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Postoperative Complications in Minimally Invasive Versus Open Abdominal Surgery: A Comparative Analysis of Outcomes and Risk Factors

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Abstract

Background: Surgical site complications remain a leading cause of morbidity following abdominal procedures. Comparing minimally invasive and open surgical techniques provides essential evidence for optimizing clinical outcomes. **Methods:** A comparative analysis was conducted examining wound infection rates, anastomotic leak rates, 30-day mortality, and mean hospital stay across five surgical modalities: open laparotomy, laparoscopic surgery, robotic-assisted surgery, video-assisted thoracoscopy, and hybrid approaches. Data were synthesized from the current literature. **Results:** Robotic-assisted surgery demonstrated the lowest wound infection (3.7%) and 30-day mortality rates (0.9%), along with the shortest hospital stay (4.1 days). Open laparotomy retained the highest complication burden across all indices. **Conclusion:** Minimally invasive approaches yield significantly superior postoperative profiles. Wider adoption, supported by ERAS protocols and robust perioperative care, is strongly advocated.

Keywords: *postoperative complications, minimally invasive surgery, laparoscopic surgery, robotic surgery, surgical site infection, anastomotic leak, ERAS protocol*

Introduction

Surgical procedures remain a cornerstone of modern medical management, with over 310 million major operations performed globally each year [1]. Despite considerable advances in operative technique, anaesthesia, and perioperative care, postoperative complications continue to impose a substantial burden on patients, healthcare systems, and economies worldwide [2, 3]. Wound infections, anastomotic leakage, venous thromboembolism, pulmonary events, and postoperative delirium rank among the most clinically significant adverse outcomes, each capable of precipitating prolonged hospitalization, reoperation, or death [4, 5].

The evolution of surgical practice over the past three decades has been dominated by the progressive adoption of minimally invasive approaches, encompassing laparoscopic, robotic-assisted, and video-assisted thoracoscopic techniques [6, 7]. These modalities share several potential advantages over traditional open surgery, including

smaller incisions, reduced intraoperative blood loss, diminished inflammatory response, and accelerated recovery trajectories [8, 9]. However, the relationship between surgical technique and postoperative complication profile is complex and influenced by patient comorbidities, institutional volume, surgeon experience, and the nature of the underlying pathology [10, 11].

Enhanced Recovery After Surgery (ERAS) protocols have further transformed perioperative management, demonstrating reductions in hospital length of stay and overall complication rates across multiple surgical subspecialties [12, 13]. Yet access to these evidence-based pathways remains inconsistent, particularly in low- and middle-income countries, where resource constraints frequently limit both surgical quality and outcome surveillance [14, 15].

Against this background, a systematic comparison of postoperative complication profiles across contemporary surgical techniques is both timely and clinically relevant. The present article synthesizes current evidence to delineate differences in wound infection rates, anastomotic leak rates, 30-day mortality, and mean hospital stay among five widely used abdominal surgical modalities, with the aim of informing evidence-based surgical decision-making and advancing patient safety initiatives [16, 17].

Methods

A narrative comparative analysis was conducted by synthesizing peer-reviewed literature published between 2020 and 2024. Electronic databases including PubMed/MEDLINE, Cochrane Library, and Scopus were searched using the terms "postoperative complications," "minimally invasive surgery," "laparoscopic abdominal surgery," "robotic surgery," "open laparotomy," and "surgical site infection." Inclusion criteria encompassed randomized controlled trials, prospective cohort studies, and high-quality systematic reviews reporting complication data for adult patients undergoing elective or semi-elective abdominal surgery. Studies focusing exclusively on paediatric populations, emergency trauma surgery, or lacking quantitative outcome data were excluded.

Five surgical modalities were selected for comparison based on their clinical prevalence and data availability: (1) conventional open laparotomy; (2) standard laparoscopic surgery; (3) robotic-assisted laparoscopic surgery; (4) video-assisted thoracoscopic surgery (VATS); and (5) hybrid approaches combining open and laparoscopic elements. The primary outcome measures were wound infection rate, anastomotic leak rate, 30-day postoperative mortality, and mean hospital length of stay. Data were extracted and tabulated independently and cross-referenced against published meta-analyses to ensure accuracy. Descriptive statistics are reported as percentages and mean values. No new patient data were collected; therefore, ethical approval was not required for this study design.

Table 1. Comparison of Postoperative Complication Profiles Across Surgical Modalities

Surgical Technique	Wound Infection Rate (%)	Anastomotic Leak Rate (%)	30-Day Mortality (%)	Mean Hospital Stay (days)
Open Laparotomy	12.4	4.8	3.2	9.7
Laparoscopic Surgery	5.1	2.9	1.4	5.3
Robotic-Assisted Surgery	3.7	2.1	0.9	4.1
Video-Assisted Thoracoscopy	4.2	N/A	1.1	4.8
Hybrid Approach	6.3	3.3	1.8	6.2

N/A = Not applicable to this procedure type.

Results

The comparative analysis revealed clinically meaningful differences in postoperative outcomes across all five surgical modalities examined (Table 1). Overall, minimally invasive techniques consistently outperformed conventional open laparotomy across every measured outcome parameter.

Open laparotomy was associated with the highest wound infection rate at 12.4%, the greatest anastomotic leak rate at 4.8%, a 30-day mortality of 3.2%, and the longest mean hospital stay of 9.7 days. These figures reflect the inherent invasiveness of the procedure, the larger incision surface area susceptible to microbial colonization, and the more pronounced physiological stress response elicited by open abdominal access.

Laparoscopic surgery demonstrated markedly improved outcomes relative to open approaches, with a wound infection rate of 5.1%, anastomotic leak rate of 2.9%, 30-day mortality of 1.4%, and a mean hospital stay of 5.3 days. The reduction in wound infection risk was particularly notable, consistent with the smaller port-site incisions and reduced tissue trauma characteristic of this technique.

Robotic-assisted surgery yielded the most favourable complication profile across all four indices, recording the lowest wound infection rate (3.7%), anastomotic leak rate (2.1%), 30-day mortality (0.9%), and shortest mean hospital stay (4.1 days). These findings align with the enhanced precision, three-dimensional visualization, and instrument dexterity afforded by robotic platforms, which may reduce intraoperative tissue handling and improve anastomotic construction quality.

Video-assisted thoracoscopic surgery (VATS), evaluated for thoracic and selected abdominal procedures, demonstrated a wound infection rate of 4.2% and a 30-day mortality of 1.1%, with a mean hospital stay of 4.8 days. Anastomotic leak data were not applicable to the VATS cohort given the procedure spectrum included. The hybrid approach, combining elements of open and laparoscopic techniques, produced

intermediate outcomes: wound infection 6.3%, anastomotic leak 3.3%, mortality 1.8%, and mean stay 6.2 days—results that reflect the mixed operative exposure involved in this modality.

Across all minimally invasive groups combined, the weighted mean wound infection rate was 4.3% compared to 12.4% for open surgery, representing an approximately threefold reduction in infection risk. Similarly, 30-day mortality across minimally invasive approaches averaged 1.1% versus 3.2% for open laparotomy, and mean hospital stay was shortened by an average of 4.5 days. These differences were consistent with findings reported in the broader meta-analytic literature and highlight the reproducible safety advantage of minimal-access surgical strategies in abdominal surgery.

Discussion

The findings of this analysis confirm and extend current evidence demonstrating the superior postoperative safety profile of minimally invasive surgical techniques relative to conventional open laparotomy [18, 19]. The near-threefold reduction in wound infection rates associated with laparoscopic and robotic approaches reflects the well-established pathophysiological advantages of reduced incision size, diminished tissue devitalization, and attenuated systemic inflammatory response [20, 21].

Anastomotic leakage represents one of the most feared complications in gastrointestinal surgery, associated with significantly elevated morbidity, reoperation rates, and mortality [22, 23]. The lower leak rates observed with robotic-assisted surgery (2.1%) and laparoscopic approaches (2.9%) compared to open surgery (4.8%) suggest that operative precision and improved visualization afforded by these technologies may contribute to more consistent anastomotic integrity [24, 25]. However, it is important to acknowledge that anastomotic leak rates are multifactorial, influenced by patient nutritional status, bowel preparation, intraoperative blood flow assessment, and surgeon experience [26, 27].

The accelerated hospital discharge observed with minimally invasive approaches carries significant healthcare economic implications. Reduced length of stay translates to decreased institutional resource utilization, lower infection acquisition risk in the nosocomial environment, and improved patient quality of life through earlier return to functional independence [28, 29]. This finding provides additional impetus for integrating ERAS protocols with minimally invasive surgical strategies, as evidence consistently demonstrates synergistic reductions in both complication rates and recovery times when these approaches are combined [30, 31].

Despite the clear advantages of minimally invasive surgery, important barriers to universal adoption persist. Robotic-assisted platforms, which demonstrated the most favourable complication profile in this analysis, require substantial capital investment, specialized training programmes, and ongoing maintenance costs that remain

prohibitive in many healthcare settings [32, 33]. In low- and middle-income countries, where the burden of surgical disease is disproportionately high, conventional open surgery frequently remains the only available option, underscoring the urgent need for international investment in surgical infrastructure and training [34, 35].

Patient selection remains a critical determinant of complication risk regardless of technique. Older patients, those with obesity, diabetes mellitus, immunosuppression, or American Society of Anesthesiologists (ASA) class III–IV designation carry significantly elevated baseline complication risk that may attenuate the benefits of minimally invasive approaches [36, 37]. Rigorous preoperative optimization, including glycaemic control, nutritional assessment, prehabilitation, and smoking cessation, is therefore essential to maximizing surgical outcomes across all modalities [38, 39].

Emerging technologies, including artificial intelligence-assisted surgical planning, intraoperative fluorescence imaging for anastomotic perfusion assessment, and wearable sensor-based postoperative monitoring, hold considerable promise for further reducing complication rates in the coming decade [40, 41]. Integration of machine learning algorithms with electronic health record data may also enable more accurate preoperative risk stratification, supporting personalized surgical decision-making and targeted preventive interventions [42, 43].

Certain limitations of the present analysis merit acknowledgement. The synthesis draws upon aggregated data from heterogeneous study populations, varying follow-up periods, and different institutional contexts, which introduces inherent comparability constraints. Differences in case complexity, patient comorbidity burden, and institutional surgical volume across the included studies may confound direct technique comparisons [44, 45]. Future prospective, multicentre, randomized controlled trials with standardized outcome definitions and long-term follow-up are needed to further refine the comparative effectiveness of these approaches [46, 47].

Conclusion

The comparative analysis presented in this study provides compelling evidence that minimally invasive surgical approaches—laparoscopic, robotic-assisted, and video-assisted—deliver substantially superior postoperative complication profiles compared to conventional open laparotomy across abdominal surgical procedures. Robotic-assisted surgery emerged as the modality associated with the most favourable outcomes, achieving the lowest wound infection rates, anastomotic leak rates, and 30-day mortality alongside the shortest hospital stays. These advantages translate into measurable benefits for patient safety, recovery quality, and healthcare resource utilization. As surgical technology continues to evolve and access to minimally invasive platforms expands, the integration of these techniques with evidence-based perioperative care pathways represents the most promising strategy for reducing the global burden of surgical complications. Concerted efforts in surgical training,

international infrastructure investment, and data-driven outcome monitoring will be essential to realizing this potential—ensuring that patients across all healthcare settings can benefit from the transformative advances that modern minimally invasive surgery offers.

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