ORIGINAL ARTICLE

Evaluation of complications after laparoscopic and open appendectomy by the American College of Surgeons National Surgical Quality Improvement Program surgical risk calculator

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ABSTRACT

BACKGROUND: This study aims to evaluate the predictive level of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) risk calculator for post-appendectomy complications.

METHODS: A total of 292 patients who were hospitalized for general appendectomy were included in the study. The age range of the patients was 18–76 years (mean: 35.3±13.6 years). The mean body mass index was 25.8±4.6. Twenty data points were entered into the ACS-NSQIP surgical risk calculator (SRC), which yielded the 17 most common complications and the average LOHS. Complications encountered in 30-day follow-up were categorized according to the complications predicted by SRC. The actual and observed complication rates and LOHS were compared

RESULTS: Post-operative complications developed in 13.4% of the patients, surgical site infection in 11.3%, serious complications in 3.1%, and readmission in 2.1%. Serious complications included pneumonia, sepsis, cardiac complications, and renal failure. The mean LOHS was 1.91±1.64 days (range: 1–14 days). No thromboembolism or mortality was observed. When the comparison of complications using SRC was made with the ROC curve, the predictive value of SRC was 84.2% for any complication, 86.7% for serious complication, 47.6% for surgical site infection, 95.9% for renal failure, 99.0% for resurgery, and 88.3% for sepsis.

CONCLUSION: Although it is rare to see complications after simple appendectomy, it is known that complication rates increase significantly in the elderly, the obese, and those with comorbidities. Tools such as SRC will be beneficial for patients with these risk factors.

Keywords: ACS NSQIP; acute appendicitis; appendectomy; post-operative complications.

INTRODUCTION

Acute appendicitis (AA) remains one of the most common diseases treated by general surgeons, and it is the most common operation in emergency settings, constituting 1% of all surgical operations.[1] Studies report that 6.7% of women and 8.6% of men in the USA will undergo surgery at some point due to AA.[2] Complicated AA with abscess, gangrene, and widespread peritonitis is observed in 20% of the general population and in 40–70% of the elderly.[3,4] Mortality related to AA decreased from 26% to 0.2% in course of time, however, the mortality rate of complicated AA cases can reach 5% and may be even higher.[5]

The American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator (ACS-NSQIP SRC) is a free program used by surgeons to inform patients about the risks of a prospective operation. This program was used in 2.7 million operations performed in 586 hospitals between 2010 and 2014, preventing an average of 250–500

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complications and 12–36 mortalities annually and reducing expenditures by millions of dollars.

MATERIALS AND METHODS

Our study prospectively evaluated patients diagnosed with AA who were admitted to the University of Health Sciences, Diskapi Yildirim Beyazit Training and Research Hospital Emergency General Surgery Outpatient Clinic between 2017 and 2019 who had undergone laparoscopic and open surgery in the General Surgery Service. When making laparoscopic and open surgery decisions, the experience of the surgeon, the patient's condition, and hospital conditions were taken into account. Operations were performed by specialist surgeons or general surgery residents under the supervision of a specialist surgeon. The surgical operations were subdivided into open or laparoscopic according to the surgical method performed. The status of the AA was categorized as perforated, plastron, or simple, according to clinical and pathological evaluation. Only patients undergoing emergency appendectomy were included in the study. Furthermore, patients who had organ resection and those who were reported as malignancy as a result of pathology were excluded from the study.

The patient data entered into the ACS-NSQIP SRC were collected by face-to-face questions with the patients and from diagnostic tests. Patients were divided into three subgroups according to body mass index (BMI; kg/m^2), namely, low and normal weight (<25), overweight (25–30), and obese (>30). Patients were further stratified by age: >65 and <65 years. On discharge, the LOHS was recorded. Post-operative data were collected during the post-operative clinical visits (examination, dressing follow-up, etc.) on the 7th, 14th, and 30th post-operative day by telephone, in-person interviews, or physical examination. Complications observed at the 30-day follow-up were categorized according to the complications predicted by the SRC. Then, the predicted and actual complication rates and LOHS were compared.

The clinical study protocol was approved by the University of Health Sciences, Diskapi Yildirim Beyazit Training and Research Hospital Local Ethics Committee (July 24, 2017, decree no: 40/03).

Statistical Analysis

The Kolmogorov–Smirnov test was used to confirm whether the continuous numerical variables were normally distributed. Levene's test was used to confirm whether the assumption of homogeneity of variances was met. Descriptive statistics were expressed as mean ± standard deviation for continuous numerical variables, while categorical variables were shown as number of cases and as percentages (%). The significance of the difference in the predictive levels of SRC between the groups with and without complications was examined with the Mann–Whitney U test. Wilcoxon signed-rank test was used to determine whether a statistically significant difference was present between the actual and predicted LOHS.

The significance of the difference in terms of LOHS between the groups was examined with the Mann–Whitney U test when the number of independent groups was two and the significance of the difference between more than 2 independent groups was examined with the Kruskal–Wallis test.

Whether the SRC generated a statistically significant prediction was determined by ROC analysis by calculating the area under the curve (AUC) and 95% confidence intervals (CIs). If the AUCs were significant, the point at which the sum of sensitivity and specificity values reached their maximum was accepted as optimal cutoff points. The sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy rates of the SRC predictions were then calculated according to the optimal cutoff points.

When the expected frequency was below 5 in at least 25% of the cells in the 2×2 cross tables, categorical data were evaluated with Fisher's exact probability test. When the expected frequency was between 5 and 25, the Chi-square test with continuity correction was used; if below 5 in at least 25% of the cells in the R×C cross tables (i.e., if at least one of the categorical variables in the row or column has more than 2 results), the categorical data in question were evaluated by the likelihood-ratio test, otherwise Pearson's Chi-squared test was used. Data were analyzed with SPSS Statistics (v. 17.0; IBM Corporation, Armonk, NY, USA). P<0.05 was considered statistically significant.

RESULTS

This study included 292 patients (217 [74.3%] males and 75 [25.7%] females) who underwent surgery for AA. The age range was 18–76 years (mean: 35.3±13.6 years), and the mean BMI was 25.8±4.6. Detailed demographic characteristics are shown in Table 1. In terms of comorbidities, 16 (5.5%) patients had diabetes and 25 (8.6%) had hypertension (Table 1). Fifty-one patients (17.5%) underwent laparoscopic appendectomy, whereas 241 (82.5%) underwent open appendectomy. Patients were classified into three groups based on the post-operative pathology report and intraoperative clinical observation.

1) Simple AA: 231 (79.1%) patients;
2) Perforated AA: 51 (17.5%) patients;
3) Plastron AA: 10 (3.4%) patients (Table 2).

Post-operative complications developed in 13.4% of the patients, surgical site infection in 11.3%, serious complications in 3.1%, and readmission in 2.1%. Serious complications included pneumonia, sepsis, cardiac complications, and renal failure. The mean LOHS was 1.91±1.64 days, while the LOHS ranged between 1 and 14 days. No patient developed venous throm-

Table 1. Demographic and clinical features of the patients

	n=292
Age (years), mean±SD	35.3±13.6
Age range (years)	18–76
Gender, n (%)	
Female	75 (25.7)
Male	217 (74.3)
ASA	2 (1–4)
Body weight (kg), mean±SD	76.0±14.5
Height (m), mean±SD	1.72±0.80
BMI (kg/m^2), mean±SD	25.8±4.6
BMI, n (%)	
Underweight	3 (1.0)
Normal	142 (48.6)
Overweight	99 (33.9)
Obese 1	37 (12.7)
Obese 2	11 (3.8)
Functional status, n (%)	
Independent	290 (99.3)
Partially dependent	2 (0.7)
Steroid use	1 (0.3)
Presence of SIRS, n (%)	
Absent	269 (92.1)
SIRS	18 (6.2)
Sepsis	5 (1.7)
History of smoking	166 (56.8)
Diabetes, n (%)	
Absent	276 (94.5)
Oral	13 (4.5)
Insulin	3 (1.0)
Hypertension	25 (8.6)
Cardiac failure	1 (0.3)
Dyspnea, n (%)	
Absent	283 (96.9)
Moderate exercise	8 (2.7)
Heavy exercise	1 (0.3)
Severe COPD	2 (0.7)

Definitions from the ACS-NSQIP (http://riskcalculator.facs.org/). ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program; ASA: American Society of Anesthesiologists; BMI: Body mass index; SIRS: Systemic inflammatory response syndrome; COPD: Chronic obstructive pulmonary disease; SD: Standard deviation.

boembolism, and no mortality was observed (Table 3). The mean rates predicted by SRC were 9.3% for any complication, 4.54% for surgical site infection, 6.4% for serious complication, and 5.26% for readmission. Whereas the mean LOHS was actually 2.59 days, the SRC predicted 0.5–13 days (Table 4).

Table 2. Frequency distributions of cases in terms of surgical methods, post-operative status and additional operation

	n=292	
	n	%
Operation		
McBurney	229	78.4
Midline	12	4.1
Laparoscopic	51	17.5
Post-operative status		
Normal	231	79.1
Perforated	51	17.5
Plastron	10	3.4

Table 3. Descriptive statistics of cases regarding actual post-operative complications and length of stay in hospital

	n=292
Complications occurred, n (%)	
Severe complication	9 (3.1)
Any complication	39 (13.4)
Pneumonia	3 (1.0)
Cardiac complications	1 (0.3)
Surgical site infection	33 (11.3)
Urinary tract infection	5 (1.7)
Venous thromboembolism	0 (0.0)
Renal failure	2 (0.7)
Readmission	6 (2.1)
Re-operation	3 (1.0)
Mortality	0 (0.0)
Discharge for rehabilitation	1 (0.3)
Sepsis	3 (1.0)
Length of stay in hospital (days), mean±SD	1.91±1.64
Range of duration in hospital (days)	1–14

SD: Standard deviation.

In patients with and without complications, statistical analysis using the Mann–Whitney U-test was performed among the rates given by SRC for each patient. These rates were statistically significant in patients with a complication, serious complication, surgical site infection, renal failure, reoperation, and sepsis. In patients who had complications such as pneumonia, urinary tract infection (UTI), and readmission, no statistically significant difference was found in terms of the predicted rates (Table 5). When the same comparison was made with the ROC curve, the prediction by the SRS was

Table 4. Descriptive statistics of the ACS-NSQIP SRC for estimated development rates and length of stay in hospital

	Mean	Standard deviation	Median	Minimum	Maximum
Severe complication	6.24	3.32	6.7	1.4	29.3
Any complication	9.03	4.60	9.9	1.8	37.5
Pneumonia	0.92	1.17	0.8	0.1	12.9
Cardiac complication	0.26	0.64	0.2	0.0	7.0
Surgical site infection	4.54	2.02	5.1	0.8	12.7
Urinary tract infection	0.27	0.12	0.3	0.1	0.9
Venous thromboembolism	0.47	0.37	0.4	0.1	3.3
Renal failure	0.32	0.70	0.2	0.0	6.9
Readmission	5.26	2.32	5.7	1.5	19.0
Re-operation	2.02	0.96	2.1	0.5	7.1
Mortality	0.23	1.10	0.1	0.0	15.0
Discharge for rehabilitation	1.77	4.63	1.0	0.3	52.0
Sepsis	0.91	0.59	1.0	0.0	3.4
Length of stay in hospital (days)	2.59	1.36	2.5	0.5	13.0

ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program.

84.2% for any complication, 86.7% for serious complication, 47.6% for surgical site infection, 95.9% for renal failure, 99.0% for resurgery, and 88.3% for sepsis. With respect to open and laparoscopic methods, no significant differences were found between the predictive rates of those who did and did not develop complications in the laparoscopic group.

The predictive value of the SRC for serious complications was statistically higher in patients who developed serious complications than in cases that did not (p=0.002; Table 5). The SRC had a significantly higher predictive value for patients who developed a complication relative to those who did not (p<0.001; Table 5). Although the pneumonia predictive value of SCR was higher in patients who developed pneumonia compared to those without pneumonia, the difference was not statistically significant (p=0.315; Table 5).

The prediction by the SCR for the likelihood of developing a surgical site infection was significantly higher in patients who developed surgical site infection compared to those who did not (p=0.040; Table 5). The prediction for the likelihood of developing a UTI did not differ significantly between patients who developed a UTI compared to those who did not (p=0.816; Table 5). The prediction for the likelihood of developing renal failure was statistically significantly higher in patients who developed renal failure compared to those who did not (p=0.015; Table 5). The prediction for the likelihood readmission did not differ significantly between patients who were readmitted and those who were not (p=0.391; Table 5). The prediction for the likelihood of developing a complication was significantly higher in patients who were reoperated than in those who were not (p=0.003; Table 5). The prediction for the likelihood of developing sepsis was significantly higher in patients who developed sepsis than in those who did not (p=0.006; Table 5).

The AUC related to the prediction for differentiating cases with and without serious complications was found to be statistically significant (AUC=0.806; 95% CI: 0.654–0.995; p=0.002; Table 6). The optimal cutoff point for serious complications was 8.15%, the sensitivity of the SRC at this point was 66.7%, the specificity was 87.3%, the positive and negative predictive values were 14.3% and 98.8%, respectively, and the diagnostic accuracy rate was 86.7%.

The AUC related to the prediction for differentiating cases with and without any complications was found to be statistically significant (AUC=0.753; 95% CI: 0.665–0.841; p<0.001; Table 6). The optimal cutoff point for any complication was 11.55%, the sensitivity of the SRC at this point was 48.7%, the specificity was 89.7%, the positive and negative predictive values were 42.2% and 91.9%, respectively, and the diagnostic accuracy rate was 84.2%.

The AUC related to the prediction for differentiating cases that developed pneumonia and those that did not was not statistically significant (AUC=0.667; 95% CI: 0.377–0.958; p=0.319). In other words, the SRC cannot predict the likelihood of developing pneumonia (Table 6). The AUC related to the prediction for differentiating cases that developed surgical site infection and those that did not was not statistically significant (AUC=0.610; 95% CI: 0.511–0.708; p=0.040). The optimal cutoff point for developing a surgical site infection was 4.1%, the sensitivity of the SRC at this point was 81.8%,

Table 5. ACS-NSQIP levels for each complication compared to cases with and without post-operative complications

	n	ACS-NSQIP	p†
Severe complication			0.002
Absent	283	5.99±2.65	
Present	9	13.98±9.08	
Any complication			<0.001
Absent	253	8.31±3.41	
Present	39	13.68±7.71	
Pneumonia			0.315
Absent	289	0.88±0.93	
Present	3	4.77±7.05	
Surgical site infection			0.040
Absent	259	4.44±2.02	
Present	33	5.34±1.86	
Urinary tract infection			0.816
Absent	287	0.26±0.11	
Present	5	0.36±0.31	
Renal failure			0.015
Absent	290	0.29±0.58	
Present	2	4.15±3.89	
Readmission			0.391
Absent	286	5.21±2.20	
Present	6	7.32±5.67	
Re-operation			0.003
Absent	289	1.98±0.87	
Present	3	5.87±1.16	
Sepsis			0.006
Absent	289	0.90±0.58	
Present	3	2.10±0.89	

Descriptive statistics are shown as mean±standard deviation. †Mann–Whitney U. ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program.

the specificity was 43.2%, the positive and negative predictive values were 15.5% and 94.9%, respectively, and the diagnostic accuracy rate was 47.6% (Table 6).

The AUC related to the prediction for differentiating patients who developed a UTI and those who did not was not statistically significant (AUC=0.528; 95% CI: 0.235–0.821; p=0.828). In other words, the SRC cannot predict the likelihood of developing a UTI (Table 6). The AUC related to the prediction for differentiating patients who developed renal failure and those who did not was found to be statistically significant (AUC=0.983; 95% CI: 0.955–1.0; p=0.019). The optimal cutoff point for developing renal failure was 1.25%, the sensitivity of SRC at this point was 100%, the specificity was 95.9%, the positive and negative predictive values were 14.3% and 100%, respectively, and the diagnostic accuracy rate was 95.9% (Table 6). The AUC related with the prediction for differentiating patients who had to be readmitted and those who did not was not statistically significant (AUC=0.602; 95% CI: 0.333–0.871; p=0.393). In other words, the SRC cannot predict the likelihood of readmission (Table 6).

The AUC related to the prediction for differentiating patients who underwent reoperation and those who did not was statistically significant (AUC=0.95; 95% CI: 0.987–1.0; p=0.003). The optimal cutoff point for reoperation was 4.7%, the sensitivity of the SRC at this point was 100%, the specificity was 99%, the positive and negative predictive values were 50% and 100%, respectively, and the diagnostic accuracy rate was 99% (Table 6). The AUC related to the prediction for differentiating patients who developed sepsis and those who did not was statistically significant (AUC=0.955; 95% CI: 0.902–1.0; p=0.007). The optimal cutoff point for developing sepsis was 1.35%, the sensitivity of SRC at this point was 100%, the specificity was 88.2%, the positive and negative predictive values were 8.1% and 100%, respectively, and the diagnostic accuracy rate was 88.3% (Table 6).

The mean LOHS predicted by the ACS-NSQIP SRC was significantly longer than the actual mean LOHS (p<0.001; Table 7). The frequency of serious complication, any complication, surgical site infection, readmission, and reoperation were significantly higher in patients aged ≥65 years (p<0.05). Furthermore, the LOHS was significantly longer in patients aged ≥65 years (p<0.001; Table 8).

No statistically significant difference was found between the normal weight, overweight, and obese groups in terms of the incidence of complications other than the development of any complication and surgical site infection (p>0.05). No statistically significant difference was found between the groups in terms of LOHS (p=0.088).

A statistically significant difference was found between the groups in terms of any complication rate (p=0.002). The explanation is that the complication rate was higher in the obese group than in the normal and overweight group (p=0.003 and p=0.007). No statistically significant difference was found between the normal weight and overweight group (p>0.999). A statistically significant difference was found between the groups in terms of surgical site infection rate (p<0.001). The explanation is the higher rate of surgical site infection in the obese group than in the normal and overweight group (p<0.001 and p=0.016). There was no statistically significant difference between the normal weight group and the overweight group (p=0.510; Table 9). Table 10 shows the frequency of occurrence of each complication.

Univariate logistic regression analysis determined whether ACS-NSQIP levels were predictive of the occurrence of

Table 6. The area under the ROC curve for ACS-NSQIP levels in predicting the occurrence of any complication, 95% confidence intervals, optimal cut-off points, and diagnostic performance indicators of the ACS-NSQIP at each cut-off point

	AUC	95% CI		p†	Optimal cut-off point	Diagnostic performance indicators (%)				
		Lower limit	Upper limit			Sensitivity	Specificity	PEV	NEV	Accuracy
Severe complication	0.806	0.654	0.959	0.002	>8.15	66.7	87.3	14.3	98.8	86.7
Any complications	0.753	0.665	0.841	<0.001	>11.55	48.7	89.7	42.2	91.9	84.2
Pneumonia	0.667	0.377	0.958	0.319	–	–	–	–	–	–
Surgical site infection	0.610	0.511	0.708	0.040	>4.1	81.8	43.2	15.5	94.9	47.6
Urinary tract infection	0.528	0.235	0.821	0.828	–	–	–	–	–	–
Renal failure	0.983	0.955	1.000	0.019	>1.25	100.0	95.9	14.3	100.0	95.9
Readmission	0.602	0.333	0.871	0.393	–	–	–	–	–	–
Re-operation	0.995	0.987	1.000	0.003	>4.7	100.0	99.0	50.0	100.0	99.0
Sepsis	0.954	0.902	1.000	0.007	>1.35	100.0	88.2	8.1	100.0	88.3

ACS-NSQIP: American College of Surgeons National Surgical Quality Improvement Program; AUC: Area under the ROC curve; PEV: Positive estimated value; NEV: Negative estimated value. †ROC analysis. CI: Confidence interval.

Table 7. Actual and predicted length of stay in hospital according to the ACS-NSQIP SRC

	Descriptive statistics	p†
Length of stay (days)		<0.001
Actual	1.91±1.64	
ACS-NSQIP SRC	2.59±1.36	

Descriptive statistics are shown as mean±standard deviation. †Wilcoxon signed-rank test. ACS-NSQIP SRC: American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator.

each complication. According to the Hosmer–Lemeshow goodness-of-fit test, there was no drawback to including the ACS-NSQIP levels into the regression model for predicting all other complications except readmission (given that p<0.05).

In the next stage, Brier scores were obtained by calculating the mean of the squares related to the differences between the estimated and actual probability. The closer the Brier score is to 0 (zero), the more likely the prediction is accurate; conversely, the closer it is to 1 (one), prediction is more likely to be unsuccessful. According to current results, Brier scores range from 0.005 to 0.10; thus, it is possible to say that ACS-NSQIP levels are very successful in predicting complications.

Finally, within each complication, C statistics and 95% CIs were evaluated by calculating whether the ACS-NSQIP levels

Table 8. Complication rates and length of stay in hospital according to age group

	age <65 (n=279)	age ≥65 (n=13)	p
Severe complication, n (%)	6 (2.2)	3 (23.1)	0.005†
Any complication, n (%)	32 (11.5)	7 (53.8)	<0.001†
Pneumonia, n (%)	2 (0.7)	1 (7.7)	0.128†
Surgical site infection, n (%)	26 (9.3)	7 (53.8)	<0.001†
Urinary tract infection, n (%)	4 (1.4)	1 (7.7)	0.205†
Renal failure, n (%)	1 (0.4)	1 (7.7)	0.087†
Readmission, n (%)	4 (1.4)	2 (15.4)	0.025†
Re-operation, n (%)	0 (0.0)	3 (23.1)	<0.001†
Sepsis, n (%)	2 (0.7)	1 (7.7)	0.128†
Length of stay in hospital (days), mean±SD	1.76±1.33	5.00±3.67	<0.001‡

†Fisher's exact probability test. ‡Mann–Whitney U. SD: Standard deviation.

Table 9. Complication rates and length of stay in hospital according to body mass index

	Normal (n=145)	Overweight (n=99)	Obeseq (n=48)	p
Severe complication, n (%)	4 (2.8)	1 (1.0)	4 (8.3)	0.081†
Any complication, n (%)	15 (10.3)[a]	10 (10.1)[b]	14 (29.2)[a,b]	0.002‡
Pneumonia, n (%)	2 (1.4)	0 (0.0)	1 (2.1)	0.271†
Surgical site infection, n (%)	10 (6.9)[a]	10 (10.1)[b]	13 (27.1)[a,b]	<0.001‡
Urinary tract infection, n (%)	1 (0.7)	2 (2.0)	2 (4.2)	0.294†
Renal failure, n (%)	1 (0.7)	0 (0.0)	1 (2.1)	0.324†
Readmission, n (%)	3 (2.1)	1 (1.0)	2 (4.2)	0.477†
Re-operation, n (%)	1 (0.7)	0 (0.0)	2 (4.2)	0.088†
Sepsis, n (%)	1 (0.7)	0 (0.0)	2 (4.2)	0.088†
Length of stay in hospital (day), mean±SD	1.80±1.39	1.84±1.68	2.37±2.14	0.088¶

[a]The difference between normal weight group and obese group is statistically significant (p<0.01). [b]The difference between overweight group and obese group is statistically significant (p<0.05). †Likelihood ratio test. ‡Pearson's chi-square test. ¶Kruskal–Wallis test.

were successful in distinguishing the cases with complication that was observed and those with no complication. The C statistic also corresponds to the AUC obtained as a result of the ROC analysis. For ACS-NSQIP levels to be decisive, 0.50 value must not be within the limits of the 95% CI for C statistics. Accordingly, it can be said that ACS-NSQIP levels have a significant decisiveness in predicting other complications except pneumonia, UTI, and readmission.

DISCUSSION

Accurate prediction of post-operative risks is highly important for patients, their families, and surgeons. Therefore, SRCs have been created to predict complications in many areas.[6–8] Cohen et al.[9] first introduced the ACS-NSQIP SRC in 2009 specifically for colorectal surgery. With the use of data collected from 393 hospitals between 2009 and 2012, the ACS-NSQIP SRC was introduced so that it could provide rates of eight potential post-operative complications in various surgical branches, which correspond to the 1557 Current Procedural Terminology (CPT) code.[10]

There have been many studies on the reliability of the SRC in hepatobiliary, colorectal, pancreatic, orthopedic, urological, and gynecological surgery. As far as we know, our study is the first to measure the predictive accuracy of the SRC in patients undergoing appendectomy. While the SRC predicted an average of 9.3% for 30-day post-operative complication rate, the actual rate of the complication was 13.4%. The SRC predicted the LOHS to average 2.59 days. The actual average LOHS was 1.91±1.64 days. The average predicted LOHS was statistically longer than the actual average LOHS (p<0.001).

The SRC appears more useful at predicting general rather than specific surgical complications. However, only the type of

Table 10. Frequency of complications, Brier scores, Hosmer–Lemeshow goodness of fit test results, C statistics, and 95% CI

	n (%)	Brier score	HL		C-statistics	95% CI	
			χ^2	p		Lower limit	Upper limit
Severe complication	9 (3.1)	0.022	4.509	0.608	0.806	0.654	0.959
Any complication	39 (13.4)	0.095	9.145	0.242	0.753	0.665	0.841
Pneumonia	3 (1.0)	0.007	7.418	0.284	0.667	0.377	0.958
Surgical site infection	33 (11.3)	0.098	12.660	0.124	0.610	0.511	0.708
Urinary tract infection	5 (1.7)	0.016	1.670	0.434	0.528	0.235	0.821
Renal failure	2 (0.7)	0.005	0.718	0.869	0.983	0.955	1.000
Readmission	6 (2.1)	0.019	15.131	0.034	0.602	0.333	0.871
Re-operation	3 (1.0)	0.006	0.121	>0.999	0.995	0.987	1.000
Sepsis	3 (1.0)	0.010	1.966	0.923	0.954	0.902	1.000

HL: Hosmer–Lemeshow test; CI: Confidence interval.

scheduled surgery can be entered into the SRC; a preliminary diagnosis cannot be entered, which can lead to false complication rates. Although complication rates are known to be elevated in perforated appendicitis, post-operative complication rates associated with laparoscopic appendectomy applied in simple appendicitis are given because laparoscopic perforated appendicitis operations do not have a CPT code and because a preliminary diagnosis cannot be entered. In our hospital, the use of laparoscopic method was restricted due to the difficulty of accessing laparoscopic instruments and finding trained personnel outside working hours. Therefore, we did not have the chance to test this situation statistically since the number of laparoscopic perforated appendicitis cases was relatively low. Studies have shown that post-operative complications are also closely related to the surgeon's experience and to hospital volume.[11,12] The SRC is also lacking in this aspect.

The fact that only one CPT code can be entered makes it difficult to accurately predict postoperative complications, especially in patients undergoing multiple surgeries and in perforated appendicitis that has no CPT code equivalent, such as laparoscopic appendectomy. Operations with a CPT code of 44970 for laparoscopic appendectomy, 44960 for appendectomy due to perforated appendectomy, and 44950 for normal appendectomy can be entered.

Post-operative complication rates are significantly higher in perforated appendicitis. Complications include intra-abdominal abscess, post-operative ileus, surgical site infection, and small intestinal obstruction due to adhesions. LOHS is prolonged due to these complications. In a retrospective study, the rate of intra-abdominal abscess was 9% in perforated appendicitis and 1.5% in simple appendicitis.[13] In our study, the rate of any complication in complicated appendicitis was 41.2%, surgical site infection was 39.2%, and serious complication was 11.8%. However, no intra-abdominal abscess was observed in either group.

Our study has limitations: The sample size was relatively low, which may have limited the predictive power of the SRC. Given that patients came from a single center, population diversity may also be limited.

Most studies have advocated the need to enter a pre-diagnosis or diagnosis into the SRC.[14–16] For example, the patient who was operated for malignancy and the patient who was operated for benign reasons should not undergo the same complication prediction assessment. We know that the presence of malignant disease plays a crucial role in the development of complications.

Mogal et al.[15] found a high predictive accuracy by the SRC for complications after pancreaticoduodenectomy. Considering the indication for surgery, changes at the level of the SRC prediction occurred. Therefore, these authors stated that predictive accuracy can be increased when evaluated in combination with the preliminary diagnosis. McMillan et al.[17] showed that the SRC predicts mortality, serious complications, and reoperation rates less accurately in patients undergoing pancreaticoduodenectomy. This can lead to patient dissatisfaction and even medicolegal pursuits. However, when used with operation-specific variables, the predictive capacity of the SRC can be enhanced. In the same study, the surgeon's experience with pancreaticoduodenectomy and the hospital volume were not associated with the development of post-operative complications.

Dave et al.[16] reported that the actual complication rates in 890 patients operated due to pancreatic neuroendocrine tumor (PNET) were higher than predicted rates for any complication, serious complication, pneumonia, cardiac complication, surgical site infection, UTI, venous thromboembolism, reoperation, rehospitalization, and mortality. Acute renal failure with discharge to the nursing home was proportionally lower than predicted. These authors concluded that although the SRC is a valuable tool, it should be employed cautiously in patients undergoing pancreatic resection due to PNET. Studies in various fields such as urology, surgical oncology, and gynecology have also yielded similar results.[18–20]

In a study performed by Massoumi et al.[21] on patients who underwent cholecystectomy due to acute cholecystitis, the SRC predicted a lower than actual mean LOHS (0.73–2.5) and any complication development (4.6–10.68%). The authors explained that the risk calculator is focused on predicting general rather than specific surgical complications. They concluded that the calculator was not useful at predicting post-operative complications and LOHS.

McCarthy et al.[22] found that the SRC predicted with a high degree of accuracy, the development of any complications, and discharge to nursing home ($p<0.0001$). They concluded that the SRC could not accurately predict specific complications in greater detail for these patients nor in cervical spinal surgery. Two single-center studies have shown that the SRC can predict major complications after colorectal surgery.[23,24] Furthermore, Cologne et al.[23] found that the SRC could not calculate the LOHS in patients who developed more serious complications. After exclusion of these patients, a longer LOHS was predicted in the next group. When all patients were taken into account, development of any complication, surgical site infection, and major complications were proportionally higher.

Edelstein et al.[25] concluded that the SRC generates acceptable predictions in cardiac complications, pneumonia, and discharge to specialized nursing facilities following elective knee and hip arthroplasty. The same study observed that the SRC was weak at predicting the development of "any complication." However, the authors concluded that the ACS-NSQIP SRC does not accurately predict complications on an individual basis and should not be used, especially with patients sched-

uled for arthroplasty. O'Neill et al.[26] stated that although the SRC predicted with a high degree of accuracy the occurrence of any complications and serious complications after breast reconstruction surgeries, they concluded that it is unsuitable for personal predictions when all findings were evaluated.

Predicting post-operative complications can prove rather challenging, especially in training hospitals, because although complications are associated with patient-related morbidity, surgical experience is also a determining factor.[27] The advantage of the SRC is its ability to inform the patient in a simplified manner of the most common and limited number of possible complications after surgery.[28]

Golden et al.[29] conducted a study on 1693 patients who underwent emergency surgical operation including hernia repair, bridectomy, small intestinal resection, gastrectomy, debridement, colectomy, appendectomy, cholecystectomy, gastrorrhaphy, drainage of soft-tissue abscesses, breast abscess, and foreign body removal in a first-level trauma center over a 5-year period. When a single disease was evaluated, the SCR accurately predicted any complication and serious complications and predicted lower LOHS both in the general population and in specific subpopulations. The authors emphasized that while the SRC generally predicts the development of complications after emergency surgery well, there are notable differences between surgeries. Similarly, in our study, the SRC estimated the complications with a high degree of accuracy following open and laparoscopic appendectomy (with the exception of a few rare complications).

Conclusion

Prediction of post-operative complications will both help the surgeon perform his duties while informing the patient and offer an opportunity to intervene in the post-operative period before the complications occur in high-risk patients. The diagnostic accuracy of the SRC was high when predicting the development of any complication, serious complication, surgical site infection, renal failure, reoperation, and sepsis. The diagnostic accuracy was low when predicting UTIs, readmission, and pneumonia. In addition, a longer LOHS was predicted. Although complications after simple appendectomy are rare, they are higher in the elderly, the obese, and patients with additional diseases. Post-operative complication rates are high in perforated appendicitis, which highlights the need for tools such as the SRC.

Ethics Committee Approval: This study was approved by the Dışkapı Yıldırım Beyazit Training and Research Hospital Ethics Committee (Date: 24.07.2017, Decision No: 40/03).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Açık ve laparoskopik apendektomi sonrası komplikasyonların "American College of Surgeon National Surgical Quality Improvment Program" risk hesaplayıcıya göre değerlendirilmesi

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AMAÇ: ACS-NSQIP (American College of Surgeons National Surgical Quality Improvement Program)'nin akut apandisitte komplikasyonları öngörü derecesinin değerlendirilmesi amaçlanmıştır.
GEREÇ VE YÖNTEM: Akut apandisit nedeniyle yatışı yapılan ve apendektomi planlanan 292 hasta çalışmaya dahil edilmiştir. Yaş aralığı 18–76 (ortalama yaş 35.3±13.6) olarak bulundu. Vücut kitle indeksi ortalama 25.8±4.6 şeklinde hesaplandı. Hastalarla ilgili 20 veri ACS-NSQIP Cerrahi Risk Hesaplayıcı'ya (CRH) girildikten sonra en sık görülen 17 komplikasyon oranı ve ortalama hastanede yatış süresi verilmektedir. Otuz günlük takiplerde gözlenen komplikasyonlar CRH'nin öngördüğü komplikasyonlara göre kategorize edildi. Gözlenen komplikasyon oranları ve hastanede yatış süreleri ile CRH'nin öngördüğü komplikasyon oranları ve hstanede yatış süreleri karşılaştırıldı.
BULGULAR: Hastalarımızda herhangi bir komplikasyon gelişenler %13.4, cerrahi alan enfeksiyonu %11.3, ciddi komplikasyon gelişenler %3.1, hastaneye tekrar başvuru %2.1 şeklinde gözlendi. Ciddi komplikasyonların içerisine, pnömoni, sepsis, kardiyak komplikasyonlar ve böbrek yetersizliği dahil edildi. Hastanede yatış süresi ortalama 1.91±1.64 şeklinde, yatış süresi aralığı ise 1–14 arasında görüldü. Venöz tromboemboli gözlenen hastamız olmadı. Hiçbir hastamızda mortalite gözlenmedi. CRH ile gerçekleşen komplikasyon karşılatırılması ROC eğrisi ile yapıldığında CRH'nin öngörü düzeyi; herhangi bir komplikasyonda doğruluk oranı %84.2, ciddi komplikasyonda %86.7, cerrahi alan enfeksiyonunda %47.6, böbrek yetersizliğinde %95.9, tekrar ameliyatta %99.0 ve sepsiste %88.3 şeklinde olduğu görüldü.
TARTIŞMA: Her ne kadar basit apendektomi sonrası komplikasyon görülmesi nadir bir durum olsa da özellikle yaşlı, obez, ek hastalıkları fazla olan hastalarda komplikasyon oranlarının belirgin artığı bilinmektedir. Öncelikle özellikli hasta ve hasta yakınlarına ameliyatın risklerini gösteren CRH gibi araçların yararı olacaktır.
Anahtar sözcükler: ACS NSQIP; akut apandisit; apendektomi; komplikasyon.

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