Objectives
At the completion of this activity, the learner will be able to:
1. Define frailty.
2. List the 5 traits of the frailty phenotype.
3. Describe the Accumulated Deficits Theory of Frailty.
4. Discuss modified frailty indexes and their potential impact on anesthesia care.
5. Examine potential anesthetic implications of frailty screening and its impact on intraoperative care management and postoperative outcomes.

Introduction
Poor outcomes resulting from postoperative complications create a costly burden on the healthcare system. Currently there is no standard accepted clinical method for identifying patients who may have a higher chance of poor outcomes following surgery. If these patients could be identified early, perhaps preoperative optimization, medication management, social support, and anticipated rescue resources could be mobilized earlier in an effort to prevent complications. Patients 65 years and older represent one population that may benefit from a standardized method of preoperative risk stratification. As of July 2016, there were almost 50 million people aged 65 or older in the United States. Furthermore, the number of people older than 65 years worldwide is expected to increase from 461 million to 2 billion people by 2050. The fastest growing segment of the population, people 85 years and older, is expected to triple in the next 40 years. As the elderly population continues to grow, the number of surgical procedures performed in these patients will likely increase, and outcomes will become a focus for improving quality of care. With increasing surgeries on this vulnerable patient population, and as reimbursement payments become more closely tied to patient outcomes, hospitals have a tremendous interest in improving care and preventing unexpected complications.

The elderly patient population is particularly vulnerable to postoperative complications because of diminished physiologic reserve and reduced tolerance to stressful events such as surgery that accompany aging. Age-associated declines in physiological reserve and tolerance of stressful events contribute to greater difficulty in recovery from surgery, regaining independence, and

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returning home in the elderly population. Of patients 65 years or older undergoing surgical procedures, 45% will require continued medical care in a skilled nursing facility, inpatient rehabilitation center, or home health services. Additionally, postsurgery discharge to a post-acute care facility such as a skilled nursing facility is associated with a fourfold increase in mortality in elderly patients. Growth in surgical procedures among the elderly population, postoperative complications, and anesthesia implications are important issues that require addressing.

Anesthesia Implications
Postoperative complications are a critical part of the discussion of surgical care of elderly patients because with postoperative complications come increased morbidity, mortality, and cost. Surgical site infection, myocardial infarction, cerebrovascular accident, pneumonia, delirium, and falls represent some potential complications affecting elderly patients who undergo surgery. Intraoperative factors affecting postoperative outcomes include patient hypothermia, blood loss, morbid cardiac events, abnormally high and low blood glucose levels, atelectasis, pulmonary edema, and shivering. Surgical site infections lead to an increased length in hospital stay by 7 to 10 days, costing $10 billion annually. Preoperative assessment of elderly surgical patients is critical because it helps identify comorbidities, cardiac, neurologic, pulmonary, and physical baseline levels for patients before surgical interventions.

Table 1. Optimal Preoperative Assessment of the Elderly Surgical Patient

<table>
<thead>
<tr>
<th>Class</th>
<th>Definitions and examples</th>
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<tbody>
<tr>
<td>1</td>
<td>Normal healthy patient who does not smoke and drinks alcohol minimally</td>
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<tr>
<td>2</td>
<td>Patient with mild systemic disease. Mild diseases only without substantive functional limitations. Examples include (but not limited to) current smoker, social alcohol drinker, pregnancy, obesity (BMI 30 to &lt; 40 kg/m²), well-controlled diabetes or hypertension, mild lung disease.</td>
</tr>
<tr>
<td>3</td>
<td>Patient with severe systemic disease that is not a constant threat to life, but poses functional limitations. Examples include (but not limited to) uncontrolled DM, hypertension, COPD, alcohol dependence, BMI &gt; 40 kg/m², pacemaker implantation, &gt; 3-month history of MI, CVA, or CAD with stents.</td>
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<tr>
<td>4</td>
<td>Patient with severe systemic disease that is a constant threat to life. Examples include (but not limited to): recent (&lt; 3 months) MI, CVA, TIA, or CAD with stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD, or ESRD not undergoing regular dialysis.</td>
</tr>
<tr>
<td>5</td>
<td>A moribund patient who is not expected to survive without surgery. Examples include (but not limited to) ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction.</td>
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<tr>
<td>6</td>
<td>A patient declared brain dead whose organs are being removed for donation</td>
</tr>
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</table>

Table 2. ASA Physical Status Classification System
Abbreviations: ARD, acute respiratory distress; BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; CVA, cerebral vascular accident; DIC, disseminated intravascular coagulation; DM, diabetes mellitus; ESRD, end-stage renal disease; MI, myocardial infarction; TIA, transient ischemic attack.

- Class 1: Normal healthy patient who does not smoke and drinks alcohol minimally
- Class 2: Patient with mild systemic disease. Mild diseases only without substantive functional limitations. Examples include (but not limited to) current smoker, social alcohol drinker, pregnancy, obesity (BMI 30 to < 40 kg/m²), well-controlled diabetes or hypertension, mild lung disease.
- Class 3: Patient with severe systemic disease that is not a constant threat to life, but poses functional limitations. Examples include (but not limited to) uncontrolled DM, hypertension, COPD, alcohol dependence, BMI > 40 kg/m², pacemaker implantation, > 3-month history of MI, CVA, or CAD with stents.
- Class 4: Patient with severe systemic disease that is a constant threat to life. Examples include (but not limited to): recent (< 3 months) MI, CVA, TIA, or CAD with stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD, or ESRD not undergoing regular dialysis.
- Class 5: A moribund patient who is not expected to survive without surgery. Examples include (but not limited to) ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction.
- Class 6: A patient declared brain dead whose organs are being removed for donation
ing the patient’s cognitive ability, screening for depression, identifying risk factors for postoperative delirium, current alcohol intake, and substance use. Additionally, cardiac and pulmonary evaluation along with assessing patient’s functional status, history of falls, social support, and nutrition status are recommended for the preoperative assessment of geriatric patients (Table 1). Through completion of these evaluations, there is the potential to identify patients with modifiable risk factors. Earlier mobilization of rescue resources might result from a thorough evaluation because changes in baseline patient status would be detected earlier. In this lies the potential for improved postoperative outcomes by optimizing high-risk patients before surgery.

Currently, there is no standard, comprehensive tool for identifying patients at highest risk of poor outcomes following surgery. The ASA physical status (ASA-PS) scale represents an attempt at evaluating each patient’s health status. The ASA-PS is designed to measure a patient’s preoperative health status using a grading scale based on comorbidities (Table 2). An interviewing anesthesia provider decides on a patient’s physical status, and this subjectivity leads to variability in scores. Healthcare providers have attempted to use the ASA-PS as a predictor of poor postoperative outcomes, but because of its subjectivity, results have been mixed. Although a higher ASA-PS is associated with postoperative complications, this phenomenon is not consistently replicable because it was meant to evaluate preoperative health status, not to predict postoperative complications.

If the healthcare team, including anesthesia providers, could identify high-risk patients, they could mobilize hospital resources earlier, establish multidisciplinary care teams, and provide targeted therapy, thereby potentially reducing poor outcomes. Geriatricians could more effectively manage patient medications, treat depression, and address social support issues before surgery. Frailty represents a novel concept to surgeons and anesthesia providers that may help stratify complication risk among surgical patients. Numerous studies found frailty assessments are valid and reliable predictors of poor outcomes in high-risk patients.

**Table 3. Five Traits Compiling the Frailty Phenotype**

1. Unintentional weight loss of ≥ 4.5 kg (10 lb) in the previous year, or a > 5% loss of body weight at follow-up
2. Strength as measured by grip strength
3. Endurance as measured by self-reports of exhaustion
4. Slowness as measured by a timed 4.5-m (15-ft) walk
5. Low physical activity level as measured by kilocalorie expenditure per week

**Figure. Fried’s Cycle of Frailty**

A broad definition of frailty addresses physiological, emotional, cognitive, and social parameters. Fried et al. posited “the multidimensional nature of frailty … [as] age associated decline in physiologic reserve and function across multiple organ systems, resulting in diminished strength and endurance, increased vulnerability to stressors, risk of falls, disability, hospitalization and mortality has been accepted.” Despite a generally accepted
A major obstacle to implementing interventions has been the lack of a standardized frailty assessment. As a concept, frailty is multifactorial involving physiologic, cognitive, emotional, and social age-related decline. This leads to impaired responses to stressors and is distinguishable from disability. A possible definition of frailty is a biologic syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across physiologic systems. Although a gradual age-related decline in physiologic reserve occurs, frailty accelerates these declines, leading to homeostatic mechanism failure. Although a gradual age-related decline in physiologic reserve occurs, frailty accelerates these declines, leading to homeostatic mechanism failure. Decreased response to stressors makes patients vulnerable to poor outcomes. Frailty is a well-established measure of outcomes in surgical patients. It is superior to age in predicting short-term outcomes and major adverse health events. Frailty represents an independent predictor of postoperative complications and length of hospital stay for elderly patients. Despite proven validity, measurement of frailty has yet to routinely occur in the clinical setting. The frailty phenotype by Fried et al and the Accumulated Deficits of Frailty Theory by Rockwood et al are 2 accepted theories attempting to define and quantify this construct.

### Phenotype of Frailty

According to Fried et al and later Bieniek and colleagues, frailty can be quantified by evaluating age-related declines in strength, balance, endurance, lean body mass, walking performance, and activity levels. Although many elderly people have at least one of these declines, multiple elements need to be found clinically to constitute a diagnosis of frailty. Because these components are interrelated, Fried et al postulate a cycle of frailty that is associated with declining reserve. The foundations of this cycle are the clinical symptoms of frailty; a decline in physiologic reserve in other systems leads to increased susceptibility and a loss of ability to withstand stress. Fried et al hypothesized that a phenotype of frailty is composed of core clinical presentations such as shrinking, weakness, poor endurance, slowness, and low activity (Figure). Common characteristics of frailty in this model include 5 traits. An unintentional weight loss of greater than or equal to 4.5 kg (10 lb) in the previous year, or a greater than 5% loss of body weight at follow-up represents 1 trait. Second, strength is measured as an indicator of frailty, specifically grip strength within the lowest 20 percentile at baseline for gender. Poor endurance and slowness represent the third and fourth elements of...
The fifth and final element to the Fried frailty phenotype is low physical activity level as determined by a weighted score of kilocalories expended per week (Table 3). For instance, male individuals expending less than 383 kcal/wk would be considered in the lowest 20th percentile (Table 4). The presence of 3 or more of these 5 elements is required for a diagnosis of frailty. Patients with 1 or 2 elements present can be classified as prefrail.

To evaluate the effectiveness of the frailty theory, Fried et al. used data from patients who were community dwelling and found the overall prevalence in frailty for this population to be 6.9%. The study indicated frailty was more strongly associated with being African American, lower educational level, poorer income and health, and higher rates of comorbidity. Assessing the 5 elements of the frailty cycle allowed Fried and colleagues to identify patients at most risk of poor healthcare outcomes. Although this 5-point assessment method serves as an invaluable tool for assessing frailty, the practicality of using the frailty phenotype to identify inpatients at risk of complications in the hospital is limited. Often, hospital patients are bedridden and most likely unable to perform the elements of Fried’s frailty phenotype tests. A separate theory posited by Rockwood et al. involves accumulated deficits. This theory represents a more feasible tool for frailty measurement in the clinical arena.

**Table 7. Summary of Frailty Instruments**

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Frailty instrument</th>
<th>Outcome</th>
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<tbody>
<tr>
<td>Fried et al.20, 2001</td>
<td>Frailty phenotype</td>
<td>Patients with ≥ 3 frailty criteria are diagnosed as frail. Found frailty not synonymous with comorbidity or disability, but rather comorbidity is a risk factor for and disability is an outcome of frailty.</td>
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<tr>
<td>Rockwood et al.29, 2001</td>
<td>Canadian Study of Health and Aging Frailty Index (CSHA-FI)</td>
<td>Used 70 metrics to diagnose frailty</td>
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<tr>
<td>Saxton &amp; Velanovich,36 2011</td>
<td>CSHA-FI and modified frailty index (mFI)</td>
<td>Used CSHA-FI to retrospectively measure frailty in elective complex surgical procedures. Found that measurement of preoperative functional status using mFI helped identify patients at high risk of postoperative complications.</td>
</tr>
<tr>
<td>Tsiouris et al.32, 2013</td>
<td>mFI</td>
<td>Used mFI of 11 variables from mapping of CSHA-FI to NSQIP database in patients undergoing thoracic lobectomies. Found mFI may help identify patients at higher risk of postoperative complications following lobectomy.</td>
</tr>
<tr>
<td>Velanovich et al.34, 2013</td>
<td>mFI and accumulating deficits model of frailty</td>
<td>Used mFI of 11 variables created by mapping CSHA-FI to NSQIP database for cardiac, general, gynecologic, neurosurgical, orthopedic, plastic, thoracic, urologic, and vascular surgical procedures. Found a simplified frailty index correlated with morbidity and mortality for all surgical specialties in the study.</td>
</tr>
<tr>
<td>Cooper et al.16, 2016</td>
<td>Frailty phenotype and CSHA-FI</td>
<td>Used a 42-variable frailty index to prospectively compare the frailty phenotype with CSHA-FI. Found similar predictability for poor postoperative outcomes in orthopedic patients.</td>
</tr>
<tr>
<td>McIsaac et al.17,35, 2016</td>
<td>Johns Hopkins Adjusted Clinical Groups Frailty-defining diagnoses indicator</td>
<td>Found frailty was associated with increased risk of 1-year mortality following surgery</td>
</tr>
<tr>
<td>Wahl et al.31, 2017</td>
<td>mFI</td>
<td>Used an 11-variable mFI to diagnose frailty in orthopedic, general, and vascular surgical patients. Found an increased mFI score was associated with poor surgical outcomes, and improving patient functional status could be an area of focus to reduce readmission and complication rates.</td>
</tr>
<tr>
<td>Partridge et al.14, 2017</td>
<td>Comprehensive Geriatric Assessment (CGA)</td>
<td>Studied use of CGA combined with preoperative patient optimization in patients undergoing abdominal aortic aneurysm repair or lower limb arterial surgery. Found patients who received CGA and optimization had decreased length of stay, delirium, and complications.</td>
</tr>
<tr>
<td>Joseph et al.23, 2017</td>
<td>Trauma-Specific Frailty Index (TS-FI)</td>
<td>Created and validated a 50-variable frailty index called TS-FI. Found geriatric frail patients to be 3 times more likely to be diagnosed with failure to thrive.</td>
</tr>
<tr>
<td>Hall et al.37,38, 2017</td>
<td>Risk Adjusted Index (RAI)</td>
<td>Created and validated RAI to screen for frailty in surgical patients. RAI-C is a questionnaire that can be used prospectively to identify frailty, and RAI-A is a retrospective measurement tool comparing patient data and NSQIP data. Found that implementing a frailty screening initiative was associated with decreased mortality.</td>
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**Theory of Accumulated Deficits**

In the Canadian Study of Health and Aging (CSHA), Rockwood et al.27 studied the theory of accumulated deficits in relation to frailty. During the first stage of...
the CSHA, Rockwood’s group enrolled 10,263 people 65 years and older into a 5-year prospective cohort study, where deficits were considered in aggregate, and a rules-based definition of frailty was used. In the study, a 70-item CSHA Frailty Index (CSHA-FI) was created and found to have strong predictive value with regard to poor health outcomes in elderly patients (Table 5). The deficit accumulation approach was cross-validated by counting deficits in the standardized Comprehensive Geriatric Assessment.19 Rockwood et al28 established scales for function and overall clinical frailty, with the main objective of creating a tool for risk stratification of vulnerability in the elderly population.20 The frailty index was created to identify patients at greatest risk of increased morbidity and mortality. Frailty scores were found by dividing the number of deficits by the total number of 70 possible metrics. The closer the ratio came to 1, the frailer a patient. Specifically, the resulting ratio was used to identify someone as robust (ratio of 0.0-0.12), prefrail (ratio of 0.13-0.43), or frail (ratio of ≥ 0.44).29,30 These stratifications were found to be predictive of increased morbidity and mortality.10,16,27,31,32 Rockwood et al19 and others22,25 compared the frailty index to Fried’s phenotype and found it comparable for predicting adverse health outcomes. Despite its uselessness in predicting adverse outcomes, the 70-item scale is time-consuming to perform in a clinical environment. Additional retrospective research projects using smaller frailty indexes have shown that variations of the CSHA frailty index may be useful in identifying vulnerable patients.2,14,16,17,33-35

**Modified Frailty Index**

Research has validated use of a modified frailty index (mFI) for identifying patients at high risk of poor health outcomes following surgery. Various modified frailty indexes have used 5 to 42 variables from the CSHA frailty index with similar predictability of poor outcomes.14,16,34 For example, Velanovich et al24 matched 11 items from the National Surgical Quality Improvement Program (NSQIP) to the 70-item CSHA frailty index and found a stepwise increase in mortality and morbidity for each unit increase in frailty index across surgical specialties (Table 6). Additional research from Saxton and Velanovich36 created an mFI by matching 15 variables from the NSQIP to 11 variables from the CSHA-FI.

Hall et al37 developed a similar mFI, the Risk Analysis Index (RAI). The RAI represents a 14-item tool for measuring frailty in surgical patients. It can be used prospectively to identify frail patients by using a clinical questionnaire (RAI-C) or retrospectively using variables from the NSQIP (RAI-A).37 The RAI is based on adaptations from the Minimum Data Set Mortality Risk Index-Revised, in which 12 variables that consistently predicted mortality were selected. From these variables, a 14-point survey was created for measurement purposes.37 The easily administered survey relies on patient reports. In their research, Hall et al38 validated the RAI-C and the RAI-A as effective tools for measuring frailty compared with other measures. The RAI has similar predictive ability regarding frailty as the CSHA-FI and the mFI created by Saxton and Velanovich, and moderate correlation between these measures has been noted.37 The research by Hall and colleagues38 demonstrated that a large frailty screening initiative is feasible and can allow the directing of resources to patients who need them most in an effort to improve outcomes. Table 7 summarizes the frailty measures discussed in this article, which are rooted in the gerontology20,29 literature or the surgical literature.14,16,17,23,31,32,34-38

The lack of a clear, concise assessment of frailty has led to the creation of a multitude of instruments to measure it. The frailty phenotype and various frailty indexes have been validated through retrospective research. However, high-quality prospective studies are currently lacking. Despite the usefulness of frailty measurements, tremendous difficulty operationalizing them clinically remains. The creation of a standardized modified frailty index using the theory of accumulated deficits may help address the use of frailty as a predictor of outcomes following surgical procedures.

A standardized mFI applied during the preoperative setting may help anesthesia providers stratify patient risk of complications and direct more resources to the patients with higher frailty scores. Potential resources include cardiac, pulmonary, neurologic, and geriatric consults in an effort to establish patient baseline status and create a tailored care plan to improve outcomes.3,38,39 During the intraoperative setting, anesthesia plans for these high-risk patients could be modified. For instance, maintaining normothermia and normal blood glucose levels, avoiding benzodiazepines and anticholinergic medicines, minimizing narcotic administration, and use of nonopioid pain medications could mitigate potential postoperative delirium. Perhaps, types of anesthesia techniques other than general endotracheal anesthesia such as regional anesthesia could also reduce intravenous narcotic administration, thereby avoiding side effects such as somnolence and nausea.3,40 During the postoperative setting, avoiding patient shivering, maintaining blood pressure as close to baseline as possible, normal blood glucose levels, and monitoring for delirium and falls risk could reduce the potential for poor outcomes following surgery.3,40,41

**Conclusion**

Frailty has been validated in retrospective research.19-21,42 There is benefit to the use of a high-quality multidisciplinary preoperative assessment, including an mFI as a means to identify surgical patients at high-risk of poor
surgical outcomes. As the number of surgical procedures performed annually on this patient population increases, improving postoperative outcomes will gain increased importance. Fried's theory regarding the phenotype of frailty and Rockwood's Accumulated Deficits Theory of Frailty represent foundations on which to base future frailty studies. Using frailty scores may improve postoperative outcomes in surgical patients because high-risk patients can be identified early thereby leading to earlier mobilization of care resources in an effort to optimize these patients.

REFERENCES


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DISCLOSURES

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