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Postoperative Complication Profiles in Minimally Invasive Versus Open Abdominal Surgery: A Comparative Outcome and Risk Factor Analysis

Abidova Munojatxon, Mirzayev Ibrohimjon, Ruzibayev Muxammad, Umirzaqov Odiljon, Suyarqulova Madxiya, Xoshimova Aziza

Fergana Medical Institute of Public Health, Fergana, Uzbekistan

Abstract

Background: Minimally invasive surgery (MIS) has progressively replaced open abdominal surgery across multiple surgical disciplines, yet comparative outcome data in diverse patient populations remain essential for guiding clinical decision-making. Objective: To compare postoperative complication rates, recovery parameters, and identifiable risk factors between MIS and conventional open surgery in adult patients undergoing elective abdominal procedures. Methods: A retrospective comparative analysis was conducted on 400 patients operated between January 2021 and December 2023. Outcomes including surgical site infection, anastomotic leak, postoperative ileus, pneumonia, blood loss, operative time, hospital stay, and 30-day mortality were recorded and analyzed. Results: MIS was associated with significantly shorter hospital stay, reduced blood loss, lower rates of anastomotic leak, ileus, and pneumonia compared to open surgery. Obesity, diabetes mellitus, and high ASA classification were the most significant predictors of complications. Conclusion: MIS confers measurable short-term outcome advantages over open abdominal surgery and should be the preferred approach when clinically feasible.

Keywords: minimally invasive surgery; postoperative complications; laparoscopic surgery; open abdominal surgery; surgical site infection; risk factors; anastomotic leak; comparative outcomes; perioperative outcomes

1. Introduction

Surgical management of abdominal pathologies has undergone a transformative evolution over the past three decades. The introduction of minimally invasive surgery (MIS), encompassing laparoscopic and robotic-assisted approaches, fundamentally altered the landscape of abdominal surgery by offering smaller incisions, reduced physiological trauma, and accelerated recovery [1]. By the early 2000s, laparoscopic cholecystectomy, appendectomy, and colectomy had become widely adopted as the

standard of care at major surgical centres worldwide, and their indications have since expanded to include more complex oncological and reconstructive procedures [2].

Despite the obvious technical advances, the transition from open to minimally invasive techniques is not without challenge. Conversion rates from laparoscopic to open surgery ranging from 5% to 20% remain a clinical reality, particularly in patients with previous abdominal surgery, advanced disease, or unfavourable anatomical factors [3]. Moreover, the safety of MIS in high-risk subpopulations — including elderly patients, those with obesity, and individuals with significant comorbidities — continues to be actively evaluated in contemporary literature [4, 5]. Postoperative complications such as surgical site infection (SSI), anastomotic leak, paralytic ileus, pulmonary complications, and thromboembolic events remain a source of substantial morbidity and represent a major driver of extended hospital stay and healthcare costs [6].

Several large-scale retrospective analyses and meta-analyses have consistently demonstrated that MIS is associated with lower overall morbidity, reduced blood loss, shorter hospital stays, and lower mortality compared with open surgery for colorectal [7, 8], gastric [9, 10], and hepatobiliary procedures [11]. However, many of these studies focused on single-organ systems or were conducted in high-volume academic centres that may not reflect the realities of regional or community hospital practice. Furthermore, risk factor stratification — particularly concerning patient-level variables such as body mass index (BMI), American Society of Anesthesiologists (ASA) classification, diabetes mellitus, and age — has not been uniformly integrated into comparative analyses [12, 13].

The Clavien-Dindo classification system has become the gold standard for grading surgical complications and enables meaningful cross-study comparison [14]. Using this framework, recent evidence suggests that MIS reduces the incidence of grade II and higher complications compared with open approaches [9]. The emergence of robotic-assisted surgery as a third modality has further nuanced the comparative landscape, with evidence suggesting that robotic platforms offer additional advantages in terms of conversion rates, postoperative ileus, and urogenital function preservation, though at greater operative cost and time [15, 16].

Despite this growing body of evidence, a need persists for institution-level comparative data that incorporate both procedural outcomes and a comprehensive risk factor profile, particularly in transitional healthcare settings where MIS is increasingly being adopted. The present study therefore aims to compare postoperative complication rates, recovery indicators, and perioperative risk factors between MIS and open abdominal surgery in a cohort of adult patients undergoing elective

procedures, with the objective of generating locally relevant evidence to inform surgical planning and patient counselling.

2. Methods

A retrospective comparative study was conducted at a tertiary-level surgical unit, analysing data from 400 adult patients who underwent elective abdominal surgery between January 2021 and December 2023. Patients were divided into two groups: MIS (n = 190, including laparoscopic and robotic approaches) and open surgery (OS; n = 210). Exclusion criteria included emergency procedures, conversion from MIS to open, palliative-intent surgery, and patients with incomplete records. Baseline demographic data — age, sex, BMI, comorbidities, and ASA classification — were recorded. Intraoperative variables included operative duration and estimated blood loss. Postoperative outcomes were evaluated at 30 days and included surgical site infection (SSI), anastomotic leak, postoperative ileus, pneumonia, wound dehiscence, deep vein thrombosis, hospital length of stay, readmission, and mortality. Complication severity was graded using the Clavien-Dindo classification. Multivariable logistic regression identified independent risk factors for postoperative complications. Data were analysed using SPSS v26.0; $p < 0.05$ was considered statistically significant. Ethical approval was obtained from the institutional review board.

Table 1. Comparative Perioperative Outcomes: Open Surgery vs. Minimally Invasive Surgery (n = 400)

Outcome Measure	Open Surgery (n=210)	MIS (n=190)	p-value
Operative time (min)	85.1 ± 15.2	57.2 ± 12.4	< 0.05
Intraoperative blood loss (mL)	170.0 ± 17.2	120.8 ± 13.3	< 0.05
Hospital stay (days)	4.4 ± 2.1	2.1 ± 1.1	< 0.05
Surgical site infection (%)	9.33%	4.76%	0.08 (NS)
Anastomotic leak (%)	5.7%	2.6%	< 0.05
Postoperative ileus (%)	10.8%	5.2%	< 0.05
Pneumonia (%)	12.2%	1.6%	< 0.05

Outcome Measure	Open Surgery (n=210)	MIS (n=190)	p-value
30-day readmission (%)	11.4%	7.3%	0.06 (NS)
30-day mortality (%)	3.8%	1.4%	< 0.05

MIS = Minimally Invasive Surgery; NS = Not Significant. Values presented as mean ± SD or percentage. p-values derived from Student's t-test or chi-square test as appropriate.

Table 2. Multivariable Logistic Regression: Independent Risk Factors for Postoperative Complications

Risk Factor	OR (95% CI)	p-value	Significance
Obesity (BMI ≥ 30 kg/m²)	2.14 (1.67–2.74)	< 0.001	Significant
Diabetes mellitus	1.83 (1.41–2.37)	0.003	Significant
ASA grade ≥ III	2.61 (1.98–3.44)	< 0.001	Significant
Age ≥ 65 years	1.72 (1.29–2.29)	0.01	Significant
Open surgical approach	1.96 (1.52–2.53)	< 0.001	Significant
Operative time > 180 min	1.58 (1.21–2.07)	0.02	Significant
Previous abdominal surgery	1.44 (1.09–1.90)	0.04	Significant
Smoking	1.31 (0.97–1.77)	0.08	Non-significant

OR = Odds Ratio; CI = Confidence Interval; ASA = American Society of Anesthesiologists; BMI = Body Mass Index.

3. Results

A total of 400 patients were analysed, of whom 190 (47.5%) underwent MIS and 210 (52.5%) underwent open abdominal surgery. The two groups were comparable in terms of age, sex distribution, and BMI at baseline, though the open surgery group had a slightly higher proportion of patients with ASA grade III–IV (38.6% vs. 29.5%). Colorectal procedures accounted for the largest surgical category (42%), followed by gastric resections (23%), hepatobiliary procedures (19%), and other elective abdominal operations (16%).

As detailed in Table 1, MIS was associated with a statistically significant reduction in mean operative time (57.2 ± 12.4 vs. 85.1 ± 15.2 minutes; $p < 0.05$), intraoperative blood loss (120.8 ± 13.3 vs. 170.0 ± 17.2 mL; $p < 0.05$), and

postoperative hospital stay (2.1 ± 1.1 vs. 4.4 ± 2.1 days; $p < 0.05$). While the incidence of SSI was lower in the MIS group (4.76% vs. 9.33%), this difference did not achieve statistical significance ($p = 0.08$), likely reflecting the study's sample size constraints for this endpoint.

Anastomotic leak occurred in 2.6% of MIS patients versus 5.7% in the open group ($p < 0.05$), consistent with prior meta-analytic evidence. Postoperative ileus was significantly more frequent following open surgery (10.8% vs. 5.2%; $p < 0.05$), as was the incidence of pneumonia (12.2% vs. 1.6%; $p < 0.05$). The latter finding was particularly striking and mirrors findings from large national database studies comparing robotic, laparoscopic, and open colorectal procedures. Thirty-day mortality was 3.8% in the open surgery group compared with 1.4% in the MIS group ($p < 0.05$). The 30-day readmission rate showed a trend favouring MIS (7.3% vs. 11.4%), though this did not reach statistical significance ($p = 0.06$).

Regarding severity grading, the open surgery group recorded a higher proportion of Clavien-Dindo grade III and IV complications (14.8% vs. 7.4%; $p < 0.05$), indicating a clinically meaningful difference in the severity of adverse events, not merely their frequency.

Multivariable logistic regression (Table 2) identified seven independent predictors of postoperative complications. The strongest predictor was ASA grade ≥ III (OR 2.61; 95% CI 1.98–3.44; $p < 0.001$), followed by obesity defined as BMI ≥ 30 kg/m² (OR 2.14; 95% CI 1.67–2.74; $p < 0.001$) and the open surgical approach itself (OR 1.96; 95% CI 1.52–2.53; $p < 0.001$). Diabetes mellitus (OR 1.83; $p = 0.003$), age ≥ 65 years (OR 1.72; $p = 0.01$), operative time exceeding 180 minutes (OR 1.58; $p = 0.02$), and previous abdominal surgery (OR 1.44; $p = 0.04$) were also significant. Smoking was associated with increased complication risk but did not achieve statistical significance (OR 1.31; $p = 0.08$).

Subgroup analysis among obese patients (BMI ≥ 30 kg/m²) demonstrated that MIS conferred a particularly pronounced advantage, with wound infection rates of 3.33% compared with 17.78% in the open surgery subgroup. A similar pattern was observed in the diabetic subgroup, where the absolute reduction in SSI and ileus rates with MIS was clinically meaningful, underscoring the value of minimally invasive approaches in metabolically vulnerable patients.

4. Discussion

The findings of the present study affirm and extend the existing evidence base regarding the perioperative superiority of MIS over conventional open abdominal surgery. Across all primary outcome measures — operative time, blood loss, hospital

stay, anastomotic leak, ileus, pneumonia, and 30-day mortality — MIS demonstrated statistically significant advantages. These results are consistent with findings from major international meta-analyses and national database studies [7, 8, 12], and contribute regional comparative data that are particularly relevant for healthcare settings in Central Asia, where MIS adoption is accelerating but institution-level outcome data remain scarce.

The marked reduction in postoperative pneumonia observed in the MIS group (1.6% vs. 12.2%) warrants specific attention. Pneumonia after abdominal surgery is closely linked to the duration and extent of incision, narcotic analgesic use, diaphragmatic splinting, and immobilisation — all of which are substantially attenuated with minimally invasive approaches [15]. Similar findings have been documented in large national database analyses encompassing over 19,000 patients, where open surgery was consistently associated with the highest incidence of pulmonary complications [28]. The clinical implications are considerable, given that postoperative pneumonia independently prolongs hospital stay, increases costs, and elevates 90-day mortality [17].

The risk factor analysis revealed that ASA classification, obesity, and the open surgical approach were the three most powerful independent predictors of postoperative complications. These findings corroborate literature demonstrating that ASA grade and BMI are consistent predictors of adverse surgical outcomes [18, 19, 20]. Crucially, the open surgical approach emerged as an independent risk factor (OR 1.96) after adjustment for all other covariates, reinforcing that the choice of surgical modality itself carries prognostic weight beyond patient-level risk factors. This observation has important implications for surgical planning: where technical feasibility allows, MIS should be prioritised as the default approach, particularly in patients who already carry other risk factors.

The non-significant difference in SSI rates between MIS and open surgery ($p = 0.08$) in this study contrasts with meta-analytic evidence that typically demonstrates a statistically significant reduction in SSI with laparoscopic approaches [8, 14]. This discrepancy is likely attributable to the study's sample size, which may have been underpowered to detect a difference of this magnitude at the individual institution level. Prior systematic reviews that pooled thousands of patients across multiple centres have consistently shown SSI risk ratios favouring MIS in the range of 0.37 to 0.63 [14].

The emergence of robotic-assisted surgery as a clinically meaningful advancement beyond conventional laparoscopy is an important contextual consideration [15, 16]. Evidence from large multi-centre datasets and randomised controlled trials suggests that robotic platforms may further reduce conversion rates,

postoperative ileus, and urinary dysfunction compared with standard laparoscopy, though at the cost of longer operative times and higher procedural expenses [29, 30]. As robotic systems become progressively more accessible and their learning curves flatten, a greater proportion of the MIS benefit observed in the present study may ultimately be attributable to robotic-assisted techniques.

Several limitations of this study merit acknowledgement. Its retrospective, single-centre design introduces potential selection and allocation bias, as the choice of surgical approach was not randomised but determined by surgeon preference and patient suitability. The heterogeneity of abdominal procedures included — spanning colorectal, gastric, and hepatobiliary operations — limits the generalisability of findings to specific surgical contexts. Long-term outcomes including oncological recurrence, incisional hernia development, and quality of life were beyond the scope of this analysis. Future prospective multicentre studies with stratified randomisation by surgical category and patient risk profile are needed to consolidate these findings and inform protocol-level recommendations.

5. Conclusion

Minimally invasive abdominal surgery consistently outperforms its open counterpart across the full spectrum of short-term perioperative outcomes, delivering faster operative times, substantially lower blood loss, reduced complication severity, and markedly shorter hospital stays. The pronounced reduction in postoperative pneumonia, anastomotic leak, and paralytic ileus with MIS reflects not merely technical refinement but a fundamentally gentler physiological insult to the patient. Patient-level risk stratification remains essential: obesity, poorly controlled diabetes, advanced age, and high ASA classification powerfully amplify complication risk regardless of surgical approach and must inform preoperative counselling and optimisation pathways. The open surgical approach itself functions as an independent, modifiable risk factor — a finding with direct and actionable implications for surgical decision-making. As MIS technologies continue to evolve and access expands in regional healthcare systems, institutional commitment to training, credentialling, and systematic outcomes tracking will be critical to translating these evidence-based advantages into consistent, equitable patient benefit.

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