	Time to Complete Assessment (min)[11–14]	Number of Items	Measurements/Items	Scoring
FRAIL Scale (Abellan van Kan et al[20] 2008)	5–10	5	Ambulation Fatigue Illnesses Resistance Weight loss	Scale: 0–5. No frailty = 0 deficits. Prefrail = 11–2 deficits. Frailty = 3 or more deficits.
Johns Hopkins Adjusted Clinical Groups (Sternberg et al[21] 2012)	Not defined	12	Barriers to access of care Decubitus ulcer Dementia Difficulty walking Falls Impaired vision Malnutrition Poverty Urine incontinence Weight loss	Frail: any one of these diagnoses are present.
mFI (Velanovich et al[22] 2013)	10–15	11	COPD Current pneumonia Diabetes Functional health status Heart failure History of MI History of TIA Hypertension Impaired sensorium Stroke Vascular disease	Scale: Number of risk factors/11; increasing frailty with increasing score.
Risk Analysis Index (RAI-C) (Hall et al[23] 2017)[c]	<2	14	Activities of daily living Age Appetite Cancer status Cognitive decline Heart failure Renal failure Residency Resting shortness of breath Sex Unintentional weight loss	Scale: 0–81. Score = sum of score of separate questions; increasing frailty with increasing score.

Abbreviations: ADL, activities of daily living; COPD, chronic obstructive pulmonary disease; FRAIL, Fatigue, Resistance, Ambulation, Illnesses, Weight Loss; IADL, instrumental activities of daily living; mFI, modified Frailty Index; MI, myocardial infarction; RAI-C, Clinical Risk Analysis Index; TIA, transient ischemic attack.

[a] Grip strength is stratified by gender and body mass index quartiles and measured in kilograms using a Jamar hand-held dynamometer. Frail patients have measurements in the 20th percentile.[3]

[b] Walking speed is stratified by gender and height. Time to walk 4 m at usual pace is measured in seconds.[24]

[c] This frailty tool was validated in patients aged ≥18 with mean age 60.7 years old.

Table 2.

Surgical Outcomes for Frail Versus Nonfrail Patients

Frailty Tool	Surgical Population	Sample Size	Increase in LOS for Frail Patients Compared to Nonfrail Patients (Days)	Postoperative Complications	Postoperative ICU Admission	30-Day Mortality	Discharge to Health Care Facility	30-Day Readmission
Brief Frailty Instrument	Emergency surgery[35]	184		NS		*a*		
Deficit Accumulation Index	Elective orthopedic procedure[5]	415	*a*	NS			*a*	NS
	Emergency surgery[36]	220	*a*	*a*	*a*	*a*	NS	
Groningen Frailty Indicator	Emergency surgery[35]	184		*a*		*a*		
	Hip fracture[37]	280				NS		
	Vascular surgery[38]	148	NS			*a*		
Physical Frailty Phenotype	Elective orthopedic procedure[5]	415	*a*	*a*			*a*	NS
	Elective surgery[39,40]	594; 127	*a*	*a*		*a*	*a*	
	General surgery[41]	298	*a*	*a*				
Vulnerable Elders Survey	Elective general surgery[12]	48	NS				NS	
	Emergency surgery[35]	184		*a*		*a*		
Clinical Frailty Scale	Elective joint replacement[42]	87	*a*				*a*	
	Emergency surgery[43,44]	937; 164	*a*	*a*		*a*		NS
	General surgery[45]	325	*a*			*a*		NS
	Hip fracture[46]	423	*a*	*a*	NS	NS	*a*	
	Vascular surgery[47]	134	*a*	NS	*a*	*a*	*a*	NS
Edmonton Frail Scale	Elective noncardiac surgery[48]	125	*a*	*a*			*a*	
	Vascular surgery[38]	148	NS			NS		
FRAIL Scale	Elective joint replacement[42]	87	*a*				NS	
	Orthopedic surgery[49]	175	*a*	*a*	NS	NS	NS	NS

Frailty Tool	Surgical Population	Sample Size	Increase in LOS for Frail Patients Compared to Nonfrail Patients (Days)	Postoperative Complications	Postoperative ICU Admission	30-Day Mortality	Discharge to Health Care Facility	30-Day Readmission
Johns Hopkins Adjusted Clinical Groups	Emergency surgery[50]	77,184	*a*			*a*	*a*	
	Major elective noncardiac surgery[51]	202,811				*a*		
mFI	Aortic Valve replacement[52]	3088		*a*		*a*		
	Elective surgery[23]	1021				*a*		
	Femur fracture[53]	321	*a*					
	General surgery[54]	683,487		*a*		*a*	*a*	*a*
	Total hip arthroplasty[55]	51,582	*a*	*a*		*a*	*a*	*a*
	Vascular surgery[6,38,56,57]	23,207; 15,843; 67,308; 148		*a*	*a*	*a*	*a*	
RAI-C	Elective surgery[23,58]	6803; 9153				*a*		
	Hepatopancreatobiliary surgery[59]	162	*a*		*a*		*a*	
	Low- and high-risk surgical procedures[11]	984,550		*a*		*a*		
	Urological procedures[60]	42,715	*a*	*a*		*a*		*a*
	Vascular surgery[52,61]	44, 832; 3088	*a*	*a*		*a*		

Blank spaces indicate that the outcome was not measured in the article.

Abbreviations: FRAIL, Fatigue, Resistance, Ambulation, Illnesses, Weight Loss; ; ICU, intensive care unit; LOS, length of stay; mFI, Modified Frailty Index; NS, not significant; RAI-C, Clinical Risk Analysis Index.

[a] $P < .05$.