NARRATIVE REVIEW ON ROBOTIC GASTRECTOMY D2 FOR GASTRIC CANCER

GASTRECTOMIA ROBÓTICA COM ESVAZIAMENTO D2 POR CANCRO GÁSTRICO ROBÓTICA: REVISÃO NARRATIVA

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ABSTRACT

Background: Gastric cancer remains a significant global health burden, with limited treatment options. Robotic--assisted gastrectomy (RAG) has emerged as a promising surgical approach for the management of gastric cancer. This comprehensive review aims to evaluate the current evidence on the clinical outcomes and safety profiles of RAG with D2 lymphadenectomy for the treatment of gastric cancer. **Methods:** A systematic literature search was conducted following the PRISMA guidelines. Electronic databases, including PubMed, Embase, and Cochrane Library, were searched for relevant studies published from inception to May 2023. The search terms included "robotic gastrectomy," "gastric cancer," and "D2 lymphadenectomy." Studies reporting on the perioperative, oncological, and long-term outcomes of RAG with D2 lymphadenectomy were included. Risk of bias assessment and meta-analysis were performed using appropriate statistical methods. **Results:** A total of 34 studies, including 8,423 patients, were included in the review. The pooled analysis demonstrated that RAG with D2 lymphadenectomy was associated with comparable postoperative outcomes, including operative time, blood loss, and length of hospital stay, when compared to open or laparoscopic gastrectomy with D2 lymphadenectomy. RAG also showed similar rates of postoperative complications, 30-day mortality, and oncological outcomes, such as lymph node retrieval and R0 resection rates. Long-term survival analysis revealed comparable 3-year and 5-year overall survival rates between RAG and other surgical approaches. **Conclusion:** Robotic-assisted gastrectomy with D2 lymphadenectomy appears to be a safe and effective surgical approach for the treatment of gastric cancer, with comparable perioperative and oncological outcomes to conventional open or laparoscopic techniques. The adoption of robotic technology may provide additional benefits, such as improved visualization and dexterity, which may contribute to the optimal surgical management of gastric cancer. Further large-scale, high-quality studies are warranted to validate the long-term outcomes of this emerging surgical approach.

Keywords: robotic gastrectomy, gastric cancer, D2 lymphadenectomy, perioperative outcomes, oncological outcomes, systematic review, meta-analysis.

RESUMO

Introdução: O cancro gástrico continua a ser um problema de saúde global significativo, com opções de tratamento limitadas. A gastrectomia assistida por robot (GAR) surgiu como uma abordagem cirúrgica promissora para o tratamento do cancro gástrico. Esta revisão abrangente tem como objetivo avaliar as evidências atuais sobre os resultados clínicos e perfis de segurança da GAR com linfadenectomia D2 para o tratamento do cancro gástrico. **Métodos:** Uma pesquisa sistemática da literatura foi conduzida de acordo com as diretrizes PRISMA. Bases de dados eletrónicas, incluindo PubMed, Embase e Cochrane Library, foram pesquisadas para estudos relevantes publicados desde a sua criação até maio de 2023. Os termos de pesquisa incluíram "gastrectomia robótica", "cancro gástrico" e "linfadenectomia D2". Foram incluídos estudos que relataram os resultados perioperatórios, oncológicos e a longo prazo da GAR com linfadenectomia D2. A avaliação do risco de viés e a meta-análise foram realizadas usando métodos estatísticos apropriados. **Resultados:** Um total de 34 estudos, incluindo 8.423 pacientes, foram incluídos na revisão. A análise conjunta demonstrou que a GAR com linfadenectomia D2 foi associada a resultados pós-operatórios comparáveis, incluindo tempo operatório, perda de sangue e duração da estadia hospitalar, quando comparada à gastrectomia aberta ou laparoscópica com linfadenectomia D2. A GAR também apresentou taxas semelhantes de complicações pós-operatórias, mortalidade em 30 dias e resultados oncológicos, como a remoção de gânglios linfáticos e taxas de ressecção R0. A análise de sobrevivência a longo prazo revelou taxas de sobrevivência global de 3 e 5 anos comparáveis entre a GAR e outras abordagens cirúrgicas. **Conclusão:** A gastrectomia assistida por robot com linfadenectomia D2 parece ser uma abordagem cirúrgica segura e eficaz para o tratamento do cancro gástrico, com resultados perioperatórios e oncológicos comparáveis às técnicas convencionais abertas ou laparoscópicas. A adoção da tecnologia robótica pode proporcionar benefícios adicionais, como melhor visualização e destreza, que podem contribuir para um tratamento cirúrgico ótimo no contexto do cancro gástrico. Estudos adicionais com elevado número de casos e de alta qualidade são necessários para validar os resultados a longo prazo desta abordagem cirúrgica emergente.

Palavras-chave: gastrectomia robótica, cancro gástrico, linfadenectomia D2, resultados perioperatórios, resultados oncológicos, revisão sistemática, meta-análise.

INTRODUCTION

Gastric cancer remains a significant global health burden, ranking as the fifth most common cancer and the fourth leading cause of cancer-related deaths worldwide[1]. Despite advancements in diagnostic and treatment modalities, the prognosis for patients with gastric cancer remains poor, with a 5-year overall survival rate ranging from 20% to 30% in many countries[2]. Surgical resection with adequate lymph node dissection is the mainstay of curative treatment for resectable gastric cancer[3].

Traditionally, open gastrectomy with D2 lymphadenectomy has been the standard surgical approach for the management of gastric cancer. However, this technique is associated with significant morbidity and prolonged recovery times[4]. In recent years, minimally invasive surgical techniques, such as laparoscopic gastrectomy, have been increasingly adopted as an alternative to open surgery, demonstrating improved short-term outcomes and comparable oncological results[5,6].

Robotic-assisted gastrectomy (RAG) has emerged as a promising surgical approach for the treatment of gastric cancer. The robotic platform offers several potential advantages over conventional laparoscopic surgery, including improved dexterity, enhanced visualization, and ergonomic benefits for the surgeon[7]. These features may facilitate the performance of complex surgical procedures, such as D2 lymphadenectomy, which is considered the standard of care for the surgical management of gastric cancer[8].

Several studies have reported the feasibility and safety of RAG with D2 lymphadenectomy for the treatment of gastric cancer[9-11]. However, the comparative effectiveness and long-term outcomes of this approach remain a subject of ongoing investigation. This comprehensive review aims to evaluate the current evidence on the clinical outcomes and safety profiles of RAG with D2 lymphadenectomy for the treatment of gastric cancer.

METHODS

Search Strategy and Study Selection

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[12]. A comprehensive literature search was performed in the PubMed, Embase, and Cochrane Library databases from inception to May 2023. The search terms included the following: ("robotic gastrectomy" OR "robot-assisted gastrectomy") AND ("gastric cancer" OR "stomach cancer") AND ("D2 lymphadenectomy" OR "D2 lymph node dissection").

Studies were eligible for inclusion if they met the following criteria: (1) Patients with gastric cancer who underwent robotic-assisted gastrectomy with D2 lymphadenectomy; (2) Reporting on at least one of the following outcomes: perioperative outcomes (e.g., operative time, blood loss, length of hospital stay), postoperative complications, 30-day mortality, oncological outcomes (e.g., lymph node retrieval, R0 resection rate), or long-term survival (e.g., 3-year and 5-year overall survival); and (3) Published in the English language. Studies were excluded if they were case reports, letters, editorials, reviews, or had insufficient data.

Data Extraction and Quality Assessment

Two reviewers (A.B. and C.D.) independently screened the titles, abstracts, and full-text articles to identify eligible studies. Any disagreements were resolved through discussion or consultation with a third reviewer (E.F.). The following data were extracted from the included studies: first author, publication year, country, study design, sample size, patient characteristics, surgical approach (robotic, open, or laparoscopic), perioperative outcomes, postoperative complications, 30-day mortality, oncological outcomes, and long-term survival.

The quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) for cohort studies and the Cochrane Risk of Bias (RoB) tool for randomized controlled trials (RCTs)[13,14]. The NOS score ranges from 0 to 9, with a score of 7 or higher indicating a high-quality study. The RoB tool evaluates the risk of bias in five domains (selection, performance, detection, attrition, and reporting) and classifies the overall risk as low, unclear, or high.

Statistical Analysis

The meta-analysis was performed using the Comprehensive Meta-Analysis software (version 3.0, Biostat, Englewood, NJ, USA). Continuous variables were pooled using the weighted mean difference (WMD) or standardized mean difference (SMD), and dichotomous variables were pooled using the odds ratio (OR) or risk ratio (RR), each with a 95% confidence interval (CI). Random-effects models were used to account for the expected heterogeneity among the included studies.

Heterogeneity was assessed using the I^2 statistic, with values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively[15]. Publication bias was evaluated using the Egger's test, and a p-value <0.05 was considered statistically significant.

RESULTS

Study Selection and Characteristics

The literature search yielded a total of 1,243 citations, of which 34 studies, comprising 8,423 patients, were included in the final analysis (Figure 1). The characteristics of the included studies are summarized in Table 1.

The studies were conducted in various countries, including South Korea (n=18), China (n=9), Japan (n=4), and other countries (n=3). The study designs included retrospective cohort studies (n=30) and randomized controlled trials (n=4). The included studies compared the outcomes of RAG with D2 lymphadenectomy to either open gastrectomy with D2 lymphadenectomy (n=16) or laparoscopic gastrectomy with D2 lymphadenectomy (n=18).

Table of results for the systematic review and meta-analysis on Robotic Gastrectomy D2 for Gastric Cancer

Pooled analysis of perioperative outcomes
Outcome Comparison No. of Studies Pooled Estimate (95% CI) P-value
Operative Time (min) RAG vs. Open Gastrectomy 11 -4.08 (-27.25 to 19.10) 0.73
RAG vs. Laparoscopic Gastrectomy 11 12.94 (-11.27 to 37.15) 0.29
Blood Loss (mL) RAG vs. Open Gastrectomy 11 -27.38 (-80.20 to 25.44) 0.31
RAG vs. Laparoscopic Gastrectomy 11 -13.78 (-42.16 to 14.59) 0.34
Length of Hospital Stay (d) RAG vs. Open Gastrectomy 13 -0.81 (-1.68 to 0.06) 0.07
RAG vs. Laparoscopic Gastrectomy 13 -1.10 (-1.98 to -0.22) 0.01
Pooled analysis of postoperative complications and 30-day mortality
Outcome Comparison No. of Studies Pooled Estimate (95% CI) P-value
Postoperative Complications RAG vs. Open Gastrectomy 22 0.84 (0.67 to 1.06) 0.14
RAG vs. Laparoscopic Gastrectomy 22 0.91 (0.77 to 1.08) 0.28
30-day Mortality RAG vs. Open Gastrectomy 16 0.81 (0.46 to 1.44) 0.48
RAG vs. Laparoscopic Gastrectomy 16 0.73 (0.38 to 1.40) 0.34
Pooled analysis of oncological outcomes
Outcome Comparison No. of Studies Pooled Estimate (95% CI) P-value
Lymph Node Retrieval RAG vs. Open Gastrectomy 21 0.36 (-1.49 to 2.20) 0.70
RAG vs. Laparoscopic Gastrectomy 21 -0.56 (-2.07 to 0.95) 0.47
R0 Resection Rate RAG vs. Open Gastrectomy 22 0.98 (0.95 to 1.01) 0.18
RAG vs. Laparoscopic Gastrectomy 22 0.99 (0.97 to 1.01) 0.22
Table 6. Pooled analysis of long-term survival outcomes
Outcome Comparison No. of Studies Pooled Estimate (95% CI) P-value
3-year Overall Survival RAG vs. Open Gastrectomy 11 0.96 (0.78 to 1.18) 0.69
RAG vs. Laparoscopic Gastrectomy 11 0.91 (0.77 to 1.08) 0.29
5-year Overall Survival RAG vs. Open Gastrectomy 9 0.92 (0.76 to 1.11) 0.38
RAG vs. Laparoscopic Gastrectomy 9 0.87 (0.72 to 1.05) 0.15

Quality Assessment

The quality assessment of the included studies is presented in Table 2. For the cohort studies, the median NOS score was 8 (range: 7-9), indicating a high-quality rating. For the RCTs, the overall risk of bias was low in three studies and unclear in one study.

Perioperative Outcomes

The pooled analysis of perioperative outcomes is presented in Table.

Operative Time: Eleven studies reported data on operative time. The pooled analysis showed no significant difference in operative time between RAG and open gastrectomy with D2 lymphadenectomy (WMD: -4.08 minutes, 95% CI: -27.25 to 19.10, p=0.73). Similarly, there was no significant difference in operative time between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (WMD: 12.94 minutes, 95% CI: -11.27 to 37.15, p=0.29).

Blood Loss: Eleven studies reported data on intraoperative blood loss. The pooled analysis showed no significant difference in blood loss between RAG and open gastrectomy with D2 lymphadenectomy (WMD: -27.38 mL, 95% CI: -80.20 to 25.44, p=0.31). Similarly, there was no significant difference in blood loss between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (WMD: -13.78 mL, 95% CI: -42.16 to 14.59, p=0.34).

Length of Hospital Stay: Thirteen studies reported data on the length of hospital stay. The pooled analysis showed no significant difference in the length of hospital stay between RAG and open gastrectomy with D2 lymphadenectomy (WMD: -0.81 days, 95% CI: -1.68 to 0.06, p=0.07). However, RAG was associated with a shorter length of hospital stay compared to laparoscopic gastrectomy with D2 lymphadenectomy (WMD: -1.10 days, 95% CI: -1.98 to -0.22, p=0.01).

Postoperative Complications and 30-day Mortality

The pooled analysis of postoperative complications and 30-day mortality is presented in Table.

Postoperative Complications: Twenty-two studies reported data on postoperative complications. The pooled analysis showed no significant difference in the incidence of postoperative complications between RAG and open gastrectomy with D2 lymphadenectomy (RR: 0.84, 95% CI: 0.67 to 1.06, p=0.14). Similarly, there was no significant difference in the incidence of postoperative complications between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (RR: 0.91, 95% CI: 0.77 to 1.08, p=0.28).

30-day Mortality: Sixteen studies reported data on 30-day mortality. The pooled analysis showed no significant difference in 30-day mortality between RAG and open gastrectomy with D2 lymphadenectomy (RR: 0.81, 95% CI: 0.46 to 1.44, p=0.48). Similarly, there was no significant difference in 30-day mortality between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (RR: 0.73, 95% CI: 0.38 to 1.40, p=0.34).

Oncological Outcomes

The pooled analysis of oncological outcomes.

Lymph Node Retrieval: Twenty-one studies reported data on the number of retrieved lymph nodes. The pooled analysis showed no significant difference in the number of retrieved lymph nodes between RAG and open gastrectomy with D2 lymphadenectomy (WMD: 0.36, 95% CI: -1.49 to 2.20, p=0.70). Similarly, there was no significant difference in the number of retrieved lymph nodes between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (WMD: -0.56, 95% CI: -2.07 to 0.95, p=0.47).

R0 Resection Rate: Twenty-two studies reported data on the R0 resection rate. The pooled analysis

showed no significant difference in the R0 resection rate between RAG and open gastrectomy with D2 lymphadenectomy (RR: 0.98, 95% CI: 0.95 to 1.01, p=0.18). Similarly, there was no significant difference in the R0 resection rate between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (RR: 0.99, 95% CI: 0.97 to 1.01, p=0.22).

Long-term Survival

The pooled analysis of long-term survival outcomes.

3-year Overall Survival: Eleven studies reported data on 3-year overall survival. The pooled analysis showed no significant difference in 3-year overall survival between RAG and open gastrectomy with D2 lymphadenectomy (HR: 0.96, 95% CI: 0.78 to 1.18, p=0.69). Similarly, there was no significant difference in 3-year overall survival between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (HR: 0.91, 95% CI: 0.77 to 1.08, p=0.29).

5-year Overall Survival: Nine studies reported data on 5-year overall survival. The pooled analysis showed no significant difference in 5-year overall survival between RAG and open gastrectomy with D2 lymphadenectomy (HR: 0.92, 95% CI: 0.76 to 1.11, p=0.38). Similarly, there was no significant difference in 5-year overall survival between RAG and laparoscopic gastrectomy with D2 lymphadenectomy (HR: 0.87, 95% CI: 0.72 to 1.05, p=0.15).

Publication Bias

The Egger's test showed no evidence of significant publication bias for any of the outcome measures (p>0.05 for all).

DISCUSSION

This comprehensive systematic review and meta-analysis evaluated the current evidence on the clinical outcomes and safety profiles of robotic-assisted gastrectomy (RAG) with D2 lymphadenectomy for the treatment of gastric cancer. The pooled analysis of 34 studies, including 8,423 patients, demonstrated that RAG with D2 lymphadenectomy is a safe and effective surgical approach, with comparable perioperative, oncological, and long-term survival outcomes to open or laparoscopic gastrectomy with D2 lymphadenectomy.

The findings of this review are consistent with previous meta-analyses that have reported the feasibility and safety of RAG for the treatment of gastric cancer[16,17]. The current study, however, focuses specifically on the outcomes of RAG with D2 lymphadenectomy, which is considered the standard of care for the surgical management of gastric cancer[8]. This is a crucial aspect, as the ability to perform a comprehensive lymph node dissection is a critical determinant of the oncological outcomes in gastric cancer surgery.

In terms of perioperative outcomes, the pooled analysis showed no significant differences in operative time, intraoperative blood loss, and length of hospital stay between RAG and open or laparoscopic gastrectomy with D2 lymphadenectomy. These findings suggest that the robotic platform does not compromise the technical feasibility of performing a D2 lymphadenectomy, while potentially offering improved ergonomics and visualization for the surgeon[7]. The shorter length of hospital stay observed with RAG compared to laparoscopic gastrectomy may be attributed to the potential benefits of the robotic system, such as enhanced dexterity and precision, which may contribute to faster postoperative recovery.

The assessment of postoperative complications and 30-day mortality revealed no significant differences between RAG and the other surgical approaches. These results indicate that RAG with

D2 lymphadenectomy is not associated with an increased risk of adverse events compared to conventional surgical techniques. This finding is particularly relevant, as minimally invasive surgical approaches, such as robotic surgery, may be associated with a learning curve, and the ability to maintain safety profiles during the adoption of new technologies is crucial.

The oncological outcomes, including lymph node retrieval and R0 resection rates, were also comparable between RAG and open or laparoscopic gastrectomy with D2 lymphadenectomy. These findings suggest that the robotic platform does not compromise the quality of the oncological resection

CONCLUSIONS

This comprehensive systematic review and meta-analysis provides robust evidence supporting the use of robotic-assisted gastrectomy (RAG) with D2 lymphadenectomy for the treatment of gastric cancer. The pooled analysis demonstrated that RAG with D2 lymphadenectomy is a safe and effective surgical approach, with comparable perioperative, oncological, and long-term survival outcomes to open or laparoscopic gastrectomy with D2 lymphadenectomy.

The adoption of robotic technology for the management of gastric cancer may offer several potential benefits, including improved visualization, enhanced dexterity, and ergonomic advantages for the surgeon. These features may contribute to the optimal surgical management of gastric cancer, particularly in the context of performing a comprehensive lymph node dissection.

While the current evidence is promising, further large-scale, high-quality studies are warranted to validate the long-term outcomes of RAG with D2 lymphadenectomy and to identify potential subgroups of patients who may derive the greatest benefit from this emerging surgical approach. Continued research and innovation in minimally invasive surgical techniques for the management of gastric cancer are essential to improve the overall prognosis and quality of life for patients.

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