

Prognostic Scoring in Rectal Cancer Surgery: Evaluating the Efficacy of E-PASS, POSSUM, CR-POSSUM and ACPGBI in Risk Assessment, Complications Analysis, and Outcome Improvement – Findings from a Single-Center Study

Valentin Calu^{1,2}, Catalin Piriianu^{1,2*}, Adrian Miron^{1,2}, Elena-Adelina Toma^{1,2}, Octavian Enciu^{1,2}, Mugur Ardelean¹ and Valentin Titus Grigorean^{2,3}

¹Department of Surgery, Elias University Emergency Hospital, 011461 Bucharest, Romania

²Department of Surgery, Carol Davila University of Medicine and Pharmacy, 020021 Bucharest, Romania

³Department of Surgery, Bagdasar-Arseni Clinical Emergency Hospital, 041915 Bucharest, Romania

*Corresponding author:

Catalin Piriianu, M.D.

Department of Surgery

Elias University Emergency Hospital

011461 Bucharest, Romania

E-mail: catalin.piriianu@umfd.ro

Abbreviations:

E-PASS: Estimation of Physiologic

Ability and Surgical Stress;

POSSUM: Physiological and Operative

Severity Score for the Enumeration of

Mortality and Morbidity;

CR-POSSUM: Colorectal

Physiological and Operative Severity

Score for the Enumeration of Mortality

and Morbidity;

ACPGBI: Association of Coloproctology

of Great Britain and Ireland;

PRS: Preoperative Risk Score;

SSS: Surgical Stress Score;

CRS: Comprehensive Risk Score;

CRC: Colorectal Cancer;

OSS: Operative Severity Score;

AL: Anastomotic Leakage;

CRP: C-Reactive Protein;

BFR: Body Fat Ratio;

NLR: Neutrophil-to-Lymphocyte Ratio.

Rezumat

Scorurile de prognostic în chirurgia cancerului rectal: evaluarea eficacității E-PASS, POSSUM, CR-POSSUM și ACPGBI în estimarea riscurilor, analiza complicațiilor și îmbunătățirea rezultatelor - concluzii ale unui studiu unicentric

Context: Sistemele de scor prognostic sunt esențiale pentru evaluarea riscului preoperator și anticiparea rezultatelor în chirurgia cancerului rectal. Acest studiu evaluează eficacitatea a patru sisteme de evaluare - estimarea capacității fiziologice și a stresului chirurgical (E-PASS), Scorul de severitate fiziologică și operatorie pentru evaluarea mortalității și morbidității (POSSUM), Colorectal-POSSUM (CR-POSSUM) și Asociația de coloproctologie din Marea Britanie și Irlanda (ACPGBI) - în prezicerea complicațiilor post-operatorii și a mortalității.

Metode: A fost efectuat un studiu retrospectiv care a implicat 67 de pacienți care au suferit intervenții chirurgicale pentru cancer rectal. Sistemele de notare au fost evaluate în ceea ce privește rezultatele postoperatorii, inclusiv complicațiile, morbiditatea și ratele mortalității la 30 de zile. Analizele statistice au inclus teste t, teste chi-pătrat și regresie logistică.

Rezultate: Pacienții cu complicații (n = 39) au demonstrat scoruri semnificativ mai mari în toate sistemele. Scorul de risc (CRS) derivat din E-PASS (11,43 versus 8,95, p=0,001) și scorul ACPGBI (1,95 versus 1,27, p=0,0005) au demonstrat cea mai semnificativă corelație cu complicațiile. Scorurile fiziologice și operatorii ridicate s-au corelat cu morbiditatea crescută, subliniind importanța lor prognostică.

Concluzii: Sistemele de evaluare precum E-PASS, POSSUM, CR-POSSUM și ACPGBI stratifică în mod eficient riscul asociat intervenției chirurgicale pentru cancer rectal. Integrarea clinică îmbunătățește identificarea pacienților cu risc ridicat, care contribuie la intervențiile menite să optimizeze rezultatele.

Received: 12.01.2025

Accepted: 22.02.2025

Cuvinte cheie: cancer rectal, complicații postoperatorii, sisteme de scor prognostic, E-PASS, POSSUM, CR-POSSUM, ACPGIBI, stres chirurgical, evaluarea riscului, predicția mortalității

Abstract

Background: Prognostic scoring systems are critical for assessing preoperative risk and forecasting outcomes in rectal cancer surgery. This study evaluates the effectiveness of four scoring systems - Estimation of Physiologic Ability and Surgical Stress (E-PASS), Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM), Colorectal-POSSUM (CR-POSSUM), and the Association of Coloproctology of Great Britain and Ireland (ACPGIBI) - in predicting postoperative complications and mortality.

Methods: A retrospective study was conducted involving 67 patients who underwent surgery for rectal cancer. The scoring systems were assessed concerning postoperative outcomes, including complications, morbidity, and 30-day mortality rates. Statistical analyses included t-tests, chi-square tests, and logistic regression.

Results: Patients with complications ($n = 39$) demonstrated significantly higher scores across all systems. The Comprehensive Risk Score (CRS) derived from E-PASS (11.43 versus 8.95, $p = 0.001$) and the ACPGIBI score (1.95 versus 1.27, $p = 0.0005$) demonstrated the most significant correlation with complications. Elevated physiological and operative scores correlated with increased morbidity, underscoring their prognostic importance.

Conclusions: Scoring systems such as E-PASS, POSSUM, CR-POSSUM, and ACPGIBI effectively stratify the risk associated with rectal cancer surgery. Clinical integration enhances the identification of high-risk patients, which informs interventions designed to optimize outcomes.

Key words: rectal cancer, postoperative complications, prognostic scoring systems, E-PASS, POSSUM, CR-POSSUM, ACPGIBI, surgical stress, risk assessment, mortality prediction

Introduction

Rectal cancer, a type of colorectal cancer (CRC), represents a considerable global health issue, with incidence and mortality rates that vary based on demographics, lifestyle, and genetic factors (1). The global burden of colorectal cancer is significant, with rectal cancer playing a notable role in this trend. The epidemiology of rectal cancer encompasses the analysis of its incidence, associated risk factors, and survival outcomes across various populations and geographical regions (2).

Rectal cancer represents a major health issue, impacting approximately 80,000 individuals each year within the European Union (3). Lifestyle factors including obesity, poor dietary habits, smoking, and alcohol consumption significantly contribute to the risk of CRC (4). Chronic inflammatory bowel diseases, such as ulcerative colitis and Crohn's disease, elevate the associated risk (5). Genetic predispositions, such as hereditary non-polyposis colorectal cancer and familial adenomatous polyposis, contribute to 3%-4% of colorectal cancer cases (5). Age is a significant determinant, as individuals over 50 years are at medium risk for rectal cancer (4).

The management of rectal cancer has undergone considerable evolution, emphasizing enhancements in survival rates and the minimization of local recurrence. This requires a multidisciplinary approach encompassing surgery, chemotherapy, and radiotherapy.

Rectal cancer surgery is frequently essential for treatment; however, it is linked to various complications that can considerably affect patient outcomes and the cost of health care. Complications may arise immediately or over the long term, influenced by factors such as surgical techniques, patient characteristics, and preoperative conditions. Comprehending these complications and their predictors is essential for enhancing surgical outcomes and patient quality of life (6).

Prognostic scoring systems, including E-PASS, POSSUM, CR-POSSUM, and ACPGIBI, are employed in rectal cancer surgery to evaluate risk, analyze complications, and enhance outcomes. These systems integrate multiple clinical and surgical variables to forecast postoperative complications and mortality, thereby facilitating patient management and decision-making. Each scoring system possesses distinct strengths and limitations, with their efficacy varying according to the specific context of rectal cancer surgery.

In addition to preventing complications, it is essential to examine the broader effects of these complications on patient recovery and long-term health outcomes. Complications may delay or inhibit essential adjuvant therapies, thereby affecting the overall efficacy of cancer treatment (7). The selection of surgical technique and preoperative treatments must be meticulously evaluated to optimize oncological outcomes while minimizing the risk of complications (8).

Cumulative risk scores from prognostic systems such as E-PASS, CR-POSSUM, POSSUM, and ACPGBI serve as effective tools for predicting and managing postoperative complications in rectal cancer surgery. The scoring systems facilitate the early identification of high-risk patients, enhancing clinical outcomes and potentially decreasing hospital stays via timely interventions. This research assesses the predictive value of these scoring systems through an analysis of a cohort comprising 67 patients who underwent rectal cancer surgery from 2020 to 2023, surgery department, Elias Emergency University Hospital. The findings seek to provide clinicians with dependable metrics for optimizing postoperative care and improving recovery via targeted interventions.

Materials and Methods

This research is a retrospective cohort analysis involving patients who received surgical treatment for rectal cancer. The study period included the COVID-19 pandemic, which influenced the selection of surgical methods, particularly laparoscopic surgery, due to the constraints and challenges posed by the pandemic.

The patients engaged in the data collection process following the fulfillment of inclusion criteria and the provision of informed consent, in accordance with Law 95/2006, Law 46/2003 regarding patient rights, WHO No. 141:0/2016, and the Ministry of Health's Order No. 482/2007, as documented in the admission files.

The inclusion criteria comprised individuals aged 18 years or older, with a confirmed diagnosis of rectal adenocarcinoma via histology, and tumors located within 0 to 15 cm from the anal margin. The exclusion criteria comprised colon cancer with tumors located more than 15 cm from the anal margin, inadequate medical records, and non-malignant abnormalities of the rectum.

During the COVID-19 pandemic, particularly in 2020 and early 2021, the decision to perform laparoscopic surgery was made with caution due to

concerns regarding aerosol generation and the potential transmission of the virus in operating rooms. Occasionally, these circumstances led to a higher rate of transition to open surgery. The choice of surgical approach was influenced by tumor characteristics, surgeon expertise, and patient preference.

The patients underwent one of three surgical procedures: Anterior Resection (AR), Abdominoperineal Excision of the Rectum (APER), or the Hartmann Procedure. All procedures were performed with the objective of patient cure, adhering to established oncological guidelines, including the application of total mesorectal excision (TME) when indicated.

Patient demographic information, including age, gender, body mass index (BMI), and comorbidities, was extracted from electronic medical records. Data on tumor characteristics, such as size, degree of differentiation, and distance to the anal verge, were also recorded. The specifics of the operation, including the anticipated blood loss, surgery duration, and the necessity of a blood transfusion, were documented. Postoperative complications were assessed according to their occurrence or non-occurrence. Patients were divided into two groups: those who experienced complications and those who did not. The analysis investigated the correlation between predictive scoring systems (E-PASS, POSSUM, CR-POSSUM, and ACPGBI) and the incidence of complications, providing a clear and clinically pertinent evaluation of risk. The results indicate that elevated scores across all systems are associated with a greater probability of postoperative complications. This demonstrates the effectiveness of these models in identifying high-risk patients and informing perioperative management.

Surgical site infections (SSI) were the most prevalent postoperative complication, affecting 16 patients. Subsequently, urinary tract infections (UTI) were observed in three patients, as well as pneumonia, which also affected three patients. The findings underscore the prevalence of infections, especially those related to surgical and urinary tract procedures, highlighting the necessity of rigorous perioperative infection prevention strategies to reduce complication rates.

Four scoring systems were employed to evaluate patient risk and forecast postoperative outcomes. The E-PASS system assessed physiological and surgical factors by calculating the Preoperative Risk Score, Surgical Stress Score, and Comprehensive Risk Score. POSSUM

(Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity) is utilized to produce predictions regarding morbidity and mortality through standardized criteria. The ACPGBI scoring system integrates patient demographics and tumor-specific characteristics to evaluate risks and outcomes. Finally, CR-POSSUM (Colorectal POSSUM) delivered mortality risk predictions specific to colorectal surgery, facilitating a more precise evaluation for this surgical group.

Statistical Analysis

Statistical analyses were conducted utilizing SPSS version 28.0 (IBM, Armonk, NY, USA) and Origin Pro 2018 software. Logistic regression models were employed to forecast postoperative complications utilizing scoring systems. Chi-square tests, t-tests, Mann-Whitney U tests, and ANOVA were employed to compare groups as deemed appropriate. A p-value of less than 0.05 was deemed statistically significant.

Results

Patient Demographics and Clinical Characteristics

The study encompassed patients both with and without postoperative complications, revealing significant differences in demographics and clinical characteristics. Patients experiencing complications exhibited a higher mean age (67.33 ± 10.34 years) than those without complications (61.21 ± 11.09 years), with a statistically significant difference ($t=2.29$, $p=0.026$). The gender distribution indicated a greater number of men in the complication group (27 males and 12 females) relative to the non-complication group (12 males and 16 females); however, this difference did not reach statistical significance ($\chi^2 = 3.64$, $p = 0.056$).

The Body Mass Index (BMI) was comparable across groups, with means of 25.98 ± 4.63 in the complication group and 26.02 ± 3.18 in the non-complication group ($p = 0.968$). The smoking status showed no statistically significant association with complications ($p = 0.155$), with 16 smokers in the complication group and 6 in the non-complication group. Patients experiencing complications exhibited a significantly greater mean number of comorbidities (3.08 ± 1.66) in contrast to those without complications (2.18 ± 2.00 , $p = 0.049$).

A chi-square test of independence was conducted to evaluate the association between the

type of surgical approach (open, laparoscopic, or conversion) and the occurrence of postoperative complications. The results demonstrated a statistically significant association between the surgical approach and complications, $\chi^2(2, N=67)$ $t = 12.24$, $p = 0.0022$. The probability of complications varies significantly based on the surgical technique utilized. Patients who underwent laparoscopic surgery demonstrated a complication rate of 43%, compared to 84% for open surgery and 100% for cases converted from laparoscopic to open surgery. The findings indicate that laparoscopic surgery is associated with a reduced occurrence of postoperative complications when compared to open and conversion procedures.

There was a significant correlation between postoperative complications and dental health ($p = 0.0108$) *Fig. 1*. Patients exhibiting poor dental health experienced more complications compared to those with healthy teeth. This indicates that inadequate dental health may influence surgical results. Bacterial translocation, or the entry of oral pathogens into the circulation post-surgery, may elevate the risk of systemic infections such as surgical site infections (SSI) or sepsis.

Dental issues may indicate nutritional deficiencies that hinder recovery or ongoing inflammatory conditions that increase postoperative risks. Diabetes and smoking, both of which independently elevate complications, may be associated with suboptimal dental health. The findings indicate that techniques for categorizing surgical risk should incorporate preoperative oral health assessments. Preoperative management of

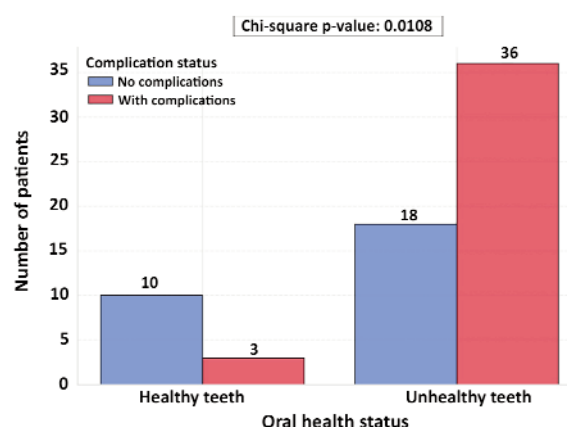


Figure 1. The bar chart illustrates the status of oral health. An association is present between oral health and postoperative complications ($\chi^2 = 6.49$, $p = 0.0108$, $df = 1$).

oral health issues can mitigate complications, particularly in high-risk patients, thereby enhancing surgical outcomes.

Surgical Outcomes

Patients with complications had longer hospital stays (15.05 ± 8.15 days) than those without complications (9.75 ± 2.44 days, $p = 0.0014$) and showed higher estimated blood loss ($265.41 \pm$

140.62 mL vs. 169.64 ± 124.23 mL, $p = 0.0046$). The T-test reveals no statistically significant difference in operative time between the two groups ($P = 0.961$), suggesting that operative time may not be a crucial factor in predicting complications.

This analysis identifies key demographics *Table 1*, clinical, and procedural differences between patients experiencing postoperative complications and those who do not, providing insights into potential risk factors.

Table 1. Patient Demographics

Category	Metric	With complications	Without complications	Results
Age (years)	mean	67.33	61.21	Welch's T-test indicated a significant difference in mean age between the groups ($T=2.29$, $P=0.026$). The Mann-Whitney U test indicated significant differences in age distribution ($U=713.0$, $P=0.034$). The results indicate that older individuals experience a higher incidence of postoperative complications.
	standard deviation	10.34	11.09	
	median	67	60	
Gender	male	27	12	The complication cohort consisted of 27 males and 12 females. A chi-square test for independence revealed a chi-square statistic of 3.64 and a P-value of 0.056 concerning gender and postoperative complications. The P-value indicates a possible trend warranting further investigation, yet it does not meet the conventional criterion for statistical significance ($P < 0.05$).
	female	12	16	
BMI	mean	25.98	26.02	A Welch's T-test revealed no statistically significant difference in BMI between the two groups ($T=-0.043$, $P=0.966$). The findings indicate that BMI may not significantly influence the likelihood of postoperative complications in this cohort.
	standard deviation	4.63	3.18	
	median	26.12	25.69	
Smoking status	smokers	16	6	A chi-square test for independence was performed to assess the association between smoking status and postoperative complications. The analysis produced a chi-square statistic of 2.02 and a P-value of 0.155. This suggests no statistically significant relationship exists between smoking status and the occurrence of postoperative complications.
	non-smokers	23	22	
Comorbidities	mean	3.08	2.18	The T-test shows that individuals with complications have a greater average number of comorbidities ($P\text{-value} = 0.049$).
	standard deviation	1.66	2.00	
	median	3.0	2.0	
Procedure	anterior resection	23	20	A chi-square test for independence was performed to evaluate the relationship between procedure type and postoperative complications. Chi-square statistic: 1.10 P-value: 0.577 The findings demonstrate no statistically significant relationship between the type of surgical procedure and the occurrence of postoperative complications.
	APER	12	6	
	Hartmann	4	2	
Surgical approach	laparoscopic	19	25	The chi-square test indicates a statistically significant difference in surgical approach between the two groups ($P = 0.002$). This suggests a correlation between the surgical method and the incidence of postoperative complications.
	conversion	4	0	
	open	16	3	
Operative time (minutes)	mean	312.2	312.0	The T-test reveals no statistically significant difference in operative time between the two groups ($P = 0.961$), suggesting that operative time may not be a critical factor in predicting complications.
	standard deviation	110.0	75.1	
	median	310.0	305.0	

Table 1. Cont'd

Category	Metric	With complications	Without complications	Results
Distance from anus (tumor) CM	mean	2.83	4.26	Patients with complications exhibited tumors that were, on average, situated nearer to the anus than those without complications.
	standard deviation	3.11	4.30	
	median	2.0	4.0	
Preoperative radiotherapy	yes	28	24	A higher percentage of patients who received preoperative radiation experienced complications compared to those who did not.
	no	11	4	
American Society of Anesthesiologists (ASA)	II	2	9	The majority of patients facing complications had an ASA score of 3, signifying a greater severity of systemic illness. Conversely, individuals without any issues exhibited a more uniform distribution across ASA 2 and ASA 3 categories.
	III	30	18	
	IV	7	1	

Prognostic Scoring Systems

E-PASS Components and Postoperative Complications

The E-PASS (Estimation of Physiologic Ability and Surgical Stress) scoring system forecasts postoperative complications as well as mortality by assessing physiological and surgical stress variables.

The E-PASS scoring system, comprising the Preoperative Risk Score (PRS), Surgical Stress Score (SSS), and Comprehensive Risk Score (CRS), was analyzed for its relationship with postoperative complications. Patients with complications demonstrated a mean PRS of 4.87 ± 0.91 , while those without complications had a mean PRS of 4.31 ± 1.35 , suggesting a trend toward statistical significance ($p = 0.061$). The mean SSS was significantly higher in patients with complications (6.56 ± 2.75) than in those without (4.64 ± 2.48 , $p = 0.004$), highlighting the influence of surgical stress on post-operative outcomes. The combined CRS, encompassing PRS and SSS, was significantly higher in the complication group (11.43 ± 3.12) than in the non-complication group (8.95 ± 2.74 , $p = 0.001$) (Fig. 2). The results demonstrate that CRS serves as a significant predictor of postoperative complications, while SSS accurately reflects the impact of surgical stress on outcomes (Fig. 3). The observed trend in PRS indicates that preoperative patient-related factors may influence complication rates. The Comprehensive Risk Score (CRS) is higher in patients experiencing multiple complications, with a mean CRS of 11.43 for individuals with one complication, in contrast to a mean CRS of 12.69 for those with multiple complications. This indicates that patients with multiple complications demonstrate a higher CRS, reflecting elevated preoperative risk and

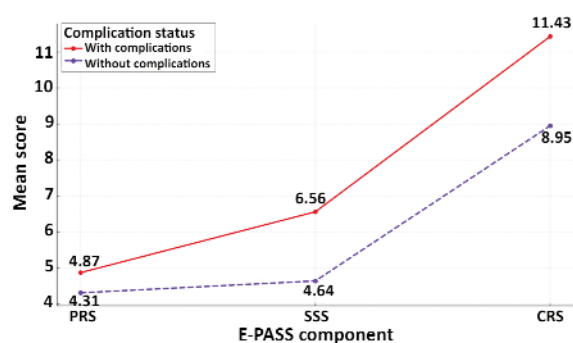


Figure 2. Line plot comparing the mean scores of the E-PASS components (PRS, SSS, and CRS) for patients with and without complications

surgical stress. E-PASS functions as a reliable predictive instrument, with CRS identified as the strongest predictor of postoperative complications.

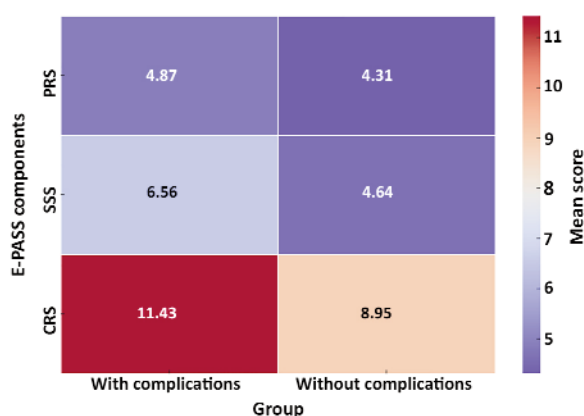


Figure 3. The heatmap shows E-PASS components mean scores (PRS, SSS, CRS) for patients with and without surgical problems. Warmer colors in the complexity group reflect higher scores across all components, with CRS differing most.

POSSUM and CR-POSSUM Scoring Systems

The POSSUM scoring system, which stands for Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity, combines the Operative Severity Score and Physiology Score to assess surgical risk and predict postoperative outcomes. In this study, patients with complications exhibited higher mean scores for both components. The mean OSS was 13.77 ± 3.34 in the complication group, compared to 12.57 ± 2.10 in the non-complication group, yielding a p-value of 0.076, indicating a potential trend towards significance. The Physiology Score demonstrated a statistically significant difference, with patients experiencing complications scoring 25.74 ± 4.82 , compared to 23.43 ± 3.95 for those without complications ($p = 0.035$). The morbidity percentage was significantly elevated in the complication group, with a mean of 64.78 ± 20.07 , in contrast to 54.23 ± 16.37 in the non-complication group ($p = 0.021$). The findings demonstrate that the combination of these ratings functions as a valuable tool for assessing risk in surgical patients, particularly in predicting postoperative morbidity.

The CR-POSSUM (Colorectal POSSUM) score system incorporates mortality as a critical factor for predicting death in patients undergoing colorectal surgery. Patients with complications demonstrated a significantly higher mean Mortality score of 10.52 ± 11.69 , compared to 5.45 ± 5.46 in patients without complications ($p = 0.021$). This outcome highlights the increased

mortality risk associated with postoperative complications and underscores the importance of incorporating mortality into risk prediction models such as CR-POSSUM.

The integration of the Operative Severity Score and Physiology Score in POSSUM, along with Mortality in CR-POSSUM Fig. 4, provides dependable tools for evaluating postoperative outcomes. Grading systems are crucial for identifying high-risk patients and tailoring peri-operative care strategies to reduce morbidity and mortality.

ACPGBI Score and Predicted 30-Day Mortality

The correlation between the ACPGBI score and the predicted 30-day mortality percentage was evaluated in relation to postoperative complications. The ACPGBI score was significantly higher in patients with complications (1.95 ± 0.76) compared to those without complications (1.27 ± 0.72 , $p=0.0005$). The notable difference underscores the predictive utility of the ACPGBI score in identifying patients at heightened risk for postoperative complications.

The analysis of Predicted 30-Day Mortality % revealed a statistically significant increase in patients with complications (5.26 ± 5.01) compared to those without complications (2.68 ± 2.41 , $p=0.007$). The findings Fig. 5 highlight the association between postoperative complications and elevated short-term mortality risk, underscoring the significance of this metric in preoperative risk evaluation. The interquartile range and median values demonstrate notable disparities between the two

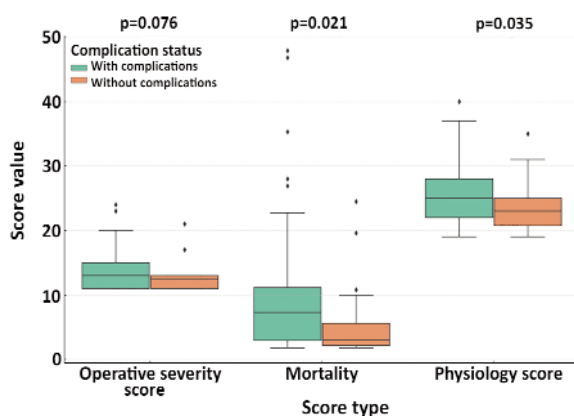


Figure 4. This boxplot illustrates a comparison of the Operative Severity Score (OSS), Mortality (CR-POSSUM), and Physiology Score among patients with complications versus those without complications.

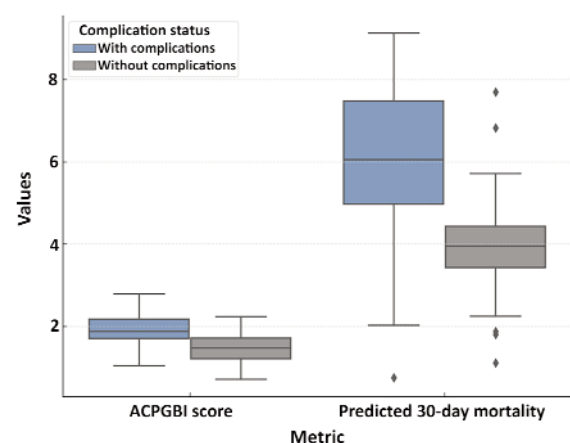


Figure 5. This figure presents a boxplot comparing ACPGBI scores and predicted 30-day mortality between patients.

groups, with elevated scores recorded in patients who experienced complications. The broader range in predicted 30-day mortality for patients with complications indicates increased variability in risk, likely affected by comorbidities, surgical complexity, and perioperative factors. Outliers in the dataset likely indicate patients with severe systemic conditions or unforeseen postoperative outcomes. The overall trend indicates that ACPG-BI effectively stratifies postoperative risk, despite the observed variability.

Figs. 4 and 5 illustrate the distribution of ACPG-BI scores alongside predicted 30-day mortality, highlighting several notable outliers. These outliers likely indicate patients with significant comorbidity, advanced disease stages, or unforeseen perioperative complications. The data points broaden the range of values and are clinically significant, demonstrating actual variations in surgical outcomes. Their inclusion does not affect the overall statistical significance of the findings, but it underscores the variability in postoperative risk.

The ACPGBI score and predicted 30-day mortality percentage are reliable indicators of postoperative outcomes, demonstrating significant differences between patients with complications and those without. The integration of these approaches into clinical practice has the potential to enhance risk assessment and facilitate tailored perioperative management strategies, ultimately improving surgical outcomes.

Discussions

Rectal cancer surgery presents various complications that can notably affect patient outcomes, healthcare expenditures, and overall quality of life. Complications may result from multiple factors, such as surgical techniques, patient characteristics, and pre-existing conditions. Comprehending these complications and their predictors is essential for enhancing surgical outcomes and patient care.

POSSUM and CR-POSSUM are established systems utilized for predicting postoperative morbidity and mortality. Recent evaluations indicate that there is a tendency to overpredict these outcomes, highlighting the necessity for revisions to enhance precision in current clinical settings (9).

The ACPGBI scoring system is utilized for colorectal cancer prognosis, emphasizing survival and recurrence rates, although it is not explicitly addressed in the provided contexts. The efficacy of this model in relation to newer models warrants additional investigation.

Recent studies demonstrate the potential of machine learning models in predicting outcomes for rectal cancer patients. Models utilizing carcinoembryonic antigen (CEA) measurements have demonstrated promising efficacy in predicting cancer recurrence with high accuracy (10). Models that integrate perioperative data have demonstrated high predictive accuracy for surgical outcomes (11).

Postoperative elevations in C-reactive protein (CRP) levels, particularly between days 4 and 7, are significant predictors of complications (12). Pre-surgical anemia, including mild instances, significantly increases the likelihood of serious postoperative complications (13). Another factor to consider is the body fat ratio (BFR); while a higher BFR is linked to increased postoperative complications, it has also been associated with improved survival rates (14). The surgical technique and patient-specific characteristics, such as open surgery, advanced age, and lower preoperative albumin levels, significantly elevate the risk of major complications (15).

Postoperative complications significantly increase healthcare costs, with affected patients experiencing substantially higher expenses compared to those without such complications (12). The creation of a permanent colostomy has a considerable impact on patients' social and psychological health, often hindering their social adjustment and mental state (16,17).

Complications may extend beyond immediate recovery, potentially delaying or obstructing the initiation of essential adjuvant therapies, which could adversely affect long-term oncological outcomes (7). The challenges underscore the need for a comprehensive strategy in rectal cancer surgery that addresses both complication prevention and their broader implications. This includes patient education, customized treatment strategies, and comprehensive postoperative monitoring to improve both short- and long-term outcomes.

Recent studies (18,19) demonstrate a correlation between oral health, particularly the number of healthy teeth, and surgical outcomes in rectal cancer. Patients with a higher count of healthy teeth demonstrate enhanced responses to preoperative chemoradiotherapy, a critical aspect of rectal cancer treatment (18). The association between dental health and surgical complications is intricate; nonetheless, these findings indicate that oral health may contribute to improved treatment efficacy and postoperative results.

Prognostic scoring systems are critical for evaluating risk, predicting complications, and

improving outcomes in rectal cancer surgery. Systems such as E-PASS, POSSUM, CR-POSSUM, and ACPGBI are essential tools for risk stratification and clinical decision-making, each offering unique advantages and disadvantages (9).

The E-PASS scoring system incorporates preoperative risk, surgical stress, and comprehensive risk scores, showing considerable predictive value for postoperative complications and mortality, particularly in elderly patients. The ability to identify high-risk individuals underscores its importance in colorectal surgery (20).

POSSUM and CR-POSSUM are widely utilized for predicting morbidity and mortality, with CR-POSSUM specifically designed for colorectal surgical procedures. CR-POSSUM exhibits a classification accuracy of approximately 70% for morbidity (21); however, these models frequently overestimate risk, particularly within enhanced recovery programs, highlighting the need for ongoing refinement (22).

The updated ACPGBI scoring system has demonstrated efficacy in predicting operative mortality. The simplicity and accuracy of the model often surpass those of CR-POSSUM, making it a preferred option in specific contexts for tailoring surgical strategies and meeting patient expectations.

Comparative analyses indicate that both POSSUM and CR-POSSUM provide valuable insights; however, they often overestimate risks, underscoring the necessity for calibration in existing surgical practices. The updated ACPGBI model shows a more precise relationship with observed outcomes, offering a balanced and practical approach (23).

While these scoring systems have advantages, they also demonstrate shortcomings. The overestimation of risk by certain models underscores the need for continuous improvement. Integrating scoring systems with novel predictive biomarkers, such as the Neutrophil-to-Lymphocyte Ratio (NLR), may enhance predictive accuracy and clinical utility (12,24). These advancements are crucial for ensuring the continued relevance of these tools in the evolving landscape of rectal cancer surgery.

Traditional scoring systems such as POSSUM and CR-POSSUM offer a basic framework for risk assessment; however, their precision limitations underscore the necessity for revised models. The incorporation of machine learning and innovative clinical parameters presents a significant opportunity to improve prognostic accuracy and customize treatment approaches in rectal cancer surgery.

Conclusion

The findings of this study highlight the significance of prognostic scoring systems, such as E-PASS, POSSUM, CR-POSSUM, and ACPGBI, in improving risk stratification and clinical outcomes in rectal cancer surgery. Each system provides unique insights into patient risk profiles, with E-PASS demonstrating high predictive accuracy for postoperative complications and mortality, particularly through its Comprehensive Risk Score (CRS). POSSUM and CR-POSSUM serve as significant tools for assessing morbidity and mortality; nonetheless, their tendency to overestimate risks underscores the need for additional refinement. The revised ACPGBI model offers robust predictions of operative mortality and aligns closely with actual outcomes, indicating its efficacy in tailoring surgical strategies.

This research emphasizes the significant influence of patient-specific variables, such as advanced age, preoperative anemia, and surgical technique, on postoperative results. The integration of new predictors, such as CRP levels and Neutrophil-to-Lymphocyte Ratio (NLR), into these scoring systems could enhance their predictive accuracy and clinical relevance.

The integration of scoring systems into perioperative workflows improves the early identification of high-risk patients, facilitating customized treatment approaches and proactive management of complications. The findings underscore the need for continuous improvement and validation of scoring models to align with advancements in surgical techniques and evolving patient demographics, thus improving both short- and long-term outcomes in rectal cancer surgery.

Author's Contributions

Conceptualization: C.P. and V.C.; methodology: C.P., V.C., and A.M.; formal analysis: C.P., A.M., and E.A.T.; data curation: C.P., A.M., O.E., and E.A.T.; writing-original draft preparation: C.P.; writing-review and editing: C.P., V.C., M.A., and V.T.G.; supervision: V.T.G. and M.A. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interests

The authors declare no conflicts of interests.

Funding

Publication of this paper was supported by the University of Medicine and Pharmacy Carol Davila, through the institutional program “Publish not Perish”.

Ethical Statement

All procedures in studies involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study protocol was reviewed and approved by the ethics committee of Elias Hospital No. 414.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

References

1. Roshandel G, Ghasemi-Kebria F, Malekzadeh R. Colorectal Cancer: Epidemiology, Risk Factors, and Prevention. *Cancers* (Basel). 2024;16(8):1530.
2. Dagnaw GG, Dejene H. Colorectal cancer in Ethiopia: Epidemiological trends, diagnostic and laboratory capacities, and challenges. *Semin Oncol*. 2024;S0093-7754(24)00051-4.
3. Spanos CP. Chapter 30 - Rectal cancer. In: Spanos CP, editor. *Colorectal Disorders and Diseases*: Academic Press; 2023. p. 127-34.
4. Calu V, Piriianu C, Miron A, Grigorean VT. Surgical Site Infections in Colorectal Cancer Surgeries: A Systematic Review and Meta-Analysis of the Impact of Surgical Approach and Associated Risk Factors. *Life* (Basel). 2024;14(7):850.
5. Bouvier AM, Manfredi S. (Epidemiology, risk factors and current screening in rectal cancer). *Rev Prat*. 2022;72(1):32-7.
6. DeLeon MF, Stocchi L. A narrative review of rectal cancer surgery: is there a role for laparoscopy? *Ann Laparosc Endosc Surg* 2023;8:16.
7. Veyssel Cem O. Complications Following Colorectal Cancer Surgery. In: Dr. Jindong C, editor. *Advances in Diagnosis and Therapy of Colorectal Carcinoma*. Rijeka: IntechOpen; 2024. p. Ch. 6.
8. Popa C, Prunoiu VM, Puia P, Schlanger D, Bratucu MN, Strâmbu V, et al. Specific Septic Complications after Rectal Cancer Surgery: A Critical Multicentre Study. *Cancers* (Basel). 2023 Apr 17;15(8):2340.
9. Bürtin F, Ludwig T, Leuchter M, Hendricks A, Schafmayer C, Philipp M. More than 30 Years of POSSUM: Are Scoring Systems Still Relevant Today for Colorectal Surgery? *J Clin Med*. 2023 Dec 28;13(1):173.
10. Mohammadian Rad N, Sosef O, Seegers J, Koolen L, Hoofwijk J, Woodruff HC, et al. Prognostic models for colorectal cancer recurrence using carcinoembryonic antigen measurements. *Front Oncol*. 2024;14:1368120.
11. Li X, Zhou Z, Zhu B, Wu Y, Xing C. Development and validation of machine learning models and nomograms for predicting the surgical difficulty of laparoscopic resection in rectal cancer. *World J Surg Oncol*. 2024;22(1):111.
12. Calu V, Piriianu C, Miron A, Grigorean VT. Utilizing C-Reactive Protein (CRP) and CRP Ratios for Early Detection of Postoperative Complications Following Rectal Cancer Surgery. *Life* (Basel). 2024;14(11):1465.
13. Yamada T, Endo H, Hasegawa H, Kakeji Y, Yamamoto H, Miyata H, et al. Presurgical mild anemia is a risk factor for severe postoperative complications of rectal cancer surgery: A Japanese nationwide retrospective cohort study. *Ann Gastroenterol Surg*. 2024;8(3):471-80.
14. Fu Y, Zhao S, Zhang C, Wang J, Li R, Cheng Y, et al. The impact of sarcopenia on postoperative complications and survival outcomes after robotic colorectal cancer surgery: a study based on single-center propensity score matching. *J Robot Surg*. 2024;19(1):13.
15. Xu S, Xiong X, Li T, Hu P, Mao Q. Preoperative low serum albumin increases the rate of perioperative blood transfusion in patients undergoing total joint arthroplasty: propensity score matching. *BMC Musculoskelet Disord*. 2024; 25(1):695.
16. Ayaz-Alkaya S. Overview of psychosocial problems in individuals with stoma: A review of literature. *Int Wound J*. 2019;16(1):243-9.
17. Duluklu B, Çelik S. Lived Experiences of Patients After Colorectal Cancer and Permanent Colostomy: A Parallel-Design Mixed-Methods Study. *Adv Skin Wound Care*. 2024;37(6):312-8.
18. Nakao T, Shimada M, Yoshikawa K, Tokunaga T, Nishi M, Kashiwara H, Takasu C, Wada Y, Yoshimoto T. Number of Healthy Teeth Can Predict the Response of Rectal Cancer to Chemoradiotherapy: A Retrospective Study. *Am Surg*. 2024;90(11):2679-86.
19. Xian P, Xuedong Z, Xin X, Yuqing L, Yan L, Jiyao L, Xiaoquan S, Shi H, Jian X, Ga L. The Oral Microbiome Bank of China. *Int J Oral Sci*. 2018;10(2):16.
20. Tominaga T, Takeshita H, Takagi K, Kunizaki M, To K, Abo T, et al. E-PASS score as a useful predictor of postoperative complications and mortality after colorectal surgery in elderly patients. *Int J Colorectal Dis*. 2016;31(2):217-25.
21. Prabakaran V, Thangaraju T, Mathew AC, Govindan V, Kannan V, Poulouse TR. CR-Possum-Can It Be Used to Predict Morbidity? A Single-Centre Retrospective Study. *Indian J Surg Oncol*. 2019;10(1):174-9.
22. Bagnall NM, Pring ET, Malietzis G, Athanasiou T, Faiz OD, Kennedy RH, et al. Perioperative risk prediction in the era of enhanced recovery: a comparison of POSSUM, ACPGBI, and E-PASS scoring systems in major surgical procedures of the colorectal surgeon. *Int J Colorectal Dis*. 2018;33(11):1627-34.
23. Richards CH, Leitch EF, Anderson JH, McKee RF, McMillan DC, Horgan PG. The revised ACPGBI model is a simple and accurate predictor of operative mortality after potentially curative resection of colorectal cancer. *Ann Surg Oncol*. 2011; 18(13):3680-5.
24. Naszai M, Kurjan A, Maughan TS. The prognostic utility of pre-treatment neutrophil-to-lymphocyte-ratio (NLR) in colorectal cancer: A systematic review and meta-analysis. *Cancer Med*. 2021;10(17):5983-97.