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ORIGINAL RESEARCH

Early Postoperative Complications in Colorectal Cancer Patients Following Colorectal Surgery Among Yemeni Patients: A Prospective Study

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Purpose: This prospective study aimed to investigate the early outcomes of colorectal surgery in patients with colorectal cancer and determine their relationships with specific risk factors and comorbidities.

Patients and Methods: This study was conducted at AL-Thawra Modern General Hospital and Kuwait University Hospital in Sana'a, Yemen, from January 2021 to December 2022. All consecutive patients who underwent surgical intervention for colorectal cancer were included. Data on patient demographics, comorbidities, tumor characteristics, surgical procedures, and postoperative outcomes were collected.

Results: A total of 73 patients, with a mean age of 52.5 years (SD = 14.3), were included in the study. Among the patients, 44 (60.3%) were male, and 29 (39.7%) were female. The most frequent complication observed was surgical site infection, which occurred in 13 (17.8%) patients, primarily as superficial infections in 11 (15.1%) patients. Other local complications included wound dehiscence, anastomotic leakage, paralytic ileus, and abdominal sepsis. Systemic complications, such as pneumonia, deep vein thrombosis, acute myocardial infarction, and urinary tract infection, were observed in 9 patients. Significant associations were found between the development of early postoperative complications and various factors. Patients aged 65 years and above had a greater rate of complications than did those aged younger than 65 years (55% vs 22.6%, p value = 0.008). Furthermore, the presence of diabetes mellitus and low serum ALB levels (<35 g/L) were associated with increased complication rates (60% vs 24.1%, p value = 0.01 and 42.9% vs 8.3%, p value = 0.02, respectively).

Conclusion: Our study demonstrated favorable outcomes with no mortality and a comparable complication rate to other studies, despite the smaller sample size. The significant associations between postoperative complications, advanced age, diabetes mellitus, and low serum ALB levels highlight the importance of a multidisciplinary approach to enhancing overall patient outcomes.

Plain Language Summary: This study examined the outcomes of surgery for colorectal cancer in Yemeni patients and examined factors that could affect these outcomes. The researchers studied 73 patients who underwent surgery for colorectal cancer. The average age of the patients was 52.5 years, and there were slightly more male patients than female patients. The most common complication after surgery was infection at the surgical site, which affected 17.8% of patients. Other complications included problems with wound healing, leakage at the surgical connection, difficulty with bowel movement, and infection in the abdomen. A small number of patients also experienced complications in other parts of their body, such as pneumonia, blood clots, heart attack, and urinary tract infection.

The study revealed that older patients aged 65 years and older had a greater risk of complications than younger patients. Patients with diabetes and low levels of a protein called albumin in their blood were also more likely to have complications after surgery.

In conclusion, this study showed that surgery for colorectal cancer in Yemeni patients had overall good outcomes, with no deaths reported. However, older age, diabetes, and low ALB levels were identified as risk factors for complications. The findings highlight the importance of a team approach to healthcare to improve outcomes, especially for older patients and those with diabetes or low albumin levels. This information can help healthcare providers in Yemen better care for patients undergoing colorectal cancer surgery and reduce the risk of complications.

Received: 18 April 2024
Accepted: 19 June 2024
Published: 26 June 2024

Keywords: colorectal cancer, surgical resection, operative complications, morbidity, mortality, Yemen

Introduction

In developed countries and various regions of Asia, colorectal cancer is the second most prevalent form of cancer and is the predominant malignancy affecting the gastrointestinal tract.[1,2] The incidence rates have shown consistency over the past two decades, with similar incidences in both men and women.[3] However, there has been a tenfold increase in mortality rates from colorectal cancer over the last half-century.[4,5]

Colorectal cancer ranks as the most common cancer among Yemeni men and is the third most common malignancy in Yemen overall.[6]

The cornerstone of treatment for nonmetastatic colorectal cancer is surgical resection, a procedure necessary for approximately 90% of colon cancer patients and often performed with curative intent.[7,8] Surgical resection is recommended for patients with confirmed adenocarcinoma of the colon without distant metastasis or contraindications to major surgery. Treatment approaches are tailored based on cancer stage and type.[9] Despite advancements in surgical techniques, bowel preparation protocols, antibiotic use, and postoperative care, colorectal surgery still has a mortality rate of 3–6% and a morbidity rate of 20%–40%.[8,10]

Colorectal cancer predominantly affects the elderly population, with only a small percentage occurring in individuals under 40 years old.[11,12] Enhancing early postoperative outcomes for colorectal cancer patients involves identifying risk factors and providing optimal preoperative care.[13]

Complications arising from colorectal surgery can be classified into two categories: intraoperative and postoperative. Intraoperative complications encompass issues like bleeding, as well as injuries to the bowel or urinary tract. These complications are influenced by factors such as abdominal adhesions, anatomical challenges, and the expertise of the surgeon. On the other hand, major postoperative complications include wound infections, anastomotic leaks, ileus, and bleeding.[1,5] Among these, surgical site infection (SSI) stands out as the most prevalent postoperative complication following colorectal surgery. SSI not only causes significant pain and suffering for patients but is also associated with negative economic consequences, increased morbidity, prolonged hospital stays, readmissions, sepsis, and even mortality.[14,15]

Recent research has highlighted various risk factors impacting intra- and postoperative complications in colorectal surgery. Factors such as age, nutritional status, surgeon experience, bowel preparation, center volume, Enhanced Recovery After Surgery (ERAS) application, fluid management during surgery, and type of regional analgesia have been identified as significant contributors to complications.[16–21]

Given that colorectal cancer ranks third in Yemen and that limited data exist on surgical management in this region, our study aimed to outline the characteristics of surgically treated colorectal cancer patients. We seek to identify prevalent risk factors for operative complications and thoroughly analyze morbidity and mortality rates compared to existing studies to enhance our understanding of current surgical practices and facilitate improvements in patient care planning.

Materials and Methods

Study Design

This was a prospective descriptive study conducted at AL-Thawra Modern General Hospital (TMGH) and AL-Kuwait University Hospital (KUH) in Sana'a city, Yemen. This study aimed to investigate early complications following colorectal surgery among patients with colorectal cancer and their associations with risk factors and comorbidities.

Study Participants

A total of 73 patients who underwent laparotomy for colorectal cancer were included in this study. The inclusion criteria were patients who were diagnosed with colorectal cancer and who underwent open surgery at the TMGH or KUH between January 2021 and December 2022. The exclusion criteria included secondary colorectal cancer, colorectal lymphoma, anal cancer, laparoscopic operations for colorectal cancer, and secondary interventions for colorectal cancer.

Data Collection

Data collection involved gathering comprehensive information on patients and their surgical outcomes using a standardized data collection form. These data included demographic and clinical details, symptom presentations, tumor characteristics, surgical procedures performed, and postoperative complications.

Surgical Technique and Perioperative Management

All operations were performed by experienced oncologic surgeons at two major teaching hospitals in Sana'a, Yemen. Prior to elective surgery (n=46), cases underwent preoperative optimization, including nutritional support, management of comorbidities, and mechanical bowel preparation. In contrast, emergency cases (n=27) required immediate resuscitation and stabilization of vital signs, with efforts made to correct fluid and electrolyte imbalances as needed. All cases received preoperative antibiotic prophylaxis on call to surgery.

Surgical procedures were performed via an open approach for all cases under general anesthesia, utilizing a standard midline incision to facilitate optimal abdominal exposure. The tumor and corresponding colonic segment were resected in all cases using standard oncologic techniques to ensure adequate lymph node harvest. Primary anastomosis was performed in 40 elective cases (13 stapled and 27 hand-sewn anastomoses); in the remaining 33 cases, primary anastomosis was not performed. A stoma was created in 43 cases: all emergency cases (n=27), 6 elective cases as palliative procedures without resection, and 10 elective cases with proximal diversion to protect the anastomosis. Intraoperative fluid management involved crystalloid infusion at 500 mL/hr in all elective cases, while fluid administration in emergency cases was guided by the patient's clinical and vital sign status.

Postoperatively, analgesia was achieved using a multimodal approach, including narcotics and non-steroidal anti-inflammatory medications as necessary. Epidural or regional anesthetic techniques were not employed. While a formal Enhanced Recovery After Surgery (ERAS) protocol was not implemented, however standard fast-track surgery principles were followed to the extent possible in all cases. This included early mobility, the judicious use of intravenous fluids, and the prompt removal of drains and urinary catheters. Oral nutrition was initiated as soon as possible after the return of bowel function.

Outcome Measures

The primary outcome measures for the study included mortality rate and postoperative complications. The secondary outcome measures to determine the impact of demographic characteristics, comorbidities, tumor characteristics, type of surgical intervention on surgical outcomes in terms of early postoperative complications.

Statistical Analysis

Data were analyzed using SPSS version 26. The results are reported as percentages, means and standard deviations, or medians and ranges, depending on the nature of the variables. To compare quantitative variables, Student's *t*-test was used, while the chi-square test (Pearson's or Fisher's exact) was used for comparing qualitative variables. In cases where the distribution of the samples was abnormal, the Mann–Whitney *U*-test was used, as confirmed by the Kolmogorov–Smirnov test. A significance level of $p < 0.05$ was considered to indicate statistical significance.

Ethical Considerations

This study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki. Ethical approval was obtained from the TMGH and KUH review boards. Informed consent was obtained from all participants before their inclusion in the study.

Results

A total of 73 patients (60.3% male, 39.7% female) with a median age of 53 years participated in the study. Among them, 20.5% were smokers, 26% were qat chewers, and 18.2% engaged in both habits. Comorbidities included diabetes (17.8%), hypertension (9.6%), neoadjuvant chemotherapy (12.3%), neoadjuvant radiotherapy (1.4%), and ischemic heart disease (1.4%) (Table 1).

Table 1 The Distribution of Patients by Special Habits and Comorbidities (n=73)

Special Habit and Comorbidity	Frequency	Percent
Smoker	15	20.5
Qat chewing	19	26
Hypertension	7	9.6
Ischemic heart disease	1	1.4
Diabetes mellitus	13	17.8
Neoadjuvant chemotherapy	9	12.3

Tumor locations were as follows: left colon (65.8%), right colon (19.2%), and rectum (15.1%). All patients had adenocarcinoma. Elective surgery was performed in 63% of patients, while emergency surgery was performed in 37% (Table 2). Resection was carried out in 72.6% of patients, with various types of resections performed. Anastomosis was performed in 54.8% of patients (Table 3).

During the 30-day postoperative period, there were no reported mortalities. Early postoperative complications occurred in 31.5% of patients, with surgical site infection (17.8%) being the most common. Other local complications included wound dehiscence (4.1%), anastomotic leakage (2.7%), paralytic ileus (4.1%), and abdominal sepsis (2.7%). Systemic complications occurred in 12.6% of patients, including pneumonia (4.1%), deep vein thrombosis (4.1%), acute

Table 2 The Distribution of Patients by Mode of Presentation

Mode of Presentation	Frequency	Percent
Elective	46	63.0
Emergency	27	37.0
Total	**73**	**100.0**

Table 3 The Distribution of Patients by the Type of Surgical Resection

Surgical Resection	Frequency	Percent
No surgical resection	20	27.4
Right hemicolectomy	8	11.0
Extended right hemicolectomy	6	8.2
Left hemicolectomy	28	38.4
LAR	9	12.3
APR	1	1.4
Total or subtotal colectomy	1	1.4
Total	**73**	**100%**

Abbreviations: LAR, lower anterior resection; APR, Abdominoperineal resection.

myocardial infarction (2.7%), and urinary tract infection (1.4%). Two patients (2.8%) experienced both local and systemic complications (Table 4).

Significant relationships were found between the development of early postoperative complications and age (65 years and above), diabetes mellitus, and low serum albumin levels (less than 35 g/L). However, no significant relationships were found with other variables examined in the study (Table 5). In the binary logistic regression model, patient age ($p = 0.023$) and albumin levels ($p = 0.002$) emerged as independent predictors of postoperative complications following colorectal cancer surgery. Specifically, for every additional year of age, the odds of complications increased by 5.9% (OR 1.059). Conversely, higher albumin levels were protective, with a 30.5% reduction in complication odds for every unit increase in albumin (OR 0.695). While there was a trend towards increased complication risk in patients with diabetes (OR 4.015), this factor did not reach statistical significance ($p = 0.058$) when controlling for age and albumin (Table 6).

Table 4 The Distribution of Patients According to Postoperative Complications (n=24)

Postoperative Complication	Frequency	Percent
Superficial incisional SSI	11	15.1
Deep incisional SSI	2	2.7
Wound dehiscence	3	4.1
Anastomotic leak	2	2.7
Abdominal sepsis or Abscess	2	2.7
Paralytic ileus	3	4.1
UTI	1	1.4
Pneumonia	3	4.1
MI	2	2.7
DVT	3	4.1

Abbreviations: SSI, surgical site infection; UTI, urinary tract infection; MI, myocardial infarction; DVT, deep venous thrombosis.

Table 5 Association of Related Variables with the Development of Early Postoperative Complications According to Univariate Analysis

Variables		Complications		p value
		No	Yes	
Gender	Male	32	12	0.337
	Female	18	11	
Age [Years]	< 65	41	12	0.008*
	≥65	9	11	
Smoking	Yes	9	6	0.309
Qat Chewing	Yes	11	8	0.191
HTN	Yes	4	3	0.385
IHD	Yes	0	1	0.315

(*Continued*)

Table 5 (Continued).

Variables		Complications		p value
		No	Yes	
DM	Yes	6	9	0.008*
Neoadjuvant Chemotherapy	Yes	4	5	0.104
Neoadjuvant Radiotherapy	Yes	0	1	0.315
Presentation	Elective	28	18	0.067
	Emergency	22	5	
Albumin [g/L]	< 35	28	21	0.002*
	≥35	22	2	
Site of tumor	Right colon	11	3	0.638
	Left colon	32	16	
	Rectum	7	4	
Type Anastomosis	Hand sewn	19	8	0.305
	Stapler	7	6	
Stoma formation	Yes	32	11	0.192
Anastomosis	Yes	26	14	0.479

Note: *Significant p value < 0.05.

Table 6 Association Between Variables and Postoperative Complications by Binary Regression

Variable	p-value	Odds Ratio	95% CI
Age	0.023*	1.059	1.008 −1.113
DM	0.058	4.015	0.955–16.879
Albumin level	0.002*	0.695	0.552–0.876

Note: *Significant p value < 0.05.
Abbreviation: Diabetes mellitus, DM.

Discussion

The diagnosis of colorectal cancer (CRC) has seen significant advancements in recent years, thanks to developments in deep learning and the Internet of Things (IoT). Deep learning algorithms have shown great promise in improving the accuracy and efficiency of CRC detection by analyzing histopathology images.[22,23] These algorithms can be trained on large datasets of images to learn patterns and features indicative of cancer, allowing for automated classification and diagnosis. Implementing these algorithms in clinical practice could revolutionize the way CRC is diagnosed, potentially leading to earlier detection and better patient outcomes.

On the other hand, the Introduction of the IoT concept within surgical practice has also brought about transformative changes.[24] IoT devices and sensors can provide real-time data during surgeries, enhancing the precision and safety of procedures. For example, IoT-enabled surgical instruments can offer real-time feedback on tissue properties, helping surgeons to identify and remove cancerous tissue while preserving healthy tissue more accurately. Additionally, IoT systems can analyze data from past surgeries to provide insights that improve future procedures. The integration of IoT

technology with deep learning algorithms could further enhance the diagnosis and treatment of CRC, creating a more personalized and effective approach to patient care.

In this prospective study enrolled a total of 73 patients from the TMGH and KUH who underwent open surgery for colorectal cancer. This study aimed to assess the outcomes of colorectal cancer surgery in these two tertiary hospitals in Yemen. Although the study's strength lies in its prospective design and inclusion of all eligible patients, the small number of patients due to the short study period remains a major limitation.

In our study, the absence of mortality within 30 days postoperatively contrasts with findings from other studies, such as the study by Khan showing a 1.6% mortality rate. This discrepancy can be attributed to factors such as the smaller sample size and the inclusion of patients over a two-year period, as well as the predominance of elective patients with thorough preoperative preparation, leading to improved outcomes.[13,25–27]

The 30-day mortality rate after colorectal surgery may not fully capture the true risk of death following the operation. Mortality rates at 90 days have been suggested to provide a more accurate representation of postoperative mortality, especially considering that a significant number of deaths occur beyond the initial 30-day period.[28] Therefore, when discussing operative risks with patients, it is essential to consider longer-term mortality data to provide a more comprehensive understanding of potential outcomes.

The incidence rate of early postoperative complications in our study was 31.5%, which is comparable to most published data.[10,13,25,29] Khan et al reported a 34.8% complication rate, while other studies by Wang et al and Oack et al reported lower rates of 19.7% and 16.9%, respectively.[13,30] The most common postoperative complication in our study was surgical site infection (SSI), which aligns with previous research.[31] However, it is worth noting that our hospitals lacked an ongoing surveillance system for SSI, which may have affected the identification and management of such complications, as reported in a previous study in Pakistan.[32]

The average age of the patients in our study was 52 years, with the majority being younger than 65 years. This age group was younger than that in other studies.[33–35] The higher prevalence of Qat chewing habits in Yemen, lifestyle factors, spicy food consumption, and a lower fiber diet may contribute to the relatively young age of patients. Genetic factors may also play a role, although further research is needed to explore this aspect. We found a statistically significant relationship between advancing age and an increased risk of complications (p value = 0.008). Older patients often have multiple comorbid diseases, requiring a multidisciplinary team approach that may not be well maintained in our hospitals.[25,36]

Smoking, which is associated with various hazards and may contribute to postoperative complications such as wound infections and impaired wound healing, was observed in 20% of patients. Additionally, Qat chewing, a common social habit in Yemen found in 26% of our patients, could increase the risk of developing colorectal cancer due to the use of illegal agricultural pesticides.

Our study revealed a lower incidence of comorbidities than other studies, with only 17.8% of patients having diabetes, 9.6% having hypertension, and 1.4% having a history of ischemic heart disease.[37] This can be attributed to the younger age group of our patients. While many studies have not shown a significant relationship between comorbidities and postoperative complications, other studies have found a significant association between hypertension and diabetes and an increased risk of complications.[28,32] In our study, we found a statistically significant relationship between diabetes and postoperative complications, with diabetic patients experiencing complications in 42.9% of patients and nondiabetic patients experiencing complications in 8.3% of patients (p value = 0.02). This can be attributed to poor diabetic control among our patients.

Neoadjuvant chemotherapy was administered to 9 patients in our study, and neoadjuvant radiotherapy was given to 1 patient. However, we did not find a significant relationship between neoadjuvant therapy and postoperative complications, possibly due to the specific protocol followed at our institute, which delayed operative intervention after neoadjuvant treatment.

Low serum ALB levels were evaluated as a marker of nutritional status in our study. We found a significant relationship between low preoperative serum ALB levels and postoperative complications. Sixty percent of patients with low serum ALB levels developed complications, compared to 24.1% of patients with serum ALB levels above 35 g/

dl (p value = 0.01). This finding is consistent with previous studies indicating that low serum ALB levels correlate with a greater risk of complications.[13]

Our study revealed a greater prevalence of left colon tumors than right colon tumors. This may be because our study focused on patients who underwent open surgery, while patients with right colon cancer often present with advanced disease and are not amenable to surgical interventions[29,37,38] We did not find a statistically significant relationship between tumor location and postoperative complications. Additionally, there was no significant association between the mode of presentation (elective vs emergency) and postoperative complications. This can be explained by the fact that diversion stoma was only performed in emergency cases in our study, limiting the impact of emergency presentations on postoperative outcomes.[39]

Our finding of no significant difference between hand-sewn and stapled anastomosis in terms of postoperative complications aligns well with the current literature. Studies have not consistently demonstrated a clear advantage of either technique in reducing postoperative complications, particularly anastomotic leakage.[16,28,40] Therefore, the choice between hand-sewing and stapling anastomoses appears to be largely dependent upon the surgeon's preference and skill level rather than directly influencing postoperative outcomes. In addition, a systematic review concluded that neither hand-sewn nor stapled anastomoses resulted in differences in anastomotic leakage rates. Additionally, a meta-analysis published in 2018 revealed no difference in anastomotic leakage rates between the two techniques.[41]

Several limitations should be considered when interpreting the Results of our study. First, the small sample size and short study period limit the generalizability of our findings. A larger sample size and longer follow-up period would provide a more comprehensive understanding of the outcomes of colorectal cancer surgery in our setting. Second, the absence of a standardized surveillance system for postoperative complications, such as surgical site infections, may have led to underreporting and suboptimal management of such complications. Implementing a robust surveillance system would improve the accuracy of complication rates and facilitate timely interventions. Third, our study primarily focused on elective cases and did not extensively evaluate emergency presentations. This may have influenced the overall incidence of complications and limited our ability to assess the impact of emergency surgery on outcomes. Fourth, the exclusive inclusion of open surgical cases, due to the limited availability of laparoscopic surgery at our facility, may not reflect the practices in settings where minimally invasive techniques are more prevalent. Fifth, the lack of accurate preoperative (cTNM) and postoperative (pTNM) cancer staging, including the prognostic AJCC stage, due to incomplete and non-standardized histopathological reporting, precluded us from assessing the effect of cancer stage on postoperative complications. Lastly, the lack of long-term follow-up data restricts our ability to assess oncological outcomes and survival rates. Future studies should incorporate long-term follow-up and strive to overcome these challenges to provide a more comprehensive evaluation of the effectiveness of colorectal cancer surgery.

Despite the aforementioned limitations, our study contributes to the understanding of colorectal cancer surgery outcomes at the TMGH and KUH. The absence of mortality within the 30-day postoperative period highlights the success of elective surgery in our setting, although caution should be exercised in generalizing these findings due to the small sample size. The high incidence of postoperative complications, particularly surgical site infections, emphasizes the need for implementing a standardized surveillance system and improving infection control measures. This would enable early detection and appropriate management of complications, ultimately improving patient outcomes. The significant associations between advanced age, diabetes, and low serum ALB levels and postoperative complications underscore the importance of comprehensive preoperative assessment and patient training. Multidisciplinary collaboration and personalized care plans should be implemented to address comorbidities, nutritional status, and age-related factors, thereby reducing the risk of complications. Future research should focus on expanding the sample size, extending the study period, and incorporating long-term follow-up to provide a more robust evaluation of colorectal cancer surgery outcomes. Additionally, investigating the impact of neoadjuvant therapy protocols and the implementation of enhanced recovery after surgery (ERAS) programs may further optimize patient outcomes in our setting.

Conclusion

In Conclusion, our study yielded good outcome results with no mortality and a complication rate comparable to that of other studies, despite our smaller sample size. However, we did observe a significant increase in postoperative

complications with advanced age and the presence of diabetes mellitus and low serum ALB levels. These findings underscore the importance of a multidisciplinary team approach to improve overall outcomes and reduce complications in colorectal surgery.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Acknowledgment

This paper has been uploaded to Research Square Server as a preprint version, posted on 28 Feb 2024: https://doi.org/10.21203/rs.3.rs-3995106/v1.

Disclosure

The authors report no conflicts of interest in this work.

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