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PREDICTIVE FACTORS OF POSTOPERATIVE OUTCOMES IN A JORDANIAN POPULATION OF COLORECTAL CANCER PATIENTS WHO UNDERWENT SURGICAL RESECTION USING A CLINICAL PREDICTION MODEL

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ABSTRACT

Background: Surgical resection is the mainstay treatment approach for colorectal cancer (CRC). However, it is associated with high mortality and morbidity rates. Mortality risk estimation and prediction is on the rise for a personalized treatment approach and can lead to better post-operative outcomes. **Purpose**: In this study, we aim to develop and validate a post-operative mortality and complications risk model using preoperative and clinical characteristics for Jordanian CRC patients. **Methods**: We retrospectively retrieved data for CRC patients from 2016 to 2024 who underwent surgical resection from King Hussein Medical Center (KHMC), Amman, Jordan. Target outcomes were post-operative complications, postoperative pain, and postoperative wound infection. Demographic and preoperative clinical variables were used as predictors including age, sex, body-mass index (BMI), smoking, type of surgery (laparoscopic or open). Logistic regression was built to predict the postoperative outcomes. All models will be evaluated for accuracy accuracy score, area under the receiver operating characteristics curve (AUC/ROC), sensitivity, and specificity. **Results**: Postoperative complications occurred in 10% of patients, with 4.2% experiencing pain and 3.0% developing wound infections. Higher preoperative BMI was significantly associated with postoperative pain (OR: 1.47, 95% CI: 1.27-1.70, $p<0.001$), and longer hospital stays were associated with overall complications. The model predicted postoperative pain with 96.7% accuracy and an AUC of 0.93. Wound infection prediction had 97.5% accuracy with an AUC of 0.79. **Conclusion**: Preoperative BMI and hospital stay duration are key factors influencing postoperative outcomes in CRC surgeries. The developed model provides a useful tool for preoperative risk stratification, though further prospective studies are necessary for broader validation.

KEYWORDS: Colorectal cancer, mortality risk, postoperative complications, prediction model, Jordan.

INTRODUCTION

Colorectal cancer is the third most common cancer in both sexes with an increasing incidence in developing countries.[1] In Jordan, it is the second most common cancer presenting in younger ages and its incidence rate been increasing over the last decade.[2] The mainstay treatment for CRC is surgical removal and can be either performed laparoscopically or through open resection with the choice being based on several factors such as tumor location and metastatic disease.[3] Several postoperative complications have been reported after CRC surgery, which can substantially contribute to increased morbidity, extended hospital stays, and even mortality.[4]

Postoperative complications after CRC surgery can be serious such as bleeding, leakage, anastomosis, and wound infection, and are often influenced by factors like abdominal adhesions, anatomical complexity, and the surgeon's skill.[4,5] In addition, there is often a delay in starting adjuvant chemotherapy if postoperative complications occurs.[6]

Prediction models have been used in cancer research to assist estimating treatment outcomes prior to treatment initiation. Accurate individual risk estimation for postoperative outcomes in CRC surgery are of such interest and focus to create a personalized approach, enhance preoperative counseling, and lead to better outcomes through improved decision-making.[7]

The factors influencing long-term survival and recurrence following curative resection for CRC remain unclear. Therefore, the objective of this study is to develop and validate a risk prediction model for postoperative outcomes and complications in Jordanian CRC patients. The model aim at utilizing preoperative and clinical characteristics to accurately assess the risk of postoperative pain, wound infection, and other complications, thus enhancing preoperative risk stratification and improving patient outcomes in CRC surgeries.

METHODS

Study design

We carried out a single-center, retrospective comparative study at King Hussien Medical Center (KHMC) in Jordan between the period of May 2014 to April 2024. Patients with non-metastatic locally advanced CRC were included. The primary outcome was to develop a predictive model for the postoperative outcomes such as pain, wound infections, and complications following CRC resection.

Patients' data were retrieved retrospectively by accessing the hospital records between the period May 2014 to April 2024. Demographic and clinical data included the following variables: hospital ID, national ID, age, gender, body mass index (BMI), smoking history, mode of surgery (laparoscopic, or open resection), tumor grade, duration of hospital stay in days, and postoperative outcomes.

Ethical Approval

This study was approved by the Institutional Review Board at King Hussein Medical Center. As a retrospective study utilizing de-identified data from existing medical records, the requirement for informed consent was waived in compliance with the Declaration of Helsinki. All procedures followed applicable ethical standards and institutional guidelines.

Statistical analysis

Continuous data was as mean (standard deviation) and analyzed using the student's t-test for normally distributed variables, while median (range) and the Wilcoxon rank-sum test was used for variables not normally distributed. Categorical data was reported as frequencies and percentages and analyzed with the Chi-square test. A logistic regression model was developed to assess the relationship between study variables and postoperative outcomes. Predictive value and model performance was evaluated using area under receiver operating characteristics curve (AUC/ROC), accuracy score, sensitivity, and specificity. A P-value of <0.05 will be considered statistically significant. All analyses will be conducted using R statistical software.

RESULTS

A total of 568 patients with CRC were included with a mean age of 58.0 (14.0) years, mean BMI of 27.5 (5.3) kg/m^2. There was a slight male predominance accounting for 55% of sample, and the majority of patients were non-smokers (89%). Laparoscopic resection was performed in 275 (48%) of patients, 270 (48%) had open resection, and 23 (4%) had laparoscopy but converted to open surgery. The majority of patients had 461 (81%) moderately differentiated tumors, 48 (8.5%) had IMDA, 31 (5.5%) had poorly differentiated tumors, and 28 (4.9%) had well differentiated tumors. The mean length of hospitalization period was 4.31 (3.22) days, 57 (10%) patients had postoperative complications, 24 (4.2%) had postoperative pain, and 17 (3.0%) patients had postoperative wound infection (**Table 1**).

Logistic regression model for the prediction of postoperative pain showed a significant association with preoperative BMI, in which higher BMI was associated with higher frequency of postoperative pain (OR: 1.47, 95% CI: 1.27-1.70, p-value <0.001) as shown in **Table 2**. The model predicted postoperative pain with 96.7% accuracy, AUC of 0.93, high specificity of 100%, but low sensitivity of 33.3% (**Table 5**). For postoperative wound infection, the logistic regression model showed no significant associations with study's variables (**Table 3**) but was able to predict postoperative wound infection with 97.5% accuracy, AUC of 0.794, high specificity of 100%, but no sensitivity (**Table 5**). There was a significant association between longer hospital stay and higher frequency of postoperative complications (OR: 1.12, 95% CI: 1.02-1.23, p-value = 0.014) as shown in **Table 4**. The model was able to predict postoperative complications with high accuracy of 91.1%, an AUC of 0.738, high specificity of 99.7%, but was not sensitive (**Table 5**).

Table 1: Demographic and clinical characteristics of included patients.

Characteristic	**N = 568**
Gender, n (%)	
Female	257 (45%)
Male	311 (55%)
Age (Years), Mean (SD)	58 (14)
BMI (kg/m^2), Mean (SD)	27.5 (5.3)
Smoking, n (%)	
Non-Smoker	506 (89%)
Smoker	62 (11%)
Type of surgery, n (%)	
Lap Converted to Open	23 (4.0%)

Laparoscopy	275 (48%)
Open	270 (48%)
Tumor grade, n (%)	
IMDA	48 (8.5%)
Moderately differentiated	461 (81%)
Poorly differentiated	31 (5.5%)
Well differentiated	28 (4.9%)
Hospital stay (Days), Mean (SD)	4.31 (3.22)
Postoperative complications, n (%)	57 (10%)
Wound infection, n (%)	17 (3.0%)
Stoma, n (%)	196 (35%)

Table 2: Logistic regression model for the prediction of postoperative pain.

Predictor	Odds ratio	Lower	Upper	p-value
Gender:				
Female – Male	2.50	0.73	8.55	0.145
Age	1.03	0.99	1.08	0.18
BMI	1.47	1.27	1.70	**<0.001**
Smoking:				
Non-smoker – Smoker	0.27	0.05	1.55	0.142
Stoma:				
Yes – No	0.87	0.22	3.46	0.843
Mode of surgery:				
Laparoscopy – Open	0.40	0.12	1.35	0.141
Tumor grade:				
IMDA – Moderately differentiated	0.13	0.00	4.59	0.261
Well differentiated – Moderately differentiated	0.72	0.04	13.64	0.826
Poorly differentiated – Moderately differentiated	0.00	0.00	0.00	0.991
Hospital stay (days)	0.91	0.70	1.18	0.467

Table 3: Logistic regression model for the prediction of postoperative wound infection.

Predictor	Odds ratio	Lower	Upper	p-value
Gender:				
Female – Male	1.423	0.401	5.045	0.585
Age	0.98614	0.943	1.032	0.545
BMI	1.05601	0.948	1.177	0.324
Smoking:				
Non-smoker – Smoker	1.25023	0.141	11.124	0.841
Stoma:				
Yes – No	2.85371	0.769	10.595	0.117
Mode of surgery:				
Laparoscopy – Open	2.70681	0.65	11.28	0.171
Tumor grade:				
IMDA – Moderately differentiated	0	0	0	0.993
Well-differentiated – Moderately differentiated	0	0	0	0.996
Poorly differentiated – Moderately differentiated	0	0	0	0.994
Hospital stay (days)	1.10183	0.968	1.254	0.141

Table 4: Logistic regression model for the prediction of postoperative complications.

Predictor	Odds ratio	Lower	Upper	p-value
Gender:				
Female – Male	0.4941	0.22856	1.068	0.073
Age	1.009	0.98342	1.035	0.494
BMI	1.0309	0.96536	1.101	0.364
Smoking:				
Non-smoker – Smoker	0.838	0.32408	2.167	0.715
Stoma:				
Yes – No	0.5613	0.22843	1.379	0.208

Mode of surgery:				
Laparoscopy – Open	1.3483	0.62922	2.889	0.442
Tumor grade:				
IMDA – Moderately differentiated	0.274	0.0358	2.098	0.213
Well-differentiated – Moderately differentiated	0	0	0	0.994
Poorly differentiated – Moderately differentiated	0	0	0	0.99
Hospital stay (days)	1.1205	1.0231	1.227	**0.014**

Table 5: Predictive evaluation of logistic regression models.

Model	AUC	Accuracy	Sensitivity	Specificity
Postoperative pain	0.93	0.968	0.333	1.00
Postoperative wound infection	0.794	0.975	0.00	1.00
Postoperative complications	0.738	0.911	0.03	0.997

DISCUSSION

Colorectal cancer (CRC) is the second most common cancer in Jordan, with increasing incidence in younger populations. Surgical resection, either laparoscopic or open, is the main treatment.[2,8] Therefore, we aimed to develop a prediction model for the postoperative outcomes in Jordanian CRC patients following resection. Our findings showed that 10% of patients had postoperative complications, and postoperative pain and wound infection rates were 4.2%, and 3.0% respectively. The overall rate of postoperative complications was 10%, and our results suggest that higher BMI and longer hospital duration may increase the likelihood of prolonged recovery and higher risk of postoperative complications.

The model demonstrated that higher preoperative BMI significantly increased the likelihood of postoperative pain. The model predicting postoperative pain showed excellent overall accuracy (96.7%) and a high area under the curve (AUC) of 0.93, indicating strong predictive power. However, while the model had perfect specificity, its sensitivity was low. Although BMI has been frequently utilized in colorectal cancer screening and risk assessment as a quantitative measure of weight, its influence on clinical management strategies for CRC has been largely overlooked.[9] In addition, BMI also plays a detrimental role in the choice of surgical operation, in which patients with high BMI, are more likely to transition from laparoscopic to open surgery, leading to a higher incidence of surgical complications.[10]

While our models did not reveal any significant association between smoking and higher postoperative complication risks, it has been demonstrated in previous studies that smoking is a risk factor of CRC incidence, progression, and surgical prognosis. It has been shown that smoking is associated with higher incidence of leakage, which could be attributed to the smoking-related ischemia and microthrombosis.[11,12] For the prediction of postoperative wound infection, the model did not find any significant associations between the study's variables and wound infection, however, the model was still able to predict postoperative wound infection with 97.5% accuracy and an AUC of 0.794, reflecting moderate predictive ability. In a meta-analysis by Jia et al. showed that preoperative BMI, hypoalbuminemia, DM, and longer surgical duration were significantly associated with higher risk of postoperative wound infections.[13]

Our study has several strong points. First, we included a large sample size of 568 patients, which provides robust data to evaluate postoperative in colon cancer surgery. Second, we provided insights from real-world clinical data from a single, well-established institution (King Hussein Medical Center), ensuring consistency in surgical practices and patient care. Additionally, we uniquely addressed the impact of preoperative factors in the context of postoperative recovery and complications. This focus provides valuable insights into the role of patients' characteristics in recovery after colorectal cancer surgery. However, there are some limitations to the study. First, the retrospective design limits the ability to establish causality between variables and outcomes. Additionally, the single-center nature of the study may also reduce the generalizability of the findings, as practices and outcomes may differ in other healthcare settings. Another limitation is that we were not able to evaluate the long-term outcomes such as quality of life, which would provide a more comprehensive understanding. Future prospective studies are needed to confirm these findings and explore causal relationships between patients' characteristics and postoperative outcomes. In addition, studies that include data on long-term outcomes, such as quality of life, would be valuable for patients and healthcare providers making decisions about surgical management. Furthermore, multicenter studies could help validate the results across different settings and populations. Investigating the role of neoadjuvant chemotherapy and other treatment modalities in postoperative leakage rate and postoperative recovery would also be beneficial in refining clinical strategies.

In this study, we successfully developed a predictive model for postoperative outcomes in Jordanian patients undergoing colorectal cancer resection. Higher preoperative BMI and longer hospital stays were significant predictors of postoperative pain and complications, respectively. Although no significant associations were found between study variables and postoperative wound infections, the model demonstrated

high accuracy in predicting both pain and infection. Our findings highlight the importance of preoperative risk stratification, particularly considering BMI, to improve patient outcomes in CRC surgeries. Further prospective and multicenter studies are needed to validate these results and explore long-term outcomes.

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