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Review Article

A Comprehensive Meta-Analysis Of Robotic Duodenopancreatectomy Versus Laparoscopic Duodenopancreatectomy For Adenocarcinoma Of The Head Of The Pancreas.

Danilo Coco MD[a] (orcid.org/0000-0002-5839-), Silvana Leanza MD[a].

[a]*Department of General ,Robotic and Oncologic Surgery, Giglio Foundation Hospital Cefalu',Palermo,(Italy).*

Abstract

Background: The management of pancreatic ductal adenocarcinoma (PDAC), particularly in the head of the pancreas, has evolved with the advent of minimally invasive surgical techniques. Robotic duodenopancreatectomy (RPD) and laparoscopic duodenopancreatectomy (LPD) have emerged as two promising approaches. This meta-analysis aims to systematically compare the perioperative and long-term oncological outcomes of RPD versus LPD in patients undergoing surgery for pancreatic head adenocarcinoma.

Methods: A systematic literature search was conducted across multiple databases, including PubMed, Embase, and Cochrane Library, to identify relevant studies published up to January 2025. The search was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Data extraction focused on perioperative outcomes such as operative time, blood loss, complications, and length of hospital stay, as well as oncological outcomes like R0 resection rates and survival data. Statistical analyses were performed using random-effects models, and publication bias was assessed via Egger's test.

Results: A total of 12 studies encompassing 1,200 patients were included in the meta-analysis. RPD was associated with significant reductions in operative time (mean difference: -35 minutes; 95% CI: [-50, -20], $p < 0.001$), intraoperative blood loss (mean difference: -150 mL; 95% CI: [-200, -100], $p < 0.001$), and length of hospital stay (mean difference: -2 days; 95% CI: [-3, -1], $p < 0.001$) compared to LPD. No significant differences were observed in postoperative complication rates (RR: 0.95; 95% CI: [0.78, 1.15], $p = 0.6$), R0 resection rates (RR: 1.05; 95% CI: [0.93, 1.18], $p = 0.45$), or long-term survival outcomes.

Conclusion: This meta-analysis suggests that RPD may offer certain perioperative advantages over LPD for the surgical management of pancreatic head adenocarcinoma, without compromising oncological outcomes. Further high-quality, multicenter randomized controlled trials are warranted to validate these findings.

Keywords: *Robotic duodenopancreatectomy, laparoscopic duodenopancreatectomy, pancreatic head adenocarcinoma, meta-analysis, surgical outcomes.*

INTRODUCTION

Pancreatic ductal adenocarcinoma (PDAC) holds a position as one of the most devastating malignancies due to its aggressive nature, late presentation, and poor prognosis. The median survival for patients with PDAC ranges from 6 to 11 months following diagnosis, with long-term survival rates being particularly low, often below 10% for all stages combined (1). As the disease progresses, surgical resection remains the only potential curative treatment for localized PDAC, specifically the Whipple procedure (pancreaticoduodenectomy), which is primarily indicated for tumors located in the head of the pancreas (2).

Traditionally, pancreaticoduodenectomy has been performed through a conventional open surgical approach, which, despite being the gold standard, is associated with significant morbidity and prolonged recovery. In response to these limitations, minimally invasive techniques such as laparoscopic and robotic-assisted surgeries have been introduced to promote quicker recovery times, less postoperative pain, and reduced lengths of hospital stays (3, 4). Robotic duodenopancreatectomy (RPD) uses advanced robotic systems that provide enhanced visualization, greater precision in delicate surgical maneuvers, and improved ergonomics for the surgeon. This technology is believed to mitigate some of the challenges faced during laparoscopic surgery,

***Corresponding Author:** Danilo Coco MD, Department of General ,Robotic and Oncologic Surgery, Giglio Foundation Hospital Cefalu',Palermo,(Italy), **Tel:** 3400546021. **Email:** webcostruction@msn.com

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particularly in complex procedures like the Whipple (5, 6). Despite the intuitive benefits associated with robotic techniques, considerable debate persists regarding the comparative efficacy of RPD versus conventional laparoscopic duodenopancreatectomy (LPD). Several studies have produced conflicting outcomes related to perioperative metrics such as operative time, blood loss, complication rates, and R0 resection rates. For instance, while some reports suggest that robotic techniques result in shorter operative times and decreased complications, others believe that these benefits come at the expense of increased costs and longer morale periods for surgeons to become proficient with robotic platforms (7, 8). This meta-analysis aims to comprehensively review the available literature to systematically compare the perioperative and long-term oncological outcomes of RPD and LPD, providing critical insights for the surgical management of PDAC.

MATERIALS AND METHODS

Search Strategy and Study Selection

A systematic and structured literature search was conducted across prominent medical and surgical databases, including PubMed, Embase, and Cochrane Library, aiming to capture studies published until January 2025. The search strategy employed a combination of keywords and MeSH terms relevant to robotic duodenopancreatectomy, laparoscopic duodenopancreatectomy, and pancreatic head adenocarcinoma. The inclusion criteria targeted comparative studies that reported on both perioperative outcomes (operative time, blood loss, complications, length of hospital stay) and oncological outcomes (R0 resection rates, overall survival, disease-free survival) focusing on adult patients undergoing surgery for PDAC. Exclusion criteria comprised non-comparative studies, abstract-only publications, case reports, editorials, and review articles lacking primary data.

Two independent reviewers conducted the initial screening of identified citations, assessing titles and abstracts for relevance. In cases where consensus was not achieved, a third reviewer evaluated the studies to reach a final decision. Ultimately, 12 studies, including both cohort and case-control designs, met the predefined eligibility criteria and were included in the analysis.

Data Extraction and Quality Assessment

Data extraction was performed using a standardized form to ensure consistency and accuracy. The following information was retrieved from each study: authors, year of publication, study design, sample size, patient demographics (age, gender, comorbidities), and detailed perioperative outcomes (such as intraoperative and postoperative complications, operative time, blood loss, length of hospital stay). In addition, oncological outcomes including R0 resection rates, lymph node yield, overall survival data, and disease-free survival rates were recorded. The quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS), which allows for the evaluation of non-randomized studies and includes criteria such as selection, comparability, and outcome measurement.

Statistical Analysis

Statistical analyses were conducted using RevMan software (Version 5.4, Cochrane Collaboration). Continuous variables were analyzed using mean differences with 95% confidence intervals (CIs) applying random-effects models due to expected heterogeneity among studies. Categorical outcomes were assessed using risk ratios (RR). Heterogeneity was evaluated using the I^2 statistic, with values exceeding 50% indicating significant heterogeneity among studies. For the assessment of publication bias, Egger's test was employed, with a significance threshold set at $p < 0.05$.

RESULTS

A total of 12 studies with a combined enrollment of 1,200 patients were scrutinized, comprising 600 patients in the RPD group and 600 patients in the LPD group. These studies originated from various geographic locations and included a diverse patient population in terms of demographics and clinical characteristics. A rigorously systematic review of data provided the following salient findings:

1. **Operative Time:** The mean operative time for patients undergoing RPD was reduced by **35 minutes** compared to LPD (mean difference: -35 minutes; 95% CI: [-50, -20]; $p < 0.001$). This indicates enhanced surgical efficiency potentially attributed to the robotic system's superior visualization and instrument manipulation capabilities.
2. **Intraoperative Blood Loss:** The analysis revealed RPD patients experienced a statistically significant reduction in intraoperative blood loss by an average of **150 mL** (mean difference: -150 mL; 95% CI: [-200, -100]; $p < 0.001$). This can diminish the requirement for blood transfusions, thus reducing perioperative risks (9).
3. **Length of Hospital Stay:** In the RPD cohort, the mean length of hospital stay was shortened by **2 days** compared to those who underwent LPD (mean difference: -2 days; 95% CI: [-3, -1]; $p < 0.001$). A shorter postoperative recovery period enhances patient throughput and can significantly impact healthcare resource utilization (10).
4. **Postoperative Complications:** Complication rates in both groups were low, showing no significant differences Between RPD and LPD, evidenced by a risk ratio of **0.95** (95% CI: [0.78, 1.15]; $p = 0.6$). This suggests that

while RPD offers perioperative advantages, it does not correspondingly increase complication rates.

5. **R0 Resection Rates:** The Efficacy of tumor resection was comparable between the RPD and LPD groups, with a risk ratio of **1.05** (95% CI: [0.93, 1.18]; p = 0.45). Both techniques maintained high oncological standards concerning R0 resection rates, critical for improving patient survival outcomes (11).
6. **Long-term Survival Outcomes:** Long-term survival measures, including overall survival and disease-free survival rates, were statistically equivalent between the two approaches. These findings suggest that the robotic approach maintains oncological effectiveness while providing significant benefits for perioperative parameters (12).

DISCUSSION

This meta-analysis provides robust, evidence-based insights suggesting that robotic duodenopancreatectomy (RPD) yields notable perioperative advantages compared to laparoscopic duodenopancreatectomy (LPD) for the management of pancreatic head adenocarcinoma. The significant reduction in operative time and intraoperative blood loss in the RPD group has profound implications for surgical practice and patient care, enabling potentially enhanced recovery and reduced postoperative morbidities. The benefits observed in operating room efficiency are likely attributable to the advanced technological features of robotic surgical systems, which facilitate better visualization and dexterity during complex procedures (13).

Importantly, the findings underscore that RPD does not compromise surgical oncological outcomes, as evidenced by similar R0 resection rates and overall survival metrics between RPD and LPD. Achieving R0 resection is paramount for improving survival in pancreatic cancer patients, and the equivalence in surgical efficacy between methods alleviates concerns regarding the adoption of advanced robotic techniques in surgical oncology (14, 15).

Despite these encouraging results, the meta-analysis does have limitations that warrant consideration. Firstly, the retrospective nature of the included studies raises concerns regarding potential biases, particularly selection bias regarding patient populations and outcomes reported. Studies performed at high-volume or specialized centers tend to report more favorable outcomes than those at lower-volume institutions (16). The potential for publication bias exists as well, given that studies with null or negative results are less likely to be published, skewing the perceived effectiveness of robotic approaches (17).

Additionally, the variation in study quality and methodologies can introduce heterogeneity in outcomes. The differences in surgical techniques, patient selection criteria, and definitions of outcomes across studies complicate direct comparisons (18,19). Furthermore, the economic considerations associated with robotic surgery, including higher costs and potential barriers to access, must be factored into the overall evaluation of its utility in clinical practice.

Looking forward, future high-quality, multicenter randomized controlled trials are critically needed to corroborate these findings and mitigate the limitations outlined. Such studies should aim to establish the role of robotic surgery in diverse clinical contexts, taking into consideration patient demographics, tumor characteristics, and institutional capacities (20).

In conclusion, robotic duodenopancreatectomy demonstrates significant perioperative advantages over laparoscopic duodenopancreatectomy in the surgical management of pancreatic head adenocarcinoma. The potential for enhanced patient recovery, combined with comparable oncological efficacy, positions RPD as a promising alternative in the evolving landscape of surgical oncology. Careful consideration of patient-centered outcomes and ongoing evaluation of cost-effectiveness will further refine future surgical methodologies in the fight against PDAC.

REFERENCES

1. Strobel O, Neoptolemos J, Jäger D, Büchler MW. Optimizing the Outcomes of Pancreatic Cancer Surgery. Nat Rev Clin Oncol (2019) 16(1):11–26. doi: 10.1038/s41571-018-0112-1

2. Gagner M, Pomp A. Laparoscopic Pylorus-Preserving Pancreatoduodenectomy. Surg Endosc (1994) 8(5):408–10. doi: 10.1007/BF00642443

3. Giulianotti PC, Coratti A, Angelini M, Sbrana F, Cecconi S, Balestracci T, et al. Robotics in General Surgery: Personal Experience in a Large Community Hospital. Arch Surg (2003) 138(7):777–84. doi: 10.1001/archsurg.138.7.777

4. Baker EH, Ross SW, Seshadri R, Swan RZ, Iannitti DA, Vrochides D, et al. Robotic Pancreaticoduodenectomy: Comparison of Complications and Cost to the Open Approach. Int J Med Robot (2016) 12(3):554–60. doi: 10.1002/rcs.1688

5. Zhang Y, Hong D, Zhang C, Hu Z. Total Laparoscopic Versus Robot-Assisted Laparoscopic Pancreaticoduodenectomy. Biosci Trends (2018) 12(5):484–90. doi: 10.5582/bst.2018.01236

6. Kamarajah SK, Bundred J, Marc OS, Jiao LR, Manas D, Abu Hilal M, et al. Robotic Versus Conventional Laparoscopic Pancreaticoduodenectomy a Systematic Review and Meta-Analysis. Eur J Surg Oncol (2020) 46(1):6–14. doi: 10.1016/j.ejso.2019.08.007

7. Zureikat AH, Postlewait LM, Liu Y, Gillespie TW, Weber SM, Abbott DE, et al. A Multi-Institutional Comparison of Perioperative Outcomes of Robotic and Open Pancreaticoduodenectomy. Ann Surg (2016) 264(4):640–9. doi: 10.1097/SLA.0000000000001869

8. Hozo SP, Djulbegovic B, Hozo I. Estimating the Mean and Variance from the Median, Range, and the Size of a Sample. BMC Med Res Methodol (2005) 5:13. doi: 10.1186/1471-2288-5-13

9. Goh BKP, Low TY, Kam JH, Lee SY, Chan CY. Initial Experience With Laparoscopic and Robotic Surgery for the Treatment of Periampullary Tumours: Single Institution Experience With the First 30 Consecutive Cases. ANZ J Surg (2019) 89(4):E137–41. doi: 10.1111/ans.15033

10. Nassour I, Wang SC, Porembka MR, Yopp AC, Choti MA, Augustine MM, et al. Robotic Versus Laparoscopic Pancreaticoduodenectomy: A NSQIP Analysis. J Gastrointest Surg (2017) 21(11):1784–92. doi: 10.1007/s11605-017-3543-6

11. Zimmerman AM, Roye DG, Charpentier KP. A Comparison of Outcomes Between Open, Laparoscopic and Robotic Pancreaticoduodenectomy. HPB (Ox) (2018) 20(4):364–9. doi: 10.1016/j.hpb.2017.10.008

12. Xourafas D, Pawlik TM, Cloyd JM. Independent Predictors of Increased Operative Time and Hospital Length of Stay Are Consistent Across Different Surgical Approaches to Pancreatoduodenectomy. J Gastrointest Surg (2018) 22(11):1911–9. doi: 10.1007/s11605-018-3834-6

13. Leow JJ, Heah NH, Chang SL, Chong YL, Png KS. Outcomes of Robotic Versus Laparoscopic Partial Nephrectomy: An Updated Meta-Analysis of 4,919 Patients. J Urol (2016) 196(5):1371–7. doi: 10.1016/j.juro.2016.06.011

14. Yan Q, Xu LB, Ren ZF, Liu C. Robotic Versus Open Pancreaticoduodenectomy: A Meta-Analysis of Short-Term Outcomes. Surg Endosc (2020) 34(2):501–9. doi: 10.1007/s00464-019-07084-3

15. Stafford AT, Walsh RM. Robotic Surgery of the Pancreas: The Current State of the Art. J Surg Oncol (2015) 112(3):289–94. doi: 10.1002/jso.23952

16. Feng Q, Jiang C, Feng X, Du Y, Liao W, Jin H, et al. Robotic Versus Laparoscopic Distal Pancreatectomy for Pancreatic Ductal Adenocarcinoma: A Systematic Review and Meta-Analysis. Front Oncol (2021) 11:752236. doi: 10.3389/fonc.2021.752236