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"A National Study Demonstrating the Need for Improved Frailty Indices for Preoperative Risk Assessment of Common Urologic Procedures"

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Abstract

Objective: To compare the associations between frailty indices and postoperative complications among older adults undergoing common urologic procedures. Frailty is known to be strongly associated with poor postoperative complications; however, the optimal way to measure frailty remains unknown.

Methods: We identified the 20 most common urologic procedures from 2013–2016 in the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database. Frailty was measured using the NSQIP frailty index (NSQIP-FI), simplified frailty index (sFI), and Risk Analysis Index (RAI). Multivariable logistic regression models were performed with each index and the American Society of Anesthesiologists (ASA) classification system with postoperative complications (any, major, or minor) as the outcomes. Statistical models were compared using the following fit parameters: area under the curve (AUC), Akaike information criterion (AIC) and Bayesian information criterion (BIC).

Results: A total of 158,855 procedures were identified. All frailty indices (i.e., NSQIP-FI, sFI, and RAI) and ASA were associated with increased odds for any, major, and minor complications (all p-values <0.001). ASA demonstrated stronger model fit parameters for any, major, and minor complications compared to all other indices, with an AUC of 0.63, 0.64, and 0.64, respectively (all p-values <0.001). Adding ASA to each frailty index resulted in slight improvement of model fit parameters (p-value <0.001).

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Conclusions: ASA slightly outperforms current frailty indices in predicting postoperative complications among individuals undergoing commonly performed urologic procedures. Our findings highlight the need for improved frailty measures for preoperative risk assessment.

Keywords

Geriatrics; Surgery; Outcomes; Complications

INTRODUCTION

More than two-thirds of all urologic procedures are performed in patients ≥65 years of age [1], a large proportion of whom are frail [2]. Frailty is defined as a decline in physiologic reserve and function among older adults that is associated with an increased risk of poor health outcomes [2–6]. Numerous studies using data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) demonstrate that frailty is associated with increased rates of postoperative complications and decline in functional status, longer hospital stays, and higher rates of discharge to skilled or assisted nursing facilities (SNF) [2,7–9].

Historically, the American Society of Anesthesiologists (ASA) classification system, which describes the overall health of a patient, has been used in literature to predict postoperative complications [10,11], however has been widely criticized for its subjectivity. Several frailty indices have been developed to objectively improve upon the ability to predict postoperative complications among older patients, however, there is a lack of consensus on which index to use. Many studies use the NSQIP frailty index (NSQIP-FI) [2,12–16], which is a well-known 11-item cumulative deficits model developed from the 70-item questionnaire from the Canadian Study on Health and Aging. In response to recent changes in ACS-NSQIP variables and a desire to simplify frailty measurement [17,18], other modified frailty indices have been developed including the simplified Frailty Index (sFI) [8,19] and the Risk Analysis Index (RAI) [7]. The comparative predictive ability of each of these indices to determine postoperative complications, however, remains unknown.

Using data from ACS-NSQIP from 2013 to 2016, we examined and compared the associations of each tool (NSQIP-FI, sFI, RAI and ASA) with 30-day postoperative complications among older adults undergoing common urologic procedures. Findings from this study will be helpful to determine which tools should be used to evaluate postoperative complications using ACS-NSQIP and similar data sources among individuals undergoing common urologic procedures.

MATERIALS AND METHODS

Patients and Database

This is a retrospective cohort study of men and women undergoing urologic surgery from 2013–2016 using the ACS-NSQIP Participant Data Use File. The ACS-NSQIP database is a prospectively maintained national database of validated data collected from trained Surgical Clinic Reviewers (SRCs). SRCs examine medical records and classify perioperative clinical data through 30-day postoperative outcomes across a sample of surgical procedures of randomly assigned patients [20,21]. As of 2017 the Participant Use Data File contained 1,028,713 cases that were submitted by 708 participating sites nationwide [20]. From this database, we identified all urologic procedures using the urology surgical specialty variable and included the 20 most commonly performed procedures (Appendix A). Given the fact that female sling procedures are performed by both urologists and gynecologists, this particular procedure (Current Procedure Terminology [CPT-4] code 57288: sling operation for stress incontinence, e.g. fascia or synthetic) included both specialty types. Common urologic procedures were grouped together to ensure adequate power for predicting risk of complications for each frailty index. This study was determined to be exempt by our institutional review board.

Outcomes

Data on 30-day complications were obtained from the ACS-NSQIP database. Complications were classified as either minor (e.g. urinary tract infection [UTI], superficial wound infection, pneumonia or blood transfusion) or major (e.g. hospital readmission, return to the operating room, sepsis, deep vein thrombosis [DVT], CVA, reintubation, renal failure, myocardial infarction, pulmonary embolus, dehiscence, cardiac arrest, deep wound infection, coma or death] in accordance with previous studies examining complications using these data [2,7,8,12,15–16].

Covariates

Frailty was assessed using several indices previously designed and validated specifically for ACS-NSQIP data including (1) NSQIP-FI, (2) sFI, and (3) RAI. The NSQIP-FI is a cumulative deficits model and includes 11 items in total: history of diabetes mellitus (DM); impaired functional status; history of chronic obstructive pulmonary disease (COPD) or pneumonia; history of congestive heart failure (CHF); history of myocardial infarction within 6 months of surgery; history of percutaneous coronary intervention, cardiac surgery, or angina; use of anti-hypertensive medications; peripheral vascular disease (PVD) or rest pain; impaired sensorium; transient ischemic attack or cerebral vascular accident (CVA). Items are summed and divided by the total number of items (11) for the composite NSQIP-FI score, whereby a NSQIP-FI score of 1/11 would be 0.09, a NSQIP-FI score of 2/11 would be 0.18, etc. We categorized patients into groups based on corresponding NSQIP-FI score (0, 0.09, 0.18, and 0.27+). This index was selected because it has been shown to have excellent correlation with both mortality and morbidity in all surgical subspecialties, including urology, and distinctly measures frailty, as opposed to comorbidity [12,16].

The sFI was derived from the five most common components of NSQIP-FI and was first introduced to improve the practical usefulness of NSQIP-FI [8]. The five variables included in this index are history of DM, functional status, history of COPD, history of CHF, and hypertension requiring treatment. To calculate sFI, the presence of each variable is attributed 1 point, with a maximum score of 5 points possible [8]. We classified patients into three categories, similar to a previously published study [19], denoted as a score of 0, 1, and ≥2 due to the nature of the compressed scale and reduced frequency of patients with a score ≥3.

The RAI was adapted from the Minimum Data Set (MDS) Mortality Risk Index-Revised (MMRI-R) and is based on clinically focused variables including gender, age, diagnosis of cancer, history of weight loss, renal failure, CHF, dyspnea, cognitive deterioration, residence other than living independently, and functional status [7]. Each variable has weighted numerical value and the RAI is calculated using a scoring system with a range of 0–81 [7]. We categorized patients from our cohort into four groups: (1) RAI score of 0–15, (2) score of 16–25, (3) score of 26–35, and (4) score of ≥36 similar to distributions from previously published literature [7].

The ASA classification system, while not a frailty index, was first introduced clinically in 1941 as a method to describe a patient's underlying systemic illnesses prior to undergoing a procedure with an anesthesia professional [10,11]. The ASA scale assigns increasing order of risk from 1–6. In order to appropriately compare frailty indices, we grouped patients as ASA 1 (normal, healthy), 2 (mild systemic disease), 3 (severe systemic disease), or 4+ ([4] severe systemic disease, a constant threat to life, [5] moribund, not expected to survive without the operation, or [6] declared brain-dead for donor organ harvest).

Additional covariates extracted from the ACS-NSQIP database included patient characteristics (age, gender, race, BMI, and smoking status) and procedure characteristics (surgical setting [inpatient vs. outpatient], type of anesthesia [general, monitored anesthesia care, or other], and calendar year of operation).

Statistical Analysis

Patient- and procedure-level characteristics as well as frailty index and ASA scores of patients were reported as frequencies and percentages. Unadjusted and adjusted logistic regression models were created to assess predictive ability of any, major, and minor postoperative complications. Models were adjusted for age, gender, race, BMI, and smoking status and separate models were created for each index individually (e.g., NSQIP-FI, sFI, RAI and ASA). To determine the combined effect of ASA with each frailty index, we performed separate multivariable logistic regression analyses for each frailty index in combination with ASA. Quality of statistical models were estimated and compared by performing model selection methods including area under the curve (AUC), Akaike information criterion (AIC), and Bayesian information criterion (BIC). AUC should be interpreted such that a value of 0.5 reflects an accuracy of chance and a model with perfect accuracy has an AUC of 1.0. AIC estimates the quality of each model relative to other models, whereby a lower value suggests a better model. Similarly, BIC is used as a criterion for model selection and the model with the lowest BIC is preferred. All analyses were performed with SAS®, version 9.4. All p-values were two-sided and 0.05 was set as the level of statistical significance.

RESULTS

Based on inclusion criteria, 158,855 relevant urologic procedures were identified in the ACS-NSQIP data set between 2013 and 2016. Table 1 outlines patient and procedure-level characteristics, in addition to frailty and ASA scores for our cohort. The cohort mean age was 64.6 ± 13.2 years, mean BMI was 29.2 ± 6.0 kg/m^2, 22.9% were female, and 16.0%

were smokers. Fifty-four percent of cases were performed in the inpatient setting and 91.0% were done under general anesthesia. Mean NSQIP-FI score was 0.073 +/− SD 0.07, while 16.9% and 1.8% had a NSQIP-FI score of 0.18 and ≥0.27, respectively. Mean sFI score was 0.8 ± 0.2 and 18.8% of the cohort had a sFI score of ≥2. Mean RAI score was 7.4 +/− SD 4.3 and 4.55% of the cohort had an RAI score of >15. Finally, mean ASA was 2.5 +/− SD 0.7 and 3.9% of the cohort had an ASA of ≥4. Appendix B shows complication rates by each individual complication within the patient cohort. The rate of major complications was 8.2% and the rate of minor complications was 8.6%. The most common major complication was readmission (5.8%) followed by return to the operating room (2.0%) and the most common minor complication was blood transfusion (4.8%) followed by UTI (3.1%).

Logistic regression models for each frailty index and ASA (adjusted for age, gender, race, BMI, and smoking status) are shown in Table 2. These models demonstrate that increasing severity of frailty (for each frailty index) and increasing ASA score correlated with increased odds for any, major, and minor complications (all p-values <0.001) (Table 2).). NSQIP-FI score of 0.27+ was associated with major complications (adjusted odd ratio [aOR] 3.1, 95% confidence interval [CI] 2.8–3.4). In comparison, a sFI score of ≥2 was associated with an aOR of 1.9 (95% CI 1.8—2.0) and an RAI score of ≥36 was associated with an aOR of 6.5 (95% CI 4.1–10.5) for risk of major complications respectively. However, an ASA of 4+ had the highest association of major complications with an aOR of 7.2 (95% CI 5.9–8.8). Table 3 summarizes the model fit parameters for each of the frailty indices and ASA. ASA demonstrated stronger model fit parameters for any, major, and minor complications (compared to all of the frailty indices) with an AUC of 0.63, 0.64, and 0.64, respectively. In comparison, NSQIP-FI and sFI both had the lowest AUC values of 0.59, 0.60, and 0.59 for any, major, and minor complications, while RAI had AUC values of 0.59, 0.61, and 0.59 for any, major, and minor complications. Values for AIC and BIC showed similar trends.

Because ASA demonstrated the strongest fit parameters for postoperative complications in our models, we decided to model ASA combined with each frailty index to determine whether or not this combination improved model fit. Table 4 summarizes these findings and shows that there was slight improvement of all fit parameters (AUC, AIC, and BIC) when ASA was combined with each frailty index. For example, NSQIP-FI alone had an AUC of 0.59, whereas, the combination of the NSQIP-FI and ASA demonstrated an AUC of 0.63, p-value <0.001 comparing the two models. This trend was consistent when ASA was combined with each frailty index. The combination of RAI and ASA was the strongest predictor of odds of any, major, and minor complications with AUCs of 0.64, 0.65, and 0.64, respectively.

COMMENT

This national study highlights the strong association between increased frailty and postoperative complications among older adults undergoing common urologic procedures. However, our findings suggest that the current tools commonly used to quantify frailty (NSQIP-FI, sFI, and RAI) are relatively poor, as shown by our statistical models demonstrating model fit parameters. Interestingly, we found that ASA was marginally superior to all frailty indices. Additionally, there was modest improvement of the accuracy to predict postoperative complications when fit parameters were measured for each frailty index in combination with ASA.

Other studies that examined specific subsets of urologic patients from the ACS-NSQIP database have previously compared fit parameters between different frailty indices. One study compared NSQIP-FI, sFI, and ASA to evaluate the predictive ability of sFI as a risk assessment tool in patients who underwent radical cystectomy. This study compared AUCs between NSQIP-FI, sFI and ASA for models predicting Clavien Grade III-V complications and demonstrated slightly higher AUCs for the frailty indices (AUCs for NSQIP-FI and sFI were both 0.56) compared to ASA (AUC of 0.544) [8]. This finding differs from our study, which found the reverse to be true, whereby AIC (and other fit parameters) demonstrated that ASA slightly outperformed the frailty indices in predicting complications. This difference is likely due to the contrasting patient populations evaluated in each study. Cystectomy patients represent only 4.2% of our study population and are likely to be among the most frail individuals compared to patients undergoing other common urologic procedures included in our cohort. Regardless of the frailty of the patient population studied, however, differences between ASA and frailty indices in predicting postoperative complications are relatively small, highlighting the point that there may not be much difference between the each type of instrument.

Another study showed the validity of RAI predicting postoperative outcomes among surgical patients at a Veterans Affair institution. However, the NSQIP-FI and RAI models also demonstrated weak predictability of postoperative mortality and prompted authors to call on future efforts for determining an optimal preoperative frailty assessment [7]. This finding is similar to our study such that NSQIP-FI and RAI fitness models demonstrates the poor quality of these tools as predictors for postoperative complications among older patients.

While other reports have demonstrated the association between higher ASA class and worsened perioperative morbidity [22,23], the utility of ASA as a prognostic metric for postoperative complications across surgical subspecialties remains poor. Particularly in select patient populations (i.e., vascular surgery patients or very elderly patients), the ASA classification system has been shown to have limited predictive utility because these patients are most often confined to ASA grade III or IV as a result of having several comorbid conditions. These studies have argued to distinguish such patients with the addition of an independent tool to assess functional capacity in order to improve operative risk evaluation [24–26]. Furthermore, numerous articles have explored and quantified inter-observer reliability among anesthesia trained physicians [27,28] and reduced inter-rater variability between anesthesia trained physicians compared to other clinicians, particularly in patients with higher ASA scores [29,30]. Overall, despite the slight advantage of ASA compared to frailty indices as shown in our study, there continues to be a lack of a high-quality and accurate method to predict an older patient's ability to withstand the demands of surgery.

The findings of this study should be considered with certain limitations in mind. First, due to the nature of the ACS-NSQIP database, the variables that may be utilized to define frailty are limited and we recognize that such variables may not truly capture what it means to be frail. Second, the ACS-NSQIP database is limited by a short time-frame of 30-day postoperative follow-up and the absence of long-term complications. Due to the nature of this database, specific complications may be underrepresented, particularly post-operative UTI's. While this may be true, 30-day complications have become an important metric to report for evaluating quality of care and carry significant value in the current healthcare landscape.

CONCLUSIONS

While several tools to measure frailty exist, they remain relatively poor predictors of any, major, and minor complications following common urologic procedures. ASA, often thought of as an historic and subjective tool describing the overall health of a patient, also showed relatively low utility as a predictive tool but had slight advantage compared to frailty indices (e.g., NSQIP-FI, sFI, and RAI). Our findings highlight the need for improved frailty assessment tools for preoperative risk stratification for older adults undergoing common urologic procedures.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Patient characteristics, procedure characteristics and frailty index/ASA scores of patients undergoing common urologic procedures

Variable		
Patient Characteristics		
Age (years), frequency (%)		
Age (Mean ± SD (N))	64.6 ± 13.2 (N=158,855)	
<65	73157	(46.1)
65–74	49934	(31.4)
75–84	27127	(17.%)
≥85	8637	(5.4)
Gender, frequency (%)		
Male	122400	(77.1)
Female	36455	(22.9)
Race, frequency (%)		
White	111589	(86.8)
Black	11602	(9.0)
Other	5368	(4.2)
BMI (kg/m^2), frequency, (%)		
BMI (Mean ± SD (N))	29.2 ± 6.0 (N=157,457)	
Underweight (<18.5)	1507	(1.0)
Normal (18.5–24.9)	35777	(22.7)
Overweight (25–29.9)	60775	(38.6)
Obese (≥30.0)	59398	(37.7)
Smoking status, frequency (%)		
Smoker	25474	(16.0)
Procedure Characteristics		
Surgical setting, frequency (%)		
Inpatient	85800	(54.0)
Outpatient	73055	(46.0)
Type of anesthesia, frequency (%)		
General	144597	(91.0)
Monitored Anesthesia Care (MAC)	4092	(2.6)
Other	10125	(6.4)
Year of Operation, frequency (%)		
2013	30512	(19.2)
2014	34578	(21.8)
2015	43207	(27.2)
2016	50537	(31.8)
Frailty index and ASA scores		

Variable		
NSQIP-FI score, frequency (%)		
NSQIP-FI score (Mean ± SD (N))	0.07 ± 0.07 (N=158,855)	
0	63737	(40.1)
0.09	65391	(41.2)
0.18	26797	(16.9)
≥0.27	2930	(1.8)
sFI score, frequency (%)		
sFI score (Mean ± SD (N))	0.8 ± 0.2 (N=158,855)	
0	63737	(40.1)
1+	65391	(41.2)
≥2	29,727	(18.8)
RAI score, frequency (%)		
RAI Score (Mean ± SD (N))	7.4 ± 4.3 (N=158,855)	
0–15	151688	(95.5)
16–25	6183	(3.9)
26–35	898	(0.6)
≥36	86	(0.05)
ASA, frequency (%)		
ASA (Mean ± SD (N))	2.5 ± 0.7 (N=158,492)	
1	7757	(4.9)
2	71545	(45.1)
3	72996	(46.1)
≥4	6194	(3.9)

Table 2.

Summary of logistic regression rodels for each frailty index and ASA demonstrating odds of any complications, major and minor complications. (models are adjusted for age, gender, race, BMI and smoking status)

	Any Complication				Major complications				Minor complications			
	Odds Ratio	**Lower 95% CI**	**Upper 95% CI**	**P-value**	**Odds Ratio**	**Lower 95% CI**	**Upper 95% CI**	**P-value**	**Odds Ratio**	**Lower 95% CI**	**Upper 95% CI**	**P-value**
NSQIP-FI												
0.00	1.0				1.0				1.0			
0.09	1.4	1.3	1.4	<0.001	1.4	1.3	1.4	<0.001	1.4	1.3	1.4	<0.001
0.18	1.7	1.6	1.8	<0.001	1.8	1.7	1.9	<0.001	1.7	1.6	1.8	<0.001
≥0.27	2.8	2.5	3.1	<0.001	3.1	2.8	3.4	<0.001	2.4	2.2	2.7	<0.001
sFI												
0	1.0				1.0				1.0			
1	1.4	1.3	1.4	<0.001	1.4	1.3	1.4	<0.001	1.4	1.3	1.4	<0.001
≥2	1.8	1.7	1.9	<0.001	1.9	1.8	2.0	<0.001	1.8	1.7	1.9	<0.001
RAI												
0–15	1.0				1.0				1.0			
16–25	2.8	2.6	3.0	<0.001	2.7	2.5	2.9	<0.001	2.8	2.6	3.0	<0.001
26–35	4.0	3.4	4.7	<0.001	4.2	3.5	5.1	<0.001	3.5	2.9	4.2	<0.001
≥36	8.7	5.4	14.2	<0.001	6.5	4.1	10.5	<0.001	6.2	3.9	10.0	<0.001
ASA												
1	1.0				1.0				1.0			
2	2.0	1.7	2.3	<0.001	1.9	1.5	2.3	<0.001	2.1	1.8	2.6	<.0.001
3	4.0	3.5	4.6	<0.001	3.7	3.1	4.5	<0.001	4.6	3.8	5.6	<.0.001
≥4	7.9	6.8	9.2	<0.001	7.2	5.9	8.8	<0.0011	9.0	7.4	11.0	<0.001

** (Each model includes age, BMI, smoking status, recent weight loss as independent variables)

Table 3.

Model fit parameters of frailty Indices and ASA predicting odds of complications (adjusted for independent variables: age, gender, race, BMI and smoking status)

	Any Complication				Major Complication				Minor Complication			
	NSQIP-FI	**sFI**	**RAI**	**ASA**	**NSQIP-FI**	**sFI**	**RAI**	**ASA**	**NSQIP-FI**	**sFI**	**RAI**	**ASA**
AUC	0.59	0.59	0.59	0.63	0.60	0.60	0.61	0.64	0.59	0.59	0.59	0.64
AIC	102237.45	102329.89	101482.98	100316.60	71648.81	71736.22	71324.64	70628.42	74233.37	74261.16	73738.19	72670.54
BIC	102374.10	102456.77	101619.62	100453.22	71785.45	71863.10	71461.28	70765.04	74370.01	74388.04	73874.83	72807.16

** (all p-values were <0.001 when each index was compared to ASA for any complication, major complication, minor complication)

Table 4.

Summary of regression models predicting odds of complications with ASA added to the each frailty index

	Any Complication			Major complications			Minor complications		
	NSQIP-FI & ASA	**sFI & ASA**	**RAI & ASA**	**NSQIP-FI & ASA**	**sFI & ASA**	**RAI & ASA**	**NSQIP-FI & ASA**	**sFI & ASA**	**RAI & ASA**
AUC	0.63	0.63	0.64	0.64	0.64	0.65	0.64	0.64	0.64
AIC	100191.00	100233.68	99330.60	70492.18	70538.74	70034.37	72625.90	72631.98	72125.74
BIC	100356.90	100389.82	99496.50	70658.07	70694.87	70200.27	72791.79	72788.12	72291.64

** (all p-values were <0.001 when each index was compared in combination with ASA)