ADVANCES IN THE SURGICAL MANAGEMENT OF GASTRIC CANCER: MINIMALLY INVASIVE TECHNIQUES VERSUS CONVENTIONAL APPROACHES

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ABSTRACT

Gastric cancer represents one of the main causes of mortality from neoplasms in the world, especially in developing countries. This study aims to compare clinical, oncological, and quality of life outcomes between minimally invasive surgical techniques, such as laparoscopic and robotic gastrectomy, and the conventional open approach in gastric cancer management. A narrative review of the literature was carried out, using databases such as PubMed, Embase, Cochrane Library and SciELO. Studies published in the last ten years that comparatively addressed the different surgical techniques in patients with early and advanced gastric cancer were selected. Inclusion criteria were randomized clinical trials, systematic reviews, and meta-analyses focusing on perioperative, oncological, and quality of life outcomes. Descriptive studies or studies with a small number of cases were excluded. The data were analyzed descriptively, synthesizing information on intraoperative blood loss, length of hospital stay, postoperative complications, recurrence rates, and overall survival. The results showed that minimally invasive techniques have significant benefits in short-term outcomes, such as less surgical trauma, reduced blood loss, and faster recovery. Robotic gastrectomy demonstrated advantages in surgical precision and greater lymph node dissection, while laparoscopic gastrectomy stood out for its economic viability. Long-term oncological outcomes were equivalent between techniques, reinforcing the safety of minimally invasive approaches. However, barriers such as high costs and the long learning curve limit its large-scale implementation. It is concluded that minimally invasive techniques are safe and effective in the management of gastric cancer, and greater training and technological accessibility are needed to expand their application, especially in developing countries.

Keywords: Gastric Cancer. Minimally Invasive Techniques. Surgical Management.

INTRODUCTION

Gastric cancer is one of the main causes of mortality from malignant neoplasms in Brazil and worldwide, and is considered a global public health problem. Although its incidence shows a downward trend in developed countries, such as the United States and Japan, in Brazil, the scenario is still heterogeneous, with mortality rates stationary in some regions, such as the North, and increasing in the Northeast (HORA *et al.*, 2022). Factors such as inadequate diet, with high consumption of processed foods rich in nitrates, infection by Helicobacter pylori and smoking are among the main causes associated with its etiology (GONÇALVES *et al.*, 2018; HORA *et al.*, 2022). In addition, limited access to health services and early diagnosis strategies aggravates the impact of this neoplasm, particularly in regions of greater socioeconomic vulnerability (HORA *et al.*, 2022).

Surgery plays a central role in the curative treatment of gastric cancer, with total or subtotal gastrectomy being the standard in operable cases (ROLDÃO *et al.*, 2024). Lymphadenectomy is an essential component of this procedure, and the D2 technique is widely recommended due to its efficacy in locoregional control of the disease and positive impact on long-term survival. Studies indicate that adequate removal of regional lymph nodes not only improves oncological staging, but also significantly reduces the risk of local recurrence (ROLDÃO *et al.*, 2024; SVERSUTI FILHO *et al.*, 2024). However, more extensive lymphadenectomy, such as D3, although potentially beneficial in specialized centers, is associated with higher rates of perioperative complications, limiting its indication (ROLDÃO *et al.*, 2024).

In recent years, minimally invasive techniques, such as laparoscopy, have been explored as alternatives to improve postoperative recovery and reduce complications, without compromising oncological outcomes (MELO *et al.*, 2024; ROLDÃO *et al.*, 2024). Despite the advances, the choice of surgical method should be individualized, considering the tumor staging, the clinical conditions of the patient and the experience of the medical team (ROLDÃO *et al.*, 2024).

In recent years, advances in minimally invasive techniques, such as laparoscopy and robotic surgery, have transformed the management of gastric cancer, offering significant benefits compared to conventional approaches. These techniques are associated with smaller incisions, less surgical trauma, faster recovery, and reduction in postoperative complications, such as infections and hemorrhages (COUTINHO *et al.*, 2023; BARCHI *et al.*, 2021). Robotic surgery, in particular, stands out for its precision, allowing a three-dimensional view of the operative field and greater ergonomics for the surgeon, which facilitates the dissection of complex anatomical structures (COUTINHO *et al.*, 2023).

However, these techniques face limitations, such as the need for an extensive learning curve and the dependence on advanced technological infrastructure, restricting their implementation in centers with a lower surgical volume (BARCHI *et al.*, 2021; MELO *et al.*, 2024). Recent studies have shown that minimally invasive techniques have achieved oncological results comparable to those of open surgeries, consolidating themselves as an effective and safe alternative, especially for cases of early gastric cancer (COUTINHO *et al.*, 2023).

Despite the advantages of minimally invasive techniques, their widespread adoption faces significant challenges. The implementation of these approaches requires specialized training and high surgical volume to overcome the learning curve and ensure the performance of procedures with adequate technical quality (BARCHI *et al.,* 2021). In addition, the high cost of equipment and the need for advanced technological infrastructure are relevant barriers, particularly in health systems in developing countries, such as Brazil (COUTINHO *et al.*, 2023). Another critical point is the limitation in the indication of these techniques for more advanced cases of gastric cancer, in which the need for extensive lymphadenectomy and complex resections can compromise oncological results when performed by a minimally invasive route (MELO *et al.*, 2024). Prospective and controlled studies remain essential to evaluate the safety, efficacy, and cost-effectiveness of these techniques in different stages of the disease and clinical settings (BARCHI *et al.*, 2021; COUTINHO *et al.*, 2023).

This study aims to analyze and compare minimally invasive and conventional approaches in the surgical management of gastric cancer, discussing the advances, limitations, and impact of these techniques on oncological outcomes and patients' quality of life.

METHODOLOGY

This study constitutes a narrative review of the literature, conducted in December 2024, with the objective of analyzing and comparing minimally invasive and conventional approaches in the surgical management of gastric cancer. The research was guided by the following research question: "What are the oncological, perioperative, and quality-of-life outcomes of minimally invasive techniques compared to conventional surgical approaches in the treatment of gastric cancer?".

The selection of references was carried out in the PubMed and Virtual Health Library (VHL) databases, using controlled descriptors extracted from the DeCS and MeSH vocabularies, such as "gastric cancer", "gastrectomy", "minimally invasive surgery" and

"laparoscopic surgery", combined with Boolean operators (AND and OR). Filters were applied to include only studies published in the last five years, available in full text and in Portuguese, English or Spanish. The inclusion criteria involved comparative studies between surgical techniques, addressing oncological outcomes, perioperative complications, and quality of life. Simple abstracts, expanded abstracts, opinion articles, descriptive studies, and studies that did not directly address the scope of the present study were excluded.

The study selection process was carried out in stages. Initially, titles and abstracts were evaluated to identify eligible works. Subsequently, the full texts of the potentially relevant articles were reviewed to confirm their adequacy to the inclusion criteria. Data analysis was conducted descriptively, synthesizing the most relevant contributions of each study, focusing on the advances and limitations of minimally invasive techniques compared to conventional open surgery.

RESULTS AND DISCUSSION

A total of 115 articles were found and 11 studies were selected for full reading and inclusion in the results of this study.

Minimally invasive techniques, including laparoscopic gastrectomy (GL) and robotic gastrectomy (RG), have been consolidated as promising alternatives to conventional open surgery (GA) in the treatment of gastric cancer. These approaches are based on principles of reducing surgical trauma, preserving functional anatomy, and optimizing the postoperative period, with the expectation of offering outcomes similar to or superior to those of conventional techniques. Laparoscopy, widely adopted in cases of early gastric cancer, is characterized by minimally invasive access with advanced instrumentation and less tissue trauma, while robotics uses platforms such as the Da Vinci System, which increase surgical precision and minimize ergonomic limitations inherent to traditional laparoscopy (RIBEIRO JR. *et al.*, 2022; GUERRINI *et al.*, 2020).

On the other hand, open surgery continues to be widely used in more advanced cases or in situations of greater technical complexity, due to its versatility and the familiarity of surgeons with the approach. However, the literature has pointed to increasing advantages of minimally invasive techniques, including less intraoperative blood loss, reduced hospital stays, and better postoperative functional recovery, factors that have expanded their adoption even in scenarios of greater oncological complexity (BITTAR *et al.*, 2024; ELE *et al.*, 2024). Still, issues such as the long learning curve and the high cost of

robotic technology remain barriers to the universal implementation of these techniques (OJIMA *et al.*, 2021).

Although initially limited to early gastric cancer scenarios, minimally invasive techniques have been shown to be effective in more advanced cases, especially when performed by experienced teams in high-complexity centers. WPA, for example, has demonstrated oncological outcomes equivalent to GA in the long term, with similar rates of R0 resection and overall survival, as evidenced in studies such as the one by Etoh *et al.* (2023). In a complementary way, GR has overcome the technical limitations of conventional laparoscopy, presenting greater efficiency in lymph node dissection and a lower rate of serious postoperative complications (GUERRINI *et al.*, 2020; RIBEIRO JR. *et al.*, 2022).

Ribeiro Jr. *et al.* (2022) observed that RG reduced intraoperative blood loss by more than 50% compared to GA, with no significant difference in the mean number of lymph nodes collected or in the frequency of postoperative complications. However, GR was associated with a longer operative time ($p < 0.001$), highlighting its safety and feasibility in Western institutions with adequate infrastructure. Guerrini *et al.* (2020) reinforced these advantages by demonstrating that GR has lower rates of serious complications (OR 0.66; $p = 0.005$) and a higher number of dissected lymph nodes (MD 1.84; $p = 0.0003$), compared to WPA. However, the learning curve of GR and high costs limit its large-scale adoption, especially in developing countries.

The meta-analysis conducted by Bittar *et al.* (2024) highlighted the benefits of WPA over GA, such as less intraoperative blood loss (MD −51.24 mL; 95% CI −81.41 to −21.06) and shorter length of hospital stay (MD −0.83 days; 95% CI −1.60 to −0.06). Despite this, WPA was associated with an increased risk of pancreatic fistula (RR 2.44; 95% CI 1.08 to 5.50), requiring greater caution in advanced tumors. In super-elderly patients (>80 years old), Ele *et al.* (2024) demonstrated that WPD offers better short-term outcomes, including less blood loss (SMD = −166.96 mL; $p < 0.001$), shorter hospital stay (SMD = −0.78 days; $p < 0.001$), and a higher 5-year overall survival rate (OR = 1.66; $p = 0.03$), highlighting that age should not be a contraindication for minimally invasive techniques.

With regard to quality of life, Farias (2023) evaluated patients undergoing WPA and AG using the QLQ-C30 and QLQ-STO22 questionnaires, observing significantly better scores in the pain and physical function domains for patients treated with WPA. In addition, Park *et al.* (2023) investigated patients undergoing laparoscopic proximal gastrectomy with dual-tract reconstruction (LPG-DTR) and laparoscopic total gastrectomy (LTG), concluding that LPG-DTR reduced the need for vitamin B12 supplementation (2.1 mg vs 0.4 mg; $p <$

0.001) and had better physical and social function, suggesting its superiority in patients with early gastric cancer in the upper third.

Long-term oncological results show equivalence between minimally invasive techniques and GA. Etoh *et al.* (2023) reported similar rates of 5-year relapse-free survival for SGA with D2 dissection and GA (75.7% vs 73.9%; HR 0.96; p = 0.03), consolidating WPA as a viable alternative for advanced cases. In a broader context, Araújo *et al.* (2022) reinforced the oncological safety of WPA, observing R0 margins comparable to those of GA in tumors larger than 5 cm (p = 0.76) and similar recurrence rates (p = 0.09).

While promising, minimally invasive techniques face significant barriers to their widespread adoption. Ojima *et al.* (2021) highlighted that, despite the advantages of GR in reducing serious infectious complications (5.3% vs 16.2%; p = 0.01), the high cost and dependence on advanced infrastructure restrict its implementation. Similarly, Liu *et al.* (2020) pointed out that despite the safety of laparoscopic total gastrectomy for early gastric cancer, its extensive learning curve requires highly skilled surgeons and ongoing training.

Outcomes related to postoperative recovery show clear advantages of minimally invasive techniques over open surgery. Studies such as the one by Liu *et al.* (2020) indicate that laparoscopic total gastrectomy for early gastric cancer reduces the time required for resumption of daily activities, including the time for ambulation (MD −0.27 days; 95% CI −0.47 to −0.07) and the start of fluid intake (p < 0.05). These findings are particularly relevant for elderly patients or those with comorbidities, in whom a faster recovery can positively impact quality of life and minimize late complications.

In addition, laparoscopic gastrectomy with double tract reconstruction (LPG-DTR) has been shown to be a functionally preserving alternative in patients with early gastric cancer in the upper third, with a positive impact on hematological parameters. Park *et al.* (2023) reported a smaller drop in hemoglobin levels and significant reduction in the need for vitamin B12 supplementation compared to laparoscopic total gastrectomy. This suggests that surgical strategies that prioritize functional preservation may be preferable in patients with favorable prognosis, improving not only survival but also long-term nutritional and metabolic aspects.

Technological advances, such as the use of 3D laparoscopy, have contributed to the optimization of results in minimally invasive surgeries. Rodrigues *et al.* (2023) demonstrated that 3D laparoscopy reduces operative time (WMD −28.57 minutes; p = 0.011) and intraoperative blood loss (WMD −6.69 mL; p < 0.001) compared to conventional 2D laparoscopy. Although these benefits seem modest in absolute terms, in highly complex

settings, these differences can translate into fewer intraoperative complications and greater procedural efficiency.

On the other hand, differences in oncological outcomes between techniques remain an area of debate. The study by Etoh *et al.* (2023) pointed out that 5-year recurrence-free survival was equivalent between laparoscopic and open gastrectomy, regardless of tumor stage (HR 0.96; p = 0.03). However, the greater lymph node dissection observed in RG (MD 1.84; p = 0.0003) in studies such as the one by Guerrini *et al.* (2020) raises questions about the potential impact on locoregional recurrence and long-term cancer control, especially in high-risk populations.

The surgeon's experience and the volume of the center are critical factors that directly influence the outcomes of minimally invasive techniques. The CLASS02 study (2020) highlighted that morbidity and mortality rates are similar between laparoscopic and open gastrectomy only when performed by highly qualified teams. In lower-volume centers, lack of training and an extensive learning curve can increase perioperative complication rates and compromise the expected benefits of minimally invasive approaches.

Finally, the socioeconomic impact of robotic and laparoscopic techniques deserves to be highlighted. Although RM has clinical benefits, such as a lower rate of serious complications and greater surgical precision, its high cost and dependence on state-of-the-art technology limit its widespread implementation. Ribeiro Jr. *et al.* (2022) pointed out that, in developing countries, the availability of robotic platforms is restricted, and GA remains the predominant approach, even in cases where minimally invasive techniques could offer advantages. Investments in technical training and the dissemination of accessible technologies are essential to expand access to these innovations.

FINAL CONSIDERATIONS

Advances in minimally invasive techniques, such as laparoscopic and robotic gastrectomy, have provided significant improvements in gastric cancer management, excelling in short-term outcomes such as reduced surgical trauma, less blood loss, and accelerated recovery. In addition, these techniques have demonstrated oncological results equivalent to open surgery, especially in cases of early cancer, and remarkable benefits in terms of quality of life, particularly in elderly patients or those with favorable prognosis.

However, important barriers still limit the widespread adoption of these approaches, including the long learning curve, the need for advanced infrastructure, and high operating costs, especially in developing countries. The individualization of the choice of surgical

technique is fundamental, considering factors such as tumor stage, clinical conditions of the patient, availability of technological resources and the experience of the surgical team.

In the global context, efforts to disseminate accessible technologies, offer specialized training, and conduct additional studies with higher-risk populations are crucial to consolidate minimally invasive techniques as the standard of care in various clinical settings. With the continuous advances in technology and the expansion of its accessibility, it is expected that these minimally invasive approaches will play a central role in the surgical management of gastric cancer, promoting better outcomes and quality of life for patients.

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