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The American College of Surgeon's surgical risk calculator's ability to predict disposition in older gynecologic oncology patients undergoing laparotomy

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Abstract

Objectives: The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) surgical risk calculator calculates risk of postoperative complications utilizing clinically apparent preoperative variables. If validated for patients with gynecologic , this can be an effective tool in to use for shared decision-making, especially in the older (70+ years of age) patient population for whom surgical risks and potential loss of independence is increased. The primary objective of this study was to evaluate the ability of the ACS NSQIP surgical risk calculator to predict discharge to a post-acute care among older (age 70+ years) gynecologic oncology patients undergoing laparotomy. The secondary objectives were to assess its ability to predict postoperative complications and death.

Methods: This was a retrospective cohort study of gynecologic oncology patients 70+ years of age undergoing laparotomy. Surgical procedures, 21 preoperative variables, postoperative complications, and patient disposition were abstracted from the medical record. Risk scores for seven postoperative complications and discharge to post-acute care were calculated. The association between risk scores and outcomes were assessed using logistic regression and predictive ability was evaluated using the c-statistic and Brier score.

Results: 204 surgeries were performed on 200 patients between January 1, 2009 and December 31, 2013. The mean age was 76.3±5.1 years; 87% were independent at baseline. A total of 79 (41%) were discharged to post-acute care. The calculator's ability to predict discharge to post-

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AUTHOR CONTRIBUTIONS

SS contributed to the data acquisition, quality control of data and algorithms, data analysis and interpretation, manuscript preparation, editing, and review. CR contributed to the study concepts and study design, manuscript editing, and manuscript review. RN contributed to the data acquisition, manuscript editing, and manuscript review. RIV contributed to the data analysis and interpretation, statistical analysis, manuscript preparation, editing, and review. DT contributed to the study design and concepts, quality control of data and algorithms, data analysis and interpretation, manuscript preparation, editing, and review.

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CONFLICTS OF INTEREST AND DISCLOSURES

Conflicts of interest: None

acute care was reasonable (c- statistic =0.708, Brier=0.205). Although the calculator did not accurately predict all postoperative complications, the calculator's ability to predict death was strong (c-statistic=0.811, Brier=0.015).

Conclusion: For older patients with an elevated calculated risk of discharge to post acute care the possibility of discharge to post-acute care should be discussed preoperatively. For patients with a higher risk of death, non-surgical management options should be considered when available.

Keywords

Gynecologic Oncology; laparotomy; NSQIP; older patient; post-acute care; surgical risk calculator; discharge planning

INTRODUCTION

The mean age at diagnosis of ovarian cancer, which commonly requires an extensive laparotomy surgery, is 63 years, but 45% of patients diagnosed with ovarian cancer will be older than age 65 years, and 24% will be older than age 74 years[1]. Population-based studies have shown higher rates of perioperative morbidity and 30-day postoperative mortality in older patients undergoing surgery with any indication[2,3]. Additionally, 14% of patients age 70–79 years and 33% of patients older than 80 years will require discharge to post-acute care[3]. However, individual patient risk for discharge to post-acute care will vary by performance status and other medical comorbidities. Previous studies have shown that fulfillment of preoperative patient expectations is associated with improved patient satisfaction, postoperative quality of life, and decreased disability[4]. If individual patient risk is determined, personalized preoperative counseling and planning can occur.

The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) surgical risk calculator is designed to predict the risk of any complication, serious complication (defined as death, cardiac arrest, myocardial infarction, pneumonia, progressive renal insufficiency, acute renal failure, pulmonary embolus, deep venous thrombosis, return to the operating room, deep incisional surgical space infection (SSI), organ space SSI, systemic sepsis, unplanned intubation, urinary tract infection (UTI), wound disruption), and seven specific postoperative complications, length of stay, and discharge to post-acute care[5,6]. The calculator was developed using a regression model to determine the strength of association between preoperative variables and postoperative outcomes using data from 1.4 million patients at 393 NSQIP hospitals. The variables within the calculator were weighted based on the regression coefficient[5,6]. Data from all surgical specialties except trauma and transplant were included in the development of the calculator, but gynecologic surgery patients comprised only 5.3% of the original cohort, and only 1.1% of the population that was used to develop the discharge prediction tool[5,6]. Other retrospective studies of the predictive ability of the calculator in gynecologic oncology patients have shown poorer performance compared to its performance in colorectal surgery patients who served as the original validation cohort for the calculator[5,7,8]. The higher postoperative morbidity and mortality rate in older patients may improve the predictive ability of the calculator. Additionally, particularly relevant to this older cohort, a risk percentage for discharge to post-acute care has been added to the calculator, which was not available at the

time of previous analyses[6]. The primary objective of this study was to evaluate the ACS NSQIP surgical risk calculator's ability to predict discharge to post-acute care in older (70 years of age or older) gynecologic oncology patients undergoing laparotomy. Secondary objectives were to evaluate the ability of the calculator to predict postoperative complications and death in this population.

METHODS

This retrospective cohort study was reviewed by the University of Minnesota Institutional Review Board and meets the requirements for protection of human subjects. The gynecologic oncology surgical database was queried to identify patients who underwent a laparotomy procedure with the gynecologic oncology service at the University of Minnesota Medical Center from January 1, 2009 through December 30, 2013. All patients 70 years of age or older at the time of their laparotomy procedure were included in this study. Data coding and entry of surgical procedures into the ACS NSQIP surgical risk calculator have been described previously[7]. In brief, surgical procedures were categorized as detailed in Table 2. "Less than Hysterectomy" included exploratory laparotomies with limited biopsies and/or adnexal surgery; "staging" referred to any procedure performed to assess the extent of malignancy, including but not limited to omentectomy, lymphadenectomy, peritoneal biopsies; "debulking" included any procedures to remove gross tumor excluding bowel resection which had its own category due to the unique risks associated with this procedure (e.g. delayed bowel function; anastomotic leak). Common Procedural Terminology (CPT) codes for the procedures performed were entered into the surgical risk calculator. For surgeries with more than one CPT code, a different iteration was run under each CPT code and the CPT code resulting in the highest estimated surgical risk was used in the analysis.

The 21 preoperative variables required for the ACS NSQIP surgical risk calculator were abstracted from the electronic health record and are detailed in Table 1. These data along with the CPT code, as described above, were entered into the calculator and prediction scores for discharge to post-acute care, length of stay and risk of any postoperative complication, serious complication, seven specific complications (pneumonia, cardiac complications defined as cardiac arrest or myocardial infarction, superficial, deep or organ space SSI, UTI, VTE, and renal failure, death) were calculated and recorded.

The primary outcome of interest was discharge to post-acute care; secondary outcomes included postoperative complications and length of hospital stay. Information on each patient's discharge location and postoperative complications within 30 days of surgery were abstracted from the medical record. Patients who were discharged to hospice or a long-term care facility were also categorized as discharged to post-acute care.

Baseline demographic and clinical characteristics were summarized and descriptive statistics are presented. For each outcome, an aggregate median risk score for each event was calculated for those who did and did not experience an event. The association between the median calculated risk score of discharge to post-acute care and actual disposition was calculated using logistic regression. The ability of the calculator to accurately predict those who would and would not need post-acute care was assessed using the c- statistic and Brier

score. The c-statistic is the area under a receiving operating characteristic (ROC) curve. A c-statistic (range 0.5–1.0) of 1.0 indicates the model perfectly predicts the outcome, and a c-statistic of 0.5 indicates that the prediction model is no better than chance. Models are considered “reasonable” when the c-statistic is higher than 0.7 and “strong” when it is greater than 0.8[9]. The Brier score describes the mean squared differences between the predicted risk and the actual outcome. A model that perfectly predicts the outcomes of all individuals has a Brier score of 0. Data were analyzed using SAS 9.4 (Cary, NC) and p-values <0.05 were considered statistically significant.

RESULTS

Between January 1, 2009 and December 31, 2013, 200 individuals underwent a total of 204 surgeries; four individuals underwent two separate eligible surgeries at least 30 days apart and risk scores from both surgeries were included in the study. The demographic data are presented in Table 2. The mean age of patients was 76.3±5.1 years. Most were independent (defined by NSQIP as having the ability to perform activities of daily living, without the aid of another person, although prosthetics, devices or other equipment may be used) prior to surgery (87%), and only one patient resided in a nursing home prior to surgery. Almost half (45%) had an ASA class III and IV. Three-quarters of patients were overweight or obese (76%). A majority of patients (86%) had a final diagnosis of malignancy (Table 3), and 47% of all patients had disseminated cancer diagnosed on imaging preoperatively. A total of 72 patients (35%) underwent staging surgeries, and an additional 66 (32%) underwent debulking procedures.

Two patients died prior to discharge from the hospital and disposition location was not documented for seven cases. Of the remaining 195 cases for which disposition data were available, 79 patients (41%) received a recommendation for postoperative discharge to post-acute care, including the one patient who lived in a nursing home prior to surgery. Two patients were discharged to home despite a recommendation for discharge to an acute rehabilitation facility, and these patients were analyzed as discharged to post-acute care. The median calculated risk for patients who were discharged to post-acute care was 8.6% compared to 4.0% for those discharged to home (OR=1.14, 95% CI 1.08–1.20; p<0.0001) (Table 4). The surgical risk calculator reasonably predicted discharge to post-acute care (c-statistic=0.708, Brier=0.205) (Table 5).

Higher calculated aggregate median risk scores were associated with increased rate of any complication (OR 1.06, 95% CI 1.02–1.09; p=0.003), any serious complications (OR 1.08; 95% CI 1.03–1.14; p=0.003), and UTI (OR 1.12, 95% CI 1.02–1.22; p=0.01). Despite these associations, the calculator was not a good predictor of these complications with c-statistics of less than 0.7 and high Brier scores (Table 5). The calculator performed best for predicting death (c-statistic=0.811, Brier=0.015), although this statistic was based on only three death events. Median risk score for those who died was 6.0% compared to 1.0% for those who did not have the event (OR=1.12, 95% CI 1.01–1.25; p=0.03).

DISCUSSION

Independent of postoperative complications, a substantial proportion of previously independent older women are not be able to return immediately home after surgery due to need for additional physical, occupational therapy, or other nursing care[2,3]. While results are not uniform, a systematic review of 60 studies including 13 surgical subspecialties showed realistic postoperative expectations to be positively associated with patient reported outcomes in 40% of studies, including satisfaction, quality of life and disability[4]. For example a study of patients undergoing colorectal surgery found that patients with inflated postoperative expectations experienced worse postoperative disability and increased postoperative fatigue[10]. Therefore, Center for Medicare and Medicaid services requires that discussion of disposition to post-acute care be included in the informed consent process when indicated[11]. Our study showed that the ACS NSQIP calculator was a reasonable predictor of discharge to post-acute care for older gynecologic oncology patients undergoing laparotomy. This is supported by previous validation of the ACS NSQIP surgical risk calculator, which showed that the calculator was a strong predictor of discharge to post-acute care among all surgical patients[6]. It is not entirely clear why our study showed decreased predictive ability compared to the initial validation study, but this may be due to differences in the study design or study population. In the initial validation cohort, only 35% of the patients were older than 65 years of age, while in our study all patients were age 70 years or older. We hypothesized the older patient population would enhance the predictive ability of the calculator since the initial study found age older than 85 years to be a significant predictor of discharge to post-acute care, however this was not confirmed by our study's results. It is notable that the calculator does not consider postoperative complications in its discharge prediction; it is possible that our patients who are often older and sicker but who still undergo aggressive surgical procedures in the setting of cancer had a higher likelihood of post-acute care discharge due to postoperative complications. Our findings in patients with gynecologic cancers are supported by another retrospective cohort study showing reasonable but decreased predictive ability of the ACS NSQIP calculator in patients with bladder cancer undergoing radical cystectomy with urinary diversion. Also similar to our study, a discrete cut-off value for prediction of discharge to post-acute care and death could not be determined[12]. Although the original validation paper suggests that the discharge risk score should be used to inform shared decision-making when deciding whether or not to proceed with surgery, the results of our study and other oncology studies suggest that this should be part of the discussion but should not be the only factor in the decision making process for patients with cancer due to the large overlap in risk scores among patients who did and did not require post-acute care.

Other efforts to preoperatively predict postoperative risks include the addition of a frailty score (calculated using unintentional weight loss, grip strength, exhaustion, level of physical activity, and walking speed) to other predictors of postoperative outcomes such as ASA class. A study of 595 patients undergoing elective surgery found that the addition of the frailty score strengthened the predictive ability of these other indices to a predictive ability of approximately 80%[13]. A retrospective cohort study utilized a modified frailty index which used diabetes, impaired functional status, chronic obstructive pulmonary disease, impaired

sensorium, transient ischemic attack, and cerebral vascular accident to assess baseline frailty in patients with endometrial cancer undergoing hysterectomy, and its association with discharge to post-acute care. With frailty defined as having two of the eleven indices present, the study showed frailty had an odds ratio of 1.95 (95% CI 1.91–5.01) and disseminated cancer had an odds ratio of 10 (95% CI 2.28–44.1) for discharge to post-acute care[14]. The strong association between the presence of disseminated cancer and discharge to post-acute care may partially explain why our study, in which almost half the patients had disseminated cancer, found the ACS NSQIP calculator tended to overestimate risk of discharge to post-acute care and thus decreased predictive ability compared to studies in the general surgery population.

Age 70 years or older has been shown to be an independent risk factor for postoperative cardiac and non-cardiac major morbidity[2,3]. Additionally, for patients with advanced malignancies, even less severe surgical complications may cause a delay in adjuvant therapies such as chemotherapy or radiation, which may be detrimental to the patient's overall disease outcome[15]. The Society of Gynecologic Oncology (SGO) and American Society of Clinical Oncology (ASCO) have published joint practice guidelines recommending that patients with a high-risk of perioperative morbidity receive neoadjuvant chemotherapy rather than primary cytoreductive surgery for treatment of clinically advanced ovarian cancer[16] based on randomized controlled trials showing lower postoperative morbidity with neoadjuvant chemotherapy and similar overall and progression-free survival[17,18]. Our study showed that though the ACS NSQIP calculator was a poor predictor of postoperative complications, it was able to predict death in our older gynecologic oncology population. Although our results need to be interpreted with caution given that the statistics are based on only three death events, neoadjuvant chemotherapy should be considered in those patients with advanced-stage ovarian cancer who have a higher-than-average risk of death per the surgical risk calculator. This is supported by previous research showing that the ACS NSQIP surgical risk calculator reasonably predicted death among gynecologic oncology patients undergoing a surgery with the gynecologic oncology service regardless of age[7,8], as well as other studies in non-gynecologic patients with cancer[19]. Additionally, a prospective study in patients without cancer showed the postoperative mortality rate can be significantly decreased with preoperative optimization of medical comorbidities and palliative care as indicated[20].

The strengths of our study include the relatively large number of older patients who underwent laparotomy procedures, which are standard for a gynecologic oncology practice. We had complete preoperative data for all patients, allowing for accurate risk score calculations. All surgeries were performed in a university setting by fellowship-trained gynecologic oncologists, which may limit generalizability of our results. However, the university is a large referral center for patients from varying geographic, racial, and socioeconomic backgrounds, and accepts patients with and without health insurance, thus increasing generalizability to a number of practice settings. Additionally, the statistical tests used in the original calculator validation study were applied in this study. The limitations of our study are largely due to a retrospective assessment of a tool that is designed for prospective use. The calculator has a "surgeon risk adjustment" tool that allows a surgeon to increase or decrease the risk based on the patient's overall status, and this tool could not be

applied retrospectively. Although we have complete preoperative data on all patients, we were missing disposition data on seven patients (3%), and due to our large referral base which includes rural Minnesota, North and South Dakota, it is possible that information on postoperative complications between the two-week outpatient postoperative evaluation and postoperative day 30 could be missing due to treatment at outside facilities; however, a previous study conducted by our group showed that we had complete postoperative data on 95% of patients through phone notes and other communication from patients, their family members, or outside healthcare providers[21]. Since the calculator tends to over-estimate risk, under-reporting of postoperative complications may falsely decrease the predictive ability of the calculator. Additionally, only patients who underwent laparotomy were included in this study, and we do not have data on patients for whom the surgeon recommended against surgery due to co-morbidities or on patients who elected not to proceed with surgery. Lastly, although the statistical results of our study suggest that the ACS NSQIP surgical risk calculator is a reasonable predictor of discharge to post-acute care and a strong predictor of death, there is a large overlap in risk scores between those who did and did not experience an event. For example, for those who died, the median risk score was 6.0 compared to 1.0 for those who did not die, but 95% confidence intervals were wide at 1.0–22.0 and 0.5–37.0, respectively, making it difficult to determine a specific risk score above which surgery should not be recommended. In general the calculator tends to overestimate the risk of adverse events, thus achieving a high sensitivity but a low specificity.

In conclusion, the ACS NSQIP surgical risk calculator may be used to identify older gynecologic oncology patients who are at higher risk of discharge to post-acute care, and should be incorporated into preoperative planning and discussion with patients. However, since the calculator over-predicted the number of patients who would require discharge to post-acute care, we caution the use of the risk score as a determinate of whether or not to proceed with surgery. Additionally, for those patients with an increased risk score for death, non-surgical treatment options should be considered when available. Despite these strengths of the ACS NSQIP surgical risk calculator, a better tool is needed to predict postoperative complications in the older gynecologic oncology population undergoing laparotomy.

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Table 1.

Preoperative variables and predicted postoperative outcomes of the ACS NSQIP surgical risk calculator

Preoperative Variables	Postoperative Outcomes
Age	Death
Sex	Any serious complication
Functional Status	Cardiac complication
Emergency Case	Pneumonia
ASA * Class	Progressive renal insufficiency
Wound Class	Acute renal failure
Steroid use for chronic condition	VTE *
Ascites within 30 days of surgery	Return to the operating room
Systemic sepsis within 48 hours before surgery	Deep incisional or organ SSI *
Ventilator dependent	Systemic sepsis
Disseminated cancer	Unplanned re-intubation
Diabetes	UTI *
Hypertension requiring medication	Wound disruption
Previous cardiac event	Any complication
CHF * in 30 days prior to surgery	Pneumonia
Dyspnea	Cardiac Complication
Current Smoker	SSI *
History of severe COPD *	UTI *
Dialysis	VTE *
Acute renal failure	Renal failure
BMI * Category	Readmission
	Return to OR
	Death
	Discharge to Acute Rehab

* ASA, American Society of Anesthesiologists; CHF congestive heart failure; COPD, chronic obstructive pulmonary disease; BMI, body mass index; VTE, venous thromboembolic event; SSI, surgical site infection; UTI, urinary tract infection

Table 2.

Patient baseline characteristics (N=204)

Variable	n	(%)
Age, years, mean ± SD	76.3±5.1	
Functional Status		
Independent	177	(86.8)
Partially dependent	22	(10.8)
Totally dependent	5	(2.5)
Emergency Case		
No	202	(99.0)
Yes	2	(1.0)
ASA Class		
Healthy patient	12	(5.9)
Mild systemic disease	98	(48.0)
Severe systemic disease	93	(45.6)
Severe systemic disease/threat to life	1	(0.5)
Wound Class		
Clean	43	(21.2)
Clean/contaminated	153	(75.4)
Contaminated	7	(3.5)
Steroid use of chronic condition		
No	196	(96.0)
Yes	8	(4.0)
Ascites within 30 days prior to surgery		
No	174	(85.3)
Yes	30	(14.7)
Systemic sepsis within 48 hours before surgery		
No	204	(100)
Ventilator dependent		
No	204	(100)
Disseminated cancer		
No	108	(52.9)
Yes	96	(47.1)
Diabetes		
None	161	(78.9)
Oral	32	(15.7)
Insulin	11	(5.4)
Hypertension requiring medication		
No	70	(34.3)
Yes	134	(65.7)

Variable	n	(%)
Previous cardiac event		
No	171	(83.8)
Yes	33	(16.2)
Congestive heart failure in 30 days prior to surgery		
No	195	(95.6)
Yes	9	(4.4)
Dyspnea		
None	176	(86.3)
Moderate exertion	21	(10.3)
At rest	7	(3.4)
Smoker		
No	190	(93.1)
Yes	14	(6.9)
History of severe COPD		
No	190	(93.1)
Yes	14	(6.9)
Dialysis		
No	204	(100)
Acute renal failure		
No	200	(98.0)
Yes	4	(2.0)
BMI Category		
Underweight (<18.5 kg/m^2)	3	(1.5)
Normal (18.5–24.9 kg/m^2)	46	(22.8)
Overweight (25–29.9 kg/m^2)	68	(33.7)
Obese (≥30 kg/m^2)	85	(42.1)
Missing	2	
Surgery		
Less than Hysterectomy	28	(13.7)
Hysterectomy with or without bilateral salpingo-oophorectomy	31	(15.2)
Staging	72	(35.3)
Debulking	66	(32.4)
Exenteration	7	(3.4)

Table 3.

Malignancy origin (N=200)

Malignancy	n	(%)
Cervix	4	2.0
Fallopian tube	7	3.5
Ovary	72	36.0
Primary Peritoneal	13	6.5
Uterine	55	27.5
Vagina/Vulva	6	3.0
Non-Gynecologic	14	7.0
Benign	29	14.5

Table 4.

Median calculated risk scores for those who did and did not have an event (N=204)

	Did Not Have Event		Had Event	
Outcome	**n**	**Median (Min, Max)**	**n**	**Median (Min, Max)**
Death	201	1.0 (0.5–37.0)	3	6.0 (1.0–22.0)
Any serious complication	144	9.0 (4.0–34.0)	60	11.0 (5.0–35.0)
Any complication	105	11.0 (3.0–46.0)	99	15.0 (5.0–48.0)
Pneumonia	193	1.0 (0.5–7.0)	11	1.0 (0.5–2.0)
Cardiac complication	197	0.5 (0.5–4.0)	7	0.5 (0.5–1.0)
SSI	167	4.0 (1.0–36.0)	37	5.0 (1.0–17.0)
UTI	173	4.0 (1.0–29.0)	31	5.0 (3.0–19.0)
VTE	199	1.0 (0.5–6.0)	5	2.0 (0.5–2.0)
Renal failure	198	0.5 (0.5–4.0)	3	1.0 (0.5–1.0)
Discharge to post-acute care *	116	4.0 (1.3–20.3)	79	8.6 (1.4–53.5)

* Excludes 2 patients who died prior to discharge and 7 without discharge information

Table 5.

Complication rates and model statistics for the ACS NSQIP surgical risk calculator in older gynecologic oncology patients (N=204)

Outcome	Events, n (%)	Odds Ratio (95% CI), p-value	c-statistic	Brier score
Death	3 (1.5)	1.12 (1.01–1.25), p=0.03	0.811	0.015
Any serious comp	60 (29.4)	1.08 (1.03–1.14), p=0.003	0.629	0.198
Any complication	99 (48.6)	1.06 (1.02–1.09), p=0.003	0.652	0.237
Pneumonia	11 (5.4)	0.79 (0.39–1.63), p=0.53	0.486	0.051
Cardiac	7 (3.4)	0.77 (0.12–4.90), p=0.78	0.480	0.033
SSI	37 (18.1)	1.10 (0.99–1.22), p=0.07	0.637	0.146
UT1	31 (15.2)	1.12 (1.02–1.22), p=0.01	0.661	0.125
VTE	5 (2.5)	0.94 (0.43–2.07), p=0.88	0.468	0.024
Renal failure	3 (1.5)	1.23 (0.21–7.36), p=0.82	0.646	0.015
Post-acute care *	79 (40.5)	1.14 (1.08–1.20), p<0.0001	0.708	0.205

* Excludes 2 patients who died prior to discharge and 7 without discharge information