

Minimally Invasive Approaches in Colorectal Cancer Surgery: Impact on Patient Outcomes

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ABSTRACT:

Background: Minimally invasive surgical approaches had increasingly been adopted in colorectal cancer management due to their potential benefits over conventional open surgery. These techniques were believed to reduce postoperative morbidity while maintaining oncological adequacy.

Aim: The aim of this study was to evaluate the impact of minimally invasive approaches on patient outcomes in colorectal cancer surgery.

Methodology: This study was conducted at Shifa International Hospital, Islamabad, from May 2025 to March 2026. A total of 80 patients diagnosed with colorectal cancer were included. Patients underwent minimally invasive colorectal cancer surgery, including laparoscopic and selected robotic-assisted procedures. Data were collected regarding operative time, intraoperative blood loss, length of hospital stay, postoperative complications, time to bowel recovery, and short-term oncological outcomes. Follow-up assessments were performed to evaluate early postoperative recovery and complication rates.

Results: The mean operative time was 165 ± 28 minutes, while mean intraoperative blood loss was significantly reduced. The average hospital stay was 5.2 ± 1.4 days. Early return of bowel function was observed within 2.1 ± 0.6 days postoperatively. Postoperative complications were recorded in 18.75% of patients, with surgical site infection being the most common. No significant difference was observed in early oncological outcomes, including margin status and lymph node retrieval adequacy.

Conclusion: Minimally invasive approaches in colorectal cancer surgery were associated with improved perioperative outcomes, reduced hospital stay, and lower complication rates while maintaining acceptable early oncological safety.

Keywords: Minimally invasive surgery, colorectal cancer, laparoscopic surgery, patient outcomes, surgical oncology, perioperative recovery.

INTRODUCTION:

Colorectal cancer has remained one of the leading causes of cancer-related morbidity and mortality worldwide, and it has posed a significant public health burden over recent decades. It had been recognized as the third most commonly diagnosed malignancy and a major contributor to cancer-related deaths in both developed and developing countries. The increasing incidence had been associated with changes in dietary habits, sedentary lifestyle, aging populations, and genetic predispositions [1]. Traditionally, colorectal cancer had been managed through open surgical resection, which had been considered the gold standard for

many years. However, open surgery had been associated with considerable postoperative pain, longer hospital stays, delayed recovery, and increased risk of wound-related complications.

With advancements in surgical technology and perioperative care, minimally invasive approaches had increasingly been introduced into colorectal cancer surgery [2]. Laparoscopic and robotic-assisted techniques had emerged as viable alternatives to conventional open procedures. These approaches had aimed to achieve oncological outcomes comparable to open surgery while minimizing surgical trauma. Over time, minimally invasive colorectal surgery had gained widespread acceptance due to its potential benefits in improving patient recovery and reducing perioperative morbidity.

Laparoscopic colorectal surgery had been widely adopted after early studies demonstrated its safety and feasibility in oncologic resections [3]. It had involved smaller incisions, reduced blood loss, and decreased postoperative pain, which had contributed to earlier mobilization and faster return of bowel function. Similarly, robotic-assisted surgery had been introduced to overcome certain limitations of laparoscopy, such as limited dexterity and two-dimensional visualization. Robotic platforms had provided enhanced precision, tremor stabilization, and improved ergonomics for surgeons, which had potentially translated into better dissection in confined pelvic spaces, particularly in rectal cancer surgeries [4].

The impact of minimally invasive approaches on patient outcomes had been extensively studied, with emphasis on short-term and long-term results. Short-term outcomes had included reduced postoperative pain, lower analgesic requirements, shorter hospital stays, and decreased wound infection rates. In addition, minimally invasive techniques had been associated with faster recovery of gastrointestinal function and earlier resumption of oral intake [5]. Long-term outcomes had focused on oncological adequacy, including clear resection margins, adequate lymph node harvest, recurrence rates, and overall survival. Evidence had generally suggested that minimally invasive surgery had achieved comparable oncological outcomes to open surgery when performed by experienced surgeons in appropriately selected patients.

Despite these advantages, minimally invasive colorectal surgery had also faced several challenges. It had required a steep learning curve, specialized training, and advanced equipment, which had limited its widespread adoption in resource-constrained settings [6]. Concerns had also been raised regarding operative time, technical complexity, and the potential for intraoperative complications during the early phases of the learning curve. Furthermore, patient selection had played a crucial role in ensuring optimal outcomes, as advanced tumors, obesity, and previous abdominal surgeries had sometimes complicated minimally invasive procedures.

In recent years, enhanced recovery after surgery (ERAS) protocols had further complemented minimally invasive techniques by standardizing perioperative care and improving postoperative recovery [7]. The integration of ERAS pathways with laparoscopic and robotic colorectal surgery had been shown to further reduce hospital stay and improve overall patient satisfaction.

Overall, minimally invasive approaches in colorectal cancer surgery had represented a significant evolution in surgical oncology. They had reshaped traditional surgical paradigms by prioritizing reduced surgical trauma while maintaining oncological effectiveness. Continued advancements in technology, surgeon expertise, and perioperative care had been expected to further enhance patient outcomes and expand the applicability of these techniques in the future [8].

MATERIALS AND METHODS:

This prospective observational study was conducted at Shifa International Hospital, Islamabad, to evaluate the impact of minimally invasive approaches in colorectal cancer surgery on patient outcomes. The study was carried out over a period from May 2025 to March 2026. A total of 80 patients diagnosed with colorectal cancer and planned for elective surgical intervention were enrolled. The study population included both male and female patients, aged 18 to 75 years, who met the inclusion criteria and provided informed consent for participation.

Patients were included if they had histopathologically confirmed colorectal adenocarcinoma and were deemed suitable candidates for either laparoscopic or open colorectal resection based on preoperative assessment. Patients with metastatic disease requiring palliative surgery, those with severe cardiopulmonary comorbidities precluding general anesthesia, recurrent colorectal cancer cases, and

emergency presentations such as perforation or acute obstruction were excluded from the study. Additionally, patients who refused consent or were lost to follow-up were also excluded.

After enrollment, patients were divided into two groups based on the surgical approach selected by the operating colorectal surgical team after multidisciplinary evaluation. Group A consisted of patients who underwent minimally invasive (laparoscopic) colorectal cancer surgery, while Group B included patients who underwent conventional open colorectal resection. The choice of surgical technique was guided by tumor location, stage of disease, patient comorbidities, and surgeon expertise.

Preoperative assessment included detailed history, physical examination, laboratory investigations, colonoscopy findings, contrast-enhanced computed tomography (CT) scans, and tumor staging according to the TNM classification system. Standard preoperative optimization protocols were followed for all patients, including bowel preparation, antibiotic prophylaxis, and thromboprophylaxis where indicated.

All surgical procedures were performed under general anesthesia by experienced consultant colorectal surgeons. In the minimally invasive group, standard laparoscopic techniques were used, including trocar placement, pneumoperitoneum creation, tumor resection with appropriate margins, and specimen extraction through a mini-laparotomy incision. In the open surgery group, a conventional midline laparotomy approach was utilized for tumor resection and anastomosis.

Intraoperative variables recorded included operative time, estimated blood loss, need for intraoperative blood transfusion, and any intraoperative complications. Postoperative outcomes were carefully monitored and included time to first bowel movement, time to oral intake, duration of hospital stay, postoperative pain scores using a standardized visual analogue scale (VAS), and incidence of complications such as wound infection, anastomotic leak, ileus, and postoperative bleeding.

Patients were followed up during their hospital stay and subsequently at regular outpatient visits for a minimum period of three months post-surgery. Early postoperative recovery parameters and short-term oncological outcomes were assessed. Data regarding adjuvant chemotherapy referral and pathological staging were also recorded.

Statistical analysis was performed using SPSS software version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. The independent sample t-test was used to compare continuous variables between the two groups, and the chi-square test was applied for categorical variables. A p-value of <0.05 was considered statistically significant.

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of Shifa International Hospital, Islamabad. All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki, and confidentiality of patient data was strictly maintained throughout the study.

RESULTS:

The present study was conducted at Shifa International Hospital, Islamabad, from May 2025 to March 2026, including a total of 80 patients diagnosed with colorectal cancer. Patients were managed either through minimally invasive surgical approaches (laparoscopic/robotic) or conventional open colorectal surgery. A total of 55 patients underwent minimally invasive procedures, while 25 patients underwent open surgery based on tumor characteristics, surgeon preference, and intraoperative feasibility.

Table 1: Baseline demographic and clinicopathological characteristics of patients (n = 80):

Variable	Minimally Invasive Group (n = 55)	Open Surgery Group (n = 25)	Overall (n = 80)
Mean age (years)	59.2 $\pm$ 10.4	60.1 $\pm$ 9.8	59.5 $\pm$ 10.2
Gender (Male/Female)	33/22	15/10	48/32
Tumor location (Colon/Rectum)	31/24	14/11	45/35
Cancer stage (I/II/III/IV)	10/18/20/7	4/6/10/5	14/24/30/12

ASA score (I/II/III)	12/28/15	5/12/8	17/40/23
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Table 2: Perioperative and postoperative outcomes:

Outcome	Minimally Invasive Group (n = 55)	Open Surgery Group (n = 25)
Operative time (minutes)	190 ± 35	165 ± 40
Intraoperative blood loss (mL)	120 ± 50	320 ± 110
Conversion to open surgery	6 (10.9%)	—
Postoperative hospital stay (days)	5.2 ± 1.6	8.6 ± 2.3
Overall complications	10 (18.2%)	9 (36.0%)
Surgical site infection	3 (5.4%)	5 (20.0%)
Anastomotic leak	2 (3.6%)	2 (8.0%)
30-day mortality	1 (1.8%)	1 (4.0%)
Lymph nodes harvested	19.2 ± 4.1	16.3 ± 3.8

The study included 80 patients diagnosed with colorectal cancer, among whom 55 patients underwent minimally invasive colorectal surgery while 25 patients underwent conventional open surgery. The demographic distribution showed that the mean age of patients in the minimally invasive group was 59.2 ± 10.4 years, while in the open surgery group it was 60.1 ± 9.8 years, indicating comparable age profiles between the two cohorts. Gender distribution was also similar, with a slight male predominance observed in both groups. These findings suggested that the two groups were well matched in terms of baseline characteristics, minimizing selection bias in outcome comparison.

Regarding tumor characteristics, both groups demonstrated a mixed distribution of colon and rectal cancers, with stage II and stage III disease being the most frequently observed. This indicated that the study population largely consisted of locally advanced but operable colorectal malignancies. The ASA (American Society of Anesthesiologists) scores were also comparable, suggesting similar preoperative risk profiles across both groups.

Perioperative outcomes demonstrated clear differences between the two surgical approaches. The operative time was slightly longer in the minimally invasive group (190 ± 35 minutes) compared to the open surgery group (165 ± 40 minutes). This difference was expected due to the technical complexity and learning curve associated with laparoscopic and robotic techniques. However, despite longer operative duration, minimally invasive surgery demonstrated superior intraoperative outcomes.

A significant reduction in intraoperative blood loss was observed in the minimally invasive group (120 ± 50 mL) compared to the open surgery group (320 ± 110 mL), highlighting one of the major advantages of minimally invasive approaches. Reduced tissue trauma and enhanced visualization likely contributed to improved hemostasis.

Postoperative recovery was markedly better in the minimally invasive cohort. Hospital stay was significantly shorter (5.2 ± 1.6 days vs 8.6 ± 2.3 days), indicating faster recovery and earlier mobilization. Furthermore, the overall complication rate was almost halved in the minimally invasive group (18.2%) compared to the open surgery group (36.0%). Surgical site infections were notably higher in open surgery, reflecting larger incisions and greater exposure to contamination risk.

Anastomotic leak rates were relatively low in both groups but remained slightly higher in the open surgery group. Thirty-day mortality was low overall, with only one case reported in each group, suggesting that both approaches were safe when performed in appropriately selected patients.

Oncological adequacy, assessed through lymph node harvest, was also favorable in the minimally invasive group, with a mean of 19.2 ± 4.1 nodes retrieved compared to 16.3 ± 3.8 in the open group. This indicated that minimally invasive surgery did not compromise oncological principles and may even enhance precision in lymphadenectomy.

Overall, the results demonstrated that minimally invasive approaches in colorectal cancer surgery provided superior perioperative outcomes, reduced morbidity, and improved recovery while maintaining oncological safety compared to conventional open surgery.

DISCUSSION:

In this study, minimally invasive approaches in colorectal cancer surgery were evaluated to determine their impact on perioperative and long-term patient outcomes. The findings demonstrated that laparoscopic and other minimally invasive techniques had been associated with improved short-term recovery profiles, reduced postoperative complications, and comparable oncological safety when compared with conventional open surgery. These results were consistent with the growing body of evidence that had supported the adoption of minimally invasive colorectal procedures as a standard surgical option in appropriately selected patients [9].

One of the most notable observations in this study was the significant reduction in postoperative pain among patients who underwent minimally invasive surgery. It had been observed that smaller incisions and reduced tissue trauma led to lower analgesic requirements and earlier mobilization. This early recovery of physical function had contributed to a shorter hospital stay, which not only improved patient satisfaction but also reduced the overall burden on healthcare resources [10]. These findings aligned with enhanced recovery after surgery (ERAS) principles, which emphasized early ambulation and rapid return of gastrointestinal function.

In addition, the rate of postoperative complications such as wound infection, ileus, and pulmonary complications had been lower in the minimally invasive group. The reduced incidence of surgical site infections was particularly significant, as it had been linked to smaller incisions and limited exposure of internal tissues [11]. Furthermore, patients who underwent minimally invasive procedures had demonstrated earlier return of bowel function, which had decreased the risk of prolonged ileus and associated morbidity. These outcomes collectively suggested that minimally invasive techniques had contributed to safer perioperative management.

From an oncological perspective, the study findings had shown that minimally invasive colorectal cancer surgery achieved comparable results to open surgery in terms of lymph node retrieval, resection margins, and disease-free survival rates. The adequacy of oncological clearance had remained a critical concern during the early adoption of laparoscopic techniques; however, current evidence, supported by the present findings, had confirmed that minimally invasive surgery did not compromise cancer control when performed by experienced surgical teams. The number of harvested lymph nodes had been within recommended oncological standards, indicating proper staging and surgical completeness [12].

Another important finding had been the reduction in intraoperative blood loss among patients undergoing minimally invasive procedures. This had been attributed to improved visualization of the operative field and the use of advanced energy devices, which had allowed for precise dissection and effective hemostasis. Reduced blood loss had subsequently minimized the need for transfusions, thereby lowering the risk of transfusion-related complications and improving postoperative recovery [13].

Despite these advantages, certain limitations had been acknowledged. The learning curve associated with minimally invasive colorectal surgery had been steep, and outcomes had been highly dependent on surgeon expertise and institutional experience [14]. In some complex or advanced-stage tumors, conversion to open surgery had still been required due to technical difficulties or intraoperative findings. Additionally, the cost of equipment and operative time in the early phase of implementation had been slightly higher compared to conventional surgery, although these differences had tended to decrease with increasing surgical proficiency [15].

Overall, the findings of this study had reinforced that minimally invasive approaches in colorectal cancer surgery had provided significant benefits in terms of reduced morbidity, faster recovery, and equivalent oncological outcomes. These results had supported the continued expansion of minimally invasive techniques as a preferred surgical approach in colorectal cancer management, particularly in centers with adequate expertise and resources.

CONCLUSION:

Minimally invasive approaches in colorectal cancer surgery had demonstrated significant benefits in improving patient outcomes compared to traditional open surgical techniques. The study findings had shown that laparoscopic and robotic-assisted procedures were associated with reduced intraoperative blood loss, shorter hospital stay, and earlier return of bowel function. Postoperative pain levels had been consistently lower, leading to decreased analgesic requirements and improved patient comfort. Furthermore, complication rates, including wound infections and pulmonary issues, had been comparatively reduced in minimally invasive groups. Oncological outcomes, such as margin clearance and lymph node retrieval, had remained comparable to open surgery, confirming the safety and effectiveness of these techniques. Overall survival and disease-free survival had shown no inferiority to conventional methods. It was concluded that minimally invasive colorectal cancer surgery had provided a safe, effective, and patient-centered alternative, and it had become an important component of modern surgical oncology practice, especially in appropriately selected patients.

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