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ORIGINAL ARTICLE

Preoperative frailty predicts postoperative complications and mortality in urology patients

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Abstract
Purpose Our objective was to determine the impact of preoperative frailty, as measured by validated Risk Analysis Index (RAI), on the occurrence of postoperative complications after urologic surgeries in a national database comprised of diverse practice groups and cases.
Study design The National Surgical Quality Improvement Program (NSQIP) database was queried from 2005 to 2011 for a list of abdominal, vaginal, transurethral and scrotal urological surgeries using Current Procedural Terminology codes. The study population was subdivided into two groups based on the nature of procedures performed: complex procedures (inpatient) and simple procedures (outpatient). Risk Analysis Index score was calculated using preoperative NSQIP variables to determine preoperative frailty. Major postoperative morbidities (pulmonary, cardiovascular, renal and infectious), mortality, return to operating room, discharge destination and readmission to the hospital were examined.
Results The study identified 42,715 patients who underwent urological procedures, 25,693 complex and 17,022 simple procedures. Mean RAI score (range) was 7.75 (0–53). The majority of patients scored low on the RAI (90.57 % with RAI < 10). As the RAI score increased, there was a significant increase in postoperative complication and mortality rate (both $p < 0.0001$). Similarly, the rate of return to operating room and hospital readmission rate increased as RAI increased (both $p < 0.0001$). Additionally, rate of discharge to home decreased. Interestingly, mortality rate in patients with high RAI did not differ comparing simple to complex procedures ($p = 0.90$), whereas complications were significantly greater in the complex operation ($p = 0.01$).
Conclusions Increase in frailty, as measured by RAI score, is associated with increased postoperative complications and mortality. RAI may allow for rapid identification and counseling of patients who are at high risk of adverse perioperative outcomes.

Keywords Frailty · Complications · Mortality · NSQIP · Risk Analysis Index

Introduction

The population of older Americans are growing, and by age 2030, 1 in 5 will be older than 65 years of age [1]. The majority of elderly Americans undergo surgeries in the year before their death when the physiological reserves of the body have declined [2]. In addition to the age-related decline in physiological reserves, the elderly population is also more vulnerable to frailty. Frailty is broadly defined as a state where a minor stressor can deplete homeostatic reserve, leading to poor health status [3, 4]. Frailty recently has been associated with poor surgical outcomes, and its effect has been studied in various surgical specialties.

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However, the impact of frailty on patients undergoing urological surgeries has not been extensively studied [5–8].

The objective of this study was to identify the impact of frailty on postoperative complications and mortality rate in a urological population. We also investigated frailty's impact on the perioperative outcomes like the median length of stay, discharge destination, readmission rates and return to the operating room that are important in counseling of patients prior to surgery. We used previously validated Risk Analysis Index (RAI) score to measure frailty that is simple enough that it can be calculated from preoperative history and physical examination without requiring extensive evaluation [9]. We calculated RAI score for urology patients in the national database of American College of Surgeons National Surgical Quality Improvement Program (NSQIP) to study the impact of frailty on the postoperative outcomes in urology patients.

Materials and methods

We performed a retrospective review of NSQIP database for a period of 2005–2011. Patients who underwent urological procedures were identified using the Current Procedural Terminology (CPT®) codes.

Identified urological procedures were divided into two groups: complex procedures and simple procedures based on the nature of procedure. Inpatient urological procedures were considered complex procedures, and outpatient urological procedures were considered simple procedures (Table 1, lists CPT codes). Extensive surgeries of prostate, kidney, bladder, adrenal, retroperitoneal lymph node dissection, suburethral sling placement and laparoscopic pyeloplasty were included as complex procedures. Simple procedures included: transurethral resection of prostate, transurethral resection of bladder tumor, ureteroscopy, hydrocelectomy, orchiectomy, spermatocelectomy, epididymectomy and varicocelectomy.

Preoperative frailty score in these identified patients was calculated using previously validated RAI score [10]. This frailty index was developed after modification of the Revised Minimum Data Set Index (MMRI-R) based on the nationally collected Minimum Data Set. MMRI-R is a 12-item mortality index designed to use in nursing home residents [11]. RAI score includes 11 variables and excludes dehydration from MMRI due to the subjective nature of dehydration evaluation in patients undergoing the surgical procedures. Following variables were included in RAI score: age, gender, admission to nursing home in last 3 months, unintentional weight loss within 3 months, renal failure, chronic heart failure, poor appetite, shortness of breath, active cancer diagnosis, deteriorated cognitive skills within 3 months and activity of daily living score (Fig. 1). RAI score was calculated from the preoperative variables in NSQIP database for patients undergoing urological procedures identified by CPT codes. RAI score ranged from 0 to 81 with a higher score indicating higher frailty. For the purpose of analysis, we grouped together any score greater than 35 as >35 due to a low number of patients with score 40 or higher.

Primary outcomes studied were postoperative mortality and major complications. Major complications were

Table 1 CPT codes of the procedures included in the study

Procedure	CPT codes
Complex procedures	
Prostatectomy	55801, 55810, 55812, 55815, 55821, 55831, 55840, 55842, 55845, 55866
Nephrectomy	50220, 50225, 50230, 50234, 50236, 50240, 50543, 50545, 50546, 50548
Cystectomy	51550, 51555, 51565, 51570, 51575, 51580, 51585, 51590, 51595, 51596, 51597
Adrenalectomy	60540, 60545, 60650
Retroperitoneal lymph node dissection	38564, 38570, 38780
Vaginal sling placement	57288
Laparoscopic pyeloplasty	50544
Simple procedures	
Transurethral resection of prostate	52601, 52630, 52647, 52648, 52649, 52450
Transurethral resection of bladder tumor	52234, 52235, 52240
Cystourethroscopy	52341, 52342, 52344, 52345, 52346
Hydrocelectomy	55040, 55041
Orchiectomy	54520, 54530
Spermatocele excision	54840
Epididymectomy	54860
Varicocele excision	55530

Sex	Male = 5/Female = 0	
Weight loss in past 3 months (>10 lbs)	Yes = 5/No = 0	
Renal Failure	Yes = 6/No = 0	
Congestive heart failure	Yes = 4/No = 0	
Poor appetite	Yes = 4/No = 0	
Shortness of breath at rest	Yes = 8/No = 0	
Residence other than independent living	Yes = 8/No = 0	
Cancer	If yes, see age score	
Age	With cancer = (13-20)	
	Without cancer = (2-9)	
Cognitive decline over the last 3 months	If yes, see ADL score	
Activities of Daily Living (ADL)	With cognitive decline = (2-21)	
	Without cognitivie decline = (0-16)	
	Total Score (0-81)	

Fig. 1 Risk analysis index score

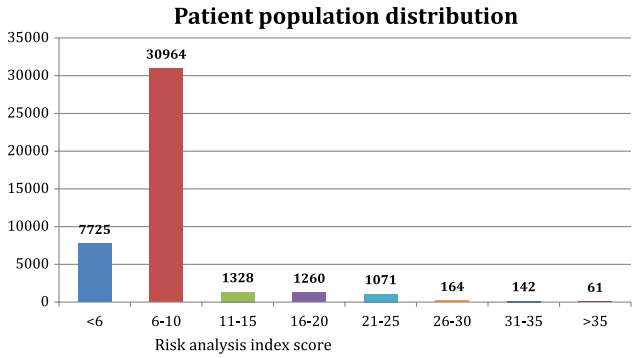

Fig. 2 Patient population distribution based on preoperative RAI (Risk Analysis Index) score. Majority of patient population (approximately 90 %) had low frailty as measured by RAI score

defined as Clavien–Dindo III–V included pulmonary, cardiovascular, renal and infectious complications. Secondary outcomes studied were the length of hospital stay after the procedure, rate of returning to the operative room, readmission rate to a hospital within 30 days after the procedure and discharge destination after the procedure. For the variable "discharge destination," data were available only for the year 2011.

Descriptive statistics and graphs were used to summarize the data. Chi-square tests or Mantel–Haenszel Chi-square tests, as appropriate, were used to determine differences in rates between frailty and procedure groups.

Results

Mortality and complications data were available for a total of 42,715 patients: 25,693 patients in the complex procedure group and 17,022 patients in the simple procedure group. The overall mortality rate for all the included patients was 0.77 %, and complication rate was 6.05 %. The majority of patients undergoing urological surgeries had a low frailty score with 90 % of patients with a score <10. The distribution was skewed to the right when based on RAI score (Fig. 2).

Mortality and complications rates significantly increased with increase in Risk Analysis Index score in the included urological patients (Fig. 3a). The mortality rate increased from 0.47 % in patients with RAI score <6 to 29.51 % in patients with RAI score >35. On subgroup analysis, mortality rate and complications rate significantly increased in both complex and simple procedure groups. We compared mortality and complications rates between the complex and simple surgery groups. The mortality rate was not significantly different between the groups; however, patients in the complex surgery group had significantly higher complications rate compared to patients in the simple surgery group (Fig. 3b, c).

We also studied the impact of frailty on the perioperative outcomes in the patients undergoing urological surgeries. The median length of stay for all urological procedures was longer for those who were frailer. On subgroup analysis, patients undergoing complex surgeries had increase in median length of stay. Procedures included in the simple surgery group being mostly outpatient urological surgeries comparatively had shorter length of stay (median length of stay was 0–1 day). However, even in this simple procedure group, patients with higher RAI score had a median length of stay of up to 6 days (Fig. 4a). We also studied the impact of frailty on the discharge destination and hospital readmission rates. Data for these variables were available in the NSQIP database for only year 2011 with patient sample of 18,560 patients. With increasing in frailty as measured by increase in RAI score, discharge to home significantly decreased and discharge to alternative places like skilled nursing care, acute care and rehabilitation facility increased. In patients with a RAI score <6, 94 % were discharged to home compared to 33 % with an RAI score of >35. Rate of return to the operating room within 30 days after the procedure increased with increase in RAI score. Also, with an increase in frailty score readmission to the hospital within 30 days after the procedure significantly increased (Fig. 4b, c).

Discussion

Urological diseases often present in the elderly population who are vulnerable to frailty [4]. In addition to aging,

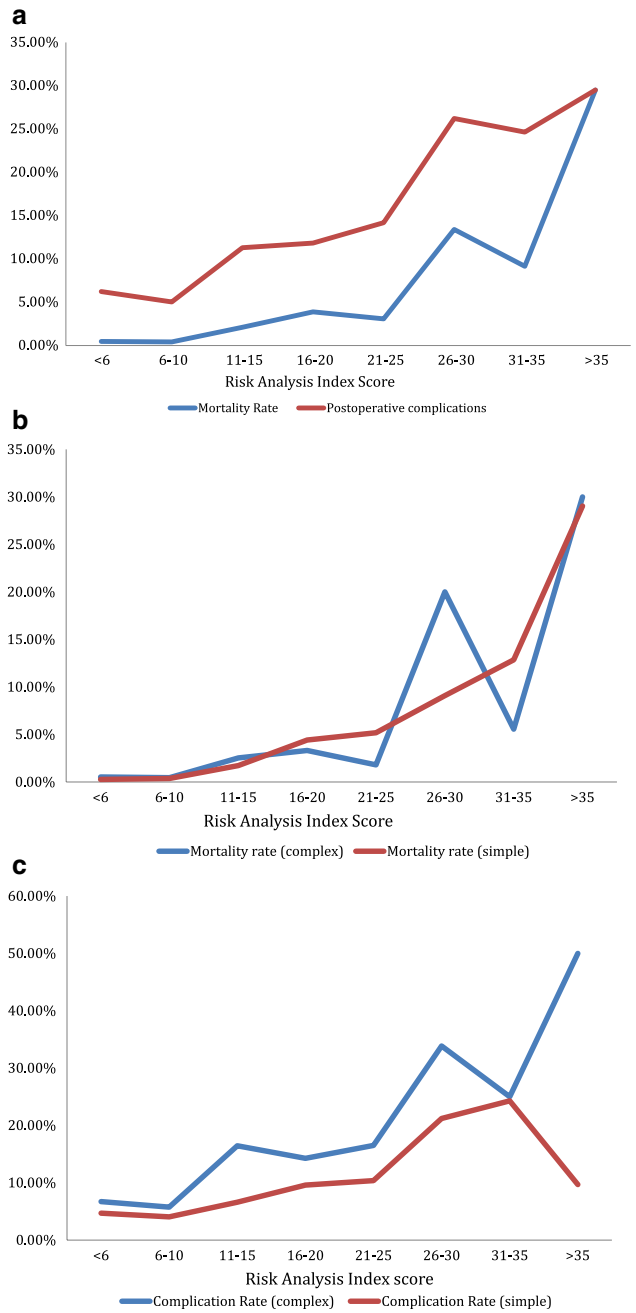

Fig. 3 **a** Mortality rate and complications rate increased with increase in frailty as measured by increase in RAI score (both $p < 0.0001$). **b** Comparison of increase in mortality rate with increase in RAI score between complex and simple procedure groups. Mortality rate increased in both groups with increase in RAI score; however, this increase in the rate did not differ significantly based on the procedure type ($p = 0.90$). **c** Comparison of increase in complications rate with increase in RAI score between complex and simple procedure groups. Patients who underwent complex procedures had significantly greater increase in complications rate compared to simple procedure group with increase in RAI score ($p < 0.01$)

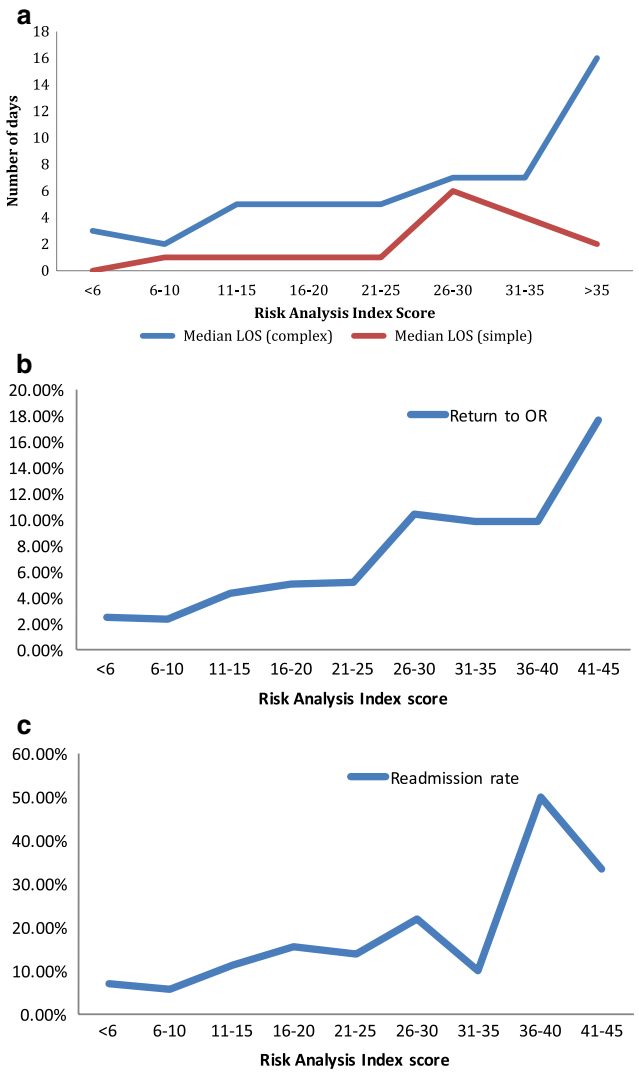

Fig. 4 **a** Median length of postoperative hospital stay increased with increase in RAI score. This effect was less pronounced in simple procedure group as most of the procedure included being outpatient in nature; however, in patients with higher RAI score even in simple procedure group the median length of stay was longer. **b** Rate of return to operating room (OR) significantly increased with increase in frailty as measured by RAI score ($p < 0.001$). **c** With increase in frailty measured by RAI score, readmission to the hospital within 30 days significantly increased ($p < 0.001$)

frailty is a strong predictor of outcomes after undergoing surgical procedures, so it is essential to identify patients who are frail and so proper risk/benefit assessment can be performed. Often surgeons assess patients as surgical candidates by "eyeball test" that is subjective and does not truly correlate with the risk of postoperative complications [12]. In this study, we objectively quantified frailty using

RAI score. Increasing RAI score and, therefore, increase in frailty resulted in an increased incidence of major postoperative complications and mortality rate in urological surgery patients. In addition, the important perioperative outcomes like return to operating room, median length of stay, discharge destination and readmission rate were adversely affected by the increase in frailty score. This impact of frailty on perioperative outcomes is important for surgeons to provide proper counseling to the patients to set realistic expectations about the recovery process after surgery. The majority of patients (approximately 90 %) who underwent urological procedures had low Risk Analysis Index score. There was very small number of patients that had high (>35) Risk Analysis Index score, but these are the patients who are most prone to have significant morbidity or mortality after the procedure based on our results. So it becomes even more important to identify these small numbers of frail patients in clinical settings to discuss the risks and potential alternatives to the surgery.

A recent study by Lascano et al. [13] showed similar finding while specifically studying the impact of frailty on major urological oncology surgeries. Lascano et al. used a modified frailty index derived using the variables from Canadian Study of Health and Aging (CSHA) frailty index. CSHA frailty index is 70 points index that is too cumbersome for application during a preoperative visit to a surgeon [14]. Various modifications of CSHA frailty index have been developed to measure frailty in surgical patients that includes fewer variables but are still able to accurately determine the frailty of patients [15]. Unfortunately, modified frailty index has not been used in clinical setting. In contrast, our study used the RAI score that has 11 variables, has been implemented system wide and can be calculated at the bedside or clinic setting without extensive workup making its application much easier.

Recently, sarcopenia has been associated with poor outcomes in urological patients; however, it requires imaging studies to determine the loss of muscle mass [16]. Urologists could use sarcopenia in addition to frailty index when imaging studies are available, and loss of muscle mass can be determined to supplement the frailty index. Whatever frailty index urologists choose to implement in clinical settings, it is important for them to be cognizant of the fact that frailty is associated with significantly increased risk of adverse surgical outcomes.

Our study has several limitations. It was retrospective analysis of prospectively collected data. NSQIP database collects data only from participating sites so it may not represent a true national sample. Also, NSQIP database collects postoperative data for only 30 days after surgery so delayed complications or mortality may not be captured. NSQIP variables were closely matched to calculate the RAI score since the study was retrospective in nature, and determination of RAI score was extrapolated from available NSQIP variables. The goal of this study was to use RAI score as a bedside/clinic tool to easily identify frail patients, so proper risk assessment could be performed to identify whether patient would be a good surgical candidate. To better power our study, we grouped our data into complex and simple procedures and did not evaluate the impact of frailty on individual surgical procedure outcomes. While procedures like large gland transurethral resection of prostate or large bladder tumor resection could be complex, determination of volume of resection could not be noted in the NSQIP retrospective database and was grouped in simple procedures since the majority of these cases are simple. Also, retrospective nature of this database limited our ability to evaluate factors other than nature of surgery to affect the length of stay in the hospital. The number of patients decreased in RAI score group with increasing frailty score with 61 patients in group with RAI score > 35. These small cohorts may have added some variability in our results, leading to higher mortality rate in complex surgery patients in Fig. 3b in RAI score group (26–30) compared to score group (31–35). Further validation of RAI score to measure frailty and impact of frailty in urological patients can be performed in prospective institutional databases.

Our study demonstrates the association of frailty with adverse perioperative and postoperative outcomes in patients undergoing urological surgeries. Risk Analysis Index score can be used with ease by urologists in clinical settings to determine frailty to better select good surgical candidates and counsel those patients who are at high risk of complications.

Authors's contribution S Isharwal was involved in project development and data collection and wrote the manuscript. J Johanning was involved in project development. J Dwyer was involved in data collection and edited the manuscript. K Schmid was involved in data collection and data analysis. CA Lagrange was involved in project development and edited the manuscript.

Compliance with ethical standards

Conflicts of interest None.

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