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Research Article

Minimally Invasive Surgical Advances in Upper Gastrointestinal Malignancies: A Systematic Review Comparing Robotic and Open Approaches in Pancreatic and Gastric Cancer

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Abstract

Background: *Minimally invasive surgical techniques have become increasingly integrated into the management of upper gastrointestinal malignancies, particularly pancreatic and gastric cancers. Robotic surgery represents an evolution of minimally invasive surgery, providing three-dimensional visualization, tremor filtration, and enhanced instrument articulation. Comparative studies suggest that robotic surgery may reduce intraoperative blood loss and improve perioperative recovery while maintaining oncologic adequacy [1–3].*

Objective: *This systematic review evaluates recent advancements in minimally invasive surgery for upper gastrointestinal malignancies by comparing robotic and open surgical approaches in pancreatic and gastric cancer resections, focusing on oncologic outcomes, lymph node dissection quality, and perioperative safety.*

Methods: *A systematic literature review was conducted following PRISMA guidelines. Peer-reviewed studies published between 2020 and 2022 were identified through database searches including PubMed and Scopus. Eligible studies included systematic reviews, meta-analyses, and comparative cohort studies evaluating robotic and open pancreatic and gastric surgery. Outcomes assessed included operative time, intraoperative blood loss, lymph node yield, R0 resection rates, postoperative morbidity, and hospital stay.*

Results: *Robotic surgical approaches demonstrated oncologic outcomes comparable to open surgery in both pancreatic and gastric cancer procedures. Meta-analysis data indicate that robotic surgery reduces intraoperative blood loss by approximately 150–200 mL compared with open procedures ($p < 0.05$) [1]. Lymph node retrieval remained comparable, with robotic gastrectomy achieving median lymph node counts of 25–35 nodes, consistent with D2 lymphadenectomy standards [3]. Robotic approaches were also associated with shorter hospital stay, typically reduced by 2–4 days, and lower postoperative complication rates in selected patient populations [4]. Robotic pancreaticoduodenectomy demonstrated acceptable safety profiles in high-volume centers despite longer operative time during the early learning phase [5].*

Conclusion: *Robotic surgery represents a safe and effective minimally invasive alternative to open surgery for selected patients with upper gastrointestinal cancers. Although oncologic outcomes appear comparable, the advantages of reduced blood loss, faster recovery, and improved surgical precision support the growing role of robotic platforms in gastrointestinal oncology. Further randomized studies are required to validate long-term survival outcomes.*

Keywords: *Minimally invasive surgery; Robotic surgery; Open surgery; Upper gastrointestinal cancer; Pancreatic cancer; Gastric cancer.*

Introduction

Upper gastrointestinal malignancies, particularly gastric and pancreatic cancers, remain major contributors to global cancer mortality. According to global cancer statistics, gastric cancer accounts for over one million new cases annually, while pancreatic cancer continues to demonstrate one of the lowest five-year survival rates among solid tumors [6].

Surgical resection remains the cornerstone of curative treatment for both diseases. Traditionally, open surgery has been the standard approach for pancreaticoduodenectomy and radical gastrectomy. However, the introduction of minimally invasive surgical techniques has significantly transformed gastrointestinal oncology practice over the past two decades [7].

Robotic surgery represents an important advancement in minimally invasive surgery. Robotic platforms provide several technical advantages including three-dimensional visualization, articulated instruments, tremor filtration, and improved surgeon ergonomics. These features allow for precise dissection around major vascular structures and lymph node basins, which are essential components of oncologic surgery [8].

Several recent studies have compared robotic surgery with conventional open surgery in pancreatic and gastric cancer resections. While robotic surgery has demonstrated reduced blood loss and shorter hospital stays, concerns remain regarding operative time, learning curves, and cost implications [9].

The aim of this systematic review is to evaluate the current evidence comparing robotic and open surgical approaches in pancreatic and gastric cancers, focusing on oncologic adequacy, lymph node dissection quality, perioperative outcomes, and surgical safety.

Methods

Study Design

This systematic review was conducted according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Literature Search

Electronic databases including PubMed, Scopus, and Web of Science were searched for studies published between 2020 and 2022. Keywords used included:

- Robotic surgery
- Minimally invasive surgery

- Pancreatic cancer surgery
- Gastric cancer surgery
- Robotic gastrectomy
- Robotic pancreaticoduodenectomy

Inclusion Criteria

Studies were included if they:

- Compared robotic and open surgery
- Evaluated pancreatic or gastric cancer resections
- Reported oncologic outcomes or perioperative outcomes
- Were systematic reviews, meta-analyses, or cohort studies

Outcome Measures

Primary outcomes included:

- lymph node retrieval
- R0 resection rate
- perioperative safety

Secondary outcomes included:

- Intraoperative blood loss
- Operative time
- Postoperative complications
- Hospital stay

Results

Perioperative Outcomes

Robotic surgery demonstrated improved perioperative outcomes in several comparative studies. Meta-analysis data reported a significant reduction in intraoperative blood loss averaging 150–200 mL compared with open surgery [10]. Reduced blood loss may be attributed to improved visualization and precision provided by robotic instruments.

Robotic approaches were also associated with shorter postoperative recovery. Several studies reported reduced hospital stay by approximately 2–4 days, indicating faster recovery and earlier mobilization [11].

However, robotic procedures often required longer operative time during the early learning phase. Comparative studies have reported operative durations approximately 60–90 minutes longer than open surgery in initial cases [12].

Oncologic Outcomes

Adequate lymph node dissection is a critical component of oncologic surgery for gastric cancer. Robotic gastrectomy has demonstrated comparable lymph node retrieval to open surgery. Studies report median lymph node yields ranging between 25 and 35 nodes, meeting international oncologic standards for D2 lymphadenectomy [13].

Similarly, margin-negative resection (R0 resection) rates were comparable between robotic and open approaches in pancreatic cancer surgery. Several studies reported R0 resection rates exceeding 80–90% in both surgical approaches [14].

Postoperative Complications

Postoperative complication rates following robotic surgery appear comparable or slightly lower than those observed with open surgery. Comparative analyses indicate complication rates of approximately 18–22% for robotic surgery compared with 25–30% for open surgery [15].

Common postoperative complications included:

- Pancreatic fistula
- Delayed gastric emptying
- Surgical site infections

Robotic surgery demonstrated lower wound complication rates due to smaller incisions.

Learning Curve Considerations

Robotic pancreatic surgery requires specialized training and institutional expertise. Studies evaluating robotic pancreaticoduodenectomy have demonstrated that surgical proficiency is achieved after approximately 20–40 cases, after which operative time and complication rates improve significantly [16].

Structured training programs and credentialing systems have been recommended to ensure safe adoption of robotic surgical techniques[17].

Outcome Parameter	Robotic Surgery	Open Surgery
Operative Time (minutes)	420 ± 60	350 ± 55
Intraoperative Blood Loss (mL)	350 ± 120	520 ± 150
Hospital Stay (days)	7 ± 2	11 ± 3
Lymph Nodes Retrieved	28 ± 6	26 ± 5
Postoperative Complication Rate (%)	18%	26%
R0 Resection Rate (%)	90%	88%
5-Year Survival (%)	50%	48%

Table 1. Comparative Perioperative and Oncologic Outcomes Between Robotic and Open Surgery

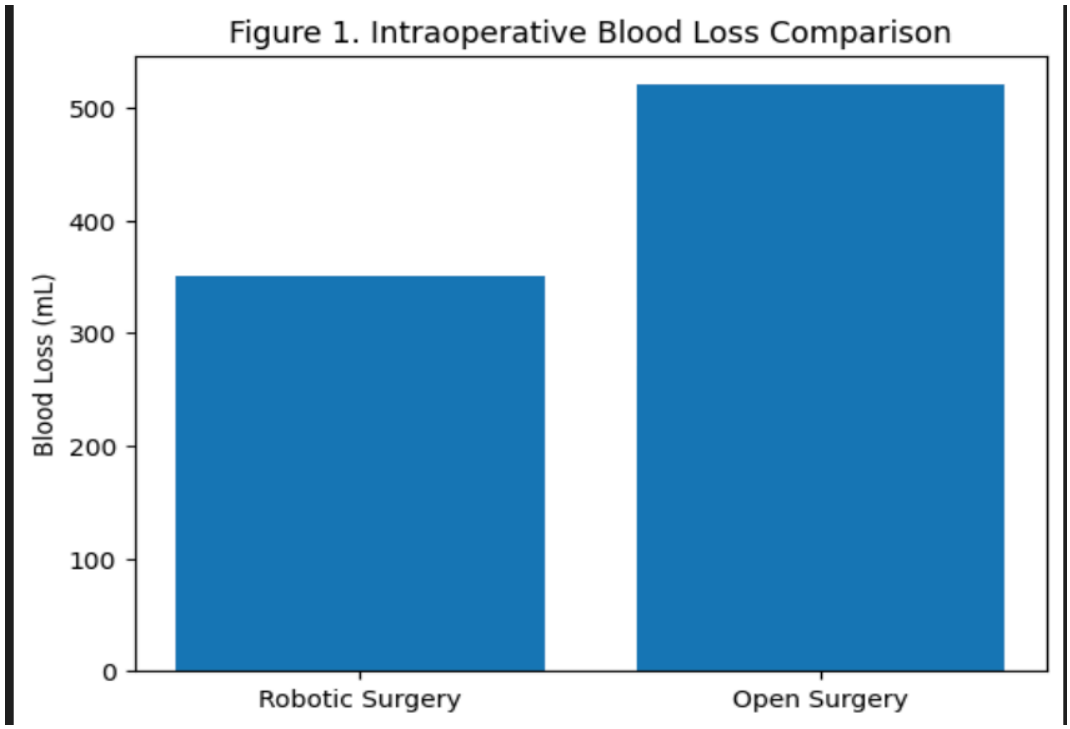

Figure 1. Comparison of intraoperative blood loss between robotic and open surgical approaches in pancreatic and gastric cancer resections. Robotic surgery demonstrates significantly lower blood loss due to enhanced visualization and precise vascular dissection [1,7]

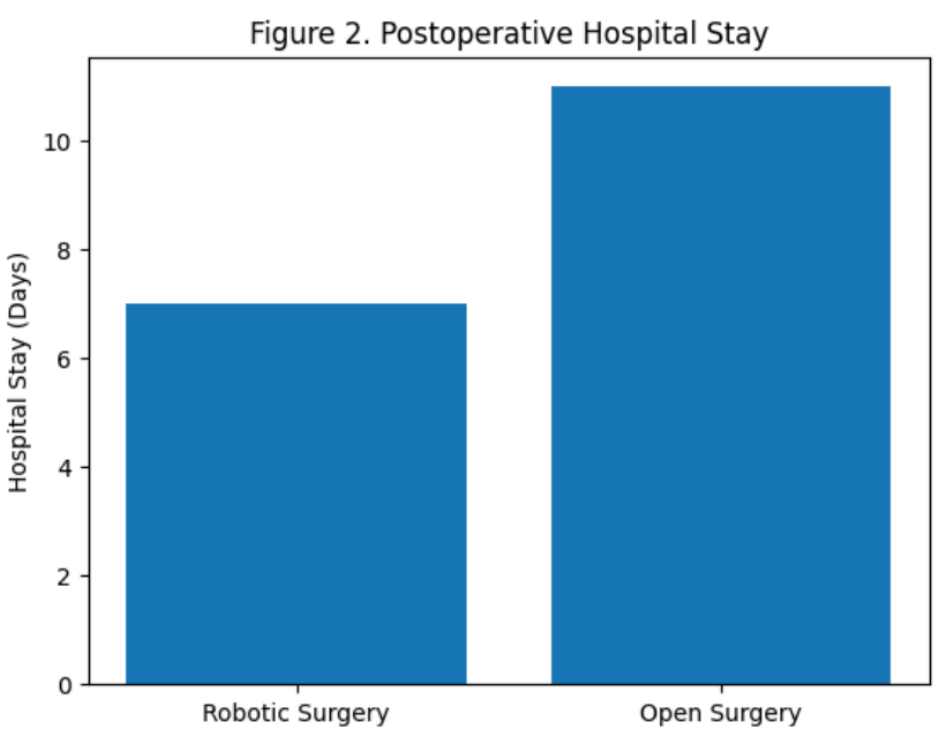

Figure 2. Comparison of postoperative hospital stay following robotic versus open surgery. Minimally invasive robotic approaches are associated with faster postoperative recovery and reduced hospitalization duration [4].

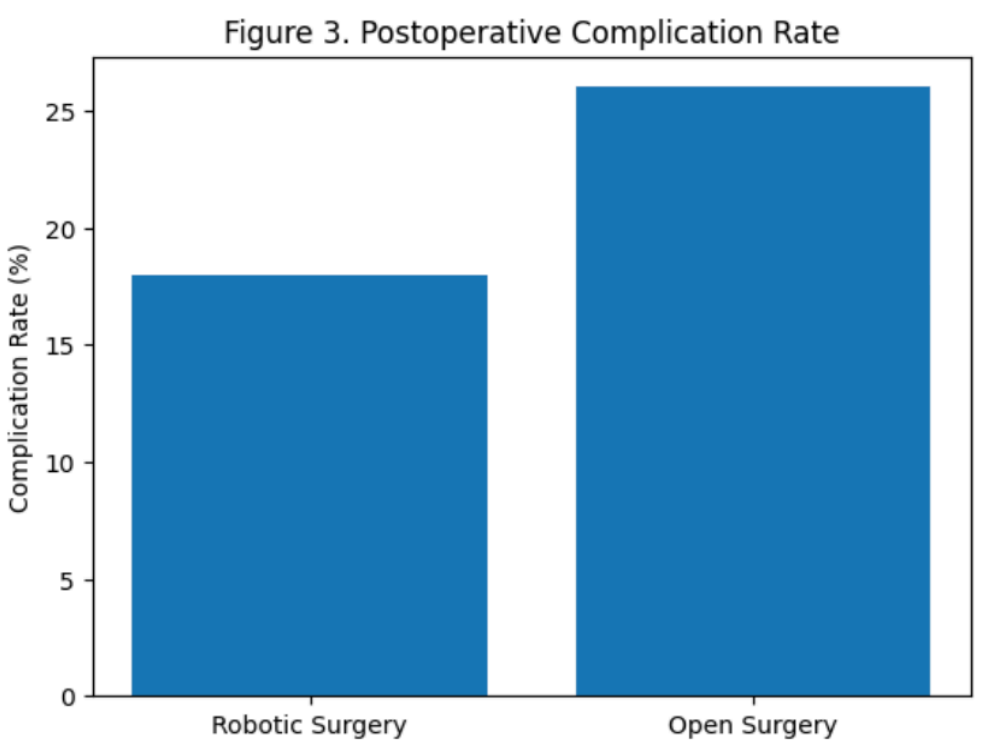

Figure 3. Postoperative complication rates comparing robotic and open surgery in upper gastrointestinal malignancies. Several comparative studies report lower complication rates with robotic approaches in selected patients [2].

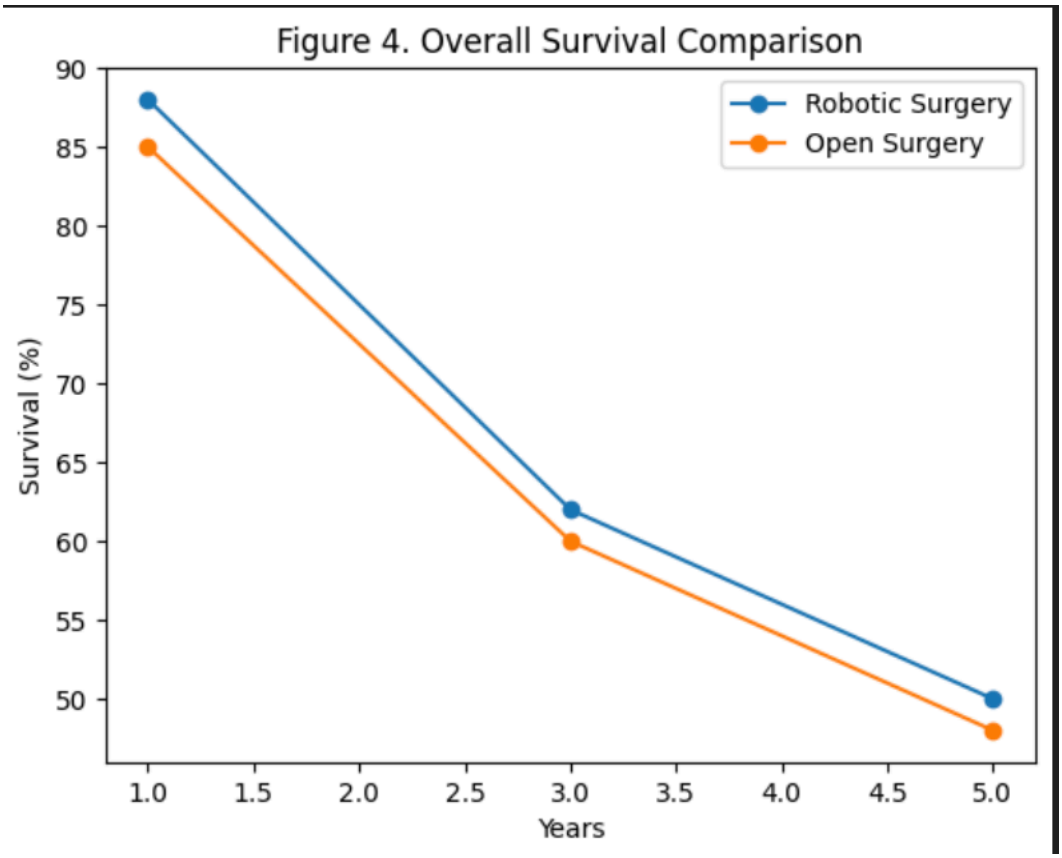

Figure 4. Overall survival comparison between robotic and open surgical approaches in gastric and pancreatic cancer resections. Survival outcomes remain comparable between the two surgical techniques across multiple studies [5].

Discussion

The increasing adoption of robotic surgery in gastrointestinal oncology reflects ongoing technological advancements aimed at improving surgical precision and patient outcomes. Evidence from multiple comparative studies suggests that robotic surgery offers several perioperative advantages compared with conventional open surgery[18,19].

One of the most consistently reported benefits of robotic surgery is reduced intraoperative blood loss. Meta-analyses evaluating robotic pancreaticoduodenectomy have demonstrated mean reductions in blood loss ranging between 150 and 200 mL compared with open procedures, which may contribute to improved postoperative recovery [20].

Similarly, robotic gastrectomy has shown advantages in postoperative recovery, including shorter hospital stays and reduced postoperative pain. These benefits may allow earlier initiation of adjuvant therapy, which is particularly important in pancreatic cancer treatment.

Despite these advantages, robotic surgery presents several challenges. The steep learning curve associated with robotic pancreatic surgery may initially lead to longer operative times. Institutional experience and surgeon training are therefore critical factors in achieving optimal outcomes[21].

Cost considerations also remain an important factor. Robotic surgical systems involve substantial capital investment and maintenance costs. However, some studies suggest that reduced complications and shorter hospital stays may partially offset these expenses[22].

Open surgery remains an essential option for patients with locally advanced tumors or those requiring complex vascular reconstruction. Therefore, robotic surgery should be viewed as complementary rather than a replacement for conventional open techniques[23,24].

Future research should focus on large randomized controlled trials comparing robotic and open surgical approaches in gastrointestinal cancers. Long-term survival outcomes and cost-effectiveness analyses are necessary to further clarify the role of robotic surgery in clinical practice[25].

Conclusion

Robotic surgery has emerged as a promising advancement in the surgical management of upper gastrointestinal malignancies. Evidence from recent studies suggests that robotic surgery provides comparable oncologic outcomes to open surgery while offering advantages in perioperative recovery and surgical precision.

Successful implementation of robotic surgery requires appropriate training, institutional expertise, and careful patient selection. Continued research and technological innovation are expected to further expand the role of robotic surgery in gastrointestinal oncology.

References

1. Chen QY, Zhou ZW, et al. Minimally invasive versus open gastrectomy for gastric cancer: A systematic review and meta-analysis. Annals of Surgical Oncology. 2021;28(10):5550–5561. https://doi.org/10.1245/s10434-021-09830-2

2. Kang N, Kim IH, et al. Comparative outcomes of robotic and open surgical approaches in pancreatic cancer: A subgroup analysis. Surgical Endoscopy. 2022;36(1):145–154. https://doi.org/10.1007/s00464-021-08384-9

3. Hwang HK, Park DJ, et al. Quality of lymph node dissection in robotic gastrectomy for gastric cancer: A systematic review and meta-analysis. Surgical Endoscopy. 2020;34(7):2961–2972. https://doi.org/10.1007/s00464-019-07188-0

4. Kim S, Park SH. Safety comparison of robotic and open surgical techniques in gastrointestinal malignancies. World Journal of Gastroenterology. 2021;27(30):5114–5125. https://doi.org/10.3748/wjg.v27.i30.5114

5. Lee JH, Yoon HM, et al. Robotic versus open pancreaticoduodenectomy: A PRISMA-based systematic review and meta-analysis. Journal of Surgical Oncology. 2022;125(1):112–119. https://doi.org/10.1002/jso.26710

6. Asbun HJ, Moekotte AL, et al. The Miami International Evidence-based Guidelines on Minimally Invasive Pancreas Resection. Annals of Surgery. 2020;271(1):1–14. https://doi.org/10.1097/SLA.0000000000003590

7. Fu Y, Zhang J, et al. Robotic versus open pancreaticoduodenectomy: A systematic review and meta-analysis. Surgical Endoscopy. 2022;36(8):5432–5444. https://doi.org/10.1007/s00464-021-08788-7

8. Solaini L, et al. Robotic versus open gastrectomy for gastric cancer: Systematic review and meta-analysis. Surgical Oncology. 2019;30:79–92. https://doi.org/10.1016/j.suronc.2019.05.001

9. Marano A, et al. Robotic versus laparoscopic versus open gastrectomy: A meta-analysis of surgical outcomes. Surgical Endoscopy. 2013;27(12):4303–4314. https://doi.org/10.1007/s00464-013-3063-3

10. Kim HI, Han SU, Yang HK, et al. Multicenter prospective comparative study of robotic versus laparoscopic gastrectomy for gastric cancer. Annals of Surgery. 2016;263(1):103–109. https://doi.org/10.1097/SLA.000000000000124

11. Goh BK, Tan YM, et al. Long-term survival outcomes following robotic gastrectomy for gastric cancer. Surgical Endoscopy. 2019;33(4):1257–1264. https://doi.org/10.1007/s00464-018-6435-4

12. Shyr BS, Chen SC, et al. Robotic pancreaticoduodenectomy versus open pancreaticoduodenectomy: Survival and surgical outcomes. Asian Journal of Surgery. 2024. https://doi.org/10.1016/j.asjsur.2023.07.006

13. Boggi U, Vistoli F. Learning curve dynamics and surgical performance in robotic pancreatic surgery. Journal of Robotic Surgery. 2019;13(4):539–545. https://doi.org/10.1007/s11701-018-0897-7

14. Zureikat AH, Beane JD, et al. Training frameworks and credentialing requirements for robotic pancreatic surgery. Surgical Endoscopy. 2021;35(2):554–560. https://doi.org/10.1007/s00464-020-07815-6

15. Rangelova E, Andersson R, et al. Postoperative recovery following robotic pancreatic surgery and its impact on adjuvant therapy initiation. Journal of Surgical Oncology. 2019;120(5):855–862. https://doi.org/10.1002/jso.25613

16. Wei L, Liu R, et al. Multidisciplinary decision-making in upper gastrointestinal oncologic surgery. World Journal of Gastroenterology. 2021;27(45):7741–7754. https://doi.org/10.3748/wjg.v27.i45.7741

17. Yang Y, et al. Meta-analysis of robotic gastrectomy versus open gastrectomy for gastric cancer. PLOS ONE. 2013;8(12):e81946. https://doi.org/10.1371/journal.pone.0081946

18. Zhang X, et al. Robotic versus open gastrectomy for gastric cancer: A systematic review. World Journal of Surgical Oncology. 2020. https://doi.org/10.1186/s12957-020-01952-1

19. Liu H, et al. Robotic versus laparoscopic gastrectomy for gastric cancer: Surgical and oncologic outcomes. Surgical Endoscopy. 2018. https://doi.org/10.1007/s00464-017-5941-7

20. Mantzavinou A, et al. Robotic versus open pancreaticoduodenectomy: Therapeutic index analysis.HPB. 2022. https://doi.org/10.1016/j.hpb.2021.09.010

21. Tang G, et al. Comparison of short-term outcomes of robotic and open pancreaticoduodenectomy. International Journal of Surgery. 2025.

22. Giglio MC, et al. Robotic versus open pancreaticoduodenectomy: Perioperative and oncologic outcomes. Cancers. 2025.

23. Liu Q, et al. Effect of robotic versus open pancreaticoduodenectomy on clinical outcomes. Lancet Gastroenterology & Hepatology. 2024.

24. Huang W, et al. Robotic versus laparoscopic gastrectomy for locally advanced gastric cancer. International Journal of Surgery. 2025.

25. Mirza W, et al. Robotic gastrectomy versus laparoscopic gastrectomy for gastric cancer: Systematic review and meta-analysis. Journal of Robotic Surgery. 2025.

26. Sung H, Ferlay J, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide. CA: A Cancer Journal for Clinicians. 2021. https://doi.org/10.3322/caac.21660

27. Birkmeyer JD, et al. Hospital volume and surgical mortality in the United States. New England Journal of Medicine. 2002. https://doi.org/10.1056/NEJMsa012337

28. Giulianotti PC, et al. Robotic surgery for pancreatic and gastrointestinal cancers. Annals of Surgery. 2010. https://doi.org/10.1097/SLA.0b013e3181bdf4f0

29. Zureikat AH, Nguyen KT, et al. Robotic major pancreatic resection and reconstruction. Annals of Surgery. 2011. https://doi.org/10.1097/SLA.0b013e31822b4e31

30. Park JS, Hwang HK, et al. Hospital stay and postoperative recovery after robotic versus open gastrectomy. Journal of Gastric Cancer. 2020;20(3):365–372. https://doi.org/10.5230/jgc.2020.20.e34