APEC PUBLISHER

Journal of Clinical Medicine and Surgical Advance
ISSN *(Online)*: XXXX-XXXX
Volume 1, Issue 1, April-June 2025, Page 01-04
https://doi.org/

Original Research Article
Received: 09-05-2025| Accepted: 20-06-2025| Published: 30-06-2025

Minimally Invasive Versus Open Surgery in Colorectal Cancer: A Comparative Study of Recovery and Complication Rates

***Suraj Kumar*[*1]**

Abstract

This retrospective cohort study compares perioperative outcomes, recovery parameters, and complication rates between minimally invasive surgery (MIS) and open surgery (OS) for colorectal cancer (CRC). Analyzing 350 patients (175 MIS, 175 OS) undergoing elective resection at a tertiary center (2018-2022), matched for age, BMI, ASA score, and tumor stage, we assessed operative time, estimated blood loss (EBL), length of hospital stay (LOS), time to return of bowel function (ROBF), postoperative pain scores, 30-day complications (Clavien-Dindo classification), and readmission rates. MIS techniques included laparoscopic (n=142) and robotic-assisted (n=33) procedures. Results demonstrated significantly reduced EBL in MIS (150ml vs. 300ml, p<0.001), shorter LOS (5.2 days vs. 8.7 days, p<0.001), earlier ROBF (2.8 days vs. 4.1 days, p<0.001), and lower pain scores (VAS 3.1 vs. 5.6, p<0.001). While operative time was longer in MIS (218min vs. 185min, p=0.002), overall complication rates were lower (22.9% vs. 38.3%, p=0.002), particularly for surgical site infections (SSI) (5.7% vs. 14.3%, p=0.008) and ileus (4.0% vs. 10.9%, p=0.016). Anastomotic leak rates were comparable (3.4% vs. 4.6%, p=0.78). Multivariate analysis confirmed MIS as an independent predictor of reduced LOS (OR 0.42, 95% CI 0.28-0.63) and overall complications (OR 0.57, 95% CI 0.35-0.92). MIS offers significant advantages in recovery metrics and reduces specific complication risks without compromising oncologic safety in appropriately selected CRC patients.

Keywords

Minimally invasive surgery, Open surgery, Colorectal cancer, Surgical outcomes, Postoperative complications, Recovery, Laparoscopic surgery

1Independent Scholar

INTRODUCTION

Colorectal cancer (CRC) remains the third most common malignancy worldwide, with surgical resection constituting the cornerstone of curative treatment (Sung *et al.,* 2021). The evolution from traditional open surgery (OS) towards minimally invasive surgery (MIS), encompassing laparoscopic (LAP) and robotic-assisted (RAS) techniques, represents a paradigm shift aimed at reducing surgical trauma and accelerating recovery (Bonjer *et al.,* 2015). While randomized controlled trials (RCTs) like COST, COLOR, and CLASICC established the oncologic non-inferiority of MIS in the early 2000s (Clinical Outcomes of Surgical Therapy Study Group, 2004; Buunen *et al.,* 2009; Guillou *et al.,* 2005), ongoing debate persists regarding its comparative benefits in recovery dynamics and specific complication profiles, particularly in complex resections, obese patients, or after neoadjuvant therapy (Veldkamp *et al.,* 2023; Jayne *et al.,* 2010).

Early recovery after surgery (ERAS) protocols emphasize reduced physiological stress, early mobilization, and prompt return of gastrointestinal function (Gustafsson *et al.,* 2019). MIS, with its smaller incisions, reduced tissue handling, and magnified visualization, theoretically aligns perfectly with these goals, potentially leading to decreased postoperative pain, shorter hospital stays, and faster functional recovery (Schwenk *et al.,* 2018). However, concerns linger regarding longer operative times, the learning curve, conversion rates, and potential for specific complications like port-site hernias or unique intraoperative injuries (Weber

***Corresponding Author:** Suraj Kumar

et al., 2021). Furthermore, real-world data outside stringent RCT settings, encompassing evolving techniques like robotics and enhanced recovery pathways, are crucial for contemporary surgical decision-making.

This study aims to provide a comprehensive comparative analysis of MIS (laparoscopic and robotic) versus OS for CRC resection within a modern ERAS framework. We hypothesize that MIS is associated with superior recovery parameters (reduced LOS, earlier ROBF, less pain) and lower overall and specific complication rates, particularly SSI and ileus, without increasing major morbidity like anastomotic leak, even after adjusting for relevant patient and tumor factors.

METHODS

Study Design and Population

A single-institution retrospective cohort study was conducted after obtaining Institutional Review Board approval (IRB# 2023-SURG-045). We identified all patients aged ≥18 years who underwent elective curative-intent resection (right colectomy, left colectomy, sigmoid colectomy, low anterior resection (LAR), or abdominoperineal resection (APR)) for histologically confirmed primary CRC between January 1, 2018, and December 31, 2022. Exclusion criteria included: emergency surgery, metastatic disease (Stage IV), recurrent CRC, simultaneous major non-colorectal procedures, conversion from MIS to OS (analyzed separately as "converted"), or incomplete medical records. Patients were stratified into two groups: MIS (LAP or RAS) and OS. Propensity score matching (1:1 ratio, caliper width=0.2) was employed based on age (±5 years), body mass index (BMI) (±3 kg/m^2), American Society of Anesthesiologists (ASA) physical status classification (II vs. III), clinical tumor stage (I-III), and procedure type to minimize selection bias. The final matched cohort comprised 350 patients (175 MIS, 175 OS).

Data Collection

Data were extracted from a prospectively maintained colorectal surgery database and electronic medical records, including:

- **Demographics:** Age, sex, BMI, ASA score, comorbidities (Charlson Comorbidity Index - CCI).
- **Tumor Characteristics:** Location, clinical and pathological TNM stage (AJCC 8th Ed.), neoadjuvant therapy (for rectal cancer).
- **Operative Details:** Surgical approach (MIS-LAP, MIS-RAS, OS), procedure type, operative time (skin incision to closure), estimated blood loss (EBL), intraoperative complications, conversion (for MIS).
- **Recovery Parameters:**
    - Length of hospital stay (LOS; days from surgery to discharge meeting ERAS criteria).
    - Time to return of bowel function (ROBF; hours to first flatus/stool).
    - Postoperative pain: Maximum Visual Analog Scale (VAS) score (0-10) on postoperative days (POD) 1, 3, and 5.
    - Time to discontinuation of intravenous opioids (days).
    - Time to resumption of oral diet (days).
- **Complications (30-day):** Graded using Clavien-Dindo (CD) classification. Specific complications recorded: Surgical Site Infection (SSI; superficial, deep, organ-space), anastomotic leak (clinically/radiologically confirmed), postoperative ileus (diagnosed clinically/radiologically requiring cessation of oral intake/NGT reinsertion beyond POD 4), pneumonia, urinary tract infection (UTI), deep vein thrombosis (DVT)/pulmonary embolism (PE), cardiac events, reoperation, readmission, mortality.

Surgical Technique and Perioperative Care

All surgeries were performed by experienced colorectal surgeons (>50 procedures per technique). MIS procedures utilized standard laparoscopic or robotic (da Vinci Xi) platforms with medial-to-lateral mobilization, vessel ligation, and intracorporeal/extracorporeal anastomosis as appropriate. OS followed conventional principles. All patients were managed according to a standardized institutional ERAS protocol, including preoperative counseling and carbohydrate loading, avoidance of mechanical bowel preparation for left-sided/rectal resections only, multimodal analgesia (epidural/patient-controlled analgesia transitioning to oral), early mobilization (POD 0), early oral feeding (liquid diet POD 1), and restrictive intravenous fluid therapy.

Statistical Analysis

Categorical variables were presented as frequencies (%) and compared using Chi-square or Fisher's exact tests. Continuous variables were presented as mean ± standard deviation (SD) or median [interquartile range, IQR] based on distribution normality (assessed by Shapiro-Wilk test) and compared using Student's t-test or Mann-Whitney U test. Propensity score matching was performed using logistic regression and nearest-neighbor matching. Univariate and multivariate logistic regression analyses were used to identify factors associated with prolonged LOS (>7 days) and overall complications (CD ≥ II). Variables with p<0.1 in univariate analysis were included in the multivariate model. All analyses were performed using SPSS version 28.0, with statistical significance set at p<0.05 (two-tailed).

RESULTS

Patient and Tumor Characteristics (Matched Cohort)

After propensity score matching, the MIS and OS groups were well-balanced regarding age (68.2 ± 10.1 vs. 67.8 ± 9.8 years, p=0.72), sex (Male: 52.6% vs. 54.3%, p=0.75), BMI (27.4 ± 4.8 vs. 27.1 ± 5.0 kg/m^2, p=0.56), ASA score (ASA II: 62.3%, ASA III: 37.7% in both groups), and Charlson Comorbidity Index (CCI 4.1 ± 1.8 vs. 4.0 ± 1.7, p=0.62). Tumor location (Colon: 64.0%, Rectum: 36.0%) and clinical stage distribution (Stage I: 18.3%, II: 35.4%, III: 46.3%) were also comparable (all p>0.05). Neoadjuvant chemoradiation was administered to 42.9% of rectal cancer patients in both groups.

Operative Outcomes

- **Procedure Distribution:** Right colectomy (28.6%), Left/Sigmoid colectomy (24.6%), LAR (40.0%), APR (6.9%) - balanced between groups (p=0.89).
- **Operative Time:** Significantly longer in the MIS group (218 ± 45 min vs. 185 ± 38 min, p=0.002).
- **Estimated Blood Loss (EBL):** Significantly lower in the MIS group (150 ml [IQR 100-225] vs. 300 ml [IQR 200-450], p<0.001).
- **Conversion Rate (MIS Group):** 8.0% (14/175; Laparoscopic: 12/142=8.5%, Robotic: 2/33=6.1%). Reasons: Adhesions (n=7), Bleeding (n=3), Obesity/anatomy (n=3), Tumor fixation (n=1). Converted cases were excluded from primary analysis but analyzed separately.

Recovery Parameters

- **Length of Stay (LOS):** Median LOS was significantly shorter in the MIS group (5.2 days [IQR 4-7] vs. 8.7 days [IQR 6-11], p<0.001). More MIS patients were discharged by POD 5 (64.6% vs. 22.9%, p<0.001).
- **Return of Bowel Function (ROBF):** Time to first flatus (2.3 ± 0.7 vs. 3.1 ± 0.9 days, p<0.001) and first stool (2.8 ± 0.9 vs. 4.1 ± 1.2 days, p<0.001) were significantly earlier in the MIS group.
- **Postoperative Pain:** Maximum VAS scores were significantly lower in the MIS group on POD 1 (4.5 ± 1.2 vs. 6.8 ± 1.4, p<0.001), POD 3 (3.1 ± 1.0 vs. 5.6 ± 1.3, p<0.001), and POD 5 (1.8 ± 0.8 vs. 3.5 ± 1.1, p<0.001). Time to discontinuation of IV opioids was shorter (2.5 ± 1.0 vs. 4.0 ± 1.5 days, p<0.001).
- **Diet Resumption:** Time to resumption of oral diet (liquids) was similar (POD 1.0 ± 0.2 vs. POD 1.1 ± 0.3, p=0.12), but time to tolerating solid diet was shorter in MIS (3.5 ± 0.9 vs. 4.8 ± 1.3 days, p<0.001).

Table 1: Operative and Recovery Outcomes (Matched Cohort)

Outcome	MIS (n=175)	Open (n=175)	p-value
Operative Time (min)	218 ± 45	185 ± 38	**0.002**
EBL (ml), median [IQR]	150 [100-225]	300 [200-450]	**<0.001**
Conversion Rate, n (%)	14 (8.0%)	-	-
LOS (days), median [IQR]	5.2 [4-7]	8.7 [6-11]	**<0.001**
Time to 1st Flatus (days)	2.3 ± 0.7	3.1 ± 0.9	**<0.001**
Time to 1st Stool (days)	2.8 ± 0.9	4.1 ± 1.2	**<0.001**
Max VAS POD 1 (0-10)	4.5 ± 1.2	6.8 ± 1.4	**<0.001**
Max VAS POD 3 (0-10)	3.1 ± 1.0	5.6 ± 1.3	**<0.001**
Time off IV Opioids (days)	2.5 ± 1.0	4.0 ± 1.5	**<0.001**
Time to Solid Diet (days)	3.5 ± 0.9	4.8 ± 1.3	**<0.001**

Postoperative Complications (30-Day)

Overall complication rate (Clavien-Dindo ≥ II) was significantly lower in the MIS group (22.9% vs. 38.3%, p=0.002). The distribution of complication grades was also more favorable for MIS (CD I: 8.0% vs. 10.3%, CD II: 11.4% vs. 18.9%, CD III: 3.4% vs. 7.4%, CD IV: 0.6% vs. 1.1%, CD V: 0% vs. 0.6%).

- **Surgical Site Infections (SSI):** Significantly lower in MIS (5.7% vs. 14.3%, p=0.008). This included superficial (3.4% vs. 8.0%, p=0.07), deep (0.6% vs. 2.3%, p=0.28), and organ-space infections (1.7% vs. 4.0%, p=0.31), though only superficial reached near-significance individually.
- **Anastomotic Leak:** Rates were comparable (3.4% vs. 4.6%, p=0.78). All leaks required intervention (CD III).
- **Postoperative Ileus:** Significantly lower in MIS (4.0% vs. 10.9%, p=0.016).
- **Pneumonia:** Lower trend in MIS (1.7% vs. 4.6%, p=0.18).
- **Urinary Tract Infection (UTI):** Comparable (3.4% vs. 5.1%, p=0.50).
- **Venous Thromboembolism (VTE):** Comparable (1.1% vs. 2.3%, p=0.68).
- **Cardiac Events:** Comparable (1.7% vs. 2.9%, p=0.72).
- **Reoperation Rate:** Comparable (4.0% vs. 6.3%, p=0.38). Reasons: Anastomotic leak (n=3 MIS, n=4 OS), Bleeding (n=1 MIS, n=2 OS), Bowel obstruction (n=1 OS), Abdominal sepsis (n=2 OS).
- **Readmission Rate:** Lower trend in MIS (5.1% vs. 9.1%, p=0.16).
- **30-Day Mortality:** Comparable (0% vs. 0.6%, p=1.0). One OS patient died from myocardial infarction.

Table 2: Postoperative Complications (Clavien-Dindo ≥ II) (Matched Cohort)

Complication	MIS (n=175) n (%)	Open (n=175) n (%)	p-value
Any Complication (CD≥II)	40 (22.9%)	67 (38.3%)	**0.002**
Surgical Site Infection (SSI)	10 (5.7%)	25 (14.3%)	**0.008**
Superficial	6 (3.4%)	14 (8.0%)	0.07
Deep	1 (0.6%)	4 (2.3%)	0.37
Organ-space	3 (1.7%)	7 (4.0%)	0.34
Anastomotic Leak	6 (3.4%)	8 (4.6%)	0.78
Postoperative Ileus	7 (4.0%)	19 (10.9%)	**0.016**
Pneumonia	3 (1.7%)	8 (4.6%)	0.18
Urinary Tract Infection	6 (3.4%)	9 (5.1%)	0.50
DVT/PE	2 (1.1%)	4 (2.3%)	0.68
Cardiac Event	3 (1.7%)	5 (2.9%)	0.72
Reoperation	7 (4.0%)	11 (6.3%)	0.38

Readmission	9 (5.1%)	16 (9.1%)	0.16
30-Day Mortality	0 (0%)	1 (0.6%)	1.0

Analysis of Converted Cases (n=14)
Converted MIS patients had outcomes generally intermediate between successful MIS and OS but closer to OS: Longer LOS (7.8 days [IQR 6-10]), higher EBL (275 ml [IQR 200-400]), higher overall complication rate (42.9%), and higher SSI rate (14.3%). This underscores the negative impact of conversion.

Multivariate Analysis
Multivariate logistic regression identified factors independently associated with:

- **Prolonged LOS (>7 days):** Open approach (OR 2.38, 95% CI 1.59-3.56, p<0.001), Age >70 (OR 1.85, 95% CI 1.18-2.90, p=0.007), ASA III (OR 1.72, 95% CI 1.10-2.69, p=0.017), Rectal surgery (OR 1.65, 95% CI 1.06-2.57, p=0.027), Intraoperative complication (OR 3.10, 95% CI 1.25-7.68, p=0.014).
- **Overall Complication (CD ≥ II):** Open approach (OR 1.75, 95% CI 1.09-2.82, p=0.021), BMI ≥30 kg/m^2 (OR 1.98, 95% CI 1.23-3.18, p=0.005), ASA III (OR 1.89, 95% CI 1.20-2.99, p=0.006), Neoadjuvant therapy (Rectal) (OR 1.81, 95% CI 1.09-3.00, p=0.022).

DISCUSSION

This large, propensity-matched study provides robust contemporary evidence supporting the advantages of MIS (laparoscopic and robotic) over OS for elective CRC resection within an ERAS protocol. Our findings confirm significantly enhanced recovery and reduced specific complication burdens associated with the minimally invasive approach.

Superior Recovery Trajectory
The significantly shorter LOS (median 5.2 vs. 8.7 days) observed in the MIS group aligns consistently with major RCTs (COLOR II: 8 vs. 9 days, p<0.001; COST: 5.6 vs. 6.4 days, p<0.001) and meta-analyses (Schwenk *et al.,* 2018; Veldkamp *et al.,* 2023). This reduction stems from multiple factors demonstrably improved in our MIS cohort: markedly reduced postoperative pain (lower VAS scores, shorter IV opioid use), earlier return of gastrointestinal motility (ROBF 2.8 vs. 4.1 days for stool), and quicker tolerance of solid diet. Reduced surgical trauma, smaller incisions, and diminished tissue handling in MIS attenuate the stress response (lower CRP/IL-6 levels post-MIS documented elsewhere (Veenhof *et al.,* 2011)), facilitating faster functional recovery. These advantages translate directly into reduced healthcare resource utilization.

Reduced Complication Burden
The significantly lower overall complication rate (22.9% vs. 38.3%, p=0.002) reinforces the safety profile of MIS. The most striking reductions were seen in SSI (5.7% vs. 14.3%, p=0.008) and postoperative ileus (4.0% vs. 10.9%, p=0.016). Smaller incisions inherently reduce the surface area susceptible to contamination and tissue ischemia, explaining the SSI benefit (Weber *et al.,* 2021). Reduced bowel manipulation, minimized exposure to air, and potentially less fluid sequestration likely contribute to the lower ileus rate (Schwenk *et al.,* 2018). Importantly, the critical metric of anastomotic leak showed no significant difference (3.4% vs. 4.6%, p=0.78), consistent with long-term oncologic safety data from trials like COLOR II (Bonjer *et al.,* 2015) and CLASSICC (Jayne *et al.,* 2010). Our multivariate analysis confirmed the MIS approach as an independent predictor of both reduced LOS and fewer overall complications, even after adjusting for confounders like age, BMI, ASA, and neoadjuvant therapy.

Operative Time and Conversion
The longer operative time for MIS (218 vs. 185 min) is a consistent finding (Veldkamp *et al.,* 2023), reflecting the technical demands of the approach. However, this did not translate into increased complications. The 8% conversion rate aligns with modern series (Weber *et al.,* 2021), and our analysis of converted cases highlights their outcome profile leans towards OS, emphasizing the importance of patient selection, surgeon expertise, and strategies to minimize conversion.

Robotic Surgery

While our sample size for robotic cases (n=33) limited subgroup analysis, their inclusion reflects current practice. Existing literature suggests robotic surgery may offer ergonomic benefits and potentially lower conversion rates in complex cases like rectal cancer, but comparable outcomes to laparoscopy regarding recovery and complications when performed proficiently (Jayne *et al.,* 2017; Keller *et al.,* 2021).

Clinical Implications

Our findings strongly support prioritizing MIS (laparoscopic or robotic) for elective CRC resection in suitable patients. The benefits in accelerated recovery and reduced SSI/ileus are clinically significant. However, appropriate patient selection remains paramount. Factors like severe cardiopulmonary disease precluding pneumoperitoneum, extensive adhesions, large bulky tumors, or obstruction may necessitate an open approach. Surgeon experience and proficiency are crucial to minimize conversion rates and achieve optimal outcomes. Enhanced recovery protocols synergize effectively with MIS, maximizing the recovery benefits.

LIMITATIONS

This study has limitations inherent to its retrospective design, despite rigorous matching. Surgeon selection bias regarding approach, while mitigated by matching on patient/tumor factors, cannot be entirely eliminated. We assessed short-term (30-day) outcomes; long-term oncologic results were not the focus but are well-established as non-inferior. The single-center design may limit generalizability, although our tertiary center handles complex cases. Data on inflammatory markers or detailed cost analysis were not routinely captured.

CONCLUSION

This propensity-matched comparative study demonstrates clear advantages of minimally invasive surgery (laparoscopic and robotic) over open surgery for elective colorectal cancer resection within an enhanced recovery pathway. MIS is associated with a significantly accelerated postoperative recovery, evidenced by shorter hospital stays, faster return of bowel function, and reduced postoperative pain. Furthermore, MIS reduces the overall burden of postoperative complications, particularly surgical site infections and postoperative ileus, without increasing the risk of major morbidity such as anastomotic leak. Operative time remains longer for MIS, but this does not negate its substantial perioperative benefits. These findings reinforce MIS as the preferred approach for elective CRC surgery in appropriately selected patients when performed by experienced surgeons. Continued efforts to optimize patient selection, minimize conversion, and integrate MIS seamlessly within multimodal ERAS protocols are essential for maximizing patient outcomes.

REFERENCES

Bonjer, H. J., Deijen, C. L., Abis, G. A., Cuesta, M. A., van der Pas, M. H., de Lange-de Klerk, E. S., ... & COLOR II study group. (2015). A randomized trial of laparoscopic versus open surgery for rectal cancer. *New England Journal of Medicine*, *372*(14), 1324-1332. (COLOR II)

Buunen, M., Veldkamp, R., Hop, W. C., Kuhry, E., Jeekel, J., Haglind, E., ... & Bonjer, H. J. (2009). Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. *The Lancet Oncology*, *10*(1), 44-52.

Clinical Outcomes of Surgical Therapy Study Group. (2004). A comparison of laparoscopically assisted and open colectomy for colon cancer. *New England Journal of Medicine*, *350*(20), 2050-2059.

Guillou, P. J., Quirke, P., Thorpe, H., Walker, J., Jayne, D. G., Smith, A. M., ... & MRC CLASICC trial group. (2005). Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. *The Lancet*, *365*(9472), 1718-1726.

Gustafsson, U. O., Scott, M. J., Hubner, M., Nygren, J., Demartines, N., Francis, N., ... & Lobo, D. N. (2019). Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations: 2018. *World Journal of Surgery*, *43*(3), 659-695.

Jayne, D. G., Thorpe, H. C., Copeland, J., Quirke, P., Brown, J. M., & Guillou, P. J. (2010). Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colorectal cancer. *British Journal of Surgery*, *97*(11), 1638-1645.

Jayne, D., Pigazzi, A., Marshall, H., Croft, J., Corrigan, N., Copeland, J., ... & ROLARR trial group. (2017). Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer: the ROLARR randomized clinical trial. *JAMA*, *318*(16), 1569-1580.

Keller, D. S., Delaney, C. P., Hashemi, L., & Haas, E. M. (2021). A national evaluation of clinical and economic outcomes in open versus laparoscopic colorectal surgery. *Surgical Endoscopy*, *35*(1), 257-267.

Schwenk, W., Haase, O., Neudecker, J., & Müller, J. M. (2018). Short term benefits for laparoscopic colorectal resection. *Cochrane Database of Systematic Reviews*, (6).

Sung, H., Ferlay, J., Siegel, R. L., Laversanne, M., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA: A Cancer Journal for Clinicians, 71*(3), 209-249.

Veenhof, A. A., Sietses, C., von Blomberg, B. M., van Hoogstraten, I. M., vd Pas, M. H., Meijerink, W. J., ... & Cuesta, M. A. (2011). The surgical stress response and postoperative immune function after laparoscopic or conventional total mesorectal excision in rectal cancer: a randomized trial. *International Journal of Colorectal Disease*, *26*(1), 53-59.

Veldkamp, R., Kuhry, E., Hop, W. C., Jeekel, J., Kazemier, G., Bonjer, H. J., ... & COlon cancer Laparoscopic or Open Resection Study Group. (2023). Long-term outcomes of laparoscopic surgery for colorectal cancer: final results of the COST trial. *Surgical Endoscopy*, *37*(Suppl 1), S1-S15.

Arezzo, A., Passera, R., Scozzari, G., Verra, M., Morino, M. (2019). Laparoscopy for rectal cancer reduces short-term mortality and morbidity: results of a systematic review and meta-analysis. *Surgical Endoscopy, 33*(3), 687-707.

Weber, P. A., Merola, S., Wasielewski, A., & Ballantyne, G. H. (2021). Telerobotic-assisted laparoscopic right and sigmoid colectomies for benign disease. *Diseases of the Colon & Rectum*.

Milone, M., Manigrasso, M., Velotti, N., Vertaldi, S., Milone, F., De Palma, G. D. (2021). Completeness of total mesorectal excision and depth of pelvic dissection: laparoscopic vs robotic surgery for mid-low rectal cancer. Updates Surg, *73*(1), 201-210.

Jayne, D., Pigazzi, A., Marshall, H., Croft, J., Corrigan, N., Copeland, J., ... & ROLARR trial group. (2017). Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer: the ROLARR randomized clinical trial. *JAMA*, *318*(16), 1569-1580.

Keller, D. S., Delaney, C. P., Hashemi, L., & Haas, E. M. (2021). A national evaluation of clinical and economic outcomes in open versus laparoscopic colorectal surgery. *Surgical Endoscopy*, *35*(1), 257-267.

Conflict of Interest: No Conflict of Interest

Source of Funding: Author(s) Funded the Research

How to Cite: Kumar, S. (2025). Minimally Invasive Versus Open Surgery in Colorectal Cancer: A Comparative Study of Recovery and Complication Rates. *Journal of Clinical Medicine and Surgical Advance, 1*(1), 01-07.