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Review

Prediction of surgical complications in the elderly: Can we improve outcomes?

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Abstract As the number of Americans aged 65 years and older continues to rise, there is projected to be a corresponding increase in demand for major surgeries within this population. Consequently, it is important to utilize accurate preoperative risk stratification techniques that are applicable to elderly individuals. Currently, commonly used preoperative risk assessments are subjective and often do not account for elderly-specific syndromes that may pose a hazard for geriatric patients if not addressed. Failure to accurately risk-stratify these patients may increase the risk of postoperative complications, morbidity, and mortality. Therefore, we aimed to identify and discuss the more objective and better-validated measurements indicative of poor surgical outcomes in the elderly with special focus on frailty, patient optimization, functional status, and cognitive ability.

1. Introduction

Over the last decade, the number of elderly individuals in the United States has dramatically risen. Nearly 13% of the United States population is aged 65 years or older, and this group is expected to comprise over 20% of Americans by 2030 [1]. In 2007, over one-third of all inpatient surgical procedures were performed on this population, a number which is projected to double by 2020 [2,3]. This rising demand for surgical interventions necessitates accurate preoperative risk stratification techniques that are applicable to elderly individuals. While commonly used preoperative risk assessments incorporate patient laboratory values, presence of comorbidities, and functional status to predict postoperative outcomes, most of these measures often do not account for elderly-specific syndromes that may pose a hazard for geriatric patients if not addressed. Prediction of surgical complications and postoperative morbidity and mortality is vital to the informed consent process and can help the surgeon guide patient expectations after surgery,

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particularly with regards to quality of life and ability to convalesce to their preoperative baseline level of functioning.

The most widely used scale has been the American Society of Anesthesiology (ASA) score, initially developed to classify a patient's physical status based on subjective degree of systemic disease prior to surgery rather than "operative risk" [4,5]. ASA score is used most commonly to give surgeons and anesthesiologists an estimate of risk of postoperative complications. However, it has been criticized for its lack of accuracy and its inconsistencies between evaluators [6]. Scoring systems such as the Preoperative Score to Predict Postoperative Mortality (POSPOM) incorporate objective markers such as dementia, diabetes, dialysis dependence, and heart failure to determine perioperative and postoperative risk of mortality, but do not include the individual's postoperative quality of life and morbidity [6]. Additionally, the Charlson Comorbidity Index is another commonly used scale that uses pre-existing chronic disease to determine a patient's 1-year mortality risk, and can help providers in deciding how aggressively to treat a condition in the preoperative period [7].

Overall, these assessments, among several others, shed insight on determining and improving upon physical, functional, and social issues in patients with the goal of optimizing outcomes. Unfortunately, preoperative assessments have not been adapted to identify geriatric-specific conditions and provide an opportunity for intervention in order to reduce risk. Comprehensive preoperative evaluation with execution of patient-focused treatment strategies is thought to reduce morbidity and mortality in otherwise potentially risky patients [8]. However, these assessment modalities can be particularly subjective and may demonstrate poor reliability between evaluators, ultimately resulting in variability of results [9].

Currently, there is no uniformly accepted method for preoperative prediction of surgical complications and few studies have highlighted specific recommendations for their use in elderly patients. Therefore, our purpose was to discuss the more objective and better-validated measurements indicative of poor surgical outcomes in the elderly. Specifically, we discuss considerations for frailty, patient optimization, functional status, and cognitive ability.

2. Frailty

Frailty can be defined as an increased susceptibility to stressors as a result of age- and disease-related declines in function across multiple domains [10,11]. This vulnerability results in decreased physiologic reserves, which compromises the ability to cope with stressors and potentially increases the risk of mortality and poor postoperative outcomes [11,12]. The prevalence of frailty is high among the elderly and increases with age, as it is seen in 40% of patients aged 80 years or older compared with 10% of patients aged between 65 and 75 years [13]. As compared to more fit patients, frail patients who undergo surgery have a greater likelihood of developing postoperative complications, being discharged to care facilities, and having longer hospital stays [14]. Postoperative complications can result in

a series of events leading to loss of independence, disability, decline in quality of life, increased healthcare costs, and even death [15]. Therefore, adequate assessment of frailty as a domain of preoperative health status has been proposed so as to ascertain vulnerability in older adult patients.

The American College of Surgeons has recommended two modalities for evaluating frailty. One strategy is the multidimensional frailty assessment, which has shown to be a useful tool in identifying high-risk older patients in the preoperative setting [16—18]. This method assigns point values to each of the following seven assessments: functional dependence, nutritional status, mobility (timed up-and-go test [19]), presence of comorbidity (Charlson index [20]), age, cognitive ability, and presence of a geriatric syndrome (having one or more falls within 6 months of assessment) [21]. Robinson et al. [22] used this strategy to determine that geriatric patients with four or more of these markers have a greater 6-month postoperative mortality rate compared to those with fewer than four markers, with a sensitivity of 81% and specificity of 86%, independent of the procedural intervention. Specifically, they noted that impaired cognition, anemia, low albumin levels, lack of functional independence, and increased number of comorbidities were strong predictors of 6-month mortality ($p < 0.01$ for all).

Another way to evaluate frailty utilizes its phenotypic definition, which includes the following five features, each worth one point: shrinking (unintentional weight loss of 4.5 or more kilograms in the last year), weakness (decreased grip strength as measured by a handheld dynamometer), self-reported exhaustion (low effort and motivation), low physical activity (Minnesota Leisure Time Activities Questionnaire) and slow walking speed (several ways to assess) [23]. Patients with higher scores are categorized as more frail. Makary et al. [24] prospectively evaluated preoperative frailty in 594 patients aged 65 years or older using this scale. Patients scoring 0 to 1 were categorized as non-frail, 2 to 3 were intermediately frail, and 4 to 5 were frail. The authors determined that patients classified as frail had an increased risk for postoperative complications (odds ratio (OR) 2.54; 95% confidence interval (CI) 1.12—5.77), greater length of hospital stay (incidence rate ratio (IRR) 1.69; 95%CI 1.28—2.23), and greater likelihood of being discharged to a skilled or assisted-living facility after previously living at home (OR 20.48; 95%CI 5.54—75.68). Additionally, intermediately frail patients were associated with an increased risk for postoperative complications (OR 2.06; 95%CI 1.18—3.60), greater length of hospital stay (IRR 1.49; 95%CI 1.24—1.80), and discharge to a skilled or assisted-living facility after previously living at home (OR 3.16; 95%CI 1.0—9.99). This assessment helped predict complications after minor procedures, with an incidence of 3.9% in non-frail, 7.3% in intermediately frail, and 11.4% in frail patients. Furthermore, after major procedures, the incidence of complications was 19.5% in non-frail patients, 33.7% in intermediately frail, and 43.5% in frail patients.

Given the projected annual increase in operations performed on the elderly, it is important to be aware of factors that may influence surgical outcomes. Utilizing an appropriate frailty assessment index may provide additional insight to help surgeons make better predictions for the best interests of the patient.

3. Patient optimization

Malnutrition has an estimated prevalence of 23% among the elderly and is associated with several contributing factors, such as altered metabolism, decreased appetite, medication use, and chronic disease [25]. There is currently a paucity of effective measures in place to prevent its onset; however, scoring systems have been developed as a means to evaluate patients' nutritional status. For example, models such as the Nutritional Risk Index (NRI) [26] and the Maastricht Index [27] utilize equations to provide objective assessments. While these tools may be reliable in identifying malnourished patients, they are fairly ineffective at determining patients who are moderately malnourished or at risk of malnutrition. Malnourishment is also taken indirectly into account by incorporating weight loss into global evaluations of a standardized definition of frailty as discussed above, and has been shown to be associated with postoperative complications and ultimate disposition (i.e., rehabilitation facility *vs.* home) [24].

For a more comprehensive assessment, subjective scoring scales were developed such as the Mini Nutritional Assessment-short form (MNA-sf) and the Subjective Global Assessment (SGA). The MNA-sf is a six-question scale that assesses mobility, diet, general health (including acute disease and neuropsychological stresses), and anthropometric measures such as weight loss and body mass index (BMI) [28,29]. The SGA is a non-mathematical scoring model that assesses food intake and complaints such as diarrhea, vomiting, and weight loss [30]. The Malnutrition Universal Screening Tool (MUST) combines both subjective and objective factors such as BMI, degree of weight loss and presence of acute disease to determine risk of malnutrition [31]. A study by Poulia et al. [31] compares the ease and validity of six screening tools, especially with regards to the elderly population, to find that the MUST screening tool the most valid as well as simple to execute.

With this armamentarium of screening tools, surgeons can make use of a variety of therapies to optimize nutritional status preoperatively with the help of primary care providers. Enteral supplementation, including protein nutritional shakes, multivitamins, and iron supplementation, are simple interventions that may help support wound healing in the postoperative period [32].

4. Functional status

Assessment of preoperative functional status can be a valuable predictor of postoperative outcomes in elderly patients. The degree of preoperative functional status may have implications on a variety of factors including infection, pulmonary complications, and discharge disposition [33]. With this knowledge, surgeons can counsel patients on ways to recover or surpass preoperative functional levels in the postoperative period.

In a retrospective analysis of 318 patients from seven hospitals over 5 years, Chen et al. [34] demonstrated that lack of independence with activities of daily living (ADLs) is an important risk factor for methicillin resistant staphylococcus aureus (MRSA) surgical site infection (SSI). Patients who required assistance in three or more ADLs had a significantly greater risk for MRSA SSI as compared to those who required assistance in fewer than three ADLs (OR 2.73, 95%CI 1.16—6.46). Arozullah et al. [35] analyzed 81,719 patients from the National Veterans Affairs Surgical Quality Improvement Program (NSQIP) database to develop a preoperative risk index for predicting postoperative respiratory failure (PRF), defined as mechanical ventilation for more than 48 h postoperatively or reintubation and mechanical ventilation after postoperative extubation. In total, 3.4% of patients ($n = 2746$) developed PRF. The authors determined that functional status was a significant preoperative predictor for this complication. Specifically, they noted that patients who were partially dependent were 1.5 times more likely (95%CI 1.34—1.68) to develop PRF, while patients who were totally dependent were 2.24 times more likely (95%CI 1.88—2.66) to develop PRF. Partially dependent patients required the use of an assistive device or another individual to complete some ADLs, whereas totally dependent patients could not perform any ADLs alone. In another study, Legner and colleagues [36] prospectively assessed 586 patients to determine the association between preoperative self-reported exercise tolerance and unanticipated nursing home placement following major non-emergent surgery. Poor preoperative exercise tolerance (inability to climb two flights of stairs or ambulate four blocks without limitation) was reported in 324 patients, of which, 12% ($n = 40$) had unanticipated nursing home placement as compared to only 4% of patients with reported good exercise tolerance (10 of 262 patients). Logistic regression analysis revealed that poor preoperative exercise tolerance increased the likelihood of unanticipated nursing home placement after surgery (OR 2.8, 95%CI 1.3—6.2).

Functional status is a strong predictor of postoperative complications in the elderly. Because pathogens like MRSA can be devastating in this particular population, interventions such as targeted screening and appropriate antimicrobial prophylaxis should be considered. Additionally, patients should be encouraged to take measures to improve functional independence as well as exercise tolerance well before the perioperative period.

5. Cognitive ability

Elderly adults have a greater frequency of perioperative complications and poor postoperative outcomes, including cognitive decline [37]. A decline in cognition and memory in elderly patients usually results in a loss of independent function that affects families, caregivers, and the healthcare system in general. This is a substantial burden, considering that nearly 10%—20% of adults older than 65 years have some degree of cognitive impairment [37]. Furthermore, several studies have demonstrated that individuals with mild cognitive impairment have a greater risk of developing dementia [38,39], which has an annual incidence of 1%—2% in the United States [40]. Dementia is well-known to increase the risk of morbidity and mortality within the geriatric population [41]. Cognition can also be affected after surgery in these patients, with postoperative delirium occurring in up to 42% of cases [42,43]. Consequently, it is imperative for surgeons to understand the

relationship between preoperative cognitive ability and postoperative morbidity.

Despite the availability of several means to assess patients' preoperative cognition, the validated Mini–Cog test is currently recommended by recent guidelines from the American College of Surgeons and the American Geriatrics Society [44]. This test provides a quick assessment of several domains including memory, cognitive function, visual-motor abilities, executive function, and language comprehension. Robinson et al. [45] used this assessment to prospectively evaluate 186 patients aged 65 years or older and planning to undergo an elective operation. Eighty-two patients (44%) in this group had baseline impaired cognition. Compared to patients with normal cognition, the cognitively impaired cohort demonstrated higher 6-month mortality (13% *vs.* 5%; $p = 0.040$), higher incidence of delirium (78% *vs.* 37%; $p < 0.001$), greater incidence of ≥ 1 postoperative complications (41% *vs.* 24%; $p = 0.011$), increased length of hospital stay (15 $\pm$ 14 days *vs.* 9 $\pm$ 9 days; $p = 0.001$), and a greater rate of discharge to an institutional care facility (42% *vs.* 18%; $p = 0.001$). Additionally, logistic regression analysis revealed that patients with impaired baseline cognition were more likely to develop one or more postoperative complications (OR 2.40; 95%CI 1.18–4.86; $p = 0.015$).

Aykut and colleagues [46] prospectively studied 48 patients over 70 years of age who planned to undergo elective coronary artery bypass graft (CABG) surgery. Patients' cognition was determined using the validated Montreal Cognitive Assessment test (MoCA), which is a 10-min, 30-point, cognitive screening tool to assist in the detecting mild cognitive impairment. Patients in the cognitively impaired cohort ($n = 25$) had significantly higher rates of postoperative atelectasis (84% *vs.* 17%; $p < 0.001$) and prolonged mechanical ventilation (24% *vs.* 0%; $p < 0.05$) compared to those with no cognitive impairment ($n = 23$). Because the MoCA test assesses several cognitive domains, it may have utility in screening patients with multiple comorbidities who plan to undergo other procedures as well.

A study by Galanakis et al. [42] prospectively analyzed 105 consecutive patients aged 65 years or older to determine the incidence and risk factors for the development of postoperative acute confusional state in patients undergoing hip surgery due to fracture or elective hip arthroplasty. Preoperative cognitive impairment was measured by the Mini-Mental State Exam (MMSE) and postoperative confusional state was assessed using the Confusion Assessment Method (CAM). No patients had any cognitive deficiencies at baseline, however, postoperative acute confusional state developed in 25 patients (23.8%). Moreover, multiple regression analysis showed an increased risk of developing postoperative acute confusional state in patients who had prior cognitive impairment (OR 1.32, 95%CI 1.07–1.22).

As the proportion of aging Americans continues to rise, assessment of pre-existing cognitive impairment becomes increasingly important in the preoperative setting [47]. Given the strong association between preoperative cognitive impairment and postoperative complications [48,49], surgeons should strive to identify patients at risk of declining postoperatively.

6. The role of the urologist

It is becoming clear that advances in medical care can extend life, and patients are now surviving many diseases once considered lethal. As a result, they are often left with less physiologic reserve than younger, healthier patients. When they then develop more "mundane" diseases following such illnesses, it is critical to recognize that these patients are more prone to complications due to their comorbidities, medications, and overall frailty. One need only consider acute urologic disease presentation in the post-coronary artery stent period, during which antiplatelet agents require continuous administration. Our practice patterns are already being dictated by medical necessity in such patients.

Overall, elements such as frailty, nutritional status, functional ability, and cognition are of greater consideration in elderly surgical patients compared to younger surgical patients, though they are likely to be impactful across all patient demographics. Deficiencies in these areas may place elderly patients at increased risk for postoperative morbidity, complications, increased length of hospital stay, and greater likelihood of being discharged to a care facility. In addition, postoperative patients are routinely instructed to take measures such as walking, physical therapy, and use of incentive spirometry in an effort to mitigate complications. Inability to comprehend or accomplish these instructions can ultimately lead to postoperative complications in already frail patients, who are also the least suited to sustain any additional insult.

Therefore, it is vital for urologists to perform a thorough preoperative risk assessment. Risk stratification can be accomplished using a variety of tools, scales, and indices, but regardless of the modality used, the objective should be geared towards achieving the best outcome after surgery, or in deciding that the risks of surgery are higher than the disease condition itself and that surgical intervention should be avoided.

Finally, as we develop the most critical metrics to ensure the best care, identification of opportunities for preoperative optimization can be made. If a given frailty domain can be identified, we must ask if it can be mitigated in some way and thereby affect the risk of adverse outcomes. We need to determine if it is possible to decrease perioperative risks by correcting deficits in ADL or frailty in advance of surgery in the same way that we can mitigate risk by correcting an underlying coronary condition.

Once the risks of surgery have been deemed tolerable for an elderly patient, urologists can arrange for more focused, high-quality perioperative care. Preoperative measures should be taken to optimize the patient's physical, mental, and physiologic status in the preoperative setting. This approach can be particularly useful in patients undergoing non-emergent surgery, where the procedure can be delayed in order to modify risk factors (nutritional optimization, physical rehabilitation, or limitation of polypharmacy). Targeted strategies have the potential for boosting physiologic reserve, improving mental status, and enhancing function. If implemented correctly, early intervention may positively impact postoperative outcomes in elderly adults, and ultimately, could improve the quality of care provided for these high-risk surgical patients.

Further studies are desperately needed to define where we can optimally inform and manage our patients, particularly in an era where they are surviving longer and with greater medical and physiological frailty.

Conflicts of interest

The authors declare no conflict of interest.

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