



Review Article

Advances in Robotic and Laparoscopic Gastrectomy for Gastric Cancer: A Comparative Review of Surgical Outcomes and Techniques

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Abstract

The comparison between robotic and laparoscopic gastrectomy in gastric cancer treatment has sparked considerable interest due to the unique benefits and limitations of each technique. Both approaches aim to provide minimally invasive alternatives to open surgery to reduce morbidity and enhance recovery. Robotic surgery offers enhanced precision and three-dimensional visualization, potentially improving oncological outcomes, particularly in complex cases. However, it also incurs higher costs and longer operative times, which may impact accessibility and resource allocation, especially in lower-resource settings. In contrast, laparoscopic gastrectomy remains a widely adopted, cost-effective approach with established efficacy in early-stage tumors but may be limited in more advanced cases requiring extensive lymphadenectomy. This review evaluates critical factors such as operative duration, oncological radicality, cost-effectiveness and long-term survival while exploring the potential role of artificial intelligence in robotic surgery. We address the challenges of implementing robotic systems in low- and middle-income countries and examine the psychological impact of surgical choice on patient outcomes. Although both techniques have demonstrated favorable short-term outcomes, there remains a need for long-term, large-scale studies to determine their comparative effectiveness in survival and recurrence. Comprehensive guidelines tailored to tumor staging and patient characteristics are essential to optimize the surgical approach. This review highlights the current knowledge gaps and suggests directions for future research to advance minimally invasive surgical options for gastric cancer.

Keywords: Robotic Surgical Procedures; Laparoscopy; Stomach Neoplasms; Gastrectomy; Treatment Outcome

Introduction

Gastric cancer stands as one of the most prevalent malignancies globally, representing a significant burden on healthcare systems and causing a high mortality rate, particularly in regions with late-stage diagnoses. The aggressive nature of this disease, combined with often limited options for early detection, emphasizes the need for effective surgical interventions [1-3]. For years, surgical resection has remained the primary curative approach, involving gastrectomy with thorough lymphadenectomy to ensure comprehensive removal of cancerous tissues. As surgery continues to be central to treatment, innovations in surgical techniques are essential to reduce morbidity while maintaining or enhancing oncological outcomes [4-6]. In recent decades, there has been a marked shift from traditional open surgery to minimally invasive techniques, which aim to minimize trauma and promote faster recovery. Laparoscopic gastrectomy has emerged as one of the most widely adopted minimally invasive approaches for gastric cancer due to its associated benefits [7-9].

Compared to open surgery, laparoscopy offers reduced blood loss, less postoperative pain, shorter hospital stays and a quicker return to daily activities. These benefits make it an attractive option, though the technique has limitations, particularly regarding maneuverability and depth perception, which can hinder precise dissections in challenging anatomical regions [10-12]. One of the primary limitations of laparoscopic surgery is its rigid, straight instruments and two-dimensional view of the operative field, which restricts the surgeon's ability to maneuver in confined spaces [13]. This limitation becomes especially relevant in cases requiring extensive lymphadenectomy or intricate anastomosis, where precision is paramount. Laparoscopic surgery demands a steep learning curve, affecting its accessibility across healthcare systems, as acquiring proficiency requires significant time and training [14,15]. Robotic-assisted surgery was introduced to address these challenges and expand the possibilities of minimally invasive approaches in complex surgeries. Robotic gastrectomy offers enhanced visualization through three-dimensional, high-definition imaging, giving the surgeon a stable and magnified view of the operative field [16-18]. The robotic instruments mimic the natural movements of the human wrist, offering seven degrees of freedom and increased dexterity, which enables precise dissections even in confined spaces. These technological advancements present robotic surgery as a promising option, particularly for complex or technically demanding cases [19-21].

Despite these technological advantages, robotic surgery faces notable challenges. The most prominent concern is the significantly longer operative time compared to laparoscopic surgery, attributed to the setup, docking of the robotic system and the time required for learning [22,23]. Although some proponents argue that robotic systems may have a faster learning curve than laparoscopy due to their intuitive controls, operative times remain a logistical consideration, especially in high-volume centers where surgical throughput is critical [24]. The cost associated with robotic systems is another major factor limiting their adoption. Robotic platforms require a substantial initial investment and high maintenance and operational expenses, considerably more significant than those associated with laparoscopic equipment [25,26]. In healthcare systems with restricted budgets, these financial demands become a crucial point of consideration. While robotic surgery may reduce certain postoperative complications and facilitate faster recovery, cost-effectiveness remains a key concern, particularly in resource-limited settings [27,28]. Clinically, both robotic and laparoscopic approaches seek to achieve the primary oncological goals of adequate lymph node dissection and clear surgical margins, both of which are critical for optimal tumor control and survival [29]. Studies indicate that robotic and laparoscopic gastrectomy achieve similar lymph node yield and margin status outcomes, suggesting comparable oncological safety [30]. However, there remains an ongoing debate about whether robotic gastrectomy provides any distinct oncological advantage, particularly in complex cases or advanced-stage diseases where precision is essential [15,31]. Postoperative recovery metrics also demonstrate differences between the two approaches. Robotic gastrectomy is frequently associated with lower intraoperative blood loss, reducing patients' physiological stress and speeding up postoperative recovery [32-34]. Patients undergoing robotic surgery often report a speedier return of bowel function, shorter hospital stays and reduced pain levels, all of which align well with Enhanced Recovery After Surgery (ERAS) protocols. These protocols emphasize early mobilization and discharge, making robotic surgery a potentially ideal choice within ERAS frameworks [35-37].

While robotic surgery offers certain recovery advantages, questions remain regarding its impact on long-term functional outcomes and quality of life. For patients undergoing major surgeries such as gastrectomy, postoperative quality of life is a critical outcome measure and limited long-term data is comparing robotic and laparoscopic approaches in this regard [38-40]. Understanding how these techniques affect survival and functional recovery remains an important area of research, particularly as minimally invasive approaches become more common [26]. The learning curve associated with robotic gastrectomy is a central consideration in its broader adoption. While robotic systems are often seen as more intuitive than laparoscopy, the learning curve for complex procedures, particularly those requiring extensive lymph node dissections, can still be substantial [41-43]. Surgeons new to robotic systems may experience increased operative times and complication rates during the initial learning period, highlighting the need for comprehensive training protocols to ensure safe and effective adoption [39,44]. Safety remains a priority when comparing robotic and laparoscopic gastrectomy, with both approaches demonstrating favorable perioperative outcomes. Some studies suggest that robotic surgery may offer additional safety benefits, such as a lower rate of intra-abdominal infections, attributed to the increased precision and stability of robotic instruments [22,45]. This advantage is especially pertinent for patients with elevated BMI or complex anatomical features, where maintaining surgical precision can be challenging with traditional laparoscopic tools [46]. Economic analysis further emphasizes the disparities between these two approaches. The substantial costs associated with robotic surgery raise questions about its accessibility and affordability within the broader healthcare context [47]. Cost-effectiveness analyses continue to explore whether the short-term benefits associated with robotic surgery, such as reduced hospital stay and faster recovery, justify the higher expenses. These findings are essential for healthcare providers,

particularly in settings where budget constraints dictate the feasibility of advanced surgical options [48].

The adaptability of robotic and laparoscopic platforms to emerging intraoperative technologies, such as fluorescence-guided surgery and near-infrared imaging, represents an exciting frontier in gastric cancer surgery [31,49]. These advanced imaging techniques offer potential benefits in visualizing tumor margins and lymphatic structures, enhancing surgical accuracy and minimizing residual disease. With their enhanced imaging capabilities, robotic platforms may be particularly well-suited to incorporate these technologies, potentially elevating the precision of gastric cancer resections [50-52]. As gastric cancer treatment continues to evolve, the roles of robotic and laparoscopic gastrectomy are increasingly scrutinized. Each approach has distinct advantages and limitations, with robotic systems offering enhanced dexterity and visualization at a more significant financial cost [8,53]. At the same time, laparoscopic techniques remain a more economical yet technically challenging option. The decision to adopt one approach over the other should consider patient-specific factors, surgeon expertise and institutional resources to achieve optimal outcomes [37].

Current research underscores the importance of a nuanced approach to gastric cancer surgery, where surgical decisions are tailored to each patient's individual characteristics. This includes considerations of tumor stage, patient anatomy and comorbidities, all of which can impact the feasibility and outcomes of minimally invasive surgery [47,54]. The availability of experienced surgeons and institutional support for advanced surgical technologies also plays a crucial role in determining the most appropriate surgical approach [20]. Robotic and laparoscopic gastrectomy offer valuable options for the surgical management of gastric cancer, each contributing uniquely to the field of minimally invasive surgery. As advancements continue, high-quality comparative studies are essential to clarify each approach's specific advantages and limitations, guiding surgical practice and policy [55-57]. This review aims to critically analyze and compare robotic and laparoscopic gastrectomy for gastric cancer, evaluate outcomes, technical challenges and cost considerations and discuss the potential future roles of these techniques in minimally invasive surgical oncology.

Methods

This review aimed to systematically examine the comparative outcomes of robotic versus laparoscopic gastrectomy for gastric cancer, focusing on oncological effectiveness, economic viability and technological advancements, including artificial intelligence applications in surgical practice. To achieve this objective, a systematic search was conducted across several databases, including PubMed, Scopus, Embase, Web of Science, SciELO and Google Scholar, covering literature up to the current date. The search terms included "Robotic Surgical Procedures," "Laparoscopy," "Stomach Neoplasms," "Gastrectomy," and "Treatment Outcome." Boolean operators (AND, OR) were employed to refine and streamline the search, maximizing the relevance of the studies retrieved. This review incorporated diverse study types, including randomized controlled trials, cohort studies, case-control studies, cross-sectional studies, case series, systematic reviews and meta-analyses, to provide a broad and reliable foundation of evidence. Studies were selected based on their examination of various outcomes, such as surgical success, oncological thoroughness, patient survival, cost-efficiency and technological integration in robotic and laparoscopic gastrectomies. Selection criteria were structured to focus on studies directly comparing these surgical methods in terms of survival metrics, postoperative recovery and the potential of artificial intelligence to enhance precision and decision-making in robotic surgery. Two reviewers independently screened titles and abstracts to maintain objectivity, with discrepancies resolved through discussion or by a third reviewer when necessary. Reviewers were blinded to study authorship and institutional details to minimize bias. Data extraction followed a standardized approach, capturing details on study type, patient demographics, primary findings and specific outcomes related to robotic and laparoscopic procedures. Data were analyzed thematically, with central themes organized around surgical duration, oncological rigor, cost-benefit assessment, long-term survival and the accessibility of robotic systems, particularly in low-resource settings.

Additionally, the analysis explored the psychological effects of surgical choices on patients and their recovery experience. The potential impact of artificial intelligence on surgical precision and efficiency, especially within robotic platforms, was also reviewed. This review synthesizes current literature to clarify the strengths and limitations of robotic and laparoscopic gastrectomies for gastric cancer. By identifying existing gaps in knowledge, the review provides insights into areas for future research, aiming to improve patient outcomes, optimize surgical practices and expand access to innovative surgical options across different healthcare environments.

Results and Discussion

Author	Study	Results
Guerrini GP, et al. (2020) [1]	Meta-analysis	Robotic gastrectomy was associated with lower postoperative complication rates and decreased intraoperative blood loss compared to laparoscopic gastrectomy. However, robotic procedures require significantly longer operative times. Long-term oncologic outcomes were similar between both approaches.
Ojima T, et al. (2021) [2]	Randomized Clinical Trial	It demonstrated that robotic gastrectomy could achieve similar short-term outcomes as laparoscopic gastrectomy, with potential benefits in reducing blood loss and hospital stays, although robotic surgery was associated with increased costs
Beyer K, (2023) [3]	Systematic Review	Highlighted the technical advantages of robotic surgery, such as improved dexterity and maneuverability, which may enhance precision in lymphadenectomy. Despite these benefits, robotic surgery's high costs and prolonged learning curve remain limiting factors for widespread adoption.
Lu J, et al. (2024) [5]	Phase 2 Randomized Trial	Found that robotic distal gastrectomy provided higher lymph node yields and enabled quicker postoperative recovery, yet incurred higher costs. This approach also showed reduced postoperative complications in comparison to laparoscopic surgery, though survival benefits were inconclusive.
Baral S, et al. (2022) [6]	Mega Meta-analysis	Compared multiple studies, finding that robotic gastrectomy improved recovery outcomes with a reduced length of hospital stay and decreased postoperative pain. However, it posed higher costs and required an extended learning period for surgeons. Long-term oncologic benefits were still undetermined.
Zizzo M, et al. (2022) [8]	Systematic Review	It is concluded that robotic gastrectomy may offer advantages in complex anatomical cases due to enhanced precision, particularly in advanced cancer with extensive lymph node involvement. Noted, however, that the technique's benefits must be weighed against increased operative time and resource demands.
Marano L, et al. (2021) [10]	Review	Provided evidence that robotic gastrectomy could potentially enhance perioperative safety by reducing intraoperative bleeding and postoperative complications. However, overall survival benefits compared to laparoscopic approaches remained minimal.
Shi Z, et al. (2023) [12]	Systematic Review & Meta-analysis	It showed that robotic gastrectomy significantly reduced blood loss and shortened hospital stays compared to laparoscopic gastrectomy. Robotic surgery had higher operative costs and longer procedure times, but it offered comparable oncologic efficacy in terms of margin clearance and lymph node retrieval.
Fukunaga T, et al. (2022) [14]	Nationwide Cohort Study	Analysis of nationwide data indicated that both robotic and laparoscopic approaches provided comparable long-term oncologic outcomes, though robotic surgery was linked to a faster recovery trajectory and reduced postoperative pain, particularly in complex or advanced-stage cases.
Tsutsui A, et al. (2023) [15]	National Database Analysis	Observed that robotic surgery was more advantageous in advanced gastric cancer cases, especially for thorough lymph node dissection and lower postoperative pain. However, high costs associated with robotic systems limit their widespread use in less resource-rich institutions.
Sun Y, et al. (2023) [17]	Systematic Review	Found both techniques to achieve similar oncologic outcomes; however, robotic surgery showed an edge in precision, potentially leading to improved recovery and reduced complication rates. Long-term survival data, however, remained inconclusive.
Lee H, et al. (2023) [19]	Propensity Score-Matched Analysis	Compared robotic and laparoscopic gastrectomy in patients with advanced gastric cancer, revealing that robotic surgery led to fewer postoperative complications and improved functional outcomes. However, it was noted that these benefits come at a higher operational cost.
Zhao H, et al.	Retrospective Study	Indicated that robotic gastrectomy provided enhanced precision in dissection, which contributed to fewer anastomotic complications and improved postoperative outcomes,

(2022) [22]		especially in patients with higher body mass index. Robotic surgery had longer setup times but was linked to shorter recovery periods.
Park JH, et al. (2023) [24]	ERAS Protocol Comparison	Evaluated outcomes under Enhanced Recovery After Surgery (ERAS) protocols, showing that robotic gastrectomy improved pain management, bowel function and reduced discharge times when compared with laparoscopic approaches. This effect was more pronounced in elderly patients or those with complex medical histories.
Yoon J, et al. (2023) [26]	Nonrandomized Controlled Trial	Fluorescence-guided imaging during robotic gastrectomy demonstrated increased lymph node detection rates, suggesting that robotic surgery may aid in more comprehensive oncologic resections. The study highlighted the potential for robotics in enhancing tumor margin accuracy.
Kang BH, et al. (2023) [27]	Multicenter Retrospective Analysis	Found that robotic gastrectomy was associated with lower postoperative morbidity and improved lymph node retrieval accuracy compared to laparoscopic surgery. The study emphasized the ergonomic and visual benefits of robotic systems in complex cases.
Zheng J, et al. (2023) [28]	Propensity Score-Matched Study	Demonstrated that in obese patients, robotic gastrectomy facilitated more accurate tissue handling, resulting in fewer complications and improved postoperative outcomes compared to laparoscopic methods. The higher cost remained a notable barrier for broader application.
Jeong O, et al. (2023) [30]	Learning Curve Study	Assessed the learning curve for robotic gastrectomy, noting that while initial cases required more time, surgeons became proficient with fewer cases than typically required for laparoscopic techniques. The study underscored robotic surgery's potential for more rapid skill acquisition.
Wang J, et al. (2023) [32]	Comparative Study on Enhanced Recovery Outcomes	Reported that robotic gastrectomy under ERAS protocols resulted in shorter hospital stays and improved patient-reported pain scores. The robotic approach showed particular benefits in patients undergoing extensive lymphadenectomy.
Lee WS, et al. (2023) [34]	Comparative Study	Focused on lymphadenectomy outcomes, demonstrating that robotic surgery allowed for more accurate and complete lymph node retrieval, particularly in advanced cancers. Improved ergonomic control was identified as a significant advantage in complex dissection cases.

Table 1: Comparative outcomes of robotic vs. laparoscopic gastrectomy for gastric cancer.

The comparison between robotic and laparoscopic gastrectomy in the treatment of gastric cancer has drawn significant interest and debate within the surgical and oncologic communities. Both methods aim to provide minimally invasive solutions that reduce morbidity and enhance recovery (Table 1) [58-60].

Still, questions remain about each approach's long-term oncological efficacy, cost-effectiveness and suitability across diverse patient populations. Robotic and laparoscopic techniques have successfully achieved clear resection margins and acceptable lymph node retrieval rates in early-stage cancers [61,62]. However, as cases become more advanced and anatomically complex, distinct differences in each technique's effectiveness and clinical outcomes become apparent [35].

The enhanced precision and high-definition, three-dimensional visualization provided by robotic systems offer theoretical advantages, especially in intricate dissections around critical structures [63]. However, it remains uncertain whether these technological benefits translate into improved survival rates or reduced recurrence, primarily due to a lack of long-term, large-scale studies focusing on these critical endpoints [64].

One major factor influencing the choice between robotic and laparoscopic gastrectomy is operative time. Robotic procedures generally require a more extended setup and docking time and involve complex intraoperative maneuvers, leading to increased operative durations [65,66]. This extended surgical time not only affects hospital resources by reducing operating room availability but also raises concerns about prolonged anesthesia exposure, especially for elderly patients or those with multiple comorbidities who may be more susceptible to perioperative complications [58,67].

Some proponents of robotic surgery argue that its precision and stability could mitigate postoperative complications and lead to faster recovery [11]. However, there remains a lack of consistent evidence to support these claims, emphasizing the need for more robust prospective studies to evaluate whether the technical advantages of robotic surgery justify the longer operative times, especially in high-risk populations [26,68].

The radicality of oncologic resection is essential in gastric cancer surgery, particularly regarding achieving negative resection margins and performing adequate lymphadenectomy [50,59]. The enhanced precision and control offered by robotic systems may facilitate more thorough dissection around complex vascular structures and lymphatic regions, which could be particularly beneficial in cases of locally advanced disease [14].

Some studies indicate that robotic gastrectomy enables more extensive lymph node retrieval than laparoscopic surgery, which is crucial for both accurate staging and therapeutic benefit in advanced gastric cancer [69]. However, the correlation between robotic precision and long-term oncologic outcomes, such as disease-free survival and recurrence rates, remains inconclusive [22]. The scarcity of consistent, long-term data on survival outcomes following robotic versus laparoscopic gastrectomy complicates efforts to draw definitive conclusions about the superiority of robotic systems in achieving curative surgical outcomes [70].

The role of neoadjuvant and adjuvant therapies is another consideration that influences the choice of surgical approach. Neoadjuvant therapy, aimed at reducing tumor burden and improving resectability, can lead to tissue fibrosis and anatomical changes that complicate surgery [71,72].

Robotic systems, with their enhanced precision and flexibility, may offer advantages in such challenging cases by potentially reducing the risk of complications associated with fibrosis and adhesions [73,74]. However, current evidence is limited and further studies are needed to confirm whether robotic systems offer significant benefits over laparoscopic surgery for patients undergoing neoadjuvant or adjuvant treatments. Postoperative recovery, complication rates and treatment tolerance in this context could provide valuable insights into the advantages and limitations of each approach for patients receiving multimodal therapy [75,76].

Tumor staging also plays a crucial role in determining the appropriate surgical approach. Early-stage gastric tumors, which generally require less extensive resection and lymphadenectomy, may not necessitate the advanced visualization and instrument dexterity provided by robotic systems. In such cases, laparoscopic gastrectomy might be more cost-effective and efficient [77-79].

In locally advanced cases requiring meticulous dissection and comprehensive lymphadenectomy, robotic surgery may be advantageous. Establishing clear guidelines on robotic versus laparoscopic approaches based on tumor stage and complexity could aid in optimizing patient outcomes and resource allocation, ensuring that each patient receives the most suitable surgical intervention [80-82].

Cost remains a substantial barrier to the widespread adoption of robotic gastrectomy. Robotic systems are associated with high initial capital investment, ongoing maintenance expenses and increased operative times, collectively contributing to their financial burden [74,83]. Proponents of robotic surgery argue that the reduced rates of postoperative complications, faster recovery times and shorter hospital stays associated with robotic procedures may help offset these costs. However, evidence supporting these economic advantages is limited [84].

Comprehensive cost-benefit analyses that evaluate direct and indirect healthcare expenses, including hospitalization, recovery time and long-term follow-up, are essential to understand better the economic feasibility of robotic surgery in gastric cancer treatment, particularly in low- and middle-income countries where financial efficiency is a priority [85,86]. Long-term survival outcomes following robotic versus laparoscopic gastrectomy have yet to be conclusively established. Some studies report comparable survival rates between the two approaches, while others suggest that the enhanced dissection capabilities of robotic systems may provide superior oncological control in advanced cases. However, the lack of robust, long-term data remains a significant limitation [87,88].

Future research should focus on comparing survival and recurrence rates between robotic and laparoscopic gastrectomy to determine whether the robotic approach offers a distinct survival advantage for gastric cancer patients, particularly those with advanced disease requiring complex oncologic resection [3;27].

Integrating Artificial Intelligence (AI) into robotic systems represents a promising frontier in surgical innovation. AI can support real-time decision-making, assist in anatomical recognition and even perform autonomous tasks during surgery, potentially enhancing the precision and safety of robotic procedures. AI-driven image recognition could improve lymph node identification and margin assessment, which are crucial in oncologic surgery [89,90].

AI into robotic surgery presents both ethical and practical challenges, including the need for rigorous safety protocols, specialized surgeon training and regulatory oversight. As AI advances, further research and development will be essential to assess AI applications' feasibility, safety and potential efficacy in gastric cancer surgery [63,91].

Access to robotic systems remains a significant issue, particularly in low- and middle-income countries with limited healthcare resources. The high costs associated with robotic systems and the need for specialized training and maintenance restrict their availability to high-resource settings, creating disparities in access to advanced surgical care [58,69]. Developing cost-effective robotic platforms and implementing financial support programs could help make robotic surgery more accessible in underserved regions. Ensuring equitable access to innovative surgical technologies is crucial for promoting global health equity, particularly in the treatment of high-burden cancers like gastric cancer [86,92].

Psychological aspects of surgical choice also warrant exploration, as robotic surgery is often perceived as a more technologically advanced option, potentially boosting patient confidence and satisfaction [60,83]. Patients who perceive their treatment as optimal may experience enhanced psychological well-being, which could contribute to a more favorable recovery trajectory. However, there is limited empirical data on the psychological effects of robotic versus laparoscopic gastrectomy [77,93]. Qualitative studies exploring patient-reported outcomes, satisfaction and perceived quality of care could reveal valuable insights into the psychosocial aspects of surgical choice, thereby enriching the patient-centered approach to gastric cancer treatment [52,94].

The decision-making process for elderly patients, who frequently present with multiple comorbidities, poses unique challenges. Minimally invasive surgery is generally preferred for this population to reduce surgical trauma and facilitate faster recovery [89,92]. Still, the comparative safety and efficacy of robotic versus laparoscopic approaches in elderly patients is not well-documented. Although robotic systems may offer ergonomic benefits, the extended operative times associated with robotic surgery may pose additional risks for this vulnerable demographic. More studies examining postoperative outcomes, complication rates and recovery trajectories in elderly patients undergoing either robotic or laparoscopic gastrectomy are needed to guide surgical decisions in this high-risk group [93-95].

Enhanced Recovery After Surgery (ERAS) protocols, which aim to accelerate recovery and reduce hospital stays, have incorporated robotic and laparoscopic approaches. While robotic surgery may facilitate faster recovery and potentially reduce complications, evidence comparing the effectiveness of robotic and laparoscopic approaches within ERAS protocols is limited [81,90]. Studies focusing on ERAS-specific outcomes, such as pain management, bowel function and discharge times, could further clarify the role of robotic systems in optimized recovery pathways and determine whether robotic surgery provides additional benefits in ERAS settings [29,36].

The extent of lymph node dissection is a critical factor in gastric cancer surgery, as it directly impacts prognosis and disease control. Robotic systems theoretically offer greater precision for extensive lymphadenectomy, particularly in advanced-stage cancers where meticulous dissection is essential. However, data on lymph node retrieval rates are inconsistent [74,96]. Some studies suggest that robotic surgery allows for higher lymph node retrieval, while others find no significant advantage over laparoscopic techniques. Further research is needed to determine if robotic systems consistently enhance the quality of lymphadenectomy and improve survival outcomes [49,94].

Hybrid procedures that combine robotic and laparoscopic techniques have emerged as an innovative approach, enabling surgeons to leverage the strengths of both methods. These procedures, which utilize robotic systems for delicate dissection and laparoscopy for more straightforward tasks, may reduce overall operative time while maintaining precision [14,35]. However, data on hybrid approaches' clinical efficacy and practicality are limited. Comparative studies assessing surgical outcomes, cost-effectiveness and operative efficiency in hybrid versus purely robotic or laparoscopic gastrectomy could determine the viability of hybrid techniques in complex gastric cancer cases [58-60].

AI and automation in robotic surgery offer transformative possibilities, such as enhancing precision, improving anatomical navigation and providing real-time decision support [30,65]. However, integrating AI into clinical practice presents significant challenges, including ethical considerations, regulatory requirements and the need for specialized training. Rigorous research on AI applications in robotic surgery is necessary to evaluate their safety, feasibility and impact on surgical outcomes [95-97]. Addressing disparities in access to robotic surgery is critical for ensuring that technological advancements in gastric cancer treatment benefit a broad range of patients. The high costs associated with robotic systems limit their availability in lower-resource settings, leading to inequities in surgical care [97,98].

Developing cost-effective solutions, such as subsidizing robotic platforms or implementing scalable models, could help bridge this gap and promote a more equitable distribution of surgical technology [19,82]. Overall, both robotic and laparoscopic gastrectomies offer distinct benefits and limitations in gastric cancer surgery. Robotic systems provide enhanced precision and may facilitate more comprehensive resections in complex cases, yet they incur higher costs and require longer operative times [92-94]. Laparoscopy, while less costly and more widely accessible, may be less advantageous in complex oncologic resections requiring meticulous dissection. The choice between these techniques should be tailored to patient-specific factors, including tumor stage, comorbidities, previous treatments, institutional resources and surgeon expertise [98,99]. Continued comparative research and technological advancements, particularly in AI integration and cost reduction, are essential to optimize gastric cancer treatment and make advanced surgical options accessible to a broader population worldwide [56,81].

Conclusion

In conclusion, the comparative analysis of robotic and laparoscopic gastrectomy for gastric cancer reveals that each approach offers distinct advantages and limitations, which must be carefully considered in clinical decision-making. Robotic surgery provides enhanced precision, improved visualization and excellent skill, potentially facilitating more comprehensive resections and lymphadenectomies in anatomically complex or advanced cases. However, the associated costs, extended operative times and limited accessibility pose significant barriers, particularly in low-resource settings. While laparoscopic gastrectomy remains a more cost-effective option and is broadly accessible, its technical limitations may reduce its applicability in complex oncologic cases where meticulous dissection is critical. The long-term oncologic outcomes, survival rates and recurrence rates for both approaches are yet to be definitively established, highlighting the need for further prospective, large-scale studies. Factors such as patient age, comorbidities, tumor staging and the potential role of neoadjuvant or adjuvant therapy should inform the surgical choice, as these elements may influence postoperative recovery and overall treatment success. Integrating artificial intelligence and hybrid surgical models holds promise for enhancing robotic surgery's efficiency and broadening its applicability, but further research is essential to validate these advancements in clinical settings. Achieving equitable access to advanced surgical techniques for gastric cancer treatment remains a global priority. Efforts to reduce costs and increase accessibility to robotic technology could help bridge the gap for underserved populations, ensuring that all patients can benefit from minimally invasive cancer surgery innovations. Continued research, technological advancements and policy efforts aimed at improving accessibility and reducing economic disparities will be crucial for optimizing surgical outcomes and advancing the standard of care for gastric cancer patients worldwide.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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