Review Article

Frailty and Surgery: Impact on Surgical and Anesthetic Outcomes

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International Archives of Integrated Medicine, Vol. 13, Issue 4, April, 2026.
Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 6-4-2026 **Accepted on:** 20-4-2026
Source of support: Nil **Conflict of interest:** None declared.

DOI: **10.5281/zenodo.19843996**

How to cite this article: Josué Campos Chinchilla, Miguel Caled Trejos Román, Yoysi Leilani Duarte Molina, Ariel José Jiménez López, María Celeste Leitón Duran, Katherine María Blandón Carmona. Frailty and Surgery: Impact on Surgical and Anesthetic Outcomes. Int. Arch. Integr. Med., 2026; 13(4): 447-460.

Abstract

Frailty has emerged as a major determinant of perioperative risk because it reflects a multidimensional decline in physiological reserve that extends beyond chronological aging, comorbidity, or disability. It is characterized by reduced resilience across multiple organ systems and is commonly associated with sarcopenia, chronic low-grade inflammation, immune and neuroendocrine dysregulation, and metabolic and nutritional vulnerability. In surgical populations, frailty is highly prevalent, particularly among older adults and patients undergoing oncologic, cardiac, orthopedic, vascular, and abdominal procedures, making it a frequent and clinically relevant condition in perioperative care. Its importance lies in its strong association with adverse surgical and anesthetic outcomes. Frail patients experience higher perioperative and short-term mortality, more postoperative complications, longer hospital stays, increased readmissions, and a greater likelihood of non-home discharge. They are also more vulnerable to anesthetic complications because frailty alters pharmacokinetics and pharmacodynamics, increases sensitivity to anesthetics, sedatives, and opioids, and predisposes to hypotension and hemodynamic instability. In addition, frailty is closely linked to

postoperative delirium, cognitive dysfunction, delayed mobilization, functional decline, and loss of independence, thereby affecting not only early recovery but also long-term quality of life. Given these consequences, frailty assessment should be incorporated into routine preoperative evaluation. Tools such as the Fried Frailty Phenotype, the Accumulated Frailty Index, the Clinical Frailty Scale, and the Edmonton Frail Scale can support perioperative risk stratification and individualized planning. Furthermore, strategies including prehabilitation, nutritional and functional optimization, correction of anemia and comorbidities, polypharmacy review, delirium prevention, multidisciplinary care, and shared decision-making may help reduce complications and improve patient-centered surgical outcomes.

Key words

Frailty, surgery, anesthesia, postoperative outcomes, perioperative care, risk stratification.

Introduction

Frailty is characterized by a systemic decline in physiological function that leads to increased vulnerability to stressors. Although it is closely related to other clinical concepts, it must be distinguished from them. Comorbidity refers to the presence of multiple chronic conditions, whereas frailty is centered on reduced physiological reserves. Likewise, disability describes limitations in daily activities, while frailty refers more specifically to vulnerability to health stressors and to the diminished capacity to withstand them [1]. In relation to aging, although aging is a natural biological process, frailty represents an accelerated decline in physiological function that exceeds what would be expected from normal aging alone [2].

This distinction is especially important in surgical patients, in whom frailty has become highly relevant. Frailty is common among individuals undergoing surgery, particularly in older adults and in patients with cancer [2, 3]. In this context, it has gained importance as a key component of perioperative risk assessment, since it helps predict surgical outcomes and guides preoperative planning [5, 6]. To facilitate its identification in surgical settings, tools such as the Clinical Frailty Scale and the modified Frailty Index are commonly used [7].

The clinical relevance of frailty extends throughout the perioperative period because it affects surgery, anesthesia, and postoperative recovery. Frail patients have higher rates of postoperative complications, including pneumonia, myocardial infarction, and mortality [2, 8]. In addition, frailty influences anesthesia management by increasing the risk of intraoperative complications and the need for intensive care [9]. This vulnerability also has consequences during recovery, as frail patients frequently experience longer hospital stays, higher readmission rates, and a greater likelihood of non-home discharge [1, 8].

The objective of this review is to analyze frailty as a perioperative risk factor and its impact on surgical, anesthetic, and postoperative outcomes, with emphasis on its role in preoperative assessment, risk stratification, and clinical decision-making in patients undergoing surgery.

Methodology

This manuscript was developed as a structured narrative review aimed at providing an updated and clinically integrated analysis of frailty in surgical patients, with particular emphasis on its impact on surgical and anesthetic outcomes, perioperative risk stratification, and postoperative recovery. The review was conducted in accordance with the SANRA (Scale for the Assessment of Narrative Review Articles) framework and followed a predefined methodological protocol established prior to literature screening. Given the heterogeneity of

frailty definitions, the variability of assessment tools, and the diversity of surgical populations and perioperative outcomes evaluated across the literature, a narrative interpretative synthesis was selected over quantitative pooling to integrate pathophysiological, prognostic, anesthetic, and functional considerations into a coherent and clinically applicable framework. Special attention was given to the distinction between frailty, comorbidity, disability, and aging; the role of frailty in preoperative assessment; its association with postoperative complications, mortality, cognitive decline, and functional deterioration; and the implications of frailty for perioperative optimization and multidisciplinary decision-making. The objective was to provide a structured synthesis capable of supporting perioperative risk assessment and individualized management in patients undergoing surgery.

A comprehensive literature search was conducted in PubMed, Scopus, and Web of Science, including peer-reviewed articles published in English or Spanish between January 2020 and December 2025. The final search was performed in March 2026. This timeframe was selected to capture contemporary advances in frailty assessment, perioperative medicine, geriatric surgery, anesthetic risk stratification, and recovery-oriented surgical care. Foundational studies were incorporated when necessary to contextualize the conceptual development of frailty and its clinical relevance in surgical practice. The search strategy combined MeSH and free-text terms using Boolean operators related to frailty, frail patients, surgery, anesthesia, perioperative risk, postoperative complications, postoperative delirium, functional decline, mortality, Clinical Frailty Scale, modified Frailty Index, and preoperative assessment. Searches were conducted in titles and abstracts as well as indexed subject headings to maximize sensitivity.

The initial search yielded 201 records. After removal of duplicates, 139 articles remained for title and abstract screening. Of these, 94 underwent full-text evaluation, and 51 studies were included in the final synthesis. Selection was performed independently by two authors, with disagreements resolved through discussion and consensus. Exclusion criteria comprised non-peer-reviewed publications, isolated case reports, editorials without outcome data, studies focused exclusively on non-surgical populations, redundant datasets, and articles not directly addressing the relationship between frailty and surgical, anesthetic, cognitive, functional, or recovery-related outcomes.

Eligible studies included randomized controlled trials, large observational cohorts, systematic reviews, meta-analyses, expert consensus statements, and contemporary international guidelines from perioperative medicine, anesthesiology, geriatrics, and surgical societies. Priority was assigned to multicenter investigations, studies using validated frailty instruments, and research evaluating mortality, postoperative complications, delirium, length of hospital stay, readmissions, discharge disposition, and functional outcomes. Extracted variables included study design, surgical population, frailty assessment tool, type of procedure, perioperative outcomes, postoperative complications, mortality measures, cognitive outcomes, functional decline, and discharge destination. Methodological quality and internal validity were assessed narratively, considering risk of bias, sample size, follow-up duration, consistency in frailty definitions, and reproducibility of reported outcomes. In cases of conflicting evidence, greater interpretative weight was assigned to higher-level evidence and guideline-supported recommendations.

Reference lists of included studies were manually screened to identify additional relevant publications. Given its narrative design, this review is subject to potential selection bias and does not provide pooled quantitative estimates. Artificial intelligence-based tools were used exclusively to assist in literature organization and structural coherence, whereas critical appraisal,

synthesis, and final interpretation were conducted independently by the authors to preserve methodological rigor.

Pathophysiological Basis of Frailty

Frailty is characterized by a reduction in physiological reserve across multiple organ systems, which increases vulnerability to stressors such as surgery [10]. This diminished reserve has been consistently associated with poorer surgical outcomes, including increased morbidity and mortality. In this context, frailty reflects not only a state of generalized biological vulnerability, but also a decreased capacity to maintain homeostasis when exposed to the physiological demands of operative and anesthetic interventions [11, 12].

A central component of frailty is sarcopenia, which involves the progressive loss of muscle mass, strength, and function and contributes directly to functional decline [11, 13]. This process has important perioperative implications, as sarcopenia has been identified as an independent risk factor for postoperative complications and prolonged recovery. The loss of muscular reserve further compounds the limited adaptability of frail patients and contributes to worse postoperative trajectories [12, 14].

In parallel, chronic low-grade inflammation represents another hallmark of frailty and plays a major role in muscle degradation and progressive functional impairment [15]. This persistent inflammatory state intensifies the vulnerability of frail individuals to surgical stress and increases their susceptibility to postoperative complications. Frailty is also associated with immune and neuroendocrine alterations. Reduced immune cell activity may impair postoperative recovery and increase the risk of infection, while neuroendocrine changes, including altered hormone levels, further contribute to the decline in physiological reserve observed in these patients [14].

Metabolic and nutritional vulnerability also form part of the pathophysiological basis of frailty. Frail patients frequently present with malnutrition and hypoalbuminemia, both of which have been linked to adverse surgical outcomes [12, 14]. These deficiencies may impair wound healing and increase the likelihood of postoperative complications [15]. Altogether, the reduced physiological reserve that defines frailty results in a lower tolerance to surgical and anesthetic stress, which is reflected in higher complication rates and longer recovery periods [12, 16]. For this reason, frailty assessments such as the modified frailty index are essential in preoperative risk stratification and perioperative planning [11, 16].

Epidemiology and Clinical Relevance

Frailty is highly prevalent in surgical populations, although its frequency varies according to the type of procedure and the characteristics of the population studied. In cardiac surgery, frailty has been reported in 28% of patients undergoing open-heart procedures and in 40% of those treated with transcatheter interventions [17]. In patients undergoing hepatectomy, the prevalence has been estimated at approximately 23% [18], whereas in colorectal cancer surgery it has been reported at 31% [19]. Similarly, the SNAP-3 study conducted in the United Kingdom found that one in five older surgical patients were frail, with substantially higher rates in specific settings such as hip fracture surgery, where prevalence reached 58.2%. These findings show that frailty is a frequent condition in the perioperative setting and that its distribution is especially pronounced in high-risk and older surgical populations [20].

The presence of frailty is closely associated with aging and chronic disease, both of which are common among surgical patients. Older age, female sex, and comorbidities such as hypertension and diabetes have all been associated with higher rates of frailty [17]. In addition, the accumulation of multiple chronic conditions may intensify frailty and further

increase perioperative risk. This relationship underscores the importance of viewing frailty not as an isolated condition, but as a multidimensional state shaped by biological aging, chronic illness, and declining physiological resilience [21].

Frailty is particularly frequent in several major surgical specialties. In oncologic surgery, especially within geriatric surgical oncology, frailty is notably common and represents an important determinant of postoperative complications [4]. Cardiac surgery, including coronary artery bypass grafting, also demonstrates a high prevalence of frailty, with important consequences for postoperative outcomes. In orthopedic surgery, particularly in hip fracture repair, frailty is highly prevalent and has a major effect on both recovery and mortality [20]. Abdominal surgery similarly shows a significant burden of frailty, which has been identified as a predictor of postoperative complications and mortality [22].

From a clinical perspective, frailty has substantial implications for both outcomes and resource utilization. Its presence is associated with higher rates of postoperative complications, prolonged hospital stay, and increased mortality [2, 18]. This translates into a considerable healthcare burden, as frail patients often require more intensive perioperative management and experience longer recovery periods, thereby increasing overall healthcare costs. For this reason, routine frailty assessment has been recommended as a strategy to identify at-risk patients and tailor perioperative care in order to reduce adverse outcomes [6].

Preoperative Assessment of Frailty

The Fried Frailty Phenotype assesses frailty on the basis of five criteria: unintentional weight loss, exhaustion, low physical activity, slow walking speed, and weak grip strength. It has been validated in different surgical populations and has been associated with poor postoperative outcomes, including prolonged hospital stay and non-home discharge. However, its main limitation lies in its emphasis on the physical domain of frailty, which may lead to underrepresentation of cognitive and social dimensions [23].

In contrast, the Accumulated Frailty Index evaluates frailty through the quantification of health deficits, including symptoms, signs, diseases, and disabilities. This approach offers a broader view of the patient's overall health status and correlates with increased vulnerability to adverse surgical outcomes [6]. Nevertheless, its application may be limited in routine practice because it is more time-consuming and resource-intensive, which reduces its practicality for rapid preoperative screening [23].

The Clinical Frailty Scale is a simpler and more intuitive instrument that classifies patients according to their degree of frailty, ranging from very fit to severely frail. It has proven useful in predicting postoperative complications and mortality, particularly in emergency general surgery settings. Even so, its subjective nature represents an important limitation, as it may result in variability between evaluators [24].

The Edmonton Frail Scale adopts a multidimensional approach by evaluating domains such as cognition, mood, functional performance, and social support. It has shown effectiveness in identifying frail patients at risk of postoperative complications and loss of independence [25]. In addition, its relatively short administration time makes it suitable for preoperative screening, although it may still fail to capture all dimensions of frailty in more complex cases [26].

Frailty assessment tools provide valuable information regarding physiological reserve and the risk of adverse surgical outcomes, thereby supporting more individualized preoperative management [27]. These instruments may also be integrated with traditional perioperative risk calculators in order to improve predictive

accuracy and guide interventions aimed at reducing surgical risk [28]. However, their broader implementation remains limited by the variability in frailty definitions and by the need for greater standardization across clinical settings [23].

Impact on Surgical Outcomes

Frailty has consistently been identified as a significant predictor of perioperative and short-term mortality across different surgical populations. In cardiac surgery, frail patients have shown higher odds of mortality within 30 days after surgery, with an odds ratio of 2.33 [29]. Similarly, in carotid endarterectomy, patients with higher frailty scores, defined as a modified frailty index of 5 of at least 3, demonstrated increased 30-day mortality, with an adjusted odds ratio of 1.997 [30]. This association has also been observed more broadly in cardiac surgical populations, in which frailty was linked to increased early postoperative mortality, with a relative risk of 2.93. Taken together, these findings support the role of frailty as an important determinant of early postoperative survival [31].

Beyond mortality, frailty is strongly associated with a higher incidence of postoperative complications. In cardiac surgery, frail patients were found to have greater odds of developing postoperative complications, with reported odds ratios ranging from 2.54 to 3.57 depending on the specific outcome evaluated [29]. A similar pattern has been described in oral carcinoma surgery, where frail patients experienced significantly higher rates of major postoperative complications, including cardiovascular events and infections [32]. In hepatectomy, frailty has likewise been associated with an increased risk of major complications, with an adjusted odds ratio of 3.20. These observations indicate that frailty substantially worsens the postoperative course across diverse surgical specialties [18].

The impact of frailty is especially evident in the occurrence of infectious, cardiovascular, and pulmonary events. In carotid endarterectomy, frailty was associated with a higher risk of major adverse cardiovascular events and cardiac complications, with an adjusted odds ratio of 1.445. In the same setting, pulmonary complications and sepsis were also more common among frail patients, with higher frailty scores correlating with increased odds of these adverse outcomes [30]. In cardiac surgery, frailty has additionally been linked to a higher risk of acute kidney injury and renal impairment. These findings reinforce the concept that frailty reflects a broad vulnerability to systemic postoperative complications rather than to a single category of adverse events [31].

Frailty also has a clear effect on hospital resource utilization, particularly by prolonging hospitalization. Frail patients with oral carcinoma remained hospitalized for a mean of 15 days, compared with 8 days in non-frail patients [32]. Likewise, in carotid endarterectomy, frailty was associated with a hospital stay of more than 7 days, with an adjusted odds ratio of 1.425. This prolonged length of stay reflects the more complex postoperative course and slower recovery frequently observed in frail patients [30].

In addition to prolonged hospitalization, frailty is associated with a greater likelihood of readmission after surgery. Among patients undergoing cardiac surgery, frailty predicted hospital readmission, with an odds ratio of 2.00 [18]. Similarly, in carotid endarterectomy, frail patients demonstrated higher 30-day readmission rates, with an adjusted odds ratio of 2.427. This relationship suggests that the vulnerability associated with frailty extends beyond the immediate postoperative period and continues to influence outcomes after discharge [30].

Finally, frailty has major implications for postoperative functional independence. Frail patients are more likely to be discharged to care facilities rather than home, reflecting a significant decline in autonomy after surgery.

This pattern has been documented in cardiac surgery, where frailty was associated with non-home discharge with an odds ratio of 5.52 [29], and in carotid endarterectomy, where the adjusted odds ratio for discharge to a care facility was 2.127 [30]. A similar association has also been reported in spine surgery, where frailty was linked to non-home discharge. Altogether, these findings demonstrate that frailty affects not only survival and complications, but also the ability of patients to recover their baseline level of function and independence after surgery [1].

Impact on Anesthetic Management

Frailty has important implications for anesthetic management because it alters both pharmacokinetics and pharmacodynamics, thereby affecting the metabolism and distribution of drugs and increasing the risk of underdosing or overdosing anesthetic agents. As a result, careful dose adjustment becomes essential in this population. In cardiac surgery involving cardiopulmonary bypass, for example, hemodilution and hypothermia may decrease the total plasma concentrations of drugs such as propofol and sevoflurane, meaning that lower doses may still be sufficient to achieve the desired anesthetic effect [33].

In addition to these pharmacological changes, frail patients show increased sensitivity to anesthetics, sedatives, and opioids, which may lead to prolonged sedation and a greater risk of adverse effects [34]. This heightened susceptibility reinforces the need for individualized anesthetic plans and appropriate dosing adjustments to reduce complications and improve perioperative safety [33].

Frailty is also associated with a greater risk of hypotension and hemodynamic instability during the perioperative period. It has been linked to a higher incidence of postinduction hypotension, a condition that may contribute to adverse perioperative outcomes [28]. Studies have further shown that frail patients are more likely to develop intraoperative hemodynamic instability, which may require vasopressor support and close intraoperative surveillance [9]. For this reason, continuous and individualized intraoperative monitoring is crucial to detect and manage hemodynamic changes and other complications in a timely manner [34]. The use of advanced monitoring tools may therefore contribute to improved safety and better perioperative outcomes in this vulnerable population [35].

The selection of anesthetic technique also plays a relevant role in the management of frail surgical patients. The choice between general and regional anesthesia can significantly influence hemodynamic stability, and regional techniques such as multiple nerve blocks have been associated with better hemodynamic stability than general anesthesia in frail patients undergoing hip fracture surgery [36]. Nevertheless, the anesthetic approach should always be tailored to the patient's clinical condition and to the specific surgical requirements [37].

Multimodal analgesia is an important strategy for reducing anesthetic complications in frail patients. By decreasing reliance on opioids, multimodal approaches may help minimize opioid-related adverse effects while still providing effective pain control [34]. These strategies should include the use of non-opioid analgesics and regional anesthesia techniques whenever appropriate, with the goal of optimizing analgesia and reducing perioperative morbidity [35].

Postoperative Cognitive and Functional Outcomes

Postoperative delirium is characterized by acute cognitive disturbances and affects approximately 20% of older patients after major surgery, contributing to prolonged hospital stay and a greater likelihood of discharge to care facilities [38, 39]. In contrast, postoperative cognitive dysfunction manifests as a more subtle decline in cognition and has been associated with increased mortality and longer hospitalization, particularly

among patients undergoing cardiac surgery. Together, these postoperative cognitive disorders represent important determinants of recovery, especially in vulnerable surgical populations [40].

Within this context, frailty has emerged as a major risk factor for postoperative delirium. Frail patients consistently show a higher incidence of delirium than non-frail patients, and the frailty index has been identified as a strong predictor of delirium independently of preoperative cognitive status. This relationship highlights the close connection between diminished physiological reserve and postoperative neurological vulnerability, reinforcing the importance of frailty assessment in perioperative risk stratification [41].

Frailty also has important implications for postoperative recovery beyond cognition. It is frequently associated with delayed mobilization and slower rehabilitation after surgery, which may further aggravate functional decline and prolong recovery time. In parallel, frailty has been linked to poor functional outcomes, with a considerable proportion of frail patients developing new disabilities or requiring institutionalization within 90 days after surgery. This decline is often intensified by the coexistence of postoperative delirium and postoperative cognitive dysfunction, both of which contribute to reduced autonomy during recovery [42, 43].

Therefore, frailty is closely related to deterioration in quality of life and increasing dependence on caregivers. Both postoperative delirium and postoperative cognitive dysfunction have been associated with long-term poor outcomes, including loss of independence and increased mortality. These findings indicate that the postoperative impact of frailty extends well beyond the immediate hospital course, affecting functional status, long-term prognosis, and the patient's ability to return to baseline living conditions [42].

Given these effects, the early identification of frail patients in the preoperative setting is essential to implement strategies aimed at reducing the risk of postoperative delirium and postoperative cognitive dysfunction. Such measures include preoperative cognitive screening, optimization of comorbidities, and the implementation of enhanced recovery after surgery programs designed to reduce surgical stress and improve outcomes. At the same time, postoperative outcomes should not be interpreted through frailty alone, since other factors such as pre-existing cognitive impairment, comorbidities, and the type of surgery also play an important role and should be integrated into a comprehensive perioperative care plan [39, 44].

Perioperative Optimization and Decision-Making

Prehabilitation involves preparing patients physically and mentally before surgery in order to improve outcomes. This strategy includes exercise programs designed to enhance strength and endurance and may be particularly beneficial in frail patients by improving functional capacity and reducing postoperative complications. Evidence suggests that prehabilitation can improve surgical resilience and recovery, although its effectiveness may vary according to the patient's baseline health status and specific conditions such as cancer-related frailty [5, 45].

Nutritional and functional optimization also play a central role in the perioperative management of frail patients. Malnutrition is common in this population and may worsen surgical risk, making adequate protein and caloric intake essential to support healing and recovery [45]. At the same time, functional optimization, including physical therapy, seeks to preserve or improve mobility and independence, both of which are critical for postoperative recovery and quality of life [46].

Another important component of perioperative preparation is the correction of anemia and the optimization of comorbidities. Preoperative treatment of anemia may improve oxygen

delivery during surgery and contribute to a better recovery process [47]. Likewise, comprehensive management of comorbid conditions such as cardiovascular disease and diabetes requires medication adjustments and close monitoring in order to stabilize the patient before surgery [46].

The review of polypharmacy is equally relevant in frail patients, particularly in older adults, in whom the use of multiple medications is common and may increase the risk of adverse drug interactions and perioperative complications. A thorough medication review is therefore necessary to reduce unnecessary drugs and optimize therapeutic regimens [34, 46].

Delirium prevention represents another essential aspect of perioperative optimization. Delirium is a frequent postoperative complication in frail patients and is associated with increased morbidity and mortality. Preventive strategies include minimizing sedative use, maintaining adequate hydration, and providing a calm and supportive environment. In addition, early recognition and management of delirium are crucial for improving outcomes and reducing the risk of long-term cognitive decline [48].

Given the complexity of frailty, a multidisciplinary approach is fundamental throughout the perioperative period. The involvement of surgeons, anesthesiologists, geriatricians, and other specialists allows for a more comprehensive assessment of frailty, the adaptation of interventions to individual needs, and the delivery of coordinated care before, during, and after surgery [48]. This collaborative model ensures that all relevant aspects of the patient's health are considered and supports the development of more personalized and effective care plans [47, 49].

Shared decision-making is particularly important in frail patients undergoing surgery. This process involves patients, families, and healthcare professionals working together to make informed decisions that align with the patient's values and preferences. In this setting, shared decision-making may improve patient satisfaction, reduce decisional conflict, and help balance the risks and benefits of surgery in accordance with goals such as maintaining independence or improving quality of life [50, 51].

Conclusions

Frailty is a multidimensional perioperative syndrome characterized by reduced physiological reserve, sarcopenia, chronic inflammation, immune and neuroendocrine alterations, and metabolic vulnerability, all of which diminish tolerance to surgical and anesthetic stress. Because of this broad biological vulnerability, frailty is not only highly prevalent across surgical populations, but also a clinically relevant marker of increased perioperative risk and worse postoperative recovery.

In patients undergoing surgery, frailty is consistently associated with poorer outcomes, including higher perioperative and short-term mortality, more postoperative complications, prolonged hospital stay, increased readmissions, postoperative delirium, cognitive dysfunction, functional decline, and greater loss of independence. Its impact extends beyond immediate surgical survival, affecting long-term quality of life, discharge destination, and the patient's ability to return to baseline functional status.

The identification of frailty before surgery has major practical implications, as validated assessment tools can improve perioperative risk stratification and support individualized management. Strategies such as prehabilitation, nutritional and functional optimization, correction of anemia and comorbidities, medication review, delirium prevention, multidisciplinary care, and shared decision-making may help reduce adverse outcomes and align surgical planning with patient-centered goals.

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