BMJ Open

Clinical effectiveness of robotic versus laparoscopic and open surgery: an overview of systematic reviews

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To cite: Lai T-J, Roxburgh C, Boyd KA, *et al*. Clinical effectiveness of robotic versus laparoscopic and open surgery: an overview of systematic reviews. *BMJ Open* 2024;**14**:e076750. doi:10.1136/bmjopen-2023-076750

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-076750).

Received 15 June 2023
Accepted 02 August 2024

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ABSTRACT

Objective To undertake a review of systematic reviews on the clinical outcomes of robotic-assisted surgery across a mix of intracavity procedures, using evidence mapping to inform the decision makers on the best utilisation of robotic-assisted surgery.

Eligibility criteria We included systematic reviews with randomised controlled trials and non-randomised controlled trials describing any clinical outcomes.

Data sources Ovid Medline, Embase and Cochrane Library from 2017 to 2023.

Data extraction and synthesis We first presented the number of systematic reviews distributed in different specialties. We then mapped the body of evidence across selected procedures and synthesised major findings of clinical outcomes. We used a measurement tool to assess systematic reviews to evaluate the quality of systematic reviews. The overlap of primary studies was managed by the corrected covered area method.

Results Our search identified 165 systematic reviews published addressing clinical evidence of robotic-assisted surgery. We found that for all outcomes except operative time, the evidence was largely positive or neutral for robotic-assisted surgery versus both open and laparoscopic alternatives. Evidence was more positive versus open. The evidence for the operative time was mostly negative. We found that most systematic reviews were of low quality due to a failure to deal with the inherent bias in observational evidence.

Conclusion Robotic surgery has a strong clinical effectiveness evidence base to support the expanded use of robotic-assisted surgery in six common intracavity procedures, which may provide an opportunity to increase the proportion of minimally invasive surgeries. Given the high incremental cost of robotic-assisted surgery and longer operative time, future economic studies are required to determine the optimal use of robotic-assisted surgery capacity.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study is the first overview of systematic reviews to summarise the full body of evidence of clinical outcomes across a range of procedures in several specialties.
- ⇒ This overview is likely to be generalisable to all countries and procedures as the included systematic reviews in our studies are from a broad range of settings.
- ⇒ This study uses a combination of an overview approach and a novel evidence-mapping method to provide readers with both the evidence landscape and in-depth information in a visual format.
- ⇒ Our detailed review, which covered the years 2017–2023 and included studies published in English, focused on a limited number of procedures.

INTRODUCTION

Robot-assisted surgery (RAS) is a form of minimally invasive surgery (MIS) involving a telemanipulation system comprising a surgeon console, computerised control system and patient-side cart with robotic arms. RAS offers improved dexterity, better ergonomics and enhanced fixed operator-controlled visualisation and retraction, thus improving the capabilities of surgeons during complex surgery.[1] The use of RAS has grown rapidly and is performed worldwide, with 12 million procedures performed using the da Vinci system since inception.[2] The most widespread growth of RAS is in urology, with over 90% of prostatectomies in the USA and over 85% in the UK over the past decade. Globally, other specialties like upper and lower gastrointestinal (GI) surgery, hepatopancreaticobiliary (HPB) surgery and gynaecology have also experienced increased RAS volume, though it currently constitutes a small proportion of total procedural volume.[3]

The idea, development, exploration, assessment and long-term study (IDEAL) framework conceptualises the evidence shaping process for surgical innovation.[4] Research has shown that innovators often omit stages in evidence generation with a lack of randomised controlled studies and an extensive reliance on observational studies and implementation into practice.[4] This is partly because there are many difficulties in conducting randomised studies for surgical innovation, which include preferences from patients and surgeons, unwillingness to accept randomisation, difficulties in concealing allocation, inadequate subjects for effect size, learning curve and incremental innovation.[5] Moreover, evidence of clinical effectiveness can be lacking in surgical innovation because regulatory pathways do not incentivise evidence generation, and a limited number of clinical studies are required for approval.[6 7] Hospitals may invest in equipment RAS device prior to determining which procedures it will be used for, with some acquisitions motivated by the desire to enhance hospital reputation or attract top-tier surgeons and trainees.[8 9] Accordingly, an important consideration for hospitals is determining how best to optimise the utilisation of these technologies once acquired, in order to justify their initial investment and realise their full potential in enhancing patient outcomes and improving overall healthcare delivery.

The first step for decision makers is to ensure that patient safety is prioritised and that the selected procedures are at least equally effective compared with traditional methods. A previous overview review found limited evidence, with only 18 randomised controlled trials (RCTs) across various surgical procedures comparing robotic surgery to conventional approaches, highlighting challenges in drawing overall conclusions on the sustained effectiveness of robotic surgery.[10] Second, the cost-effectiveness of RAS would be assessed across the selected mix of procedures to justify initial investment and ongoing expansion, ensuring value and optimal use of resources. Given that RAS is a 'platform' technology (in that it can be used across numerous indications),[11] it is important to fill its capacity in the most cost-efficient manner, which requires decision makers to prioritise among candidate procedures. Therefore, to facilitate this decision-making process, our aim in this overview review is to present evidence comparing outcomes across different intracavity procedures in four clinical specialties (colorectal, gynaecology, upper GI and HPB, where RAS versus laparoscopic or open surgery is still in equipoise.

METHODS

Given the breadth of our scope, we adopted the overview of reviews approach as described by Cochrane methods[12] and followed Preferred Reporting Items for Overviews of Reviews (PRIOR) on reporting.[13]

Search methods for identification of reviews

Our search strategy was based on a developed strategy by the Health Improvement Scotland to identify systematic reviews comparing RAS to conventional surgical approaches in humans, and it has been verified by the University of Glasgow Information Scientist. The databases Ovid Medline, Embase and the Cochrane Library are limited to the most recent years (from April 2017 to December 2023), given the incremental evidence generation and clinical setting changes. Search terms are provided as online supplemental file 1.

Eligibility criteria for considering studies for the reviews

As our aim was to gain an overview of the clinical effectiveness evidence for the use of RAS, we included published systematic reviews (SRs) of robotic surgery in any surgical field compared with laparoscopic or open surgery and included any outcome measure. We excluded any systematic review which looked at aspects of RAS other than the clinical effectiveness of RAS. We excluded reviews which were unable to report on outcomes of RAS separately from other minimally invasive procedures. We excluded conference abstracts and review protocols as they generally provide insufficient information.[14] Reviews not in English were excluded, while this could be a limitation, and there is evidence that such language exclusion does not cause bias.[15]

Study selection

The first author (T-JL) screened the titles and abstracts of the identified articles. Duplicate publications were managed and removed using the Endnote software.[16] A random sample of 10% with an Excel algorithm of papers was screened by two authors (KAB and JB) to confirm the exclusion criteria and ensure a systematic approach to inclusion/exclusion.[17 18] Where the first author was uncertain about whether to include a paper, this was reviewed by KAB and JB and any disagreements were resolved by discussion. We introduced a two-stage study selection as we wanted to identify the volume of current evidence across specialties and examine the strength of evidence in areas where RAS is still in equipoise. In stage one, we included all systematic reviews (SRs) of the clinical effectiveness of RAS versus conventional surgeries. We then categorised identified articles by specialty in order to obtain the landscape of clinical uses of RAS. In stage two, we limited our review to a number of intracavity procedures in four specialties (colorectal, gynaecology, upper GI and HPB). We chose four specialties where there is a building evidence base but RAS is not dominant.[19] The selection process is reported in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart.[20]

Data extraction and synthesis of results

The extracted data from the systematic reviews included author, year of publication, setting, study design, sources, number of included studies, participants (ie, diagnosis for procedures), intervention (types of interventions compared, numbers assigned in each group), a range of clinical outcomes, quality rating given to the papers and conclusions of the SRs. The high level of heterogeneity in the patient population and procedure precluded meta-analysis. We conducted a descriptive analysis and tabulated the results by outcome for six procedures (colorectal oncological resection, hysterectomy, liver resection, pancreatectomy, pancreaticoduodenectomy and gastrectomy) in the four specialties of interest.

For all SRs, we summarised their clinical outcomes by using broad descriptors (positive, neutral or negative) for each procedure. The volume of defined descriptors from the SRs by clinical outcomes was counted in six procedures. We used a traffic light system to present the descriptors; green represents 'positive effect'; red represents 'negative effect', indicating a statistically significant finding in favour of the conventional surgical technique and yellow is 'neutral', which means that no statistically significant difference was found. It should be noted that these statistically significant findings may not indicate clinical significance. This bespoke mapping method allowed us to present a clear picture of the strength of the identified evidence. We did not synthesise evidence; therefore, no sensitivity analyses were conducted to assess the robustness of the synthesised results. However, we provided information on the heterogeneity of each meta-analysis in the supplementary file, if available.

Assessment of methodological quality and overlap management

We evaluated the quality and risk of bias of the included reviews using A MeaSurement Tool to Assess systematic Reviews (AMSTAR)-2 which is designed to evaluate the systematic reviews including both randomised and non-randomised study designs.[21] The assessment for the reviews was not taken as an inclusion criterion but was presented alongside the descriptive analysis of the evidence to allow the reader to form a judgement about the quality of the evidence available. Details are provided as online supplemental file 2.

In reviewing systematic reviews, there is a risk that underlying studies may be included in more than one of the identified systematic reviews. This overlap may give excessive weight to certain studies and bias the results. We used the citation matrix, the corrected covered area method (CCA) to manage this issue.[22 23] Details for CCA are provided as online supplemental file 3.

RESULTS

Study selection

Through the systematic search, 3363 potentially relevant articles were obtained initially, 1208 duplicates were removed and 2155 proceeded to screening. After assessing for exclusion, there were 628 articles remaining and then categorised by specialty. For the studies with procedures out of interest (n=451) and no accessible full text (n=12), they were excluded. A total of 165 systematic reviews were included for this overview, and the study selection process is summarised in figure 1 with a PRISMA flowchart.[20]

Volume of reviews by specialty

Our review included SRs published within 5 years from 2017–2023. Figure 2 presents the volume of reviews identified by specialty. The highest number of reviews was identified in urology (n=131), where RAS is well-established, followed by colorectal (n=89), HPB (n=77), gynaecology (n=59) and upper GI (n=50).

Evidence of clinical outcomes

We identified a wide range of outcomes across the included systematic reviews and categorised them as surgical, postoperative, oncological or long-term outcomes. These outcomes were summarised with descriptors and their numbers of sources were recorded across every procedure. The underlying data is presented in online supplemental file 4. Figure 3 shows a comparison of clinical outcomes for RAS compared with conventional laparoscopic approaches, across procedures with a colour spectrum where red represents a negative, yellow a neutral and green a positive result. Where the evidence is mixed positive, neutral and negative, this is indicated by brown. The gradient colour presents the strength of the evidence. Generally, RAS compared with conventional surgeries has an overall neutral in yellow and positive in green picture across all forms of outcome except operative time.

Operative time

Overall, operating times are equal or longer for RAS compared with laparoscopic surgery (LS) and open surgery; hence, the orange to red colour spectrum of evidence is presented in figure 3.

In colorectal oncological resection, 28 out of 33 included meta-analysis studies[24–51] and they all indicated that total operating time on average in the RAS groups was significantly longer than the LS groups. In contrast, in gynaecology, nine out of 12 studies reported insignificant operative time differences for hysterectomy compared with LS and six out of 9 studies compared with open surgery. Within HPB, the mean differences in operative time vary by procedures. In hepatectomy, 14 out of 18 reviews[52–65] reported that RAS had a significantly longer operative time compared with LS, while all included reviews reported RAS had a significantly longer operative time compared with open surgery. In pancreatectomy, two out of seven reviews[65 66] indicated that RAS had a significantly longer operative time compared with LS, two out of four reviews[65 67] compared with open surgery. In pancreaticoduodenectomy, one out of three studies[68] indicated RAS had a significantly longer operative time compared with the LS approach, and 10 out of 11 studies[67–76] compared with open surgery. In the field of upper GI, 17 out of 18 reviews[77–93] reported RAS for gastrectomy had a significantly longer operative time compared with LS, and four out of five also had a significantly longer operative time compared with open surgery.[94–97] However, there was one study that indicated robotic surgery had a significantly shorter operative time than open surgery.[98] This study took results from a network meta-analysis, a technique which compares approaches both directly and indirectly to derive evidence of relative clinical effectiveness. Only one RCT involving RAS was included in the network which may limit the validity of the conclusion.

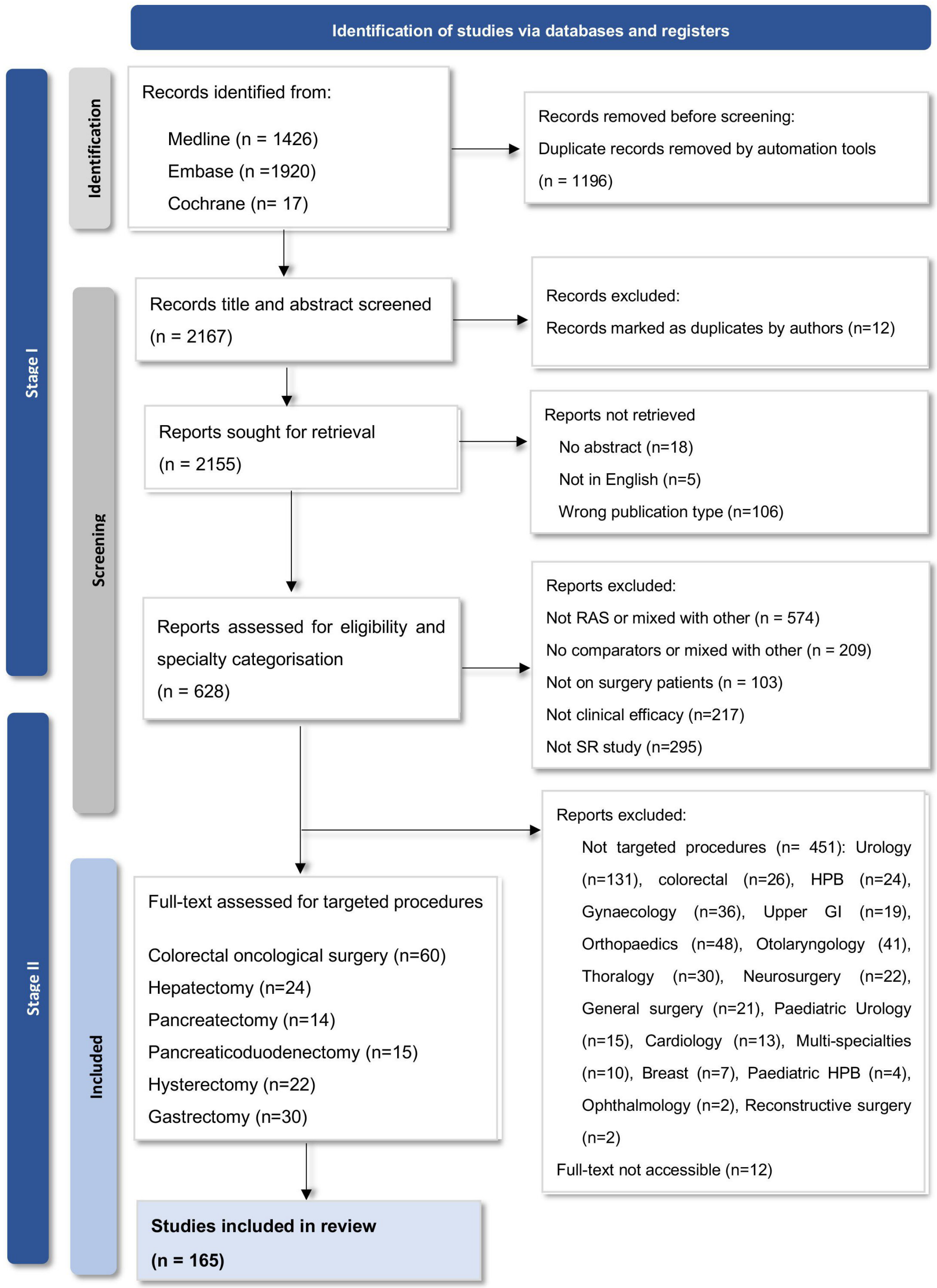

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram of systematic review selection process for the review of reviews. GI, gastrointestinal; HPB, hepatopancreaticobiliary; RAS, robot-assisted surgery.

Estimated blood loss

With the exception of hysterectomy and hepatectomy (both vs laparoscopic surgery), where the evidence for estimated blood loss was mixed, all other evidence for this outcome was in favour of RAS or neutral, as illustrated by the yellow to green spectrum in figure 3.

In the procedure of colorectal oncological resection, 12 out of 29 reviews[28 32 34 40 41 43 44 46 49 51 99 100] reported RAS had significantly less blood loss than LS, but the other 17 reviews did not find statistically significant mean differences. However, in hysterectomy, the evidence was inconsistent depending on the comparative procedures. Within the 14 reviews comparing RAS to LS which had data on blood loss, six studies indicated significantly less blood loss,[101–106] two studies reported significantly more blood loss[104 107] but six studies found no significant differences. When RAS was compared with open surgery, all eight reviews found positively that RAS had significantly less blood loss.[103 104 106–111] Within HPB, various effects could be seen depending on the procedure. For hepatectomy, among the articles comparing RAS to LS, mixed evidence was also identified. Five studies reported significantly less blood loss[55 112–115] while another four studies[52 53 59 64] indicated a contrasting result in favour of LS. But when comparing to open surgery,

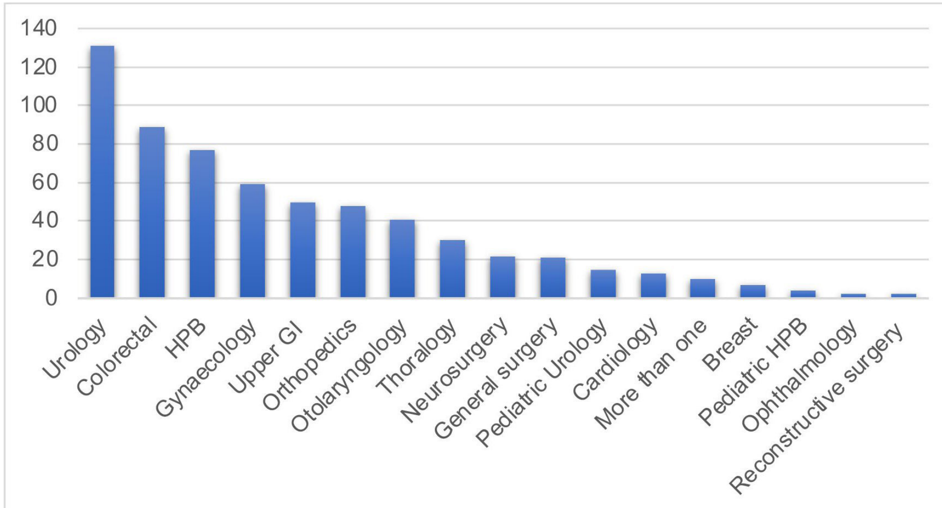

Figure 2 Number of systematic reviews identified by specialty. GI, gastrointestinal; HPB, hepatopancreaticobiliary.

five studies[59 113 116–118] indicated RAS was associated with significantly less blood loss while the other four studies found no significant differences. For pancreatectomy, three reviews reported RAS had significantly less blood loss than LS,[119–121] and three out of four reviews[67 119 122] reported RAS had significantly less blood loss than open surgery. For pancreaticoduodenectomy, two reviews identified RAS had significantly less blood loss than LS,[75 123] and all reviews indicated the result in favour of RAS compared with open surgery.[67–76 119 122 124] In respect of gastrectomy, 16 out of 20 included studies[78–89 93 95 125 126] showed that RAS had significantly less blood loss compared with LS, while all reviews reported RAS had significantly less blood loss than open surgery.[77–82 94–98]

Conversion rate

Identified evidence across all procedures showed either positive or neutral results in the conversion rate for RAS compared with LS, green to yellow is presented in figure 3.

Regarding colorectal oncological resection, 26 out of 35 included reviews[25–30 33–36 39 41–47 49–51 99 100 125–128] reported that RAS had significantly lower chances of conversion to open surgery compared with LS. In hysterectomy, three indicated RAS had significantly lower rates than LS,[101 103 106] and the other three reviews presented no significance. In respect of HPB, five of 20 included reviews indicated robotic hepatectomy had significantly lower conversion rates than LS.[54 58 112 115] For pancreatectomy

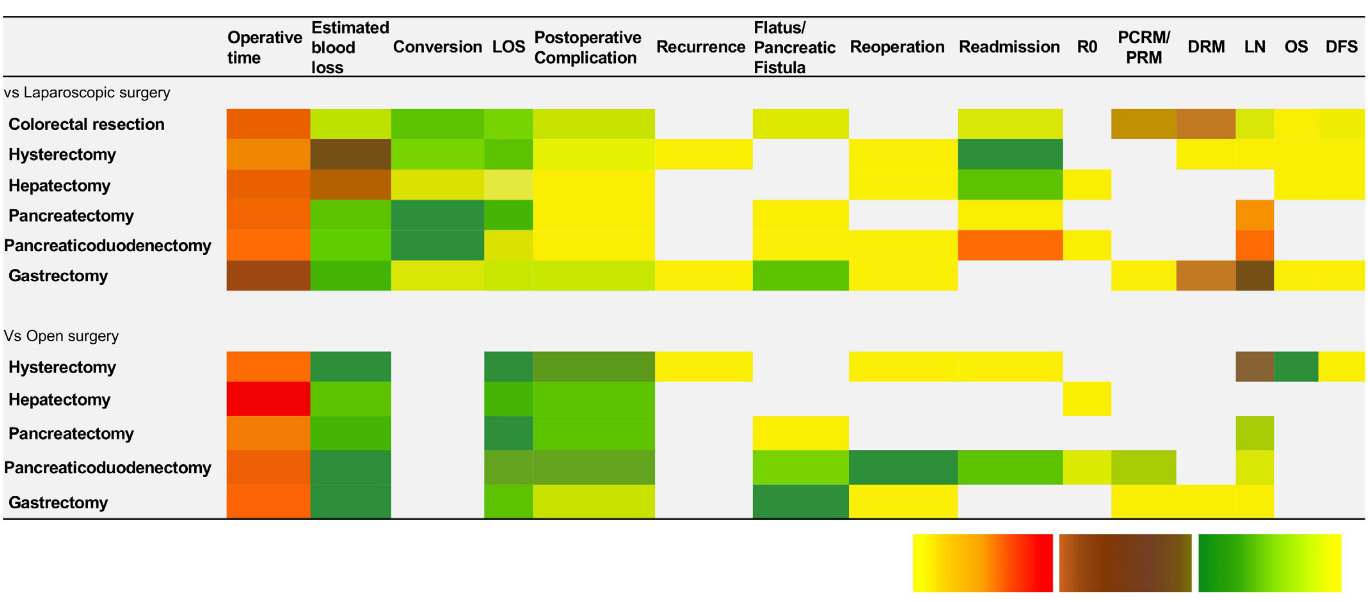

Figure 3 Evidence mapping across all targeted procedures. DFS, disease-free survival; DRM, distal resection margin; LOS, length of hospital stays; LN, lymph node; OS, overall survival; PCRM, positive circumferential resection margin; PRM, positive resection margin; R0, margin-negative resection.

and pancreaticoduodenectomy, all nine reviews suggested significantly lower conversion rates to open surgery than LS.[66 68 74 119 121 129–132] However, in gastrectomy, no significant conversion rate differences could be found from the included 13 out of 18 reviews.

Length of hospital stay

Identified evidence across all procedures showed that RAS compared with LS or open surgery had an equivalent or shorter duration of hospitalisation; hence, the green to yellow colour spectrum of evidence is presented in figure 3.

Among the included reviews of colorectal oncology surgery, 16 out of 37 articles[28 32 34–36 39 40 44–46 49 51 99 133–135] reported RAS had a significantly shorter duration of hospital stays than LS. For hysterectomy, 10 out of 13 studies[101–104 106–108 136–138] reported RAS had significantly shorter hospital stays than LS. Compared with open surgery, RAS also had a significantly shorter length of hospital stays.[103 106–111] In the field of HPB, only two studies for hepatectomy indicated RAS had a significantly shorter length of hospital stay than LS while the other 19 studies did not.[112 115] Eight out of nine[52 57 59 62 113 117 118 139] included studies showed significantly shorter duration than open surgery. Among the included systematic reviews for pancreatectomy and pancreaticoduodenectomy, six studies[65 119 129 130 140 141] reported RAS had a significantly shorter length of hospital stay than LS and almost all studies showed a significantly shorter length of hospital stay than open surgery.[65 67 68 70–74 76 119 122 124 142] As for gastrectomy, five out of 18 reviews[84 87 88 92 143] found RAS had a significantly shorter length of hospital stay than LS, and two out of four reviews[94 96] indicated RAS had significantly shorter stay compared with open approach.

Postoperative complications

For postoperative complications among all procedures, identified evidence for comparing RAS to LS tend to be neutral, while comparing RAS to open surgery tend to be positive as illustrated in the green to yellow colour spectrum in figure 3.

Among the identified reviews of colorectal oncology resection, seven out of 30 articles[34 36 43 46 50 134 144] showed that RAS in postoperative complication results were significant compared with LS. In hysterectomy, only one study found RAS had a significantly lower postoperative complication than LS,[137] while five out of eight studies were in favour of RAS than an open approach.[103 106 107 109 111] In respect of HPB including hepatectomy, pancreatectomy and pancreaticoduodenectomy, no significant difference in postoperative complication rate was found compared with LS. Some positive evidence when RAS was compared with open surgery: six out of 11 reviews for hepatectomy,[52 57 59 113 117 118] two out of five reviews for pancreatectomy[65 67] and six out of eight reviews for pancreaticoduodenectomy.[67 68 72 74 76 142] For gastrectomy, five out of 18[84 85 87 89 145] found RAS had significant differences in postoperative complication rates compared with LS, and only one compared with open surgery.[96]

Other clinical outcomes

There were other important outcomes identified among the selective procedures such as reoperation and readmission presented in figure 3. It is noted that there was various evidence identified in outcomes of readmission across all selective procedures when RAS compared with LS. Some procedures reported on postoperative mortality.[78 79 81 98 146–148]

Procedure-specific postoperative outcomes were also reported. For example, colorectal resection and gastrectomy had data on outcomes of first flatus,[32 35 39 50 81 84 85 89–92 98] pancreatectomy and pancreaticoduodenectomy on outcomes of pancreatic fistula[74 76 149] and bile leak.[150] Colorectal resection had reported urinary outcomes and sexual function[151–156] and other outcomes such as ileus and anastomotic leak.[156–158] More details for other clinical outcomes of the included systematic reviews can be found in online supplemental file 5.

Oncological outcomes

Different oncological outcomes were reported including the number of lymph node yield and resection-related outcomes (distal resection margin, positive circumferential resection margin, positive resection margin and margin-negative resection). Mix evidence in oncological outcomes was found across all procedures, especially when RAS compared with LS or open surgery, with a brown colour in the spectrum presented in figure 3. For example, lymph node yield in hysterectomy, RAS compared with open surgery had one study with a significant negative outcome,[103] three with positive outcomes[107 136 137] and four with neutral. One study also reported para-aortic lymph nodes.[159] In gastrectomy, RAS compared with LS also found eight with significant negative outcomes,[78 79 81 84 86 88 93 125] two with positive[88 90] and seven with insignificant outcomes. In pancreatectomy and pancreaticoduodenectomy, RAS compared with LS had one out of [66]six and two out of four reviews[123 132] had negative significance. Other oncological outcome was used, for example, completeness of total mesorectum excision.[160] More details can be reviewed in online supplemental file 5.

Long–term outcomes

Some reviews comparing RAS to LS reported overall survival and disease-free survival outcomes. In most of the studies, identified evidence was neutral with the yellow colour spectrum presented in figure 3, except one study showing RAS compared with open surgery had significantly longer 3-year overall survival in hysterectomy.[109]

Quality of included reviews and overlap management

Figure 4 displays that the quality of the systematic reviews was generally judged low or critically low across all procedures, using the AMSTAR-2 quality appraisal tool guidance.[21] Our assessment identified the critical flaw domain

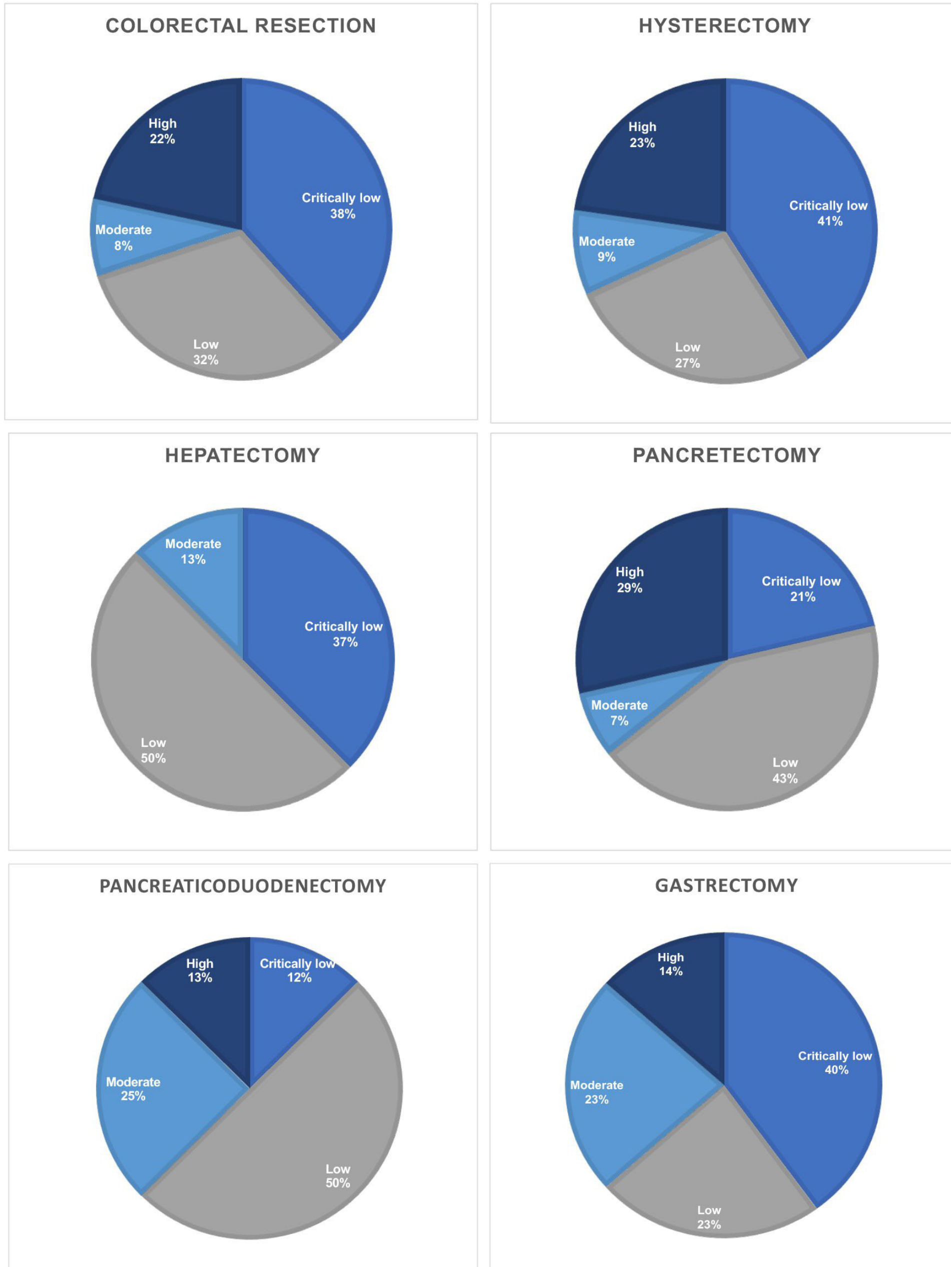

Figure 4 Quality assessment of systematic reviews in procedures of interest.

that the source of their primary studies does not impact quality, but poor management for risk of bias and publication bias does.

Regarding overlap management, the CCA value for colorectal oncological surgery is 6.4%, which is considered a moderate overlap. For hysterectomy is 3.3% which is considered just slight overlaps. For hepatectomy, pancreatectomy and pancreaticoduodenectomy, their CCA values are 13.62%, 17.6% and 22.73%, respectively considered as high and very high overlap. For gastrectomy with a CCA value of 8.42%, it is moderate. Given this level of overlap, we were aware of the risk of double-counting of individual studies within systematic reviews that would potentially impact on result and interpreted the evidence carefully.

DISCUSSION

The review offers an overview of the clinical outcomes of RAS and presents a summary of the clinical effectiveness evidence base to support the decision makers in optimising the utilisation of this technology.

We found RAS operative time was longer across all procedures. RAS had less estimated blood loss compared with open, but there was mixed evidence in hysterectomy and hepatectomy compared with LS. For conversion rate and length of stay, all the evidence indicated RAS had a lower conversion rate and shorter length of stay whether compared with LS or open. RAS had lower postoperative complications compared with open surgery, but we found no significant difference compared with LS. Across surgical procedures, we found the evidence is more positive when RAS is compared with an open approach.

A broad pattern of at least equivalent clinical outcomes of RAS was identified except for operative time. Longer operative time may be a temporary phenomenon because RAS is a relatively new technology which has a steep learning curve for individual surgeons and the whole support team. We recognise that the primary studies from the included systematic reviews covered RCTs could be quite dated, and observational studies and the different specialties which were the focus of our review are at different phases of adoption of RAS. Operative time with RAS may improve over time as the whole surgical and support team becomes more familiar with the technology.[161–164] In urology, where RAS is more established, evidence from large observational studies of robot-assisted laparoscopic prostatectomy shows a consistent decline in operative time and console time after overcoming the learning curve followed by a near-constant phase.[165] One study, also from urology, reported that surgeons with a higher caseload exhibited improved operative time compared with general caseload (266 min vs 240 min, $p<0.05$).[166]

A recent overview of reviews for RAS looked at multiple procedures (radical prostatectomy, hysterectomy, thoracic surgery (lobectomy and thymectomy), colorectal resection, nephrectomy, gastric and HPB procedures) and found, as we did, that RAS generally had a longer operative time.[10] It also found shorter operative time in hysterectomy for endometrial cancer and Roux-en-Y gastric bypass compared with LS. This may be because the review only looked at SRs including RCTs, whereas our review has included a broader range of SRs which incorporated evidence from observational studies. We found shorter operative time in gastrectomy compared with LS but this finding was from a single network meta-analysis including a single RCT.[98] Another overview of reviews which focused on a single procedure, total mesorectal excision for rectal cancer, also found that RAS had a significantly longer operative time than LS and open surgery.[167] Another two overview reviews for gastric cancer indicated that patients treated with RAS had significantly less estimated blood loss and shorter time to resumption of oral intake but prolonged operating time than patients undergoing LS.[168 169] In our overview, we also found RAS had significantly less estimated blood loss and a shorter time to resumption of oral intake than LS and open surgery in gastrectomy.

This finding was consistent with another overview of SRs.[168] Findings of poor quality mainly relate to reviewers' failure to explicitly deal with the bias inherent in real-world evidence. However, real-world evidence is critical in the evaluation of surgical techniques as randomisation is often difficult or impossible and randomised trial participants and surgeons may not be representative of the full population.

Our review is the first to summarise the full body of evidence of clinical outcomes and then further examine a number of specialties where there is still equipoise. This review is particularly relevant at the present time due to significant RAS expansion across non-urological specialties. We developed a novel evidence map with the concept of a colour spectrum to present the strength of evidence and its orientation. This study allows readers to capture both a broad perspective of the evidence landscape and in-depth information on the clinical effectiveness evidence. The results from this overview are likely to be generalisable to all countries as the SRs included studies from a broad range of settings. Although there would be a potential risk of bias when an SR included non-randomised studies, our AMSTAR-2 assessment has covered the item of risk of bias in each SR. The limitation of this overview review was that it adopted an existing search strategy supported by a two-stage selection process and focused on a selective number of procedures, given our research aim. It could have been more comprehensive.

Our findings have different implications for different categories of stakeholders. For patients, our results suggest that it is safe to move to RAS for all procedures examined, with outcomes equivalent or superior to traditional surgical methods. However, caution is advised for new procedures, as the first procedures chosen for RAS may have been the most suitable. For surgeons and other clinicians, although operative times are generally longer, they can be reassured about patient outcomes, and the presence of RAS may bring other benefits. These benefits include the attraction and retention of surgeons, the enhancement of their skill sets and the ability to work longer without fatigue or work longer before retirement. For healthcare providers, the use of RAS may bring the benefit of extending MIS to a larger proportion of patients. Where the uptake of LS has been low, perhaps due to technical difficulty, RAS may be more attractive to surgical teams.[3 170] Previous research has investigated the scalability of MIS, indicating that RAS rapidly substitutes both open and laparoscopic surgery over time, resulting in a higher proportion of MIS overall.[170 171]RAS was initially adopted for urological procedures. However, the limited operational days of surgical hardware may prompt hospitals to cross-specialty utilisation for optimal return on investment. A UK NHS study from 2000 to 2018 highlights RAS substituting incumbent technologies and expanding into diverse surgical specialties.[170] One study showed the proportion of hospitals and surgeons performing robotic surgery for selective procedures (including inguinal hernia repair colectomy, etc) increased from 3.1% in the first year to 13.1% in the fourth year after the implementation of surgical robots, leading to a trend towards less laparoscopic surgeries (−1.9%) being performed.[171] Another example where LS expansion could be considered to have stalled in the UK is laparoscopic colonic surgery. Rates of open colorectal cancer surgery remain between 30% and 40% and of those receiving laparoscopic resection, conversion to open surgery occurs in 10% in England and Wales.[172] Once the investment in RAS has been made, there may also be a higher level of institutional buy-in to extending its use, increasing the total proportion of patients being treated in a minimally invasive manner. The main concern may be around operative time. It might be a short-term phenomenon akin to a learning curve and might change over time as teams get used to new equipment. Alternatively, longer operative time could be a necessary disadvantage of a more complex set of equipment. Accordingly, other concerns for healthcare providers include the real costs of longer operative time, whether fewer procedures are being done and waiting lists are growing and whether higher prices charged for procedures compensate for the longer operative time.

In conclusion, the evidence suggests that RAS is a safe and effective alternative to LS and open surgery, with the potential to improve outcomes and enhance the capabilities of surgeons and healthcare providers and a particular opportunity to increase the proportion of minimally-invasive approaches. However, given the higher capital and running costs of the technology (ie, purchase of the robot, maintenance costs and the costs of disposables) and the longer operative times associated with its use, there is a need for careful consideration of its cost-effectiveness. Further research is needed to fully evaluate the value of these improvements in outcomes and to assess whether they outweigh the cost implications of the technology. Only through rigorous evaluation can we ensure that RAS is used in the most effective and sustainable manner possible after the initial investment, for the benefit of patients, surgeons and healthcare systems as a whole.

Acknowledgements We would like to thank the Health Improvement Scotland for providing a developed search strategy for this manuscript. We also thank Dr Charles Maxwell-Armstrong for reviewing an early draft and giving feedback.

Contributors T-JL: conceptualisation of the study, data synthesis and drafting of the manuscript. CR: critical review of the manuscript and substantial contributions to its intellectual content. KAB: conceptualisation of the study, manuscript review, editing and supervision of the research. JB: conceptualisation of the study, manuscript review, editing and supervision of the research. Each author has reviewed and approved the final version of the manuscript, and each has agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. T-JL is responsible for the overall content as guarantor. We can confirm that this manuscript has no AI used in the submission.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data sharing not applicable as no datasets generated and/or analysed for this study. All data relevant to the study are included in the article or uploaded as supplementary information.

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Supplementary File 1- DATABASE SEARCH TERMS

Table 1-1 List of search terms

Database search record		
Database:	**Saved search strategy name**	**Search strategy** (inc. limits and filters)
Cochrane Library	Robotic surgery Dec 2023	Date Run: 18/12/2023 ID Search Hits #1 MeSH descriptor: [Robotic Surgical Procedures] this term only 711 #2 ((robot* near/3 (surger* or surgical* or transplant* or laparoscop*))):ti,ab,kw 3135 #3 (("robot-assisted" or "robotically-assisted") near/3 (surger* or surgical* or transplant* or laparoscop*)):ti,ab,kw 1487 #4 (#1 or #2 or #3) in Cochrane Reviews 17
Ovid Medline	Robotic surgery Medline Dec 2023	Systematic reviews Database: Ovid MEDLINE(R) ALL <1946 to Dec 18, 2023> Search Strategy: -- 1 Robotic Surgical Procedures/ (17146) 2 (robot* adj3 (surger* or surgical* or transplant* or laparoscop*)).tw. (21673) 3 (("robot-assisted" or "robotically-assisted") adj3 (surger* or surgical* or transplant* or laparoscop*)).tw. (6280) 4 or/1-3 (30099) 5 Meta-Analysis as Topic/ (23602) 6 meta analy$.tw. (288688) 7 metaanaly$.tw. (2650) 8 Meta-Analysis/ (192167) 9 (systematic adj (review$1 or overview$1)).tw. (312303) 10 exp Review Literature as Topic/ (24187) 11 5 or 6 or 7 or 8 or 9 or 10 (481996)

		12 cochrane.ab. (142735) 13 embase.ab. (164555) 14 (psychlit or psyclit).ab. (918) 15 (psychinfo or psycinfo).ab. (62138) 16 (cinahl or cinhal).ab. (49085) 17 science citation index.ab. (3884) 18 bids.ab. (705) 19 cancerlit.ab. (639) 20 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 (261525) 21 reference list$.ab. (22756) 22 bibliograph$.ab. (23298) 23 hand-search$.ab. (8799) 24 relevant journals.ab. (1374) 25 manual search$.ab. (6335) 26 21 or 22 or 23 or 24 or 25 (56223) 27 selection criteria.ab. (37067) 28 data extraction.ab. (34536) 29 27 or 28 (68859) 30 Review/ (3257314) 31 29 and 30 (36342) 32 Comment/ (1028567) 33 Letter/ (1239422) 34 Editorial/ (677045) 35 animal/ (7365147) 36 human/ (21674355) 37 35 not (35 and 36) (5147329) 38 32 or 33 or 34 or 37 (7288093) 39 11 or 20 or 26 or 31 (575393) 40 39 not 38 (548388) 41 4 and 40 (1882) 42 limit 41 to (english language and yr="2017 - 2023") (1426)
Ovid Embase	Robotic surgery Embase Dec 2023	**<u>Systematic reviews</u>** Database: Embase <1974 to 2023 Dec 18> Search Strategy: --

		1 robot assisted surgery/ (24536) 2 (robot* adj3 (surger* or surgical* or transplant* or laparoscop*)).tw. (38463) 3 (("robot-assisted" or "robotically-assisted") adj3 (surger* or surgical* or transplant* or laparoscop*)).tw. (10035) 4 or/1-3 (50153) 5 exp Meta Analysis/ (303011) 6 ((meta adj analy$) or metaanalys$).tw. (368652) 7 (systematic adj (review$1 or overview$1)).tw. (375813) 8 5 or 6 or 7 (602549) 9 cancerlit.ab. (757) 10 cochrane.ab. (180054) 11 embase.ab. (203939) 12 (psychlit or psyclit).ab. (1011) 13 (psychinfo or psycinfo).ab. (59100) 14 (cinahl or cinhal).ab. (57034) 15 science citation index.ab. (4448) 16 bids.ab. (895) 17 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 (310979) 18 reference lists.ab. (24314) 19 bibliograph$.ab. (33883) 20 hand-search$.ab. (10741) 21 manual search$.ab. (7396) 22 relevant journals.ab. (1628) 23 18 or 19 or 20 or 21 or 22 (70842) 24 data extraction.ab. (41739) 25 selection criteria.ab. (46133) 26 24 or 25 (85120) 27 review.pt. (3211610) 28 26 and 27 (39123) 29 letter.pt. (1302410) 30 editorial.pt. (791130) 31 animal/ (2142249) 32 human/ (27182511) 33 31 not (31 and 32) (1624637)

		34 29 or 30 or 33 (3699510) 35 8 or 17 or 23 or 28 (714138) 36 35 not 34 (696659) 37 4 and 36 (2500) 38 limit 37 to (english language and yr="2017 - 2023") 1920

Supplementary File 2 - Quality assessment

The AMSTAR-2 tool has 16 domains of which 7 are deemed critical based on the guidance. The 7 critical domains are protocol registration, adequacy of the literature search, justification for excluding studies, risk of bias assessment, appropriateness of methods used for meta-analysis, consideration of risk of bias, presence of assessment and likely impact of publication bias. The 9 non-critical domains are PICO description [population, intervention, comparison, outcome], explanation of the study design, rationale of study selection, adequacy of data extraction, adequate details in the description of the included studies, reporting of sources of funding, assessment of potential impact of risk of bias, assessment of heterogeneity, and reporting of conflicts of interest. The quality assessment can be found in following tables.

In order to be judged as high quality a study must have no critical weaknesses and only one non-critical weakness. A review will be judged moderate when it has more than one non-critical weakness. A review will be judged low quality when it has one critical weakness and critically low when it has more than one critical weakness [1].

Table 2-1 Characteristics of Included Reviews and Quality Assessment for Colorectal Oncology Surgery

Review	Year	Studies included, n			Population	Intervention vs Comparator	Risk of bias tool	Critically flawed domains	Quality assessed by author (TJ LAI)
		Total	RCT	Non-RCT					
Li Xiaofei [2]	2017	17	-	17	patients with rectal cancer	RTME vs LTME	-	9, 11, 15	Critically low
Xu [3]	2017	9	-	9	patients with anus-preserving rectal cancer	RTME vs LTME	MINORS	13	Low
Lee [4]	2018	5		5	patients with low rectal adenocarcinoma	Robotic vs laparoscopic ISR	RoBANS	15	Low
Jones [5]	2018	28	1	27	patients with rectal cancer	RTME vs LTME	-	9, 13	Critically low
Holmer [6]	2018	13	2	11	patients with rectal cancer	RTME vs TME or open TME	No meta was performed	9, 13	Critically low
Ohtani [7]	2018	23	-	23	patients with rectal cancer	RTME vs LTME	MINORS	13, 15	Critically low
Pezzolla [8]	2018	5	5	-	patients with rectal cancer	RTME vs LTME	Cochrane risk of bias tool	15	Low
Sheng [9]	2018	40			patient with colorectal cancer	RAS vs LS vs open surgery	Cochrane risk of bias tool	11, 13, 15	Critically low
Tang [10]	2018	6	2	4	patients with rectal cancer	RTME vs LTME	NOS, Cochrane Collaboration tool		High
Milone [11]	2019	12	1	11	patients with rectal cancer	RTME vs LTME	Cochrane Collaboration tool		Moderate
Ma [12]	2019	13	1	12	patient with colon cancer	Robotic-assisted vs laparoscopic right colectomy	-	13	Low
Simillis [13]	2019	37	29	8	patients with rectal cancer	RTME vs LTME or TaTME	Cochrane risk of bias tool	15	Low
Grass [14]	2019	64	2	62	patients with rectal cancer	taTME or RTME vs LTME	No meta was performed	9, 13	Critically low
Liao [15]	2019	7	7	-	patients with rectal cancer	RTME vs LTME	Cochrane risk of bias tool		High
Li [16]	2019	7	7	-	patients with rectal cancer	RTME vs LTME	Jadad scale	15	Low
Ng [17]	2019	73	6	67	patient with colorectal cancer	RTME vs LTME	Cochrane risk of bias tool, NOS	15	Low
Huang [18]	2019	8	8	0	patients with rectal cancer	RTME vs LTME	Cochrane risk of bias tool	15	Low
Phan [19]	2019	11	6	5	patients with rectal cancer	Robotic vs. laparoscopic rectal cancer surgery	Cochrane Collaboration tool	15	Low

Rausa [20]	2019	48	5	43	patient with colonic neoplasms	Robotic hemicolectomy vs open vs Laparoscopic-assisted vs Total laparoscopic hemicolectomy	Cochrane risk of bias tool, NOS	15	Low
Rubinkiewicz [21]	2019	6	-	6	patients with rectal cancer	RAS vs LS	NOS	7, 15	Critically low
Sun [22]	2019	6	2	4	patients with rectal cancer	RTME vs LTME	NOS	15	Low
Eltair [23]	2020	9	9	-	patients with rectal cancer	RTME vs LTME	Cochrane risk of bias tool	11	Low
Gavriilidis [24]	2020	25	3	22	patients with rectal cancer	RTME vs LTME	NOS	15	Low
Tejedor [25]	2020	4	-	4	patients with rectal cancer	RTME vs LTME	-	9, 13, 14	Critically low
Wang [26]	2020	20		20	patients with rectal cancer	RTME vs LTME	-	9, 13, 15	Critically low
Waters [27]	2020	15	1	14	patients with rectal cancer	Robotic vs laparoscopic hemicolectomy	Cochrane risk of bias tool, NOS		Moderate
Qiu [28]	2020	7		7	patients with rectal cancer	RTME vs LTME	MINORS	13, 15	Critically low
Guo [29]	2021	14		14	patients with rectal cancer	RAS vs open rectal surgery	Jadad scale, NOS		High
Hoshino [30]	2021	59	7	52	patients with rectal cancer	RTME vs LTME	-	9, 11,13, 15	Critically low
Fleming [31]	2021	10	3	7	patients with rectal cancer	RTME vs LTME	NOS	11	Low
Ryan [32]	2021		30		patients with rectal cancer	RTME vs LTME	-	9, 13, 15	Critically low
Tang [33]	2021	7	7		patients with rectal cancer	RTME vs LTME	Cochrane risk of bias tool, Jadad scale		High
Butterworth[34]	2021	62	-	62	patients with low rectal adenocarcinoma	RTME vs TaTME	Cochrane Collaboration Tool		High
Chen [35]	2021	6	-	6	patient with rectal cancer	RTME vs TaTME	-	9, 13	Critically low
Genova[36]	2021	37	1	36	patient with colon cancer	Robotic-assisted vs laparoscopic right colectomy			High
Kowalewski [37]	2021	48	3	45	patient with colon cancer	Robotic vs. laparoscopic rectal cancer surgery	NOS	9	Low
Liu [38]	2021	15	2	13	patients with rectal cancer	Robotic vs. laparoscopic rectal cancer surgery	NOS		High
Safiejko [39]	2021	42	3	39	patient with colon cancer	Robotic TME, APR, LAR,	RoB2 tool for RCT and		High

						Hartman, ISR vs laparoscopic TME APR, LAR, Hartman, ISR	ROBINS-I bias for nRCT		
Wee [40]	2021	39	-	39	patient with colon cancer	Robotic-assisted vs laparoscopic resection	Cochrane risk-of-bias tool		Moderate
Zhang [41]	2021	5	-	5	patients with low rectal cancer	Robotic vs laparoscopic ISR	NOS	9, 13	Critically low
Zhu [42]	2021	10	-	10	patient with right colon tumor	Robotic vs laparoscopic right colectomy	NOS	9, 13, 15	Critically low
An [43]	2022	19	19	-	patient with colon cancer	Robotic vs laparoscopic colectomy	Cochrane risk of bias tool	15	Low
Ravindra[44]	2022	16	2	14	patients with colorectal cancer	Robotic vs laparoscopic APR	Cochrane risk of bias tool		Moderate
Sandlas [45]	2022	12	-	12	patients with rectal cancer	RTME vs LTME	-	7,9,13,15	Critically low
Solaini [46]	2022	11	-	11	patients with rectal cancer	Robotic vs laparoscopic left colectomy	NOS	9, 13	Critically low
Tschann [47]	2022	25	1	24	patients with colorectal cancer	Robotic vs laparoscopic right colectomy	NOS	9, 13, 15	Critically low
Cuk [48]	2023	55	3	52	patient with colonic cancer	Robotic vs laparoscopic CME	Cochrane risk of bias tool		High
Flynn [49]	2023	50	3	47	patient with rectal cancer	Robotic vs laparoscopic colectomy	-	9, 13, 15	Critically low
Khajeh [50]	2023	26	RAS vs Open, N=5; RAS vs LAS, n=24		patients with colorectal cancer	Robotic vs laparoscopic vs Open colectomy	-	9, 15	Critically low
Huang [51]	2023	11	11	-	patients with rectal cancer	Robotic vs laparoscopic colectomy	Cochrane risk of bias tool		High
Kim [52]	2023	5	-	5	patients right colon cancer	robotic vs laparoscopic right colectomy	MINORS	9, 13, 15	Critically low
Kyrochristou [53]	2023	16	-	16	patient with colonic cancer	Robotic vs laparoscopic CME	-	9, 13	Critically low
Oweira [54]	2023	7	-	7	patient with colonic cancer	Robotic vs laparoscopic CME	-	9, 13, 15	Critically low

Seow [55]	2023	47	32	15	patients with rectal cancer	RTME vs TaTME	RoB2		High
Xu [56]	2023	7	4	3	patient with colonic cancer	Robotic vs laparoscopic CME	Cochrane risk of bias tool		Moderate
Yang [57]	2023	11	2	9	patient with rectal cancer	Robotic vs laparoscopic colectomy	NOS		High
Yang [58]	2023	6	6	-	patient with colonic cancer	Robotic vs laparoscopic colectomy	Cochrane risk of bias tool		High
Yao [59]	2023	8	-	8	Patient with mid–low rectal cancer	RTME vs LTME	NOS	9	Low
Zheng [60]	2023	42	1	41	patient with colonic cancer	robotic vs laparoscopic right colectomy	NOS	9	Low
Zheng [61]	2023	15	-	15	patient with colonic cancer	robotic vs laparoscopic right colectomy	NOS	9	Low

APR abdominoperineal resection; CME, complete mesorectal excision; LS, laparoscopic surgery; LTME, laparoscopic Total Mesorectal Excision; ISR=intersphincteric resection; RAS=Robotic Assisted Surgery; RTME=Robotic Assisted Total Mesorectal Excision; TaTME= Transanal Total Mesorectal Excision; TME=Total Mesorectal Excision. MINORS, methodological index for non-randomized studies; NOS, Newcastle–Ottawa scale; RCT, randomized controlled trial; RoB, risk of bias.

Domain 2, protocol registration; 4, adequacy of the literature search; 7, justification for excluding studies; 9, risk of bias assessment for included studies; 11, appropriateness of methods used for meta-analysis; 13, consideration of risk of bias; 15, assessment of publication bias.

Table 2-2 Characteristics of Included Reviews and Quality Assessment for hysterectomy

Review	Year	Studies included, n			Population	Intervention vs Comparator	Risk of bias tool	Critically flawed domains	Quality assessed by author (TJ LAI)
		Total	RCT	Non-RCT					
Li [62]	2017	19	-	19	women with cervical cancer	RH vs LH vs OH	-		High
Laios [63]	2017	36	1	35	patients with endometrial cancer	RH vs LH	-	9, 13, 15	Critically low
Nevis [64]	2017	35	-	35	patients with endometrial and cervical cancers	RH vs OH	-		Moderate
Park [65]	2017	22	-	22	patients with cervical cancer	RH vs LH vs OH	RoB 2.0	15	Low
Jin [66]	2018	17	17	-	patients with cervical cancer	RH vs LH vs OH	PEDro	13, 15	Critically low
Behbehani [67]	2019	21	1	20	patients with gynecologic oncology conditions	RH vs LH	NOS, Cochrane risk of bias	13, 15	Critically low
Cusimano [68]	2019	51	-	51	patient with early-stage endometrial cancer	RH vs LH	NOS	15	Low
Lawrie [69]	2019	12	12	-	women with malignant/ benign gynaecological disease	RH vs LH vs OH	Cochrane risk of bias tool		High
Marra [70]	2019	50	5	45	patients with benign uterine disease/ endometrial cancer/ cervical cancer	RH vs LH	-	9, 13	Critically low
Shi [71]	2019	8	-	8	patients with ovarinan cancer	RH vs LH vs OH	MINORS		High
Zhang [72]	2019	13	-	13	patients with cervical	RH vs LH	modified MINORS, NOS		Moderate

					cancer				
Behbehani [73]	2020	65	5	60	patients with benign gynecologic conditions	RH vs LH	NOS, Cochrane risk of bias tool	13, 15	Critically low
Prodromidou [74]	2020	6	-	6	patients with benign or early-stage malignant gynecological conditions	RH vs LH	MINORS	15	Low
Wang [75]	2020	27	1	26	patients with endometrial cancer	RH vs LH vs OH	NOS, Cochrane risk of bias		High
Hwang [76]	2020	23		23	patients with benign gynecologic conditions	RH vs LH	-	9, 13	Critically low
Alshowaikh [77]	2021	25	2	23		RH vs LH	NOS	7, 9	Critically low
Kampers [78]	2022	27	2	25	patients with early cervical cancer	RH vs LH	RoB 2.0	15	Low
Huang [79]	2023	6	-	-	patients with early cervical cancer	RH vs LH	Cochrane risk of bias		High
Hwang [80]	2023	20	-	-	patients with early cervical cancer	RH vs LH		9	Low
Hwang [81]	2023	19	-	-	patients with early cervical cancer	RH vs LH		9, 11,13	Critically low
Marchand [82]	2023	35	-	35	patients with early cervical cancer	RH vs OH		9, 13, 15	Critically low
Marchand [83]	2023	33	-	33	patients with early cervical cancer	RH vs LH	Cochrane risk of bias	15	Low

LH, laparoscopic hysterectomy; OH, open hysterectomy; RH robotic hysterectomy; MINORS, methodological index for non-randomized studies; NOS, Newcastle–Ottawa scale; RCT, randomized controlled trial; RoB, risk of bias.

Domain 2, protocol registration; 4, adequacy of the literature search; 7, justification for excluding studies; 9, risk of bias assessment for included studies; 11, appropriateness of methods used for meta-analysis; 13, consideration of risk of bias; 15, assessment of publication bias.

Table 2-3 Characteristics of Included Reviews and Quality Assessment for Hepatopancreaticobiliary Surgeries

Review	Year	Studies included, n			Population	Intervention vs Comparator	Risk of bias tool	Critically flawed domains	Quality assessed by author (TJ LAI)
		Total	RCT	Non-RCT					
Lauretta [84]	2017	10		10	patient with pancreatic body-tail tumors	RDP vs LDP	NOS		Moderate
Kornaropoulos [85]	2017	13		-	patients with cancerous tumors of the head of the pancreas, malignant periampullary tumors	RPD vs LPD	-		Moderate
Peng [86]	2017	7	-	7	patients with tumors of pancreatic head, distal bile duct, duodenal or ampullary carcinomas	RPD vs OPD	NOS	13	Low
Shin [87]	2017	5		5	patient with periampullary neoplasms	RPD vs LPD vs OPD	NOS	13	Low
Hu [88]	2018	17	-	17	patients with liver neoplasms	RLR vs LLR	NOS, GRADE	15	Low
Zhao [89]	2018	15		15	patient with pancreatic adenocarcinoma	RAS vs Open	NOS	13, 15	Critical low
Machairas [90]	2019	10	-	10	patient with malignant and benign hepatic tumors	RLR vs OLR	MINORS	15	Low
Wong [91]	2019	7	-	7	patient with liver disease	RLR vs OLR	NOS	15	Low
Gavriilidis [92]	2019	36	-	36	patients with pancreatic adenocarcinoma	RDP vs LDP vs ODP	NOS	15	Low
Guan [93]	2019	13	-	13	patient with liver malignancies	RLR vs LLR	NOS	9	Low
Kamarajah [94]	2019	20	-	20	patient with pancreatic benign and malignant condictiones	RDP vs LDP	NOS		High
Niu [95]	2019	17	-	17	patients with pancreatic lesion	RDP vs LDP vs ODP	NOS, GRADE		High
Ciria [96]	2020	150	-	150	patient with liver malignancies	RLR vs LLR	NOS	13	Low
Gavriilidis [97]	2020	79	1	78	Patient with hepatocellular carcinoma	RLR vs LLR vs OLR	NOS	15	Low
Kamarajah [98]	2020	26	-	26	patient with liver malignancies	RLR vs LLR vs OLR	NOS, Cochrane Risk of Bias Tool	9	Low
Zhang [99]	2020	18	-	18	patients with tumors of pancreatic	RPD vs OPD	NOS	13	Low

					head, distal bile duct, duodenal or ampullary carcinomas				
Zhao [100]	2020	31	-	31	patients had benign and malignant liver conditions	RLR vs LLR vs OLR	NOS	13	Low
Lyu [101]	2020	46	-	46	patient with pancreatic benign and malignant tumors of the pancreatic body and tail	RDP vs LDP vs ODP	NOS		High
Mavrovounis [102]	2020	22	-	22	patients with pancreatic pathology	RDP vs LDP	NOS		Moderate
Zhou [103]	2020	7	-	7	patient with pancreatic benign and malignant conditions	RDP vs ODP	NOS	13, 15	Critical low
Aiolfi [104]	2020	41	3	39	patient with pancreatic head neoplasms	RPD vs LPD vs OPD	ROBINSI	15	Low
Kamarajah [105]	2020	44	-	44	patient with benign and malignant conditions	RPD vs LPD	NOS, the Cochrane Risk of Bias Tool		High
Podda [106]	2020	18	-	18	patients with benign and malignant periampullary disease	RPD vs OPD	ROBINS-I, GRADE		High
Yan [107]	2020	12		12	patient with malignant lesions of the pancreatic head, distal common bile duct, and duodenum	RPD vs OPD	NOS	13	Low
Coletta [108]	2021	8	-	8	patient with liver malignancies	RLR vs LLR	ROBINS-I, GRADE		Moderate
Coco [109]	2020	16	-	16	patient with liver cancer	RLR vs LLR	-		Moderate
Hu [110]	2021	6		6	patient with liver malignancies	RLR vs LLR	NOS	13	Low
Ziogas [111]	2021	7	-	7	patient with liver disease	RLR vs LLR	NOS	13	Low
Wang [112]	2021	12	-	12	patient with liver disease	RLR vs LLR	NOS	9	Low
Da Dong [113]	2021	24	-	24	patient with pancreatic head neoplasms	RPD vs OPD	ROBINS-I		Moderate
Zhang [114]	2021	18	-	18	patient with pancreatic head neoplasms	RPD vs OPD	NOS	9	Low
Di Martino [115]	2021	11	-	11	patient with pancreatic benign and malignant conditions	RDP vs LDP		9, 13, 15	Critical low

Feng [116]	2021	6	-	6	patient with pancreatic benign and malignant conditions	RDP vs LDP	NOS	9, 13	Critically low
Rompianesi [117]	2021	11	-	11	patient with pancreatic benign and malignant conditions	RDP vs LDP	NOS	9	Low
Aboudou [118]	2022	19	-	19	patient with liver disease	RLR vs LLR	NOS	9, 13	Critical low
Hajibandeh [119]	2022	7	-	7	patient with liver disease	RLR vs LLR	ROBINS-I	9, 11	Critical low
Fu [120]	2022	21	-	21	patient with pancreatic cancer	RPD vs OPD	NOS	15	Low
Lincango [121]	2022	4	-	4	patient with liver disease	RLR vs LLR	CLARITY tool		Moderate
Murtha-Lemekhova [122]	2022	8	-	8	patient with liver disease	RLR vs LLR	ROBINS-I	15	Low
Rahimli [123]	2022	14	-	14	patient with liver disease	RLR vs LLR	NOS	9, 13, 15	Critical low
Yeow [124]	2022	19	-	19	living donor right hepatectomy	RLR vs LLR vs OLR		9	Low
Kabir [125]	2022	27	4	23	patient with pancreatic head neoplasms	RPD vs LPD vs OPD	Cochrane Risk of Bias tool/ NOS		Moderate
Ouyang [126]	2022	9	-	9	patient with pancreatic head neoplasms	RPD vs LPD	NOS	9, 13	Critical low
Gao [127]	2023	22	-	22	patient with liver disease	RLR vs LLR vs OLR	NOS	9, 13	Critical low
Long [128]	2023	5	-	5	patient with liver disease	RLR vs LLR	NOS	9, 13	Critical low
Mao [129]	2023	12			patient with liver disease	RLR vs LLR	NOS	9, 13	Critical low
Papadopoulou [130]	2023	14	-	14	patient with liver disease	RLR vs OLR	MINORS	9, 13, 15	Critical low
Xuea [131]	2023	8	-	8	patient with liver disease	RLR vs OLR	NOS	9, 13	Critical low
Ziogas [132]	2023	31	-	31	patient with liver disease	RLR vs OLR	NOS	9	Low
Chaouch [133]	2023	4	4 (open label)	-	patient with pancreatic benign and malignant conditions	RDP vs ODP	MINORS/ NOS/RoB2	15	Low
Li [134]	2023	34	-	34	patient with pancreatic benign and malignant conditions	RDP vs LDP	NOS	9	Low

van Ramshorst [135]	2023	43	-	43	patient with pancreatic benign and malignant conditions	RDP vs LDP	RoB		High
Wang [136]	2023	65	3	62	patient with benign and malignant conditions	RPD vs LPD vs OPD		9, 13	Critical low

LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy; RDP, robotic distal pancreatectomy; LLR, laparoscopic liver resection; OLP, open liver resection; RLR robotic liver resection; LPD, laparoscopic pancreaticoduodenectomy, OPD open pancreaticoduodenectomy; RPD robotic pancreaticoduodenectomy; MINORS, methodological index for non-randomized studies; NOS, Newcastle–Ottawa scale; RCT, randomized controlled trial; RoB, risk of bias.

Domain 2, protocol registration; 4, adequacy of the literature search; 7, justification for excluding studies; 9, risk of bias assessment for included studies; 11, appropriateness of methods used for meta-analysis; 13, consideration of risk of bias; 15, assessment of publication bias.

Table 2-4 Characteristics of Included Reviews and Quality Assessment for Gastrointestinal oncology Surgery

Review	Year	Studies included, n			Population	Intervention vs Comparator	Risk of bias tool	Critically flawed domains	Quality assessed by author (TJ LAI)
		Total	RCT	Non-RCT					
Caruso [137]	2017	6	1	5	patients with gastric cancer	RG vs LG vs OG	NOS, Jadad's scoring system		Moderate
Chen [138]	2017	19	-	19	patients with gastric cancer	RG vs LG	NOS	9	Low
Pan [139]	2017	5	-	5	patients with gastric cancer	RG vs LG	MINORS		Moderate
Magouliotis [140]	2017				patients with gastric cancer				
Wang [141]	2017	12	-	12	patients with gastric cancer	RG vs LG	MINORS		Moderate
Wang [142]	2017	3	-	3	patients with gastric cancer	RG vs LG	Cochrane risk of bias tool	13, 15	Critically low
Yang [143]	2017	7	-	7	patients with gastric cancer	RG vs OG	NOS		Moderate
Ai [144]	2019	24	-	24	patients with gastric cancer	RG vs LG	NOS, GRADE	15	Low
Zheng [145]	2019	16	-	16	patients with gastric cancer	RG vs LG	NOS, GRADE		High
Liao [146]	2019	8	-	8	patients with gastric cancer	RG vs LG	NOS		Moderate
Guerrini [147]	2020	40	-	40	patients with gastric cancer	RG vs LG	MINORS		Moderate
Ma [148]	2020	19	-	19	patients with gastric cancer	RG vs LG	NOS		Moderate
Solaini [149]	2020	10	-	10	patients with gastric cancer	RG vs LG vs OG	NOS	15	Low
Aiolfi [150]	2021	17	17	-	patients with gastric cancer	RDG vs LDG vs ODG	Cochrane risk of bias tool	15	Low
Feng [151]	2021	20	1	19	patients with gastric cancer	RDG vs LDG	NOS	9	Low
Wu [152]	2021	11	-	11	patients with gastric cancer	RDG vs LDG	MINORS	9, 13	Critically low
Zhang [153]	2021	12	-	12	patients with gastric cancer	RDG vs LDG		9, 13	Critically low
Zhang [154]	2021	12	-	12	patients with gastric cancer	RDG vs LDG	NOS	9, 13	Critically low
Ali [155]	2022	32	-	32	patients with gastric cancer	RDG vs LDG	MINORS	9, 13	Critically low
Baral [156]	2022	48	-	48	patients with gastric cancer	RDG vs LDG	MINORS	9, 13	Critically low

Chen [157]	2022	11	-	11	patients with gastric cancer	RDG vs LDG	NOS	9, 13	Critically low
Gong [158]	2022	22	-	22	patients with gastric cancer	RDG vs LDG	ROBINS-I		High
Jin [159]	2022	31	1	30	patients with gastric cancer	RDG vs LDG	NOS	13	Low
Sun [160]	2022	8	1	7	patients with gastric cancer	RDG vs LDG	ROBINS-I		High
Davey [161]	2023	22	22	-	patients with gastric cancer	RDG vs LDG		15	Low
Lacovazzo [162]	2023	15			patients with gastric cancer	RDG vs LDG		9, 15	Critically low
Multani [163]	2023	29	-	29	patients with Situs Inversus Totalis	RDG vs LDG	JBI critical appraisal	9, 15	Critically low
Shibasaki [164]	2023	33	-	33	patients with gastric cancer	RDG vs LDG		9, 13, 15	Critically low
Ye [165]	2023	11			patients with gastric cancer	RDG vs LDG	ROBINS-I		High
Yu [166]	2023	6	1	5	patients with gastric cancer	RDG vs LDG		9, 13	Critically low

LG, laparoscopic gastrectomy; LDG laparoscopic distal gastrectomy; OG, open gastrectomy; ODG, open distal gastrectomy; RG, robotic gastrectomy; RDG, robotic distal gastrectomy;

Supplementary File 3 - corrected covered area method (CCA)

In the citation matrix table, all the included SRs were listed on the x-axis, and all the primary study sources were recorded including the name of the first author, publication year, and research location on the y-axis. Ticking mark method was used to identify in which publication was cited. We obtained the number of included primary publications, the total number of SRs and the sum of the ticked boxes for included publications. CCA was introduced to measure the percentage of primary studies included more than once in an SR, and it is presented with an overlap percentage. The formula can be found in **Figure 3-1**. The formula calculates the overlap by dividing the frequency of repeated occurrences of the index publication in other reviews by the product of index publication and reviews. The first occurrence of a primary study is defined as index publication. An estimated CCA value below 5% represents slight overlap, 6-10% moderate, 11-15% high and over 15% very high [167].

$$CCA = \frac{N-r}{rc-r}$$

Figure 3-1 The calculation formula of corrected covered area (CCA)

Where $\boldsymbol{N}$ is the number of included publications (including double counting) in evidence synthesis (this is the sum of the ticked boxes in the citation matrix); there $\mathbf{r}$ is the number of index publication (number of rows) and $\mathbf{c}$ is the number of reviews (number is columns).

Supplementary File 4

Figure 4-1 The volume of evidence from systematic reviews by outcomes in different procedures

DFS Disease-Free Survival; DRM Distal Resection Margin; EBL Estimated Blood Loss; LN Lymph Node yield; LOS Length of hospital Stays; OS Overall Survival; OT Operative Time; PCRM Positive circumferential resection margin; PF Pancreatic Fistula; PostC Postoperative Complication;; PRM Positive resection margin

Supplementary File 5

Table 5-1 Clinical Effectiveness of Colorectal cancer surgery

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy or other approach	open				
Operative time (min)								
(Li 2017)	N=16	NR	NR	-	MD=57.43 (36.70–78.15);	P<0.001	Laparoscopy	96.0%
(Xu 2017)	N=9	354	451	-	MD=33.73 (8.48, 58.99)	*P*=0.009	Laparoscopy	96%
(Jones 2018)	N =27	2,601	2,848	-	SMD=0.65 (0.43, 0.87)	P<0.00001	Laparoscopy	93%
(Lee 2018)	N =5	273	237	-	RISR vs LISR MD=41.89 (15.51, 68.27)	p= 0.002	Laparoscopy	73%
(Li 2019)	N =6	484	487	-	MD= 27.04 (-1.06, 55.14)	P = 0.06	NS	98%
(Ohtani 2018)	N =23	2068	2274	-	MD=44.80 (28.44, 61.15)	p<0.00001	Laparoscopy	97%
(Pezzolla 2018)	RCTs, N =5	344	337	-	MD=38.43 (31.84, 45.01)	p<0.00001	Laparoscopy	4%
(Huang 2019)	RCT, N =7	NR	NR	-	LS vs RAS MD=-23.491 (-3.876, -43.106)	P=0.019	Laparoscopy	NR
(Ma 2019)	N=12	656	7084	-	RRC vs LRC MD=43.61(39.11, 48.1)	P < 0.0001	Laparoscopy	92%
(Ng 2019)	NCT, N =6 nRCT, N 53	902 7391		-	MD=38.19 (28.78, 47.60)	P<0.001	Laparoscopy	93%
(Rausa 2019)	NR	414	1324	1067	RRH vs TLRH RR=-24.0 (-70.0, 21.0) RRH vs ORH RR=-4.1 (-52.0, 44.0)	NR	NS NS	90%
(Sun 2019)	N =6	819	855	-	MD=54.15 (13.02, 95.29)	P=0.01	Laparoscopy	98%
(Eltair 2020)	RCTs, N =9	728	735	-	MD=31.64 (12.09, 51.19)	P=0.002	Laparoscopy	97%
(Gavriilidis 2020)	N =26	4,734		-	MD= 50.35 (31.70, 70.69)	P<0.001	Laparoscopy	97%

(Wang 2020)	N =19	NR	NR	-	SMD = 0.48 (0.14, 0.82)	P = 0.0001	Laparoscopy	94%
(Ryan 2021)	NR	NR	NR	NR	Open vs LS MD=-38.2 (-58.4, -17.9) RAS vs LS MD=26.8(-0.49, 54.4)	NR	Open NS	NR
(Butterworth 2021)		3163	1220	-	MD=53.0 (18.8, 87.2)	P=0.002	Laparoscopy	
(Chen 2021)		NR	NR	-	NOTES vs RAS MD = 0.11 (0.34, 0.55)	P=0.642	NS	
(Genova 2021)	N=8	735	656	-	LRC vs RRC MD= -66.71(-81.08, -52.34)	P<0.00001	Laparoscopy	76%
(Safiejko 2021)	N=34	NR	NR	NR	MD= 43.39 (25.26, 61.51)	P<0.001	Laparoscopy	98%
(Zang 2021)	N=5	273	237	-	MD=43.27 (16.48, 70.07)	P=0.002	Laparoscopy	71%
(Zhu 2021)	N=6	255	267	-	MD=65.20 (53.40, 77.01)	P<0.00001	Laparoscopy	55%
(Bianchi 2022)	N=2	38	64	-	MD=104.64 (19.42, 190.87)	P=0.02	Laparoscopy	58%
(Solaini 2022)	N=10	13438	39001	-	MD=39.08 (17.26, 60.91)	NR	Laparoscopy	97%
(Tschann 2022)		NR	NR	-	LS vs RAS MD= -42.01 (-51.06, -32.96)	P<0.001	Laparoscopy	89%
(Flynn 2023)		NR	NR	-	MD=0.82 (0.60, 1.04)	P<0.001	Laparoscopy	96%
(Huang 2023)	N=9	1384	1382	-	MD=28.91 (18.00, 39.82)	P<0.00001	Laparoscopy	95%
(Khajeh 2023)		NR	NR		LS vs RAS MD=-36.29 (-47.34, -25.25)	P<0.00001	Laparoscopy	0%
(Oweira 2023)		269	408	-	MD= 36.62 (-24.30, 96.93)	P=0.24	NS	0%
(Seow 2023)		NR	-	NR	RAS vs OS MD=78 (54.1, 100)	NR	Open	
(Yang 2023)	N=5	NR	NR	-	MD=44.28 (9.36, 79.19)	NR	Laparoscopy	93%
(Yao 2023)	N=8	1350	1333	-	MD=27.32 (12.29, 42.35)	P=0.0004	Laparoscopy	95%
(Zheng 2023)		2413	11751	-	MD=50.87 (41.66, 60.09)	P<0.00001	Laparoscopy	91%
(Zheng 2023)		757	3318	-	MD=46.62 (30.96, 62.29)	P<0.00001	Laparoscopy	91%

CI confidence interval; ISR=intersphincteric resection; LRC laparoscopic right hemicolectomy; MD mean difference; NOTES Natural orifice transluminal endoscopic surgery; NR not reported; NS not significant; OR odds ratio; ORH right hemicolectomy; RCT randomised controlled study; RRC right colectomy; RRH robotic right hemicolectomy; SMD Standardized mean difference; TLRH total laparoscopic right hemicolectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Estimated blood loss (ml)								
(Eltair 2020)	RCTs, n=4	311	324	-	MD=19.65 (− 94.27, 133.57)	P=0.74	NS	94%
(Gavriilidis 2020)	n=16	3,210		-	MD=10.48 (15.50, 36.46)	P=0.43	NS	84%
(Jones 2018)	n=18	1,393	1,609	-	SMD=-0.10 (-0.26, 0.05)	P=0.20	NS	74%
(Lee 2018)	n=5	273	237	-	MD=-19.50 (− 33.5, - 5.49)	p = 0.006	**Robot**	23%
(Li 2019)	n=3	116	134	-	MD=-7.47 (-95.19, 80.24)	P = .87	NS	83%
(Li 2017)	n=11	NR	NR	-	MD=12.45 (-48.66, 23.76)	P=.500	NS	75.9%
(Ng 2019)	RCT, n=2 nRCT, n=35	209 4299			MD=87.93 (- 128.62, 304.49) MD=-25.23 (- 38.88, - 11.57)	P=0.43 P <0.001	NS **Robot**	98% 85%
(Ohtani 2018)	n=15	1143	1355		MD=-9.29 (-32.82, 14.24)	P=0.44	NS	85%
(Rausa 2019)	NR	414	1324	1067	RRH vs TLRH RR=0.4 (- 28.0, 28.0). RRH vs ORH RR=42.0 (10.0, 72.0)	NR	NS Open	89%.
(Ryan 2021)	NR	NR	NR	NR	Open vs LS MD=106 (63.3, 150) RAS vs LS MD=-30.6 (-12.4, 65.5)	NR	Laparoscopy NS	NR
(Sheng 2018)	NR	NR	NR	NR	RAS vs Open MD=-97.55 (-260.39, 68.03) RAS vs LS MD=-21.12 (-175.07, 133.17)	NR	NS	NR

(Simillis 2019)	NR	NR	NR	NR	RAS vs Open MD=-87.09 (-100.23, -73.95) RAS vs LS MD=-29.07 (-43.87, -14.27)	NR	**Robot** **Robot**	NR
(Sun 2019)	n=3	340	381	-	MD=26.82 (-7.39, 61.03)	P=0.12	NS	0%
(Wang 2020)	n=15	NR	NR	-	SMD = -0.08 (-0.31, 0.15)	NR	NS	84.6%
(Xu 2017)	n=5	253	204		MD=−41.15(−77.51, −4.79)	P=0.03	**Robot**	84%
(Ma 2019)	n=8	234	460		RRC vs LRC MD=-16.89 (-24.80, -8.89)	P<0.0001	**Robot**	35%
(Butterworth 2021)	NR	1873	611	-	MD=-45.2 (-113.5, 23.1)	P=0.194	NS	NR
(Genova 2021)	N=2	123	141	-	LS vs RAS MD=1.75(-21.69, 25.59)	P=0.87	NS	0%
(Safiejko 2021)	N=24	NR	NR	-	MD= -0.94 (-30.11, 28.22)	P=0.95	NS	98%
(Zang 2021)	N=5	273	237	-	MD= -23.31 (-41.98, -4.64)	P=0.01	**Robot**	24%
(Zhu 2021)	N=5	194	260	-	MD= -13.43 (-20.65, -6.21)	P=0.0003	**Robot**	33%
(Solaini 2022)	N=3	118	293	-	MD= -19.77 (-39.10, -0.43)	NR	**Robot**	79%
(Tschann 2022)	NR	NR	NR	-	LS vs RAS MD= 10.03 (1.61,18.45)	P=0.02	**Robot**	65%
(Huang 2023)	N=7	1098	1098	-	MD=-19.29 (-33.24, -5.35)	P=0.007	**Robot**	97%
(Yang 2023)	N=2	NR	NR	-	MD= -33.72 (-205.06, 137.63)		NS	89%
(Yao 2023)	N=7	1336	1268	-	MD= -15.72 (-23.18, -8.26)	P<0.0001	**Robot**	86%
(Zheng 2023)	NR	996	1720	-	MD= -9.48 (-20.56, 1.61)	P=0.09	NS	76%
(Zheng 2023)	NR	537	954	-	MD= -2.04 (-27.40, 23.33)	P=0.88	NS	91%
(Zheng 2023)	NR	590	3115	-	MD= -0.74 (-1.33, -0.16)	P=0.01	**Robot**	60%

CI confidence interval; LRC laparoscopic right hemicolectomy; MD mean difference; NR not reported; NS not significant; OR odds ratio; ORH right hemicolectomy; RCT randomised controlled study; RRC right colectomy; RRH robotic right hemicolectomy; SMD Standardized mean difference; TLRH total laparoscopic right hemicolectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
Conversion to open procedure (%)								
(Li 2017)	n=12				OR=0.35 (0.19–0.62)	P<0.001	**Robot**	0.0%
(Xu 2017)	n=8	3/467	29/443	-	RD=−0.05 (−0.09, −0.01)	P=0.02	**Robot**	63%
(Jones 2018)	n=24	56/2,379	169/ 2,582		OR= 0.40 (0.29, 0.55)	P<0.00001	**Robot**	0%
(Ohtani 2018)	n=21	27/1864	139/2015	-	OR=0.30 (0.19, 0,46)	P<0.00001	**Robot**	0%
(Pezzolla 2018)	RCTs, n=4	20/273	35/271		RR=0.58 (0.35–0.97)	P=0.04	**Robot**	0%
(Lee 2018)	n=2	2/153	8/143		RR 0.22 (0.05, 0.97)	p = 0.04	**Robot**	0%,
(Huang 2019)	RCT n=7	23/402	49 /412		LS vs RAS OR= 2.215 (1.357, 3.613)	P<0.001	**Robot**	NR
(Ma 2019)	n=9	8/336	26/464	-	RRC vs LRC OR=0.34 (0.15, 0.75)	P=0.008	**Robot**	0%
(Ng 2019)	NCT, n=5 nRCT, n=58	765 145,378	NR	=	OR=0.40 (0.30, 0.53)	P<0.001	**Robot**	65%
(Phan 2019)	n=11	6.7%	14.5%	-	OR=0.38 (0.30, 0.46)	P=0.472	**Robot**	0%
(Li 2019)	n=6	433	441	-	OR: 0.29 (0.09, 0.96)	P = .04	**Robot**	47%
(Rausa 2019)	NR	414	1324	1067	RRH vs TLRH RR=1.7 (0.53, 5.9)	NR	NS	23%
(Simillis 2019)	NR	NR	NR	NR	RAS vs LS RR=0.19 (0, 2228.24)	NR	NS	NR
(Sun 2019)	n=6	22/818	41/851	NR	OR=0.55 (0.33,0.93)	P=0.003	**Robot**	26%
(Eltair 2020)	RCTs, n=7	23/484	55/493	-	RR=0.46 (0.18,1.01)	P=0.05	NS	32%
(Gavriilidis 2020)	nRCT=7 RCT=3	29/1,725 20/320	113/1,656 30/319		OR = 0.26 (0.17, 0.38) OR =0.63 (0.35, 1.13)	P<0.001 P<0.12	**Robot** NS	0%
(Wang 2020)	n=17	NR	NR	-	OR=0.55 (0.44, 0.69)	NR	**Robot**	50.3%
(Butterworth 2021)		3654	1226	-	MD=− 0.003 (− 0.014 to 0.011)	P=0.908	NS	
(Genova 2021)	N=8	11/735	31/656	-	LS vs RAS	P=0.1	NS	32%

					OR=2.57 (0.85, 7.81)			
(Safiejko 2021)	N=30	76/2917	236/3255	-	OR=0.35 (0.26, 0.46)	P<0.001	**Robot**	0%
(Tang 2021)	N=6	24/436	34/450	-	OR=0.61 (0.35, 1.07)	P=0.08	NS	0%
(Zang 2021)	N=2	2/153	8/143		RR=0.23 (0.05, 1.12)	P=0.07	NS	0%
(Zhu 2021)	N=9	15/488	58/598	-	OR=0.30 (0.17, 0.54)	P<0.0001	**Robot**	43%
(Bianchi 2022)	N=3	6/364	1338/9678	-	OR=0.17 (0.04, 0.82)	P=0.03	**Robot**	38%
(Solaini 2022)	N=9	908/13281	5016/38777	-	RR=0.53 (0.50, 0.57)	NR	**Robot**	0%
(Tschann 2022)	NR	94/1534	1155/11629	-	LS vs RAS OR=1.53 (1.08, 2.17)	P=0.02	**Robot**	14%
(Flynn 2023)	NR	95/4381	301/5022	-	OR=0.34 (0.27, 0.43)	P<0.001	**Robot**	0%
(Huang 2023)	N=10	53/1590	96/1583	-	MD=0.55 (0.40, 0.76)	P=0.003	**Robot**	0
(Khajeh 2023)	NR	NR	NR	-	LS vs RAS OR=3.13 (1.87, 5.21)	P<0.0001	**Robot**	0%
(Oweira 2023)	NR	0/269	19/408	-	OR=0.17 (0.04, 0.74)	P=0.02	**Robot**	0%
(Seow 2023)	NR	NR	NR	-	RR=0.23 (0.034, 0.7)	NR	**Robot**	
(Yang 2023)	N=5	NR	NR	-	RR=0.61 (0.31, 1.17)	NR	NS	0%
(Yao 2023)	N=6	20/ 1255	41/1239	-	OR=0.49 (0.29, 0.84)	P=0.009	**Robot**	0%
(Zheng 2023)	NR	71/2179	888/9397	-	OR=0.49 (0.38, 0.64)	P<0.00001	**Robot**	18%
(Zheng 2023)	NR	33/929	141/1470	-	OR=0.30 (0.10, 0.91)	P=0.03	**Robot**	67%

CI confidence interval; LRC laparoscopic right hemicolectomy; MD mean difference; NR not reported; NS not significant; OR odds ratio; ORH right hemicolectomy; RCT randomised controlled study; RRC right colectomy; RRH robotic right hemicolectomy; SMD Standardized mean difference; TLRH total laparoscopic right hemicolectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Length of hospital stay(day)								
(Li 2017a)	n=16	NR	NR	-	MD= 0.69 (1.48, 0.10)	P=.089	NS	82%
(Xu 2017)	n=8	423	420	-	MD=−1.07 (−1.80, −0.33)	*P*=0.005	**Robot**	75%
(Jones 2018)	n=24	2409	2601	-	SMD=-0.15 (-0.27, -0.03)	P=0.01	**Robot**	74%

(Lee 2018)	n=5	273	237	-	MD=- 0.97 (- 2.11, 0.17)	p = 0.10	NS	0%
(Pezzolla 2018)	RCTs, n=4	250	262		MD=-0.61(-2.23, 1.02)	P=0.46	NS	66%
(Sheng 2018)	NR	NR	NR	NR	RAS vs Open MD=-2.90 (-5.85, -0.06) RAS vs LS MD=-0.34 (-2.93, 2.21)	NR	**Robot** NS	NR
(Li 2019)	n=3	330	335	-	MD=-0.51 (-1.92, 0.90)	P = .48	NS	74%
(Huang 2019)	RCT n=6	NR	NR		MD=0.677 (0.332, 1.69)	P=0.188	NS	43%
(Ng 2019)	NCT, n=5 nRCT, n=54	743 149,340			MD= - 0.77 (-1.12, - 0.41) MD= - 0.85 (- 1.69, 0.00)	P<0.001 P=0.05	**Robot**	88%
(Rausa 2019)	NR	414	1324	1067	RRH vs TLRH RR=2.9 (- 0.7, 6.5) RRH vs ORH RR=6.7 (2.9, 10.0).	NR	NS **Robot**	80%
(Rubinkiewicz 2019)	n=6	797	783	-	MD=-0.15 (-0.60, 0.90)	P=0.70	NS	29%
(Ma 2019)	n=10	533	7001	-	RRC vs LRC MD=-0.85 (-1.07, -0.63)	P=0.04	**Robot**	52%
(Simillis 2019)	NR	NR	NR	NR	RAS vs OS MD=-1.49 (-1.70, -1.27) RAS vs LS MD=-0.91 (-1.17, -0.65)	NR	**Robot** **Robot**	NR
(Sun 2019)	n=6	819	855	-	MD=-0.64 (-1.57, 0.29)	P=0.18	NS	54%
(Wang 2020)	n=20	NR	NR	NR	SMD = -0.15 (-0.30, 0.00)	NR	**Robot**	80%
(Eltair 2020)	RCTs, n=8	657	669	-	MD= -0.60 (-1.36,0.16)	P=0.12	NS	66%
(Gavriilidis 2020)	n=3	3,646		-	MD= -1.00 (-2.13, 0.13)	P=0.08	NS	63%
(Hoshino 2021)	RCT n=6 Cohort n=25 CMS n=8	3,460	4,191	-	RR= -0.87 (-1.38, -0.35)	P<0.001	**Robot**	70%

(Ryan 2021)	NR	NR	NR	NR	Open vs LS MD=2.6 (1.5, 3.8) RAS vs LS MD=0.16 (-1.5, 1.9)	NR	Laparoscopy NS	NR
(Butterworth 2021)	NR	3163	1083	-	MD=0.56 (− 0.89, 2.01)	P=0.447	NS	
(Genova 2021)	NR	181	408	-	MD=0.11(-0.73, 0.95)	P=0.79	NS	38%
(Safiejko 2021)	N=34	NR	NR	-	MD= -2.01 (-2.9, -1.11)	P<0.001	**Robot**	99%
(Zhang 2021)	N=5	273	237	-	MD=-1.52 (-2.10, -0.94)	P<0.00001	**Robot**	2%
(Zhu 2021)	N=4	188	254	-	MD= -0.23 (-0.73, 0.28)	P=0.38	NS	0%
(An 2022)	N=2	207	204	-	MD= -1.06 (-1.64, -0.47)	NR	**Robot**	8%
(Bianchi 2022)	N=2	38	64	-	MD= -1.86 (-3.99, 0.26)	P=0.09	NS	0%
(Ravindra 2022)	N=12	872	1101	-	MD= -0.10 (-0.19, -0.01)	P=0.04	**Robot**	0%
(Solaini 2022)	N=9	13378	38955	-	MD= -0.28 (-0.63, 0.06)	NR	NS	89%
(Tschann 2022)	NR	NR	NR	-	LS vs RAS MD=0.84 (0.29, 1.38)	P=0.03	**Robot**	87%
(Flynn 2023)	NR	NR	NR	-	MD=−0.22 (−0.33, −0.11)	P<0.001	**Robot**	99%
(Huang 2023)	N=8	1247	1249	-	MD=-0.96 (-1060, -0.33)	P=0.003	**Robot**	95%
(Khajeh 2023)	NR	NR	NR	-	LS vs RAS MD=-0.00 (-0.55, 0.54)	P=0.99	NS	96%
(Seow 2023)	NR	NR	NR	-	LS vs RAS MD=1.7 (-1.1, 7.4)	NR	NS	NR
(Yang 2023)	N=5	NR	NR		MD= -0.29 (-1.0, 0.51)		NS	0%
(Yao 2023)	N=7	1199	1189		MD= -0.97 (-1.11, -0.83)	P<0.00001	**Robot**	46%
(Zheng 2023)		2246	11548		MD= -0.59 (-0.94, -0.24)	P=0.0009	**Robot**	67%

CI confidence interval; LRC laparoscopic right hemicolectomy; MD mean difference; NR not reported; NS not significant; OR odds ratio; ORH right hemicolectomy; RCT randomised controlled study; RRC right colectomy; RRH robotic right hemicolectomy; SMD Standardized mean difference; TLRH total laparoscopic right hemicolectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy other approach	Open				
Postoperative complications (%)								
(Li 2017)	n=16	1673	1875	-	OR=1.02 (0.82–1.25)	P=.883	NS	23.9%
(Xu 2017)	n=9	64/473	108/476	-	OR=0.58(0.41, 0.83)	P=0.003	**Robot**	0%
(Jones 2018)	n=21	512/ 2,315	607/ 2,518		OR=0.92 (0.75, 1.12)	P=0.40	NS	39%
(Lee 2018)	n=5	61/273	63/237		RR=0.81 (0.59, 1.11)	p = 0.19	NS	0%
(Sheng 2018)	NR	NR	NR	NR	RAS vs Open OR=0.62 (0.21, 1.68) RAS vs LS OR=0.79 (0.28, 2.13)	NR	NS NS	NR
(Li 2019)	n=6	483	483	-	OR=1.08 (0.82, 1.43)	P = .57	NS	17%
(Ohtani 2018)	n=21	410/2005	488/2196		OR=0.93(0.77, 1.14)	P=0.49	NS	27%
(Ma 2019)	n=11	85/402	148/559		RRC vs LRC OR=0.73 (0.52, 1.01)	P=0.05	NS	1%
(Rausa 2019)	NR	414	1324	1067	RR=1.0 (0.6, 1.5)	NR	NS	20%
(Rubinkiewicz 2019)	n=4	47/695	48/742		RR = 1.01(0.60, 1.69)	P=0.98	NS	45%
(Wang 2020)	n=19	NR	NR	-	OR=0.79 (0.65, 0.97)	NR	**Robot**	39%
(Eltair 2020)	RCTs, n=8	657	669	-	RR=0.97 (0.76, 1.24)	P=0.81	NS	23%
(Tang 2021)	n=7	135/ 507	123/516	-	OR=1.18 (0.88, 1.57)	P = 0.27	NS	0%
(Hoshino 2021)	RCT n=6 Cohort n=30 CMS n=9	855/ 3,779	1080/ 4,611	-	RR=0.92 (0.85, 1.00)	P=0.05	NS	6%
(Butterworth 2021)	NR	3880	1387	-	MD=0.054 (− 0.012, 0.0123)	P=0.100	NS	
(Chen 2021)	NR	NR	NR	-	NOTES vs RAS OR = 1.03 (0.63, 1.68)	P=0.989	NS	
(Genova 2021)	N=8	184/735	174/656	-	LS vs RAS	P=0.68	NS	0%

					OR=1.06 (0.8, 1.40)			
(Liu 2021)	N=3	96/543	101/517	-	RR=0.91 (0.71, 1.17)	P=0.45	NS	0%
(Zhang 2021)	N=5	61/273	63/237	-	RR=0.81 (0.59, 1.11)	P=0.20	NS	0%
(Zhu 2021)	N=5	86/383	120/471	-	OR=0.83 (0.60, 1.14)	P=0.25	NS	0%
(An 2022)	N=6	32/199	70/195	-	RR=0.47 (0.30, 0.74)	NR	**Robot**	8%
(Bianchi 2022)	N=3	89/364	2427/ 9678	-	OR= 0.86(0.54, 1.38)	P=0.54	NS	19%
(Solaini 2022)	N=10	2868/1330	9706/38731	-	RR=0.86 (0.83, 0.90)	NR	**Robot**	0%
(Flynn 2023)	NR	1015/3302	1355/3848	-	OR=0.84 (0.76, 0.92)	P=0.0001	**Robot**	47%
(Huang 2023)	N=11	NR	NR	-	RR=3.31 (0.64,0.89)	P=0.009	**Robot**	26%
(Khajeh 2023)	NR	NR	NR	-	LS vs RAS OR=1.11 (0.86, 1.43)	P=0.44	NS	43%
(Yang 2023)	N=5			-	RR=1.15 (0.87, 1.53)		NS	0%
(Zheng 2023)	NR	573/2447	2296/9740	-	OR=0.88 (0.77, 0.99)	P=0.04	**Robot**	15%
(Zheng 2023)	NR	245/1027	381/1631	-	OR=1.01 (0.83, 1.24)	P=0.89	NS	0%

CI confidence interval; LRC laparoscopic right hemicolectomy; MD mean difference; NR not reported; NS not significant; OR odds ratio; ORH right hemicolectomy; RCT randomised controlled study; RRC right colectomy; RRH robotic right hemicolectomy; MD mean difference; TLRH total laparoscopic right hemicolectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Time to first flatus (days)								
(Li 2017a)	n=8	NR	NR	NR	MD= -0.11 (-0.26, 0.03)	P-0.13	NS	46%
(Xu 2017)	n=6	390	377		MD= −0.03 (-0.40, 0.34)	P=0.89	NS	73%
(Jones 2018)	n=13	85	86		SMD= -0.48 (-0.79, -0.18)	P=0.002	**Robot**	0%
(Lee 2018)	NR	NR	NR	NR	MD= −0.23 (-0.75, 0.29)	P=0.38	NS	0%
(Li 2019)	n=3	291			MD= −0.06 (−0.35, 0.22)	P=0.66	NS	
(Simillis 2019)	NR	NR	NR	NR	RAS vs Open MD= -1.7 (-3.34, -0.05) RAS vs LS	NR	**Robot** NS	NR

					MD= -0.61 (-2.71, 1.5)			
(Eltair 2020)	n=4	338	344		MD= -0.30 (-0.96, 0.36)	P=0.37	NS	92%
(Genova 2021)	N=4	74	146		MD=0.47 (-0.14, 1.83)	P=0.13	NS	83%
(Ryan 2021)					MD= -0.095 (-0.68, 0.50)	NR	NS	
(Safiejko 2021)	N=13				MD= -0.34 (-0.5, -0.03)	P=0.03	**Robot**	85%
(Zang 2021)	N=2	76	68		MD= -0.21 (-0.75, 0.33)	P=0.44	NS	0%
(Zhu 2021)	N=4	178	224		MD= -0.37 (-1.09, 0.36)	P=0.32	NS	83%
(Ravindra 2022)	N=7	466	655		MD= -0.03 (-0.15, 0.09)	P=0.62	NS	9%
(Tschann 2022)					LS vs RAS MD= 0.15 (-0.18, 0.48)	P=0.38	NS	93%
(Huang 2023)	N=7	996	1004		MD=-0.18 (-0.59, 0.23)	P=0.38	NS	99%
(Yang 2023)	N=2				MD=0.2 (-0.20, 0.61)		NS	0%
(Yao 2023)	N=4	935	923		MD= -0.16 (-0.25, -0.06)	P=0.001	**Robot**	0%
(Zheng 2023)		1330	1508		MD= -0.48 (-0.78, -0.19)	P=0.001	**Robot**	93%

CI confidence interval; MD mean difference; NR not reported; NS not significant; MD Mean difference;

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Time to soft diet								
(Eltair 2020)	n=3	165	167		MD= -0.50 (-0.94, -0.06)	P=0.03	**Robot**	33%
(Gavriilidis 2020)	n=11	2107			MD = -0.22 (-0.92, 0.49)	P=0.55	NS	95%
(Lee 2018)					MD= −0.09 (-0.55, 0.36)	P=0.69	NS	0%
(Ng 2019)	nRCTs=19 RCT=3	2108 265			MD= - 0.43 (- 0.68, - 0.19) MD= - 0.30 (- 0.70, 0.11)	P<0.001 P=0.15	**Robot** NS	NP
(Simillis 2019)	NR	NR	NR	NR	RAS vs Open MD= -0.68 (-2.52, 1.16) RAS vs LS MD= -0.01 (-1.90, 1.88)	NR	NS NS	NR

CI confidence interval; MD mean difference; NR not reported; NS not significant; RCT randomised controlled study; MD Mean difference;

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy or other	Open				
Ileus								
(Genova 2021)	N=5	7/160	35/385		LS vs RAS OR=1.64 (0.69, 3.89)	P=0.27	NS	2%
(Kowalewski 2021)	N=34	4525	16927		OR=0.86 (0.75, 0.98)	P=0.02	**Robot**	0%
(Ryan 2021)					RR=0.64 (0.30, 1.3)	NR	NS	
(Safiejko 2021)	N=19	787/6363	1221/8637		OR=0.94 (0.77, 1.14)	P=0.51		11%
(Tang 2021)	N=4	23/353	35/368		OR=0.66 (0.38, 1.15)	P=0.14	NS	0%
(Zhang 2021)	N=3	13/197	11/169		RR=0.90 (0.41, 1.77)	P=0.80	NS	0%
(Ravindra 2022)	N=8	14/301	20/447		RR=1.04 (0.56, 1.91)	P=0.91	NS	7%
(Solaini 2022)	N=8	915/13206	3652/38593		RR=0.97 (0.65, 1.14)	NR	NS	37%
(Tschann 2022)		70/1209	70/1209		LS vs RAS OR=1.30 (0.91, 1.87)	P=0.14	NS	18%
(Yao 2023)	N=5	24/924	27/915		OR=0.80 (0.46, 1.41)	P=0.44	NS	0%
(Zheng 2023)		92/1581	1012/10887		OR=0.80 (0.63, 1.10)	P=0.07	NS	20%
(Zheng 2023)		34/583	270/2972		OR=0.91 (0.60, 1.39)	P=0.66	NS	0%

CI confidence interval; MD mean difference; NR not reported; NS not significant; OR odds ratio;

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy or other	Open				
urinary retention/ urinary complications								
(Kowalewski 2021)	N=19	1832	2580		OR=0.66 (0.47, 0.94)	P=0.02	**Robot**	0%

(Wee 2021)	N=21	108/ 2231	152/2208		RR=0.78 (0.61, 0.99)	P=0.04	**Robot**	3%
(Zhang 2021)	N=5	7/273	20/237		RR=0.36 (0.16, 0.82)	P=0.02	**Robot**	0%
(Yao 2023)	N=6	28/1125	58/1125		OR=0.45 (0.29, 0.71)	P=0.0006	**Robot**	0%

CI confidence interval; MD mean difference; NR not reported; NS not significant; OR odds ratio;

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Re-operation (%)								
(Li 2017)	n=8	NR	NR	NR	OR=0.66 (0.41, 1.05)	P=0.80	NS	0%
(Jones 2018)	n=10	43/509	65/618		OR=0.76 (0.50, 1.16)	P=0.20	NS	0%
(Simillis 2019)	NR	NR	NR	NR	RAS vs Open OR=1.08 (0.11, 10.11) RAS vs LS OR=1.1 (0.12–10.47)	NR	NS NS	NR
(Genova 2021)	N=15	20/803	13/3588		LS vs RAS OR=1.30 (0.71, 2.37)	P=0.4	NS	0%
(Liu 2021)	N=5	18/478	25/541		RR=0.85 (0.46, 1.54)	P=0.58	NS	0%
(Ryan 2021)					RR=0.32 (0.039, 1.6)	NR	NS	
(Safiejko 2021)		67/1061	80/1120		OR=0.87 (0.61, 1.25)	P=0.46	NS	0%
(Tang 2021)	N=4	2/181	5/198		OR=0.59 (0.16, 2.21)	P=0.44	NS	0%
(Zhu 2021)	N=3	233	288		OR=1.66 (0.67, 4.10)	P=0.27	NS	0%
(Huang 2023)	N=4	20/616	36/817		RR=0.56 (0.33, 0.96)	P=0.03	NS	0%
(Khajeh 2023)					LS vs RAS OR=1.69 (1.10, 2.62)	P=0.02	**Robot**	0%
(Yao 2023)	N=3	22/836	29/786		OR=0.71 (0.40, 1.25)	P=0.23	NS	0%

CI confidence interval; RR relative risk; OR odds ratio; NR not reported; NS not significant

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy or other	Open				
Readmission(%)								
(Genova 2021)	N=12	42/1072	539/7619		LS vs RAS OR=1.02 (0.55, 1.90)	P=0.95	NS	38%
(Liu 2021)	N=4	252/2730	441/5502		RR= 1.17 (0.75, 1.83)	P=0.48	NS	57%
(Safiejko 2021)	N=11	91/882	203/2066		OR=1.14 (0.82, 1.60)	P=0.44	NS	6%
(Ravindra 2022)	N=7	18/327	24/470		RR=0.89 (0.50, 1.60)	P=0.70	NS	6%
(Huang 2023)	N=4	23/816	34/817		RR=0.68 (0.41, 1.14)	P=0.15	NS	4%
(Yao 2023)	N=3	27/870	28/859		OR=0.95 (0.56, 1.63)	P=0.86	NS	0%

CI confidence interval; RR relative risk; OR odds ratio; NR not reported; NS not significant

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Positive circumferential resection margins (%)								
(Xu 2017)	n=6	20/426	24/368		RD= −0.02(−0.05, 0.01)	*P*=0.23	NS	34%
(Li 2017a)	n=13	NR	NR		OR=0.80 (0.55–1.17)	P=.256	NS	0%
(Lee 2018)	n=3	190	172		MD=-0.39 (-2.37, 1.59)	p = 0.70	NS	0%
(Jones 2018)	n=23	91/2344	1111/ 2537		OR= 0.91 (0.68, 1.22)	P= 0.53	NS	0%
(Pezzolla 2018)	RCTs, n=2	12/248	14/241		RR=0.82 (0.38, 1.73)	P=0.6	NS	-
(Huang 2019)	n=2	16/ 300	18/ 296		LS vs RAS RR=1.139 (0.592, 2.191)	P= 0.697	NS	0%
(Li 2019)	n=5	23/407	32/415		OR: 0.71 (0.41, 1.59)	P = .24	NS	0%
(Simillis 2019)	NR	NR	NR	NR	RAS vs Open OR=0.78 (0.40, 1.53) RAS vs LS	NR	NS	NR

					OR=0.70 (0.34 1.45)			
(Sun 2019)	n=4	61/770	94/792	-	OR=0.86 (0.56, 1.32)	P=0.49	NS	0%
(Wang 2020)	n=14	NR	NR	-	OR=1.02 (0.76, 1.37)	NR	NS	0%
(Eltair 2020)	n=3	21/547	26/549		RR=0.82 (0.47, 1.44)	P=0.49	NS	0%
(Qiu 2020)	n=7	2593			MD= 0.98(0.63, 1.51)	P= 0.92	NS	0%
(Ryan 2021)					Open vs LS RR=0.8 (0.56, 1.14) RAS vs LS RR=0.7 (0.36, 1.39)	NR	NS	NR
(Guo 2021)	n=12	1067	-	1522	OR: 0.58 (0.29, 1.16)	P=0.13	NS	53%
(Butterworth 2021)		3736	1124		MD= 0.52 (0.14, 0.89)	P=0.007	**Robot**	
(Chen 2021)					NOTES vs RAS OR= 1.43 (0.76, 2.71)	P=0.333	NS	
(Genova 2021)	N=6	4/522	24/2760		LS vs RAS OR=0.73 (0.18, 2.93)	P=0.66	NS	0%
(Safiejko 2021)	N=7				MD=0.30 (-0.25, 0.86)	P=0.28	NS	66%
(Zang 2021)	N=4	12/167	14/131		RR=0.65 (0.31, 1.36)	P=0.25	NS	0%
(Khajeh 2023)					OR=1.56 (1.11, 2.20)	P=0.010	LS	0%
(Yang 2023)	N=2				RR= 1.18 (0.75, 1.87)		NS	33%

CI confidence interval; LRC laparoscopic right hemicolectomy; MD mean difference; NR not reported; NS not significant; OR odds ratio; ORH right hemicolectomy; RCT randomised controlled study; RD risk difference; RRC right colectomy; RRH robotic right hemicolectomy; MD Mean difference; TLRH total laparoscopic right hemicolectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Distal resection margin (cm)								
(Li 2017)	n=8	NR	NR		MD=1.98 (1.25, 5.22)	P=0.229	NS	68%
(Jones 2018)	n=19	1906	2017		SMD=0.00 (-0.11, 0.11)	P=0.97	NS	56%
(Lee 2018)	n=5	273	237		MD=0.01 (-0.16, 0.18)	P=0.92	NS	0%

(Li 2019)	n=4	172	185		MD=0.60 (0.09, 1.10)	P =0.02	**Robot**	66%
(Huang 2019)	n=4	NR	NR		LS vs RAS MD=-0.581 (-1.165, 0.003)	P=0.051	NS	60 %
(Simillis 2019)	NR	NR	NR	NR	RAS vs Open MD=0.76 (0.38,1.14) RAS vs LS MD=0.68 (0.29, 1.07)	NR	**Robot**	NR
(Eltair 2020)	n=5	222	233		MD=0.80 (0.26, 1.34)	P=0.004	NS	75%
(Wang 2020)	n=14	NR	NR	-	SMD=0.13 (-0.08, 0.35)	NR	NS	80.0%
(Guo 2021)	n=6	284		361	MD: -0.49(−1.04, 0.06)	P=0.08	NS	72%
(Qiu 2020)	n=5	1899			MD=1.17 (-2.42, 4.76)	P=0.52	NS	65%
(Ryan 2021)	NR	NR	NR	NR	LS vs Open MD=0.13 (-0.76, 0.95) RAS vs Open MD=-0.32 (-2.86, 1.96)	NR	NS	NR
(Tang 2021)	n=4	170	179	-	MD=0.13 (− 0.04, 0.30)	P =0.13	NS	0%
(Butterworth 2021)		3065	688		MD= 0.52 (0.14 to 0.89)	P=0.007	**Robot**	
(Safiejko 2021)	N=20				MD= -0.22 (-0.32, -0.11)	P<0.001	Laparoscopy	87%
(Zang 2021)	N=5	273	237		MD= 0.01(-0.16, 0.18)	P=0.88	NS	0%
(Huang 2023)					MD=2.16 (0.04,0.94)	P=0.03	**Robot**	92%
(Seow 2023)					RAS vs OS MD=0.93 (0.66, 1.2)		**Robot**	

CI confidence interval; CMS case-matched study; MD mean difference; NR not reported; NS not significant; RCT randomised controlled study; MD Mean difference

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Number of harvested lymph nodes								
(Li 2017a)	n=12	NR	NR	-	MD=0.49, (0.98, 1.96)	P=.515	NS	64.2%

(Lee 2018)	n=5	273	237		MD=- 1.36 (- 2.88, - 0.15)	p = 0.08	**Robot**	30%
(Jones 2018)	n=26	2342	2600		SMD=0.04 (-0.07, 0.14)	P=0.49	NS	64%
(Pezzolla 2018)	RCTs, n=5	344	350	-	MD=-0.35 (-1.83, 1.12)	P=0.84	NS	0%
(Huang 2019)	n=6	NR	NR		LS vs RAS MD=-0.154 (-1.398, 1.090)	P=0 .808	NS	11%
(Li 2019)	n=5	243	251	-	MD: 0.08 (-0.88, 1.04)	P = .87	NS	0%
(Rausa 2019)	NR	414	1324	1067	RRH vs TLRH RR=−2.2 (-6.5, 2.1) RRH vs ORH RR=-2.8 (-7.3, 1.7)	NR	NS	80%
(Simillis 2019)	NR	NR	NR	NR	RAS vs Open MD=0.48 (-0.96, 1.91) RAS vs LS MD=0.27 (-1.3, 1.84)	NR	NS	NR
(Sun 2019)	n=6	818	851	-	MD=-0.90 (-1.82, 0.02)	P=0.05	NS	0%
(Eltair 2020)	n=8	705	709		MD=0.33(-0.84, 1.49)	P=0.58	NS	56%
(Wang 2020)	n=19	NR	NR	-	SMD=0.06 (-0.05, 0.17)	NR	NS	54%
(Qiu 2020)	n=7	2593			MD=0.03 (-2.13, 2.19)	P=0.98	NS	87%
(Tang 2021)	n=7	507	516	-	MD = 0.47 (−0.41, 1.35)	P = 0.29	NS	45%
(Guo 2021)	n=12	917	-	1409	MD=-0.31(-2.16, 1.53)	P=0.74	NS	81%,
(Ryan 2021)	NR	NR	NR	NR	Open vs LS MD=0.18 (-0.71, 1.1) RAS vs LS MD=0.08 (-1.5, 1.7)	NR	NS	NR
(Butterworth 2021)		3161	1223		MD=0.25 (− 2.63, 3.13)	P=0.866	NS	
(Genova 2021)	N=6	147	356		LS vs RAS MD=-3.80 (-7.56, -0.05)	P=0.05	Laparoscopy	0%
(Safiejko 2021)	N=34				MD= -0.05 (-1.06, 0.96)	P=0.92	NS	85%

(Zang 2021)	N=5	273	237		MD= -1.83 (-3.7, 0.04)	P=0.06	NS	30%
(Zhu 2021)	N=7	344	402		MD=1.47 (-0.00, 2.94)	P=0.05	NS	0%
(Tschann 2022)					LS vs RAS MD=-0.85 (-2.19, 0.48)	P=0.21	NS	75%
(Huang 2023)	N=9	1391	1389		MD=0.61 (-0.09, 1.31)	P=0.09	NS	79%
(Khajeh 2023)					MD=0.38 (-0.39, 1.16)	P=0.33	NS	59%
(Kim 2023)	N=4				MD=− 1.20 (− 3.94, 1.54)	P=0.39	NS	13%
(Seow 2023)					RAS vs OS MD=1.2 (-0.3, 2.9)		NS	
(Yao 2023)	N=8	1350	1333		MD=1.10 (0.34, 1.85)	P=0.004	Laparoscopy	87%
(Zheng 2023)		2153	5286		MD= 1.89 (0.72, 3.06)	P=0.002	Laparoscopy	72%
(Zheng 2023)		1116	4036		MD=1.47 (-0.32, 3.26)	P=0.11	NS	83%

CI confidence interval; LRC laparoscopic right hemicolectomy; MD mean difference; NR not reported; NS not significant; OR odds ratio; ORH right hemicolectomy; RCT randomised controlled study; RD risk difference; RRC right colectomy; RRH robotic right hemicolectomy; SMD Standardized mean difference; TLRH total laparoscopic right hemicolectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
Disease free survival								
(Lee 2018) (3 year)		167/197	145/169		RR 1.00 (0.92, 1.09)	P=0.97	NS	0%
(Qiu 2020) (3 year)	n=7	2593			HR=0.93 (0.79, 1.10)	P=0.40	NS	0%
(Gavriilidis 2020) (3 year)	N=6	6, 1315			HR = 0.94 (0.72, 1.23)	P=0.65	NS	7%
(Ryan 2021) (3 year)	NR	NR	NR	NR	Open vs LS HR=1.0 (0.91, 1.1) RAS vs LS HR=1.0 (0.66, 1.6)	NR	NS	NR
(Tschann 2022) (5 years)		162/190	178/213		LS vs RAS	P=0.62	NS	0%

					OR= 0.87 (0.50, 1.51)			
(Flynn 2023) (3 year)		350/1500	371/1473		OR=0.94 (0.83, 1.08)	P=0.386	NS	23%
(Kim 2023)	NR	NR	NR	NR	HR=0.72 (0.46, 1.13)	P=0.15	NS	0%
(Seow 2023) (3 year)	NR	NR	NR	NR	RAS vs OS HR=0.97 (0.56, 1.6)		NS	

CI confidence interval; NR not reported; NS not significant; RCT randomised controlled study; RR relative risk; OR odds ratio; HR hazard ratio

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Overall survival								
(Li 2017) (3 year)	n=3	NR	NR		OR=0.71 (0.44, 1.12)	P=1.140	NS	0%, p = 0.652
(Lee 2018) (3 year)		18/273	20/237	-	RR=0.74, (0.41–1.35)	p =0.32	NS	0%, p = 0.51
(Ohtani 2018) (3 year)	n=3	611/654	552/ 587		OR= 0.92 (0.58, 1.46)	P=0.74	NS	0%, p = 0.65
(Gavriilidis 2020) (3 year)	n=6	6, 1681			HR=1.03 (0.80, 1.32)	P=0.83	NS	0%
(Qiu 2020) (3 year)	n=7	2593			HR=0.94 (0.64, 1.39)	P=0.75	NS	51%, P=0.06
(Ryan 2021) (3 year)	NR	NR	NR	NR	Open vs LS HR=0.96 (0.85, 1.1) RAS vs LS HR=1.0 (0.65, 1.7)	NR	NS	NR
(Tschann 2022) (5 year)	NR	157/190	172/213	NR	LS vs RAS OR= 0.90 (0.54, 1.52)	P=0.70	NS	0%
(Flynn 2023) (3 year)	NR	160/1890	206/1838	NR	OR=0.79 (0.65, 0.97)	P=0.03	**Robot**	60%
(Kim 2023)	NR	NR	NR	NR	HR=0.73 (0.48, 1.13)	P = 0.16	NS	0%
(Seow 2023) (3 year)	NR	NR	NR	NR	RAS vs OS HR=1.1 (0.73, 1.5)		NS	NR

CI confidence interval; NR not reported; NS not significant; RCT randomised controlled study; RR relative risk; OR odds ratio; HR hazard ratio

Table 5-2 Clinical Effectiveness of Hysterectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
Operative time (min)								
(Laios 2017)	n=27	2142	2522	-	MD=16.42 (−0.04, 32.88)	P=0.05	NS	97%
(Li 2017)	n=11 n=10	296 335	 344	307	RAS vs Open MD=39.71 (-6.69, 86.11) RAS vs LS MD=11.78 (7.09, 16.48)	P=0.09 P<0.00001	NS Laparoscopy	99% 92%
(Park 2017)	n=12	NR	NR	NR	RAS vs Open MD=16.76 (-11.87, 45.38) RAS vs LS MD=24.90 (-78.96, 29.16)	NR	NS NS	95% 97%
(Jin 2018)	NR	NR	NR	NR	RAS vs Open MD=24.24 (-24.44, 69.02) RAS vs LS MD= 7.29 (-40.40, 54.25)	NR	NS NS	NR
(Lawrie 2019)	n=2	73	75		MD= 41.18 (-6.17, 88.53)	P=0.09	NS	80.06%
(Shi 2019)	n=5	151 104	 90	259	RAS vs Open MD= 9.8527 (− 57.09, 76.80) RAS vs LS MD= − 0.856 (−46.37, 44.66)	P= 0.7730 P=0.9706	NS NS	93.3 70%
(Zhang 2019)	n=6 n=9	640 305	 373	610 -	RAS vs Open MD=36.07 (5.83, 66.31) RAS vs LS MD=18.30 (-14.94, 51.13)	P=0.02 P=0.28	Open NS	95% 93%
(Wang 2020)	n=18 n=21	1635 1664	 1996	2249	RAS vs Open MD=28.97 (7.60,50.35)	P=0.08 P = 0.04	Open Laparoscopy	99% 99%

					RAS vs LS MD= 19.87 (0.60, 39.15)			
(Kampers 2022)	N=5 N=4	139 398	204 359		LS vs RAS MD= -61.48 (-67.04, -55.92) RAS vs OS MD= 44.79 (38.16, 51.42)		Laparoscopy Open	
(Hunag 2023)	N=4	394	560		MD=13.01 (-41.38, 67.41)	P=0.64	NS	98%
(Lenfant 2023)		28042 21880 23255	91839 56822	 145890	RAS vs LS MD=7.97 (-11.76, 27.69) RAS vs OS MD= -0.98 (-6.74, 4.78) RAS vs NOTES MD=42.87 (22.94, 62.80)	P=0.79 P=0.74 P<0.001	NS NS NOTES	99% 0% 100%
(Marchand 2023)		1823		1829	MD=15.34 (2.21, 28.47)	P=0.02	Open	96%
(Marchand 2023)		1217	1480		LS vs RAS MD=6.01 (-4.64, 16.66)	P-0.27	NS	92%

CI confidence interval; MD mean difference; NR not reported; NS not significant; NOTES Natural orifice transluminal endoscopic surgery

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Estimated blood loss (ml)								
(Laios 2017)	n=28	2394	2721		MD=−57.74 (−77.20, −38.27)	P<0.00001	**Robot**	89%
(Li 2017)	n=7 n=10	215 335	 344	214	RAS vs Open MD=-1.83 (-2.06, -1.59) RAS vs LS MD=51.97 (49.07, 54.87)	P<0.00001 P<0.00001	**Robot** Laparoscopy	74% 98%
(Park 2017)	n=8 n=6	NR	NR	NR	RAS vs Open MD=-409.04 (-551.97, -266.11)	NR	**Robot** NS	94% 96%

					RAS vs LS MD=-78.08 (-192.08, 35.92)			
(Jin 2018)	NR	NR	NR	NR	RAS vs Open MD =-399.52 (-600.64, -204.78) RAS vs LS MD= -122.38 (-319.98, 71.19)	NR	**Robot** NS	NR
(Lawrie 2019)	n=1	47	48		MD=7(-18.26, 32.26)	P=0.59	NS	NA
(Shi 2019)	n=6 n=5	125 96	 79	274	RAS vs Open MD=-521 (-809.78, -233.62) RAS vs LS MD=-55.09 (139.01, 28.83)	P=0.0004 P=0.1983	**Robot** NS	94% 55%
(Zhang 2019)	n=5 n=8	460 283	 357	640 -	RAS vs Open MD=-322.59 (-502.75, -142.43) RAS vs LS MD=-22.25 (-81.38, 36.87)	P=0.0004 P=0.46	**Robot** NS	98% 89%
(Prodromidou 2020)	n=5	125	162	-	MD=-10.84 (-20.35, -1.43)	P=0.03	**Robot**	55%
(Wang 2020)	n=17 n=19	1607 1596	 1856	2263	RAS vs Open MD=-147.02 (-185.72, -108.31) RAS vs LS MD=-53.66 (-74.86, -32.47)	P < 0.00001 P < 0.00001	**Robot** **Robot**	97% 91%
(Kampers 2022)	N=5 N=4	139 398	204	 359	LS vs RAS MD= -61.10 (-64.16, -58.04) RAS vs OS MD= -287.14 (-329.99, -181.23)	P<0.01	Laparoscopy **Robot**	
(Hunag 2023)	N=6	394	560		MD= -77.69 (-132.08, -23.30)	P=0.005	**Robot**	71%
(Lenfant 2023)		2525 1099 2474	2292 4187	 7579	RAS vs LS MD= -52.31, (-98.17, -6.45) RAS vs OS	P=0.03 P=0.009 P<0.0001	**Robot** **Robot** **Robot**	95% 99% 79%

					MD= -123.01 (-214.83, -176.51) RAS vs NOTES MD= -71.18 (-85.15, -57.20)			
(Marchand 2023)		1754		1833	MD= -397.75 (-471.65, -324.24)	P<0.00001	**Robot**	94%
(Marchand 2023)		1112	1418		LS vs RAS MD= 35.24 (-0.40, 70.89)	P=0.05	NS	97%

CI confidence interval; MD mean difference; NR not reported; NS not significant; NOTES Natural orifice transluminal endoscopic surgery

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Conversion to laparotomy (%)								
(Laios 2017)	n=68	115/3106	274/3452		RR=0.41 (0.29, 0.59)	P<0.00001	**Robot**	30%
(Park 2017)	n=5	NR	NR	NR	RR 0.23 (0.04, 1.29).	NR	NS	0%
(Cusimano 2019)	n=29 n=14	- 91/1314	173/1826 -	-	LS to Open 6.5% (4.3-9.9) RAS vs Open 5.5% (3.3-9.1)	NR	NR	82% (LS) 79% (RAS)
(Lawrie 2019)	n=3	3/134	3/135		RR=1.17 (0.24, 5.77)	P=0.85	NS	0%
(Wang 2020)	n=14	48/1313	83/1442		RR=0.55 (0.38, 0.81)	P=0.002	**Robot**	29%
(Lenfant 2023)		889/39927 534/24345	6902/127973 222/64741		RAS vs LS RD= -0.037 (-0.064, -0.010) RAS vs NOTES OR= 1.23 (0.05, 33.38)	P=0.008 P=0.9	**Robot** NS	100% 99%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; NOTES Natural orifice transluminal endoscopic surgery; OR odds ratio

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Length of hospital stay(days)								

(Laios 2017)	n=25	2130	2237		MD=−0.46 (−0.66, −0.26)	P<0.00001	**Robot**	85%
(Li 2017)	n=9 n=10	274 335	344	270	RAS vs Open MD=-3.36 (-3.99, -2.73) RAS vs LS MD=-0.39 (-0.58. -0.21)	P<0.00001 P<0.00001	**Robot** **Robot**	94% 95%
(Park 2017)	n=7 n=6	NR	NR	NR	RAS vs Open MD=-4.33 (-5.96, -2.70) RAS vs LS MD=-1.39 (-2.44, -0.35)	NR	**Robot** **Robot**	96% 89%
(Jin 2018)	NR	NR	NR	NR	RAS vs Open MD=-3.49 (-5.79, -1.24) RAS vs LS MD=-0.25 (-2.60, 2.06)	NR	**Robot** NS	NR
(Lawrie 2019)	n=2	108	84		MD= -0.3 (-0.53, -0.07)	P=0.01	**Robot**	0%
(Shi 2019)		159 96	79	274	RAS vs Open MD=−5.22 (−6.15, − 4.30) RAS vs LS MD=−1.43 (−3.53, 0.67)	P< 0.0001 P= 0.1827	**Robot** NS	40.2% 69.4%
(Zhang 2019)	n=6 n=9	482 305	373	660 -	RAS vs Open MD=-2.71 (-3.74, -1.68) RAS vs LS MD=-0.24 (-1.33, 0.85)	P< 0.00001 P=0.67	**Robot** NS	78% 87%
(Prodromidou 2020)	n=4	119	209		MD=-0.32(-0.44, -0.19)	P<0.00001	**Robot**	0%
(Wang 2020)	n=18 n=21	1635 1594	1846	2319	RAS vs Open MD=-2.76 (-3.08, -2.43) RAS vs LS MD=-0.35 (-0.54, -0.17)	P< 0.0001 P< 0.0001	**Robot** **Robot**	86% 82%
(Kampers 2022)	N=5	139	204		LS vs RAS		**Robot**	

	N=4	398		359	MD= 1.07 (0.66, 1.48) RAS vs Open MD=-3.77 (-5.10, -2.44)		**Robot**	
(Lenfant 2023)		43054 31152 24217	111454 64582	 162691	RAS vs LS MD= -0.14 (-0.21, -0.08) RAS vs Open MD= -1.31 (-1.85, -0.43) RAS vs NOTES MD= -0.39 (-0.70, -0.08)	P<0.0001 P<0.0001 P=0.01	**Robot** **Robot** **Robot**	95% 100% 99%
(Marchand 2023)		2845		6274	MD= -3.99 (-4.67, -3.31)	P<0.00001	**Robot**	98%
(Marchand 2023)		1244	1640		LS vs RAS MD= 0.80 (0.38, 1.21)	P=0.0002	**Robot**	89%

CI confidence interval; MD mean difference; NR not reported; NS not significant; NOTES Natural orifice transluminal endoscopic surgery

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Postoperative complications (%)								
(Laios 2017)	n=18	4327			RR=0.85 (0.72, 1.02)	NP	NP	NP
(Li 2017)	n=10 n=10	31/284 66/335	 82/344	69/281	RAS vs Open RR=0.34 (0.21, 0.56) RAS vs LS RR=0.63 (0.32, 1.24)	P=0.0001 P=0.18	**Robot** NS	0% 57%
(Park 2017)	n=6	NR	NR	NR	RAS vs Open RR=0.78 (0.42, 1.43) RAS vs LS	NR	NS NS	0% 50%

					RR=0.78 (0.49,1.23)			
(Jin 2018)	NR	NR	NR	NR	RAS vs Open OR= 0.21 (0.08, 0.65) RAS vs LS OR=0.39 (0.14, 1.31)	NR	**Robot** NS	NR
(Lawrie 2019)	n=5	11/58 37/291	 34/242	17/58	RAS vs Open RR= 0.67 (0.35,1.27) RAS vs LS RR= 0.82 (0.42,1.59)	P=0.2 P=0.56	NS NS	0% 51.25%
(Marra 2019)*	N=15 N=11	49/2745 20/500	58/2548 31/785		RAS vs LS for endometrial cancer OR=0.94 (0.55, 1.73) RAS vs LS for cervical cancer OR=1.09 (0.60, 1.97)	P=0.93 P=0.78	NS NS	33% 0%
(Shi 2019)		159 144	 166	274	RAS vs Open RR=0.4710 (0.25, 0.87) RAS vs LS RR=1.45 (0.6502, 3.25)	P= 0.0171 P= 0.3619	**Robot** NS	0% 6%
(Zhang 2019)	n=7 n=9	152/741 47/305	 80/373	187/892	RAS vs Open RR=0.74 (0.45, 1.22) RAS vs LS RR=0.66 (0.39, 1.12)	P=0.24 P=0.13	NS NS	65% 31%
(Hwang 2020)					OR=0.94 (0.64, 1.38)	P=0.767	NS	NR
(Wang 2020)	n=15 n=16	135/1457 115/1372	 155/1669	516/2106	RAS vs Open RR=0.41 (0.33, 0.50) RAS vs LS RR=0.96 (0.76, 1.20)	P<0.00001 P = 0.69	**Robot** NS	49% 13%
(Huang 2023)	N=6	8/491	23/807		OR=0.54 (0.25, 1.19)	P=0.13	NS	0%
(Huang 2023)	N=19				OR=1.27 (0.86, 1.89)	P=0.53	NS	

(Lenfant 2023)		5441/48824 36009/29270 3348/25350	20847/138163 10076/64943	 43640/160920	RAS vs LS OR=0.83 (0.66, 1.05) RAS vs OS OR= 0.42 (0.27, 0.66) RAS vs NOTES OR= 0.75 (0.41, 1.37)	P=0.08 P=0.0001 P=0.22	NS **Robot** NS	95% 98% 96%
(Marchand 2023)		468/2450		1157/5981	OR=0.65 (0.46, 0.91)	P=0.01	**Robot**	73%
(Marchand 2023)		243/1191	250/1633		LS vs RAS OR=0.84 (0.60, 1.17)	P=0.30	NS	50%

CI confidence interval; NR not reported; NS not significant; RR relative risk; OR odds ratio

*infectious complications

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Positive resection margin rate (%)								
(Park 2017)	n=4 n=5	NR	NR	NR	RAS vs Open RR=0.66 (0.22, 1.96) RAS vs LS RR=0.87 (0.29, 2.62)	NR	NS	0% 0%

CI confidence interval; NR not reported; NS not significant; RR relative risk; OR odds ratio

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Retrieved lymph node yield/ pelvic nodes								
(Laios 2017)	n=14	2086			MD=−0.14 (−5.73, 5.46)		NS	
(Li 2017)	n=4 n=5	99 173	 180	97	RAS vs Open MD=-6.66 (-8.19, -5.12)	P=0.00001 P=0.26	**Robot** NS	93% 89%

					RAS vs LS MD=0.74 (-0.55, 2.03)			
(Park 2017)	n=9 n=4	721	 246		RAS vs Open MD=0.56 (-2.76, 3.88) RAS vs LS MD=2.81(-3.68, 9.30)	NS	NS NS	85% 92%
(Jin 2018)	NR	NR	NR	NR	RAS vs Open MD=-2.17 (-5.49, 1.08) RAS vs LS MD= -1.34 (-4.44, 1.89)	NR	NS NS	NR
(Lawrie 2019)	n=1	48		48	RAS vs Open MD=-8 (-14.97, -1.03)	P=0.02	**Robot**	NA
(Shi 2019)		141 78	 58	262	RAS vs Open (pelvic nodes) MD= 0.005 (−1.94, 1.95) RAS vs LS (pelvic nodes) MD=−0.57 (−3.16, 2.03)	P=0.9962 P= 0.6688	NS NS	37% 28%
(Zhang 2019)	n=6 n=9	482 305	 373	659	RAS vs Open MD=-3.43 (-7.74, 0.88) RAS vs LS MD=2.46 (-0.46, 5.38)	P=0.12 P=0.10	NS NS	89% 67%
(Wang 2020)	n=7 n=10	477 774	 961	629	RAS vs Open MD=3.30 (0.06, 6.04) RAS vs LS MD=0.73 (-3.62, 5.08)	P=0.05 P=0.74	Open NS	86% 96%
(Marchand 2023)		2465		4648	MD= -2.64 (-4.12, -1.15)	P=0.0005	**Robot**	86%
(Marchand 2023)		1077	1291		LS vs RAS MD= -1.22 (-3.28, 0.84)	P= 0.25	NS	88%

CI confidence interval; MD mean difference; NR not reported; NS not significant

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Postoperative recurrence (%)								
(Laios 2017)	n=2	453			RR= 0.66 (0.33, 1.34)	NR	NS	NR
(Shi 2019)		73 26	 32	59	RAS vs Open RR=0.85 (0.34, 2.16) RAS vs LS RR=0.24 (0.045, 1.28)	P=0.7332 P= 0.0944	NS NS	42% 25%
(Zhang 2019)	n=5 n=7	58/643 21/237	 26/324	62/677	RAS vs Open OR=0.85(0.58, 1.27) RAS vs LS OR=0.96(0.50, 1.87)	P= 0.43 P=0.91	NS NS	0% 0%
(Hwang 2023)	N=20				OR=1.19 (0.91, 1.55)	P=0.613	NS	0%
(Marchand 2023)		204/ 1884		227/1942	OR= 0.92 (0.75, 1.13)	P=0.44	NS	23%
(Marchand 2023)		56/635	87/841		OR= 1.14 (0.79, 1.64)	P=0.50	NS	0%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Postoperative mortality (%)								
(Behbehani 2019)		1842	2195		LS vs RAS RR= 1.12 (0.36, 3.51)		NS	0%

CI confidence interval; RD risk difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
3-year disease free survival								
(Lee 2018)		167/197	145/169		RR 1.00 (0.92, 1.09)	P=0.97	NS	0%, P=0.90
(Shi 2019)	NR	60	44		HR=1.69 (0.26, 11.12)	P=0.5850	NS	0%
(Qiu 2020)	n=7	2593			HR=0.93 (0.79, 1.10)	P=0.40	NS	0%, P=92
(Gavriilidis 2020)	N=6	6, 1315			HR = 0.94 (0.72, 1.23)	P=0.65	NS	7%
(Ryan 2021)	NR	NR	NR	NR	Open vs LS HR=1.0 (0.91, 1.1) RAS vs LS HR=1.0 (0.66, 1.6)	NR	NS NS	NR
(Marchand 2023)		1971/2282		1981/2251	OR= .094 (0.77, 1.14)	P=0.51	NS	71%
(Marchand 2023)		493/ 541	635/711		OR= 0.89 (0.59, 1.32)	P=0.55	NS	0%

CI confidence interval; HR hazard ratio; NR not reported; NS not significant.

Outcome	Studies	Participant, N	Pooled effect (95%CI)	P-value	Favours	I^2

	included, n	Robot	Laparoscopy	Open				
Overall survival								
(Shi 2019) (3 year)	NR	107 60	 44	99	RAS vs Open HR=6.44 (1.67, 24.77) RAS vs LS HR= 2.2 (0.08, 57.48)	P=0.0070 P=0.6360	**Robot** NS	0% NA
(Marchand 2023) (5 year)		1188/1316		1113/1264	OR=1.28 (0.66, 2.46)	P=0.46	NS	74%
(Marchand 2023) (5 year)		274/293	369/395		OR= 1.37 (0.51, 3.69)	P=0.53	NS	36%

CI confidence interval; HR hazard ratio; NR not reported; NS not significant.

Table 5-3 Clinical Effectiveness of Hepatopancreaticobiliary surgery

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
Operative time (min)								
(Peng 2017)	n=4	132		234	RPD vs OPD MD=114.87 (-34.19, 263.92)	P=0.131	NS	97.2%
(Shin 2017)	n=6	160		294	RPD vs OPD MD=98.58 (37.82, 159.34)		Open	90.8%
(Lauretta 2017)	n=8	228	375		RP vs LP MD=26.91 (-11.83, 65.65)	P=0.17	NS	88%
(Zhao 2018)	n=9 n=4	506 270		1194 1593	RPD vs OPD MD= 88.69 (38.38, 138.99) RP vs OP MD= 36.38 (21.92, 50.8)	P=0.0005 P < 0.00001	Open Open	93% 42%
(Hu 2018)	n=17	NR	NR	NR	RH vs LH MD=44.85 (21.81, 67.9)	P<0.001	Laparoscopy	82.6%
(Guan 2019)	n=13				RH vs LH MD=65.49 (42, 88.98)	P < 0.00001	Laparoscopy	80%
(Gavriilidis 2019)	n=5 n=17				RP vs OP MD = −8.94 (−84, 66) RP vs LP MD = 16.78 (-12, 46)	P=0.82 P= 0.25	NS NS	57% 95%
(Kamarajah 2019)	n=18	700	1377		RP vs LP MD= 28.11 (2.89, 53.33)	P=0.03	Laparoscopy	94%
(Niu 2019)	n=6	NR	NR	NR	RP vs OP MD=32.93 (17.52, 79.29) RP vs LP MD=37.27 (6.34, 68.21)	NR	Open Laparoscopy	87.8% 90.6%

(Machairas 2019)	n=9	407		645	RH vs OH MD=65.91 (22.39, 109.44)	0.003	Open	90%
(Wong 2019)	n=7	328		426	RH vs OH MD=61.47 (7.03, 115.91)	P=0.03	Open	91%
(Gavriilidis 2020)	n=10 n=17	NR	NR	NR	RH vs OH MD=50.82 (6.16, 95.47) RH vs LH MD=60.41 (-7.52, 128.35)	P=0.03 P=0.08	Open NS	100% 100%
(Mavrovounis 2020)	n=18	666	1359		LP vs RP MD=-28.28 (-49.98, -6.60)	P=0.01	Laparoscopy	87%
(Kamarajah 2020)	n=25	746	1150	-	RH vs LH MD=56.84 (36.04, 77.64)	NR	Laparoscopy	90%
(Ciria 2020)	n=24	NR	NR	NR	RH vs OH MD=64.71 (36.68, 94.75) RH vs LH MD=53.89 (32.26, 75.62)	NR	Open Laparoscopy	88.2% 90.27%
(Zhang 2020)	n=24	916	1375		RH vs LH MD=36.93 (19.74, 54.12)	P< 0.001	Laparoscopy	86%
(Zhao 2020)	n=12 n=20	NR	NR	NR	RH vs OH MD= 59.42 (21.89, 96.94) RH vs LH MD= 45.64 (27.06, 64.21)	P = 0.002 P < 0.001	Open Laparoscopy	87.5% 90%
(Zhou 2020)	n=7	515		1749	RP vs OP MD=12.95 (-32.51, 58.41)	P=0.58	NS	92%
(Aiolfi 2020)	n=32	NR	NR	NR	RPD vs OPD MD=33.1 (24.02, 42.3) RPD vs LPD MD=27.8 (17.1, 38.6)	NR	Open Laparoscopy	NR

(Kamarajah 2020)	n=5				RPD vs LPD MD=-13 (-40, 14)	P=0.3	NS	80%
(Podda 2020)		1363		11750	RPD vs OPD MD= 1.06 (0.48, 1.64)	P=0.004	Open	99%
(Yan 2020)	n=7	325		515	RPD vs OPD MD= 71.74 (23.37, 120.12)	P= 0.004	Open	95%
(Zhang 2020)	n=9	468		598	RPD vs OPD MD= 80.85 (16.09,145.61)	P < 0.00001	Open	96%
(Hu 2021)	n=6	345	748		RH vs LH MD=58.79 (25.54, 92.04)	P<0.001	Laparoscopy	86.1%
(Bhattacharya 2021)	n=7	125	292		RS vs LS MD=3.63, (-16.99, 24.25)	P=0.73	NS	90%
(Wang 2021)	n=12	297	454		RH vs LH MD=28.65 (13.12, 44.17)	P=0.0003	Laparoscopy	59%
(Ziogas 2021)	n=7	225	300		LH vs RH MD=-0.08 (-0.51, 0.34)	P=0.70	NS	76%
(Dong 2021)	N=23	2086		103131	RPD vs OPD MD= 75.17 (48.05, 102.28)	P<0.00001	Open	99%
(Di Martino 2021)	N=9	467	438		LDP vs RDP SMD- -0.09 (-0.64, 0.47)	P=0.75	NS	93%
(Feng 2021)	N=2	58	70		RDP vs LDP MD= 36.43 (-6.47, 79.33)	P=0.10	NS	74%
(Rompianesi 2021)	N=9	242	276		RDP vs LDP MD= 6.13 (-39.36, 52.33)	P=0.79	NS	97%
(Zhang 2021)	N=9	468		598	RPD vs OPD MD= 80.85 (16.09, 145.61)	P=0.01	Open	96%
(Aboudou 2022)		682	1101		RH vs LH MD= 43.99 (23.45, 64.53)	P<0.00001	Laparoscopy	86%

(Hajibandeh 2022)	N=6	140	163		RH vs LH MD= 29.40 (5.91, 52.88)	P=0.01	Laparoscopy	72%
(Fu 2022)	N=17	1924		2690	RPD vs OPD MD= 64.60 (26.89, 102.21)	P=0.001	Open	97.8%
(Kabir 2022)					RPD vs LPD MD= 33.73 (-14.54, 82.00) RPD vs OPD MD=91.08 (48.61, 113.56)	P=0.459 P=0.042	NS Open	
(Lincango 2022)	N=1 N=4	52 151	118	 248	RLDRH vs LADRH MD= 137.7 (107.4, 168.0) RLDRH vs OADRH MD= 133.4 (72.8, 194.1)		Laparoscopy Open	
(Ouyang 2022)	N=8	984	1125		RPD vs LPD MD= 13.74 (-9.46, 36.94)	P=0.25	NS	96%
(Rahimli 2022)	N=13	565	894		RH vs LH MD= 28.12 (3.66, 52.57)	P=0.02	Laparoscopy	90%
(Yeow 2022)					RH vs LH MD= 113.24 (53.28, 173.20) RH vs OH MD= 148.05 (97.35, 198.74)		Laparoscopy Open	
(Yin 2022)*		177	307		LS s RAS MD= -17.27 (-91.79, 57.25)	P=0.65	NS	99%
(Chaouch 2022)	N=4	65	91		RTP vs LTP MD=14.58 (-102.30, 131.46)	P=0.81	NS	98%
(Gao 2023)	N=19				RH vs LH SMD= 0.07 (-0.05, 0.18)	P=0.25	NS	68%
(Long 2023)	N=3	132	132		RH vs LH MD= 16.20 (-10.67, 43.07)	P=0.24	NS	0%

(Mao 2023)	N=11				RH vs LH MD=0.67 (-14.72, 27.65)	P=0.55	NS	77%
(Papadopoulou 2023)		640		1161	RH vs OH MD= 58.89 (19.44, 98.34)		Open[93]	93%
(van Ramshorst 2023)					RDP vs LDP WMD= 18.21 (2.18, 34.24)		Laparoscopy	91%
(Xuea 2023)	N=8	378		701	RH vs OH MD= 70.55 (37.58, 103.53)	P<0.00001	Open	89%

CI confidence interval; MD mean difference; NR not reported; NS not significant; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2 (P-value)**
		Robot	Laparoscopy	Open				
Estimated blood loss (ml)								
(Shin 2017)	n=6	160		294	RPD vs OPD MD=-205.70 (-367.58, -43.82)		**Robot**	62.1%
(Hu 2018)	n=14	NR	NR	NR	RH vs LH MD=39.56 (4.65, 74.4)	P=0.013	Laparoscopy	51.5%
(Zhao 2018)	n=8 n=2	423 33		1158 35	RPD vs OPD MD= −197.02 (−313.42, −80.61) RP vs OP MD= −481.5 (−759.45, −203.61)	P= 0.0009 P= 0.0007	**Robot** **Robot**	93% 0%
(Guan 2019)	N=11				RH vs LH MD= 69.88 (27.11, 112.65)	P= 0.001	Laparoscopy	67%
(Machairas 2019)	n=7	381		576	RH vs OH MD=-159.82 (-342.45, 22.81)	P=0.09	NS	93%
(Gavriilidis 2019)	n=4				RP vs OP	P < 0.001	**Robot**	55%

	n=18				MD = −426 (−558, −295) RP vs LP MD = −68.02 (−103, −33)	P < 0.001	**Robot**	98%
(Kamarajah 2019)	n=14	425	513		RP vs LP MD=−51.94 (-107.83, 3.95)	P=0.07	NS	98%
(Niu 2019)	n=4 n=10	NR	NR	NR	RP vs OP MD=-185.89 (-478.10, 103.32) RP vs LP MD=-14.94 (-125.97, 96.10)	NR	NS NS	94.1%
(Wong 2019)	n=5	302		357	RH vs OH MD=-220.44 (-447.47, 6.58)	P=0.06	NS	86%
(Ciria 2020)	n=22 n=11	NR	NR	NR	RH vs OH RR=-103.67 (-296.62, 89.29) RH vs LH RR=69.02 (4.88, 133.17)		NS Laparoscopy	98.83% 86.39%
(Kamarajah 2020)	n=24	685	1049	-	RH vs LH MD=-51.74 (-67.74, -35.75)	NR	**Robot**	99%
(Gavriilidis 2020)	 N=18	NR	NR	NR	RH vs OH MD= -163.36 (-260, -66) RH vs LH MD= -25.28 (-34.78, -15.78)	P < 0.001 P < 0.001	**Robot** **Robot**	100% 100%
(Mavrovounis 2020)	n=14	391	495		LP vs RP MD=34.00 (-10.28, 78.29)	P=0.13	NS	87%
(Zhang 2020)	n=21	829	1155		RH vs LH MD=3.58 (-31.38, 38.54)	P = 0.84	NS	78%
(Zhao 2020)	n=10 n=18	NR NR	 NR	NR	RH vs OH MD=-126.91 (-126.91, -59.21) RH vs LH	P < 0.001 P = 0.02	**Robot** Laparoscopy	75.6% 81.%

					MD=45.46(7.04, 83.89)			
(Coletta 2021)	n=7	223	238		RH vs LH MD=-0.72 (0.92, -0.52)	P<0.0001	**Robot**	80%
(Hu 2021)	n=4	169	123	-	RH vs LH MD= -1.96 (-44.04, 40.12)	0.927	NS	36.2%
(Wang 2021)	n=10	276	417		RH vs LH MD=-12.91 (-44.75, 18.09)	P=0.43	NS	0%
(Ziogas 2021)	n=6	217	297		LH vs RH MD=0.27 (-0.24, 0.77)	P=0.30	NS	84%
(Zhou 2020)	n=5	278		191	RP vs OP MD=-246.95 (-300.83, -193.07)	P < 0.00001	**Robot**	75%
(Aiolfi 2020)	n=29	NR	NR	NR	RPD vs OPD MD=− 158.5 (− 169.2, -147.9) RPD vs LPD MD=10.04 (− 3.21, 23.3)	NR	**Robot** NS	NR
(Kamarajah 2020)	n=2				RPD vs LPD MD=-80 (-170, 10)	P=0.1	NS	34%
(Podda 2020)					RPD vs OPD MD=− 0.94 (-1.45, -0.42)	P=0.0003	**Robot**	96%
(Yan 2020)	n=8	444		1314	RPD vs OPD MD= -374.03 (-506.84, -241.21)	P< 0.00001	**Robot**	96%
(Zhang 2020)	n=9	410		599	RPD vs OPD MD= -175.65 (− 251.85, − 99.44)	P< 0.00001	**Robot**	82%
(Dong 2021)	N=18	1549		2935	RPD vs OPD MD= -191.35 (-2282.12, -144.59)	P<0.00001	**Robot**	96%
(Di Martino 2021)	N=8	455	430		LP vs RP SMD= -0.05 (-0.19, 0.08)	P=0.44	NS	0%
(Hu 2021)	N=4				RH vs LH		NS	36%

					WMD= -1.96 (44.04, 40.12)			
(Wang 2021)	N=10	276	417		RH vs LH MD= -12.91 (-44.75, 18.94)	P=0.43	NS	0%
(Zhang 2021)	N=9	410		599	RPD vs OPD MD= -175.65 (-251.85, -99.44)	P<0.00001	**Robot**	82%
(Aboudou 2022)					RH vs LH MD= -20.95 (-64.90, 23.34)	P=0.36	NS	84%
(Hajibandeh 2022)	N=6	140	163		RH vs LH MD= -1.96 (-31.55, 35.47)	P=0.91	NS	40%
(Fu 2022)	N=14	1,640		1,583	RPD vs OPD MD= −185.44 (−239.66, −131.21)	p < 0.001	**Robot**	92.7%
(Kabir 2022)					RPD vs LPD MD= -112.58 (-118.20, -36.95) RPD vs OPD MD= -209.87 (-279.36, -140.39)		**Robot** **Robot**	
(Lincango 2022)	N=1 N=4	52 151	118	 248	RLDRH vs LADRH MD= -155.7 (-214.6, -96.8) RLDRH vs OADRH MD= -18.2 (-149.5, 113)		**Robot** NS	
(Ouyang 2022)	N=5	171	192		RPD vs LPD MD= -120.47 (-171.09, -69.85)	P<0.00001	**Robot**	76%
(Rahimli 2022)	N=11	404	748		RH vs LH MD= -8.56 (-70.86, 53.73)	P=0.79	NS	82%
(Yeow 2022)					RH vs LH MD= 53.07 (-116.86, 223.00) RH vs OH MD= -267.04 (-437.82, -84.26)		NS **Robot**	
(Yin 2022)*		111	174		LS vs RAS	P=0.78	NS	96%

					MD= 2.28 (-13.51, 18.06)			
(Zhang 2022)	N=3	67	154		LS vs RS MD= 1.49 (-1.47, 4.47)	P=0.33	NS	1%
(Gao 2023)	N=17				RH vs LH SMD= -0.31 (-0.48, -0.14)	P=0.0005	**Robot**	84%
(Li 2023)		342	540		RP vs LP MD= -52.029 (-82.92, -33.65)	P<0.00001	**Robot**	26%
(Mao 2023)					RH vs LH MD= -91.42, -142.18, -40.66)	P=0.0004	**Robot**	74%
(Papadopoulou 2023)		614		1092	RH vs OH MD= -182.40 (-283.02, -81.79)		**Robot**	92%
(van Ramshorst 2023)					RP vs LP WMD= -54.50 (-84.49, -24.50)		**Robot**	92%
(Xuea 2023)	N=5	281		544	RH vs OH MD= -152.2 (-266.85, -38.18)	P=0.009	**Robot**	62%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy.

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Conversion to open approach (%)								
(Lauretta 2017)	n=8	19/230	109/503		RP vs LP OR=0.33 (0.12, 0.92)	P=0.03	**Robot**	48%
(Hu 2018)	n=13				RH vs LH OR=1.36 (0.78, 2.35)	P=0.183	NS	25.8%
(Guan 2019)	N=13	25/411	41/465		RLR vs LLR OR=0.75 (0.45, 1.25)	P=0.27	NS	0%

(Gavriilidis 2019)	NR	36/590	117/764		RP vs LP OR = 0.49 (0.33, 0.71)	P= 0.002	**Robot**	33%
(Kamarajah 2019)	n=18	66/823	500/2413		RP vs LP OR=0.48 (0.35, 0.67)	P<0.0001	**Robot**	10%
(Kamarajah 2020)	n=21	606	884	-	RH vs LH OR=0.86 (0.49, 1.51)	NR	NS	32%
(Gavriilidis 2020)	n=10	27/406	39/532		RH vs LH OR= 0.95 (0.57, 1.58)	P=0.85	NS	0%
(Mavrovounis 2020)	n=18	53/759	406/2061		LP vs RP OR=2.38 (1.75, 3.22)	P<0.00001	**Robot**	22%
(Aiolfi 2020)	NR	NR	NR	NR	RPD vs LPD RR=0.71(0.59, 0.83)	NR	**Robot**	15.1%
(Kamarajah 2020)	n=6				RPD vs LPD OR= 0.45 (0.36, 0.56)	P<0.001	**Robot**	0%
(Zhang 2020)	n=22	59/920	123/1253		RH vs LH OR=0.63 (0.46, 0.87)	P= 0.005	**Robot**	48%
(Zhao 2020)	n=15				RH vs LH OR=0.66 (0.43, 1.02)	P= 0.059	NS	0%
(Ciria 2020)	n=19	514/550	871/947	-	RH vs LH RR=0.015(-0.014, 0.045)	NR	NS	NA
(Hu 2021)	n=6	347	762		RH vs LH OR= 0.403 (0.224, 0.725)	P= 0.002	**Robot**	0%
(Wang 2021)	n=10	15/254	29/402		RH vs LH OR=0.86 (0.46, 1.58)	0.62	NS	33%
(Coletta 2021)	n=6	8/168	14/109		RH vs LH RR=0.27(0.10, 0.78)	P=0.02	**Robot**	0%
(Ziogas 2021)	n=6	8/217	9/297		RH vs LH RD=0.03 (−0.01, 0.08)	P= 0.15	NS	42%

(Bhattacharya 2021)	n=8	6/202	21/358		RS vs LS OR=0.63 (0.24, 1.70)	P=0.36	NS	0%
(Di Martino 2021)	N=7	41/390	16/432		RDP vs LDP OR= 2.56 (1.31, 5.00)	P=0.06	**Robot**	11%
(Wang 2021)	N=10	255	398		RH vs LH MD= 0.15 (-0.47, 0.77)	P=0.64	NS	55%
(Zhang 2021)	N=10	615	757		RPD vs LPD MD= -2.95 (-5.33, -0.56)	P=0.02	**Robot**	87%
(Aboudou 2022)		635	1037		RH vs LH MD=0.10 (-0.38, 0.58)	P=0.69	NS	75%
(Bhattacharya 2022)	N=4	38	58		RS vs LS MD= =0.21 (-1.17, 0.75)	P=0.67	NS	86%
(Hajibandeh 2022)	N=6	140	163		RH vs LH MD= 0.22 (-0.45, 0.88)	P=0.52	NS	81%
(Kabir 2022)					RPD vs LPD MD= 0.96 (-0.86, 2.78) RPD vs OPD MD= -1.37 (-2.85, 0.10)		NS NS	
(Lincango 2022)	N=1 N=4	52 151	118	 248	RLDRH vs LADRH MD= 0.3 (-0.3, 0.9) RLDRH vs OADRH MD= -0.8 (-1.4, -0.3)		NS **Robot**	
(Ouyang 2022)	N=9	1149	2583		RPD vs LPD MD= -1.29 (-2.64, 0.05)	P=0.06	NS	89%
(Rahimli 2022)	N=11	531	846		RH vs LH MD= -0.02 (-0.56, 0.53)	P=0.94	NS	76%
(Yeow 2022)					RH vs LH MD=0.60 (−2.11, 3.31)		NS NS	

					RH vs OH MD=−1.00 (−3.43, 1.43)			
(Yin 2022)*		177	307		LS vs RAS MD= 0.89 (-0.13, 1.91)	P=0.09	NS	89%
(Chaouch 2022)		65	91		RP vs OP MD= 0.32 (-3.97, 4.61)	P=0.88	NS	93%
(Gao 2023)	N=18				RH vs LH SMD= -0.02 (-0.13, 0.08)	P=0.66	NS	62%
(Li 2023)		683	995		RDP vs LDP MD= -0.57 (-0.92, -0.21)	P=0.002	**Robot**	1%
(Long 2023)	N=4				RH vs LH MD= 1.66 (-0.10, 3.42)	P=0.07	NS	68%
(Mao 2023)	N=11				RH vs LH MD= -0.64 (-0.78, -0.49)	P<0.00001	**Robot**	46%
(Papadopoulou 2023)		640		1161	RH vs OH MD= -2.74 (-4.20, -1.28)		**Robot**	93%
(van Ramshorst 2023)					RDP sv LDP MD= -0.45 (-0.92, 0.01)		NS	71%
(Xuea 2023)	N=7	314		637	RH vs OH MD= -2.79 (-4.19, -1.40)	P<0.0001	**Robot**	88%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy.

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				

Length of hospital stay(days)								
(Shin 2017)	n=5	160		294	RPD vs OPD MD=-4.09 (-6.88, -1.31)		**Robot**	63.6%
(Peng 2017)	n=4	132		234	RPD vs OPD MD= -6.00 (-9.80, -2.21)	P<0.001	**Robot**	67.9%
(Lauretta 2017)	n=8	211	357		RP vs LP MD=-0.74 (-1.34, -0.15)	P=0.01	**Robot**	60%
(Zhao 2018)	n=8 n=4	476 270		1164 1593	RPD vs OPD MD= −2.55 (−5.21, 0.12) RP vs OP MD= −2.97 (−4.75, −1.20)	P=0.06 P=0.001	NS **Robot**	88% 67%
(Hu 2018)	n=14	NR	NR	NR	RH vs LH MD=0.16 (-0.19, 0.50)	NR	NS	5%
(Guan 2019)	n=10	401	453		RLR vs LLR OR=0.12 (-0.52, 0.77P	0.71	NS	68%
(Wong 2019)	n=7	328		426	RH vs OH MD=-2.57 (-3.31, -1.83)	P<0.00001	**Robot**	0%
(Machairas 2019)	n=9	407		645	RH vs OH MD=-2.76(-3.84, -1.68)	P<0.0001	**Robot**	61%
(Gavriilidis 2019)	n=5 n=18	NR	NR	NR	RP vs OP MD = −4.06 (-0.28, -1.14) RP vs LP MD= −0.69 (−1.16, −0.23)	P=0.002 P=0.004	**Robot** **Robot**	74% 63%
(Kamarajah 2019)	n=20	860	2456		RP vs LP MD=−1.21 (−1.88, - 0.54)	P < 0.001	**Robot**	61%
(Niu 2019)	n=6	NR	NR	NR	RP vs OP MD=-4.66 (-8.38, -0.93) RP vs LP	NR	**Robot** **Robot**	82.8% 71.0%

					MD=-1.33 (-2.53, -0.13)			
(Zhang 2020)	n=23	1095	1782		RH vs LH MD=-0.06 (-0.47, 0.34)	P=0.76	NS	86%
(Zhao 2020)	n=10 n=9	NR	 NR	NR	RH vs OH MD=−2.51(-3.14, -1.87) RH vs LH MD=0.23 (-0.41, 0.88)	P < 0.001 P=0.48	**Robot** NS	0% 52.2%
(Kamarajah 2020)	n=23	872	1552	-	RH vs LH MD=-0.27 (-0.83, 0.28)	NR	NS	80%
(Ciria 2020)	n=17	NR	NR	NR	RH vs OH MD=-3.53 (-4.35, -2.72) RH vs LH MD=-0.35 (-0.08, 0.19)	NR	**Robot** NS	87% 87%
(Gavriilidis 2020)	n=10 n=16	NR	NR	NR	RH vs OH MD= -3.10 (-4.34, -1.86) RH vs LH MD= -0.16 (-0.73, 0.41)	P<0.001 P=0.59	**Robot** NS	95% 93%
(Zhou 2020)	n=7	515		1749	RP vs OP MD= -2.42(-2.99, -1.85)	P<0.00001	**Robot**	76%
(Aiolfi 2020)	n=35	NR	NR	NR	RPD vs OPD MD=− 2.23 (− 3.6, − 0.99) RPD vs LPD MD=0.3 (− 1.2, 1.93)	NR	**Robot** NS	NR
(Kamarajah 2020)	n=6	NR	NR	NR	RPD vs LPD MD=0.81 (0.50, 1.13)	P<0.0001	**Robot**	77%
(Podda 2020)		1555		11947	RPD vs OPD MD= − 0.23 (-0.64, 0.17)	P=0.25	NS	98%
(Yan 2020)	n=11	738		1561	RPD vs OPD	P=0.002	**Robot**	96%

					MD= − 5.19 (− 8.42, − 1.97)			
(Zhang 2020)	n=10	615		757	RPD vs OPD MD=− 2.95 (− 5.33, − 0.56)	P<0.0001	**Robot**	87%
(Coletta 2021)	n=7	223	238		RH vs LH MD=-0.46 (-0.67, -0.26)	P<0.0001	**Robot**	93%
(Hu 2021)	n=4	215	155	-	RH vs LH MD=0.076 (-0.935, 0.783)	P=0.863	NS	23.2%
(Wang 2021)	n=10	255	398		RH vs LH MD=0.15 (-0.47, 0.77)	P=0.64	NS	55%
(Ziogas 2021)	n=6	217	297		LH vs RH MD=0.13 (-0.58, 0.84)	P=0.72	NS	92%
(Bhattacharya 2021)	n=4	38	58		RS vs LS MD=-0.21 (-1.17, 0.75)	P=0.67	NS	86%
(Dong 2021)	N=20	1893		9903	RPD vs OPD MD= -1.00 (-1.88, -0.12)	P=0.03	**Robot**	97%
(Di Martino 2021)	N=11	561	625		LDP vs RDP SMD= -0.00 (-0.12, 0.12)	P=0.98	NS	0%
(Hu 2021)					RH vs LH WMD= -0.08 (-0.94, 0.78)		NS	23%
(Rompianesi 2021)	N=8				RDP vs LDP MD= -1.52 (-2.84, -0.20)	P=0.02	**Robot**	72%
(Wang 2021)	N=10	255	398		RH vs LH MD= 0.15 (-0.47, 0.77)	P=0.64	NS	55%
(Zhang 2021)	N=10	615	757		RPD vs OPD MD= -2.95 (-5.33, -0.56)	P=0.02	**Robot**	87%
(Aboudou 2022)		635	1037		RH vs LH MD=0.10 (-0.38, 0.58)	P=0.69	NS	75%
(Bhattacharya 2022)	N=4	38	58		RS vs LS	P=0.67	NS	86%

					MD= =0.21 (-1.17, 0.75)			
(Hajibandeh 2022)	N=6	140	163		RH vs LH MD= 0.22 (-0.45, 0.88)	P=0.52	NS	81%
(Fu 2022)	N=20	2,496		3,220	RPD vs OPD MD=−1.90 (−2.47, −1.33)	P<0.001	**Robot**	68.5%
(Kabir 2022)					RPD vs LPD MD= 0.96 (-0.86, 2.78) RPD vs OPD MD= -1.37 (-2.85, 0.10)		NS NS	
(Lincango 2022)	N=1 N=4	52 151	118	 248	RLDRH vs LADRH MD= 0.3 (-0.3, 0.9) RLDRH vs OADRH MD= -0.8 (-1.4, -0.3)		NS **Robot**	
(Ouyang 2022)	N=9	1149	2583		RPD vs LPD MD= -1.29 (-2.64, 0.05)	P=0.06	NS	89%
(Rahimli 2022)	N=11	531	846		RH vs LH MD= -0.02 (-0.56, 0.53)	P=0.94	NS	76%
(Yeow 2022)					RH vs LH MD=0.60 (−2.11, 3.31) RH vs OH MD=−1.00 (−3.43, 1.43)		NS NS	
(Yin 2022)*		177	307		LS vs RAS MD= 0.89 (-0.13, 1.91)	P=0.09	NS	89%
(Chaouch 2022)		65	91		RP vs OP MD= 0.32 (-3.97, 4.61)	P=0.88	NS	93%
(Gao 2023)	N=18				RH vs LH SMD= -0.02 (-0.13, 0.08)	P=0.66	NS	62%
(Li 2023)		683	995		RDP vs LDP	P=0.002	**Robot**	1%

					MD= -0.57 (-0.92, -0.21)			
(Long 2023)	N=4				RH vs LH MD= 1.66 (-0.10, 3.42)	P=0.07	NS	68%
(Mao 2023)	N=11				RH vs LH MD= -0.64 (-0.78, -0.49)	P<0.00001	**Robot**	46%
(Papadopoulou 2023)		640		1161	RH vs OH MD= -2.74 (-4.20, -1.28)		**Robot**	93%
(van Ramshorst 2023)					RDP sv LDP MD= -0.45 (-0.92, 0.01)		NS	71%
(Xuea 2023)	N=7	314		637	RH vs OH MD= -2.79 (-4.19, -1.40)	P<0.0001	**Robot**	88%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy.

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Overall complication (%)								
(Peng 2017)	n=9	245		435	RPD vs OPD RR=0.65 (0.47, 0.91)	P= 0.01	**Robot**	0%
(Hu 2018)	n=16	NR	NR	-	RH vs LH OR=0.90 (0.64, 1.28)	NR	NS	0%
(Guan 2019)	N=13	83/433	118/505		RLR vs LLR OR= 0.80 (0.56, 1.14)	P=0.21	NS	16%
(Machairas 2019)	n=9	14/443		41/748	RH vs OH RR= 0.58 (0.32, 1.05)	P=0.07	NS	0%

(Zhao 2018)	n=8 n=3	141/270 89/254		223/413 844/1580	RPD vs OPD OR= 0.67 0(.47, 0.95) RP vs OP OR= 0.68 (0.51, 0.91)	P=0.02 P=0.009	**Robot** **Robot**	37% 0%
(Wong 2019)	n=7	47/328		99/426	RH vs OH RR=0.63 (0.46, 0.86)	P=0.004	**Robot**	0%
(Gavriilidis 2019)	n=17	22/102 62/530	104/729	176/734	RP vs OP OR = 1.30 (0.76, 2.22) RP vs LP OR = 1.04 (0.73, 1.47)	P=0.35 P=0.85	NS NS	48% 20%
(Kamarajah 2019)	n=14	177/447	309/629		RP vs LP OR= 0.87 (0.66, 1.14)	P=0.31	NS	0%
(Niu 2019)	n=5 n=12	NR	NR	NR	RP vs OP OR=0.55 (0.32, 0.96) RP vs LP OR=1.08 (0.74, 1.57)	NR	**Robot** NS	8.9% 0%
(Aiolfi 2020)	NR	NR	NR	NR	RPD vs OPD OR=0.79 (0.72, 0.91) RPD vs LPD OR= 1.03 (0.94, 1.13)	NR	**Robot** NS	NR
(Kamarajah 2020)	n=4	NR	NR	NR	RPD vs LPD OR= 1.04 (0.73, 1.48)	P=0.8	NS	64%
(Yan 2020)	n=10	299/529		369/746	RPD vs OPD OR= 0.85 (0.66, 1.11)	P=0.23	NS	20%
(Zhang 2020)	n=10	155/409		182/458	RPD vs OPD RR=0.78 (0.64, 0.95)	P=0.01	**Robot**	33%
(Mavrovounis 2020)	n=12	46/400	84/563		LP vs RP MD=0.92 (0.62, 1.38)	P=0.70	NS	27%

(Ciria 2020)		NR	NR	NR	RH vs OH RR= 0.093 (0.036, 0.15) RH vs LH RR=0.02 (−0.01, 0.04).	NR NR	**Robot** NS	46.49% 0%
(Kamarajah 2020)	n=25	746	1160		RH vs LH OR=0.93 (0.70, 1.24)	NR	NS	0%
(Zhang 2020)	n=25	177/994	257/1454		RH vs LH OR=1.02 (0.81, 1.28)	P = 0.90	NS	9%
(Zhao 2020)	n=12 n=21	NR	 NR	NR	RH vs OH OR=1.27 (0.93, 1.72) RH vs LH OR= 0.87 (0.67, 1.13)	P = 0.129 P = 0.297	NS NS	0% 0%
(Coletta 2021)	n=8	10/244	20/241		RH vs LH RR=0.61 (0.28, 1.32)	P=0.21	NS	0%
(Hu 2021)	n=6	345	349	-	RH vs LH OR=1.161 (0.676, 1.996)	P=0.588	NS	30.2%
(Wang 2021)	n=12	38/297	68/454		RH vs LH OR=0.98 (0.63, 1.53)	P=0.92	NS	2%
(Ziogas 2021)	n=6	40/217	84/297		LH vs RH OR= 1.42 (0.90, 2.23)	P=0.13	NS	0%
(Gavriilidis 2020)	NR	NR	NR	NR	OH vs RH OR= 0.69 (0.38, 1.24) RH vs LH OR= 0.83 (0.52, 1.33)	P=0.22 P=0.44	NS NS	0% 0%
(Bhattacharya 2021)	n=7	13/192	18/338		RS vs LS OR=0.91 (0.40, 2.06)	P=0.82	NS	0%
(Di Martino 2021)	N=6	29/276	39/341		LDP vs RDP OR= 0.99 (0.57, 1.70)	P=0.96	NS	0%

(Hu 2021)	N=6				RH vs LS OR=1.16 (0.68, 2.00)		NS	30%
(Rompianesi)	N=6	29/197	35/209		RDP vs LDP RD= -0.04 (-0.11, 0.33)	P=0.27	NS	0%
(Wang 2021)	N=12	28/297	68/454		RH vs LH OR= 0.98 (0.63, 1.53)	P=0.92	NS	2%
(Zhang 2021)	N=11	155/409		182/458	RPD vs OPD RR= 0.78 (0.64, 0.95)	P=0.01	**Robot**	33%
(Aboudou 2022)	N=11	63/437	129/769		RH vs LH OR=0.94 (0.66, 1.35)	P=0.75	NS	0%
(Bhattacharya 2022)	N=7	13/192	18/338		RS vs LS OR=0.91 (0.40, 2.06)	P=0.82	NS	0%
(Kabir 2022)					RPD vs LPD OR= 1.23 (0.81, 1.85) RPD vs OPD OR=1.02 (0.72, 1.46)		NS NS	
(Fu 2022)	N=13	1,192		1,856	RPD vs OPD OR=0.66 (0.44 to 0.97)	P<0.001	**Robot**	76.2%
(Lincango 2022)	N=1 N=3	2/52 3/100	2/118	 3/186	RLDRH vs LADRH RR=2.27 (0.33, 15.67) RLDRH vs OADRH MD=2.10 (0.44, 9.96)		NS NS	
(Murtha-Lemekhova 2022)	N=4	201 167	160	 289	RH vs LH OR= 0.61 (0.18, 2.06) RH vs OH OR=0.76 (0.49, 1.18)	P=0.28 P=0.12	NS NS	11% 0%
(Ouyang 2022)	N=8	469/984	533/1125		RPD vs LPD OR=1.03 (0.87, 1.23)	P=0.71	NS	20%

(Rahimli 2022)	N=13	534	841		RH vs LH OR= 0.78 (0.56, 1.09)	P=0.15	NS	21%
(Yeow 2022)					RH vs LH OR=0.69 (0.26, 1.87) RH vs OH OR=0.48 (0.19, 1.20)		NS NS	
(Yin 2022)*		46/307	16/177		LS vs RAS OR=1.53 (0.59, 3.94)		NS	
(Chaouch 2022)		1/65	5/91		RP vs OP OR=0.42 (0.07, 2.67)	P=0.36	NS	0%
(Gao 2023)	N=212				RH vs LH OR= 0.99 (0.86, 1.14)	P=0.91	NS	41%
(Long 2023)		55/226	49/226		RH vs LH RR= 1.12 (0.80, 1.57)	P=0.50	NS	1%
(Mao 2023)	N=11	161/752	201/774		RH vs LH OR=0.83 (0.62, 1.06)	P=0.4	NS	0%
(Papadopoulou 2023)					RH vs OH (Clavien-Dindo I–II) RR= 0.67 (0.54, 0.85) RH vs OH (Clavien-Dindo III–IV) RR= 0.67 (0.44, 1.01)		**Robot** NS	0% 0%
(Xuea 2023)	N=8	57/378		143/701	RH vs OH OR= 0.67 (0.47, 0.95)	P=0.02	**Robot**	3%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy.

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				

Pancreatic fistula (%)								
(Peng 2017)	n=7	212		341	RPD vs OPD RR= 0.77 (0.49, 1.22)	P=0.27	NS	2%
(Shin 2017)	n=4	24/130		57/263	RPD vs OPD OR=0.75 (0.44, 1.29)		NS	49.5%
(Zhao 2018)	n=9 n=3	93/506 47/253		150/1194 237/1471	RPD vs OPD OR= 1.20 (0.88, 1.63) RP vs OP OR= 1.13 (0.79, 1.62)	P=0.25 P=0.49	NS NS	37% 0%
(Gavriilidis 2019)	n=5 n=17	12/102 98/592	161/807	85/734	RP vs OP OR = 0.57 (0.28, 1.14) RP vs LP OR = 0.81 (0.60, 1.10)	P=0.11 P=0.18	NS NS	0% 0%
(Kamarajah 2019)	n=16	164/663	313/1334		RP vs LP OR= 0.95 (0.75, 1.20)	P=0.65	NS	0%
(Niu 2019)	n=5 n=11	NR	NR	NR	RP vs OP OR=0.60 (0.29, 1.24) RP vs LP OR=0.99 (0.67, 1.47)	NR	NS NS	0% 0%
(Zhou 2020)	n=7	137/515		288/1749	RP vs OP OR=1.19 (0.90, 1.57)	P=0.22	NS	2%
(Kamarajah 2020)	n=5				RP vs LP OR= 1.02 (0.81, 1.29)	P=0.9	NS	0%
(Yan 2020)	n=8	468		550	RPD vs OPD OR= 1.12 (0.64, 1.96)	P=0.69	NS	57%
(Dong 2021)	N=20	265/1909		1589/9921	RPD vs OPD OR=0.89 (0.65, 1.22)	P=0.48	NS	64%
(Di Martino 2021)	N=8	90/436	77/461		OR=1.20 (0.84, 1.71)	P=0.32	NS	0%

(Rompianesi 2021)	N=7	31/209	36/238		RDP vs LDP RD= 0.00 (-0.06, 0.07)	P=0.9	NS	0%
(Zhang 2021)		75/969		151/1078	RPD vs OPD RD=0.54 (0.41, 0.70)	P<0.00001	**Robot**	0%
(Kabir 2022)					RPD vs LPD OR= 0.73 (0.37, 1.44) RPD vs OPD OR=0.63 (0.36, 1.09)		NS NS	
(Fu 2022)	N=13	1938	2104		RPD vs OPD OR= 0.67 (0.55, 0.82)	P<0.0001	**Robot**	26.9%
(Ouyang 2022)	N=8	172/984	199/1125		RPD vs LPD OR= 0.99 (0.79, 1.24)	P=0.94	NS	0%
(Li 2023)		318/1828	410/2280		RPD vs LPD OR=0.91 (0.77, 1.08)	P=0.26	NS	0%
(van Ramshorst 2023)					RPD vs LPD OR=0.98 (0.85, 1.14)		NS	0%
(Wang 2023)	N=5 N=24				LPD vs RPD OR= 1.60 (0.79, 3.55) RPD vs OPD OR=0.63 (0.51, 0.77)	P>0.05 P<0.05	NS **Robot**	0% 25%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy.

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				

Time to oral diet (days)								
(Hu 2018)	n=4				RH vs LH MD=1.2 (0.24, 2.17)	NR	NS	82.1%
(Gavriilidis 2020)					RH vs OH MD= -0.39 (-1.5, 0.70) RH vs LH MD= -0.48 (-1.4, 0.34)		NS NS	

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy.

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
R0 or R1 resection (%)								
(Shin 2017)	n=4	116/134		206/267	RPD vs OPD OR=1.53 (0.82, 2.85)		NS	0%
(Hu 2018)	n=4	NR	NR	NR	RH vs OH OR=2.2 (0.78, 6.23)	NR	NS	0%
(Guan 2019)*		27/345	33/396		RLR vs LLR OR= 1.03 (0.41, 2.55)	P=0.95	NS	42%
(Kamarajah 2019)	n=10	299/316	794/895		RP vs LP OR=1.01 (0.59, 1.73)	P=0.97	NS	0%
(Machairas 2019)	n=7	265/304		551/605	RH vs OH RR=1.00 (0.97, 1.02)	P=0.71	NS	0%
(Aiolfi 2020)	n=27	NR	NR	NR	RPD vs OPD RR= 1.13 (0.82, 1.66) RPD vs LPD RR=1.12 (0.86, 1.30)	NR	NS NS	NR
(Kamarajah 2020)	n=17	582	891		RH vs OH	NR	NS	0%

					OR=1.24 (0.85, 1.79)			
(Zhang 2020)	n=10	407/433	597/625		RH vs OH OR=0.67 (0.37, 1.19)	P=0.17	NS	0%
(Zhang 2020)	n=13	502/589		413/513	RPD vs OPD OR=1.05 (1.00, 1.11)	P=0.05	**Robot**	1%
(Wang 2021)	n=7	167/174	181/190		RH vs OH OR=1.36 (0.48, 3.83)	P=0.56	NS	0%
(Hu 2021)	n=3	237	573	-	RH vs OH OR=0.858 (0.553, 1.332)	0.496	NS	0%
(Feng 2021)	N=6	126/148	250/401	1953	RDP vs LDP OR= 2.96 (1.78, 4.93)	P<0.0001	Laparoscopy	36%
(Hu 2021)	N=3				RH vs LH OR=0.86 (0.55, 1.33)		NS	0%
(Wang 2021)	N=7	167/174	181/190		RH vs LH OR= 1.36 (0.48, 3.83)	P=0.56	NS	0%
(Zhang 2021)		502/589		413/513	RPD vs OPD RR= 1.05 (1.00, 1.11)	P=0.05	NS	1%
(Hajibandeh 2022)*	N=5	0/124	0/138		RH vs LH RD= 0.00 (-0.03, 0.03)	P=1.00	NS	0%
(Fu 2022)	N=10	955		1026	RPD vs OPD MD=1.02 (0.79 to 1.30)	P=0.889	NS	0%
(Kabir 2022)					RPD vs LPD OR= 1.03 (0.68, 1.55) RPD vs OPD OR=1.03 (0.68, 1.55)		NS NS	
(Chaouch 2022)*		4/65		10/91	RP vs OP OR=0.76 (0.21, 2.72)	P=0.68	NS	NA
(Li 2023)		201/230	259/309		RDP vs LDP	P=0.21	NS	37%

					OR= 1.62 (0.76, 3.42)			
(Mao 2023)					RH vs LH OR=1.45 (0.91, 2.31)	P=0.12	NS	0%
(Papadopoulou 2023)		405		714	RH vs OH RR= 1.00 (0.96, 1.04)		NS	58%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy

*R1 resection (%)

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Positive resection margins (%)								
(Peng 2017)	n=8	233		365	RPD vs OPD OR= 0.40 (0.20, 0.77)	P <0.01	**Robot**	0%
(Zhao 2018)	n=7 n=2	12/199 0/21		40/171 32/271	RPD vs OPD OR= 0.29 (0.15, 0.56) RP vs OP OR= 0.42 (0.05, 3.63)	P=0.003 P=0.43	**Robot** NS	0% 0%
(Gavriilidis 2019)*	n=2 n=5				RP vs OP OR = 0.36 (0.08, 1.56) RP vs LP OR = 0.38 (0.11, 1.36)	P=0.17 P=0.14	NS NS	24% 0%
(Zhou 2020)	n=4	0/41		34/320	RP vs OP OR=0.70 (0.08, 5.95)	P=0.74	NS	0%
(Podda 2020)	n=8	66/439		113/591	RPD vs OPD OR=0.84 (0.60, 1.18)	P=0.34	NS	0%

(Mavrovounis 2020)	n=10	25/289	155/865		LP vs RP RD=0.02(-0.02, 0.07)	P=0.35	NS	48%
(Yan 2020)	n=9	283		773	RPD vs OPD OR= 1.31 (0.91, 1.87)	P=0.14	NS	46%

CI confidence interval; NR not reported; NS not significant; RR relative risk; OR odds ratio; RD Risk Difference

*R1 resection (%)

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Number of harvested lymph nodes								
(Shin 2017)	n=4	138		245	RPD vs OPD MD=-0.61 (-3.58, 2.30)		NS	71.2%
(Peng 2017)	n=3	94		172	RPD vs OPD MD=2.05 (-0.95, 5.05)	P=0.18	NS	58%
(Zhao 2018)	n=7 n=2	335 53		772 650	RPD vs OPD MD= 1.82 (−0.85, 4.48) RP vs OP MD= −2.87 (−5.04, −0.71)	P=0.18 P= 0.009	NS **Robot**	81% 0%
(Gavriilidis 2019)	n=3 n=9	NR	NR	NR	RP vs OP MD= −0.46 (−4.75, 3.84) RP vs LP MD = 2.63 (−1.0, 6.26)	P=0.60 P=0.16	NS NS	83% 99%
(Kamarajah 2019)	n=7	279	1195		RP vs LP MD = 0.95 (−0.45, 2.35)	P=0.18	NS	0%
(Mavrovounis 2020)	n=10	316	1241		LP vs RP MD=-2.09 (-4.17, -0.01)	P=0.05	Laparoscopy	86%
(Zhou 2020)	n=3	69		330	RP vs OP MD=1.18 (-0.47, 2.82)	P=0.16	NS	20%

(Aiolfi 2020)	NR	NR	NR	NR	RPD vs OPD MD=2.18 (− 1.23, 5.61) RPD vs LPD MD=− 0.51 (− 4.45, 3.42)	NR	NS NS	NR
(Kamarajah 2020)	n=2	NR	NR	NR	RPD vs LPD MD= 1.01 (0.84, 1.17)	P <0.001	Laparoscopy	0%
(Podda 2020)					RPD vs OPD MD= 0.20 (− 0.12, 0.52)		NS	85%
(Yan 2020)	n=7	399		1106	RPD vs OPD MD= 0.89 (− 1.80, 3.58)	P=0.52	NS	74%
(Zhang 2020)	n=6	222		217	RPD vs OPD MD=0.48 (-2.05, 3.02)	P=0.71	NS	72%
(Dong 2021)	N=15	908		1953	RPD vs OPD MD= 2.88 (1.12, 4.65)	P=0.0001	**Robot**	83%
(Feng 2021)	N=5	87	179		RDP vs LDP MD= -0.61 (-6.47, 5.24)	P=0.84	NS	99%
(Zhang 2021)	N=6	222		217	RPD vs OPD MD= 0.48 (-2.05, 3.02)	P=0.71	NS	72%
(Fu 2022)	N=13	1337		1699	RPD vs OPD MD= 1.13 (−0.27, 2.54)	P=0.115	NS	82.8%
(Kabir 2022)					RPD vs LPD MD= -0.98, (-3.75, 1.80) RPD vs OPD MD= 0.17 (-2.02, 2.36)		NS NS	
(Ouyang 2022)*	N=3	216	1520		RPD vs LPD MD= 3.34 (0.81, 5.88)	P=0.010	Laparoscopy	89%
(Chaouch 2022)		65		91	RP vs OP MD= 11.27 (-13.93, 36.47)	P=0.38	NS	100%

(Li 2023)	N=4	52	126		RDP vs LDP OR= 0.9 (-1.15, 2.96)	P=0.39	NS	0%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Postoperative Readmissions (%)								
(Zhao 2018)	n=7	21/265		27/347	RPD vs OPD OR=0.78 (0.41, 1.46)	P=0.43	NS	0%
(Gavriilidis 2019)	n=6	25/201	36/324		RP vs LP OR = 1.76 (0.99, 3.24)	P=0.05	NS	0%
(Kamarajah 2019)	n=8	60/496	182/1582		RP vs LP OR=1.31 (0.94, 1.83)	P=0.11	NS	0%
(Mavrovounis 2020)	n=6	26/276	86/868		LP vs RP OR=0.73 (0.44, 1.20)	P=0.21	NS	0%
(Aiolfi 2020)	NR	NR	NR	NR	RPD vs OPD OR=0.73 (0.64, 0.86) RPD vs LPD OR=1.05 (0.78, 1.72)	NR	**Robot** NS	NR
(Kamarajah 2020)	n=6	NR	NR	NR	RPD vs LPD OR= 1.32 (1.06, 1.64)	NR	Laparoscopy	0%
(Yan 2020)	n=7	601		1294	RPD vs OPD OR= 1.25 (0.97, 1.62)	P=0.08	NS	0%
(Zhang 2020)	n=9	36/842		59/843	RPD vs OPD OR=0.61 (0.41, 0.91)	P=0.02	**Robot**	0%
(Gavriilidis 2020)	NR	20/286	100/661		RH vs LH	P=0.03	**Robot**	39%

					OR= 0.38 (0.16, 0.89)			
(Kamarajah 2020)	N=4				RH vs LH OR=0.43 (0.24, 0.78)	P=0.005	**Robot**	9%
(Gao 2023)	N=13				RH vs LH OR= 1.12 (0.83, 1.51)	P=0.77	NS	0%
(Mao 2023)					RH vs LH OR= 0.63 (0.28, 1.44)	P=0.27	NS	52%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy.

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy or other	Open				
Reoperation (%)								
(Dong 2021)	N=16	100/1521		577/8723	RPD vs OPD OR= 0.80 (0.62, 1.02)	P=0.07	NS	0%
(Kamarajah 2020)	N=6				RH vs LH OR=0.88 (0.26, 2.98)	P=0.8	NS	0%
(Zhang 2021)	N=9	36/842		59/843	RPD vs OPD RR= 0.61 (0.41, 0.91)	P=0.02	Robot	0%
(Aboudou 2022)	N=3	6/156	108210		RH vs LH OR=0.69 (0.25, 1.90)	P=0.47	NS	0%
(Murtha-Lemekhova 2022)		2/84	1/101		RH vs LH OR=1.96 (0.00, 11559)	P=0.58	NS	0%
(Ouyang 2022)	N=7	58/ 960	79/1088		RPD vs LPD OR= 0.83 (0.59, 1.18)	P=0.31	NS	0%
(Chaouch 2022)	N=4	3/65	9/91		RTP vs LTP	P=0.38	NS	0%

					OR= 0.56 (0.15, 2.07)			
(Gao 2023)	N=14				RH vs LH OR=0.67 (0.38, 1.18)	P=0.20	NS	0%
(Mao 2023)					RH vs LH OR= 0.76 (0.31, 1.88)	P=0.45	NS	0%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RR relative risk; OR odds ratio; RH robotic hepatectomy; LH laparoscopic hepatectomy; OH open hepatectomy; RP robotic pancreatectomy; LP laparoscopic pancreatectomy; OP open pancreatectomy; RPD robotic pancreaticoduodenectomy; LPD laparoscopic pancreaticoduodenectomy; OPD open pancreaticoduodenectomy.

Table 5-4 Clinical Effectiveness of Gastrectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
Operative time (min)								
(Caruso 2017)	n=6	689		5434	RG vs OG MD=72.20 (48.82, 105.13)	P < 0.001	Open	85%
(Chen 2017)	n=19	1830	4123		LG vs RG MD=−49.05 (-58.18, −39.91)	P < 0.00001	Laparoscopy	88%
(Wang 2017)	n=11	949	2425		MD=42.0 (28.11, 55.89)	P < 0.0001	Laparoscopy	88%
(Wang 2017)	n=3	165	397		MD= 21.49 (12.48, 30.50)	P < 0.00001	Laparoscopy	57%
(Magouliotis 2017)	N=5				MD=−20.66 (-23.45, -17.88)	P<0.00001	Laparoscopy	92%
(Yang 2017)	n=6	NR	NR	NR	RG vs OG MD= 63.72 (33.83, 93.61)	P < 0.0001	Open	94%
(Ai 2019)	n=24	2741	5672		MD=44.11 (24.20, 64.01)	P<0.0001	Laparoscopy	99%
(Bobo 2019)	n=16	NR	NR	NR	MD=57.98 (42.96, 73.00)	P < 0.00001	Laparoscopy	94%
(Guerrini 2020)	n=38	5020	12191		MD= 44.73, (36.01, 53.45)	P < 0.00001	Laparoscopy	97%
(Ma 2020)	n=18	2481	3925		LG vs RG MD= −32.96 (−42.08, −23.84)	P < 0.001	Laparoscopy	94%
(Aiolfi 2021)	n=17	NR	NR	NR	RG vs OG MD= 19.6 (-1.74, 40.9) RG vs LG MD= -46.3 (-68.4, -24.1)	NR	NS **Robot**	59.2%
(Feng 2021)	N=17	4993	5461		MD= 39.97 (31.15, 48.79)	P<0.000001	Laparoscopy	96%
(Zhang 2021)	N=12	1339	1837		MD= 39.78 (15.97, 43.59)	P<0.000001	Laparoscopy	98%
(Zhang 2021)	N=16	1193	2100		MD= 31.41 (15.67, 47.17)	P<0.0001	Laparoscopy	98%
(Baral 2022)		5900	13199		MD= 35.72 (28.59, 42.86)	P<0.000001	Laparoscopy	97%
(Chen 2022)	N=9				RG vs OG		Open	99%

					MD=83.21 (19.88, 146.55)			
(Gong 2022)		2148	3238		MD= 43.88 (35.17, 52.60)	P<0.000001	Laparoscopy	96%
(Jin 2022)					MD= 40.19 (32.07, 48.31)		Laparoscopy	96%
(Sun 2022)		1046	1047		MD= 24.38 (20.66, 28.11)	P<0.000001	Laparoscopy	0%
(Davey 2023)					RG vs OG MD=99.3 (55.1, 145)		Open	
(Lacovazzo 2023)		1422	1397		MD= 43.45 (17.55, 69.36)		Laparoscopy	98%
(Yu 2023)	n=6	422	296		MD= 28.20 (2.76, 53.65)	P=0.03	Laparoscopy	91%
(Multani 2023)					MD= -66.22 (-154, 21.65)	P=0.1854	NS	

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Estimated blood loss (ml)								
(Caruso 2017)	n=6	689		5434	MD= -166.83 (-205.18, -65.80)	P < 0.001	**Robot**	82%
(Chen 2017)	n=18	1762	4055		LG vs RG MD=24.38 (12.32, 36.43)	P < 0.0001	**Robot**	93%
(Wang 2017)	n=11	949	2425		MD= -23.68 (-42.25, -5.10)	P=0.01	**Robot**	91%
(Wang 2017)	n=3	165	397		MD= −16.60 (−61.31, 28.11)	P=0.47	NS	94%
(Yang 2017)	n=5	NR	NR	NR	RG vs OG MD= -129.84 (-178.31, -81.16)	P < 0.0001	**Robot**	81%
(Ai 2019)	n=23	2662	5563		MD=-17.78 (-25.62, -9.94)	P<0.00001	**Robot**	89%
(Bobo 2019)	n=16	NR	NR	NR	MD=− 23.71 (−40.10, − 7.32)	P = 0.005	**Robot**	89%
(Guerrini 2020)	n=34	4799	11780		MD= -18.24 (-25.21, -11.26)	P < 0.0001	**Robot**	88%
(Ma 2020)	n=17	2422	4196		LG vs RG MD= 28.66 (18.59, 38.73)	P < 0.0001	**Robot**	81%
(Aiolfi 2021)	n=16	NR	NR	NR	RG vs OG MD=-14.4 (-38.4, -9.4)	NR	**Robot** NS	75.8%

					RG vs LG MD=33.4 (-7.92, 58.9)			
(Feng 2021)	N=16	4925	5393		MD=-15.87 (-23.35, -8.39)	P<0.000001	**Robot**	76%
(Zhang 2021)	N=11	1152	1493		MD= -31.91 (-44.03, -19.83)	P<0.000001	**Robot**	93%
(Zhang 2021)	N=15	1106	1812		MD= -29.56 (-43.01, -16.11)	P<0.0001	**Robot**	96%
(Ali 2022)	N=27	3921	8539		MD= −17.97 (−25.61, −10.32)	P <0.001	**Robot**	89%
(Baral 2022)		5905	13451		MD= -21.93 (-28.94, -14.91)	P<0.000001	**Robot**	93%
(Chen 2022)	N=7				RG vs OG MD= -114.63 (-182.37, -46.88)		**Robot**	89%
(Gong 2022)		2051	2940		MD= -24.84 (-41.28, -8.43)	P=0.003	**Robot**	97%
(Jin 2022)					MD= -20.09 (-26.86, -13.32)		**Robot**	83%
(Sun 2022)		1331	1332		MD= -36.8 (-37.72, -20.97)	P<0.00001	**Robot**	42%
(Davey 2023)					RG vs OG MD= –87.2 (–173., –2.75)		**Robot**	
(Lacovazzo 2023)		893	912		MD= 54.53 (-24.19, 133.26)		NS	99%
(Yu 2023)	N=6	422	296		MD= 0.28 (-29.66, 30.22)	P=0.99	NS	84%
(Multani 2023)					LG vs RG MD= 31 (5.43, 56.57)	P=0.0293	**Robot**	NS

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Conversion to open approach (%)								
(Chen 2017)	n=4	6	16		LG vs RG RR=0.88 (0.36, 2.17)	P=0.78	NS	0%
(Ai 2019)	n=6	9/996	18/1880		OR=1.34 (0.59, 3.01)	P=0.49	NS	0%
(Liao 2019)	n=4	4/578	7/1349		RR=0.00 (-0.01, 0.01)	P=0.67	NS	0%
(Bobo 2019)	n=4	7/365	14/866		OR=1.58 (0.60, 4.14)	P = 0.35	NS	0%

(Guerrini 2020)	n=28	20/3777	67/9584		OR=0.76 (0.45, 1.28)	P = 0.30	NS	1%
(Aiolfi 2021)	n=15	NR	NR	NR	OR= 0.55 (0.18, 1.63)	NR	NS	64.7%
(Feng 2021)	N=4	2301	2567		OR= 0.66 (0.40, 1.07)	P=0.09	NS	0%
(Ali 2022)	N=21	18/2899	55/6415		OR = (0.71 0.38,1.33)	P=0.29	NS	12%
(Jin 2022)	N=7				OR= 0.86 (0.44, 1.66)		NS	0%
(Lacovazzo 2023)		1396	1402		OR= 0.56 (0.34, 0.91)		**Robot**	20%

CI confidence interval; NR not reported; NS not significant; RR relative risk; OR odds ratio; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Length of hospital stays (days)								
(Caruso 2017)	n=6	689		5434	RG vs OG MD=-1.97 (-2.47, -1.18)	P < 0.001	**Robot**	55%
(Chen 2017)	n=19	1830	4123		LG vs RG MD=0.35 (-0.25, 0.95)	P=0.25	NS	82%
(Wang 2017)	n=11	949	2425		MD= -0.65 (-1.53, 0.23)	P=0.15	NS	84%
(Wang 2017)	n=3	165	397		MD= 0.19 (-0.91, 1.30)	P=0.74	NS	0%
(Yang 2017)	n=6	NR	NR	NR	RG vs OG MD= 4.37 (-0.75, 9.49)	P=0.09	NS	99%
(Ai 2019)	n=22	2601	5487		MD= -0.36 (-0.88, 0.16)	P=0.18	NS	87%
(Bobo 2019)	n=14	NR	NR	NR	MD= −0.49 (−0.99, 0.02)	P = 0.06	NS	45%
(Guerrini 2020)	n=39	5060	12231		MD= -0.32 (-0.71, 0.07)	P=0.11	NS	86%
(Liao 2019)	n=8	994	2180		MD= -0.24 (-0.60, 0.11)	P=0.18	NS	0%
(Ma 2020)	n=19	2677	4598		MD=0.23 (-0.53, 0.98)	P=0.56	NS	93%
(Aiolfi 2021)	n=15	NR	NR	NR	RG vs OG MD=-0.29 (-3.21, 2.42) RG vs LG MD=0.66 (-2.03, 3.62)	NP	NS NS	2.7%

(Feng 2021)	N=18	5765	6562		MD=-0.31 (-0.47, -0.15)	P=0.000001	**Robot**	25%
(Zhang 2021)	N=12	1339	1837		MD= -0.21 (-0.88, 0.47)	P=0.55	NS	94%
(Zhang 2021)	N=15	1037	1989		MD= -0.65 (-1.23, -0.07)	P=0.03	**Robot**	87%
(Gong 2022)		1952	2790		MD= -0.65 (-1.27, -0.08)	P=0.03	**Robot**	92%
(Baral 2022)		6136	13912		MD= -0.54 (-0.83, -0.24)	P=0.00003	**Robot**	80%
(Chen 2022)	N=9				RG vs OG MD= -2.21 (-4.32, -0.09)		**Robot**	97%
(Jin 2022)					MD= -0.37 (-0.75, 0.01)	P=0.06	NS	84%
(Sun 2022)		1381	1382		MD= -0.21 (-0.44, 0.01)	P=0.07	NS	0%
(Lacovazzo 2023)		1379	844		MD= 0.68 (-0.74, 2.09)		NS	89%
(Yu 2023)		355	205		MD= -0.81 (-1.25, -0.38)	P=0.00002	**Robot**	0%
(Multani 2023)					LS vs RG MD= -1.89 (-5.77, 1.99)	P=0.3382	NS	NR

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Postoperative complication (%)								
(Wang 2017)	n=12	133/1134	279/2610		OR=1.12 (0.89, 1.41)	P=0.33	NS	0%
(Wang 2017)	n=3	31/165	62/397		OR= 1.37 (0.81, 2.30)	P=0.24	NS	0%
(Yang 2017)	n=7	77/606		648/5364	RG vs OG OR=0.92 (0.57, 1.50)	P=0.75	NS	38%
(Caruso 2017)	n=6	88/689		649/5354	OR=0.95 (0.60, 1.34)	P = 0.65	NS	12%
(Chen 2017)	n=19	1830	4123		LG vs RG RR=0.96 (0.82, 1.13)	P = 0.65	NS	0%
(Bobo 2019)	n=15	190/1487	338/2939		OR=1.05 (0.86, 1.28)	P=0.65	NS	2%

(Liao 2019)	n=8	145/994	309/2180		OR=0.90 (0.72, 1.12)	P=0.34	NS	16%
(Ma 2020)	n=19	286/ 2677	492/4598		OR=1.07 (0.91, 1.25)	P=0.43	NS	0%
(Guerrini 2020)	n=31	643/5043	1535/11268		OR= 0.91 (0.79, 1.04)	P=0.16	NS	24%
(Aiolfi 2021)	n=17				RG vs OG OR=0.69 (0.41, 1.22) RG vs LG OR=0.91 (0.52, 1.67)	NP	NS NS	16%
(Feng 2021)	N=17	4823	5292		OR=0.81 (0.72, 0.91)	P=0.00003	**Robot**	29%
(Zhang 2021)	N=9	144/1149	237/1479		RR= 0.75 (0.62, 0.91)	P=0.003	**Robot**	7%
(Zhang 2021)	N=14	115/ 1122	277/2012		OR= 0.92 (0.72, 1.19)	P=0.54	NS	0%
(Ali 2022)	N=32	529/4484	1086/9101		OR = 0.87 (0.77,0.98)	P=0.02	**Robot**	33%
(Baral 2022)		737/6136	1875/13937		OR=0.88 (0.78, 1.00)	P=0.04	**Robot**	22%
(Chen 2022)	N=11				RG vs OG OR= 0.57 (0.35, 0.93)		**Robot**	65%
(Gong 2022)	N=7	8/1233	8/1741		OR= 1.60 (0.60, 4.29)	P=0.35	NS	0%
(Jin 2022)					OR= 0.81 (0.71, 0.93)	P=0.02	**Robot**	35%
(Sun 2022)		199/1381	228/1382		OR=0.84 (0.68, 1.04)	P=0.11	NS	18%
(Lacovazzo 2023)		3807	3779		OR= 0.79 (0.58, 1.07)	P=0.55	NS	0%
(Ye 2023)	N=4	41/216		119/453	RG vs OG MD= 0.78 (0.52, 1.18)	P=0.24	NS	31%
(Yu 2023)	N=4	16/157	65/669		MD= 0.88 (0.47, 1.63)	P=0.68	NS	0%

CI confidence interval; NR not reported; NS not significant; RR relative risk; OR odds ratio; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

*lymphatic complications

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				

Time to first flatus (days)								
(Chen 2017)[151, 153, 159, 160, 162, 166]	n=9	713	1231		LG vs RG MD=0.09 (-0.10, 0.27)	P= 0.36	NS	74%
(Ai 2019)	n=13	1557	2570		MD=-0.2 (-0.53, 0.14)	P=0.25	NS	98%
(Bobo 2019)	n=7	NR	NR	NR	MD= - 0.20 (-0.42, - 0.02)	P = 0.07	NS	53%
(Guerrini 2020)	n=20	2344	4566		MD= -0.19 (-0.45, 0.07)	P<0.16	NS	98%
(Ma 2020)	n=13	1888	2847		LG vs RG MD=0.16 (0.06, 0.27)	P=0.003	**Robot**	65%
(Aiolfi 2021)	NR	NR	NR	NR	RG vs OG MD=-0.52 (-1.11, -0.30) RG vs LG MD=0.32 (-0.56, 1.19)	NP	**Robot** NS	2.7%
(Feng 2021)	N=12	4270	4538		MD= -0.14 (-0.22, -0.07)	P=0.00003	**Robot**	65%
(Zhang 2021)	N=8	1073	1365		MD= -0.13 (-0.22, -0.44)	P=0.005	**Robot**	71%
(Baral 2022)		3084	5322		MD= -0.20 (-0.42, 0.02)	P=0.08	NS	97%
(Gong 2022)	N=5	599	519		MD= -0.23 (-0.59, 0.13)	P=0.22	NS	78%
(Jin 2022)					MD= -0.11 (-0.21, -0.00)	P=0.044	**Robot**	65%
(Sun 2022)		1099	1100		MD= -0.08 (-0.13, -0.02)	P=0.006	**Robot**	44%
(Lacovazzo 2023)		954	964		MD= -0.32 (-0.55, -0.09)		**Robot**	84%
(Yu 2023)		56	73		MD= -0.76 (-0.60, -0.32)	P<0.00001	**Robot**	49%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Time to oral intake (days)								
(Chen 2017)	n=9	1096	2055		LG vs RG MD=0.23 (0.13, 0.34)	P<0.0001	**Robot**	0%
(Guerrini 2020)	n=22	2828	5123		MD= -0.20 (-0.30, -0.10)	P<0.0001	**Robot**	58%

(Aiolfi 2021)		NR	NR	NR	RG vs OG MD=-0.39 (-3.95, 3.14) RG vs LG MD=0.03 (-3.81, 3.88)	NP	NS NS	7.1%
(Feng 2021)	N=15	4604	5673		MD= -0.12 (-0.18, -0.06)	P=0.00001	**Robot**	20%
(Zhang 2021)	N=7	747	760		MD= -0.0 (-0.28, -0.12)	P<0.00001	**Robot**	7%
(Zhang 2021)	N=11	748	758		MD= -0.31 (0.43, -0.18)	P<0.00001	**Robot**	51%
(Baral 2022)		3855	7160		MD= -0.20 (-0.29, -0.10)	P<0.00001	**Robot**	53%
(Gong 2022)		1312	1618		MD= -0.08 (-0.17, 0.01)	P=0.07	NS	0%
(Sun 2022)		623	623		MD= -0.04 (-0.31, 0.23)	P=0.78	NS	0%
(Yu 2023)		56	73		MD= -0.46 (-0.74, -0.19)	P=0.0010	**Robot**	0%
(Feng 2021)	N=15	4604	5673		MD= -0.12 (-0.18, -0.06)	P=0.00001	**Robot**	20%
(Zhang 2021)	N=7	747	760		MD= -0.0 (-0.28, -0.12)	P<0.00001	**Robot**	7%
(Zhang 2021)	N=11	748	758		MD= -0.31 (0.43, -0.18)	P<0.00001	**Robot**	51%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Postoperative mortality (%)								
(Chen 2017)	n=7	838	2131		RG vs LG RR =0.67 (0.26, 1.74)	P=0.41	NS	0%
(Bobo 2019)	n=8	5/808	9/2087		RG vs LG OR= 1.35 (0.49, 3.76)	NR	NS	0%
(Liao 2019)	n=4	4/578	3/1349		RG vs LG RD= 0.01 (0.00, 0.01)	P = 0.19	NS	0%
(Ma 2020)	n=5	7/768	7/1356		LG vs RG OR = 0.67 (0.24, 1.90)	P= 0.450	NS	0%
(Aiolfi 2021)		NR	NR	NR	RG vs OG	NR	NS	NR

					RR=0.93 (0.43, 2.01) RG vs LG RR=0.58 (0.22, 1.55)			

CI confidence interval; RD risk difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
Reoperation rate (%)								
(Chen 2017)	n=7	789	1796		LG vs RG RR=0.69 (0.29, 1.62)	P=0.39	NS	11%
(Bobo 2019)	n=5	16/754	16/1400		OR= 1.72 (0.89, 3.35)	P = 0.11	NS	45%
(Guerrini 2020)		25/1939	55/4467		OR= 1.01 (0.60, 1.68)	P=0.98	NS	0%
(Aiolfi 2021)	n=10	NR	NR	NR	RG vs OG OR= 0.87 (0.41, 1.88) RG vs LG OR=0.82 (0.33, 2.05)	NP	NS NS	0%
(Feng 2021)	N=5	1197	1464		OR= 0.63 (0.33, 1.20)	P=16	NS	0%
(Baral 2022)		30/2192	60/4693		OR= 1.05 (0.68, 1.62)	P=0.83	NS	0%
(Jin 2022)					OR= 0.86 (0.44, 1.66)	P=0.65	NS	0%
(Feng 2021)	N=5	1197	1464		OR= 0.63 (0.33, 1.20)	P=16	NS	0%

CI confidence interval; NR not reported; NS not significant; RR relative risk; OR odds ratio; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	Studies included, n	Participant, N			Pooled effect (95%CI)	P-value	Favours	I^2
		Robot	Laparoscopy	Open				
Recurrence rate (%)								
(Pan 2017)	n=4	23/273	99/941		OR=0.88 (0.54, 1.44)	P=0.62	NS	0%
(Chen 2017)	n=3	500	187		RR=1.09 (0.57, 2.05)	P=0.80	NS	0%

(Liao 2019)	n=7	109/863	255/1917		OR=0.92 (0.71, 1.19)	P=0.53	NS	0%
(Ma 2020)	n=5	129/1038	102/757		LG vs RG OR=0.90 (0.67, 1.21)	P=0.50	NS	0%
(Guerrini 2020)	n=10	131/1322	263.1942		OR=0.86 (0.67, 1.11)	P=0.25	NS	0%
(Wu 2021)	N=9	121/1100	281/2170		OR= 0.88 (0.69, 1.12)	P=0.31	NS	0%
(Zhang 2021)	N=3	23/231	31/222		OR=0.69 (0.39, 1.23)	P=0.21	NS	0%
(Wu 2021)	N=9	121/1100	281/2170		OR= 0.88 (0.69, 1.12)	P=0.31	NS	0%
(Zhang 2021)	N=3	23/231	31/222		OR=0.69 (0.39, 1.23)	P=0.21	NS	0%

CI confidence interval; NR not reported; NS not significant; RR relative risk; OR odds ratio; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Number of harvested lymph nodes								
(Caruso 2017)	n=6	689		5434	MD=-1.12 (-2.31, 0.58)	P = 0.10	NS	25%
(Chen 2017)	n=17	1585	3220		LG vs RG MD= -1.44 (-3.26, 0.37)	P=0.12	NS	86%
(Wang 2017)	n=10	849	2143		MD=0.91 (-1.16, 2.99)	P=0.39	NS	70%
(Wang 2017)	n=2	85	115		MD= −0.23 (−3.80, 3.35)	P=0.90	NS	0%
(Yang 2017)	n=7	NR	NR	NR	RG vs OG MD= -1.36 (-3.69, 0.97)	P=0.25	NS	67%
(Ai 2019)	n=21	2413	4592		MD=1.92 (0.34, 3.50)	P=0.02	Laparoscopy	86%
(Bobo 2019)	n=14				MD= 1.81 (0.00, 3.62)	P = 0.05	Laparoscopy	74%
(Guerrini 2020)	n=36	4731	10900		MD= 1.84 (0.84, 2.84)	P= 0.0003	Laparoscopy	79%
(Ma 2020)	n=19	2677	4598		LG vs RG MD= -0.96 (-2.12, 0.20)	P=0.10	NS	83%
(Aiolfi 2021)	n=17				RG vs OG MD=1.04 (-4.62, 6.64)	NP	NS NS	6.5%

					RG vs LG MD=3.16 (-2.49, 9.16)			
(Feng 2021) *	N=16	5004	5837		MD= 1.75 (0.90, 2.60)		Laparoscopy	70%
(Zhang 2021) *	N=11	1206	1570		MD= 1.65 (-0.14, 3.44)	P=0.07	NS	91%
(Zhang 2021) *	N=15	1170	1914		MD= 3.52 (2.07, 4.99)	P<0.00001	Laparoscopy	82%
(Ali 2022)	N=28	3813	7691		MD= 2.62 (2.14,3.11)	P<0.0001	Laparoscopy	77%
(Gong 2022)*		2061	2950		MD= 2.41 (0.77, 4.05)	P<0.004	**Robot**	86%
(Baral 2022) *		5930	13082		MD= 2.81 (1.99, 3.63)	P<0.0001	Laparoscopy	87%
(Chen 2022)	N=3				RG vs OG MD= -1.15 (-5.43, 3.14)		NS	90$
(Jin 2022) *					MD= 2.03 (0.95, 3.10)	P<0.001	Laparoscopy	
(Sun 2022)		1240	1240		MD= 3.46 (2.94, 3.98)	P<0.00001	**Robot**	24%
(Davey 2023)					RG vs OG MD= –1.95 (–5.77, 1.25)		NS	

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

*the number of resected lymph nodes

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I²**
		Robot	Laparoscopy	Open				
Proximal resection margin (cm)								
(Chen 2017)	n=9	1024	2006		MD=-0.14 (-0.36, 0.07)	P=0.18	NS	26%
(Wang 2017)	n=5	723	1733		MD= 0.10 (-0.08, 0.28)	P=0.26	NS	4%
(Yang 2017)	n=3	NR	NR	NR	RG vs OG MD= 0.10 (-0.43, 0.64)	P=0.70	NS	72%
(Bobo 2019)	n=6				MD=0.034 (− 0.012, 0.081)	P = 0.15	NS	0%
(Guerrini 2020)	n=13	1940	4978		MD= 0.01 (-0.14, 0.17)	P=0.87	NS	23%
(Ma 2020)	n=7	761	1252		LG vs RG	P=0.30	NS	28%

					MD= -0.10 (-0.29, 0.09)			
(Feng 2021)	N=6	1117	1319		MD= -0.02 (-0.20, 0.17)	P=0.85	NS	0%
(Zhang 2021)	N=5	3434	655		MD= -0.24 (-0.68, 0.19)	P=0.27	NS	66%
(Ali 2022)	N=12	1519	3315		MD =0.07 (-0.07, 0.22)	P=0.30	NS	80%
(Gong 2022)	N=6	1117	1614		MD= 0.22 (-0.04, 0.48)	P=0.10	NS	37%
(Jin 2022)					MD= -0.005 (-1.72, 0.161)	P=0.949	NS	0%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
Distal resection margin (cm)								
(Wang 2017)	n=5	723	1733		MD= 0.18 (-0.67, 1.03)	P=0.88	NS	88%
(Yang 2017)	n=3	NR	NR	NR	RG vs OG MD=0.52 (-0.76, 1.79)	P-0.43	NS	91%
(Chen 2017)	n=8	NR	NR	NR	MD=0.09 (-0.46, 0.65)	P=0.74	NS	81%
(Bobo 2019)	n=5	NR	NR	NR	MD=0.073 (−0.047, 0.193)	P = 0.23	NS	64%
(Guerrini 2020)	n=12	1889	4920		MD=0.27 (-0.15, 0.69)	P=0.21	NS	79%
(Ma 2020)	n=5	710	1194		LG vs RG MD= 0.15 (-0.21, 0.53)	P=0.41	NS	59%
(Feng 2021)	N=6	1117	1319		MD= 0.07 (-0.13, 0.27)	P=0.51	NS	12%
(Zhang 2021)	N=5	3434	655		MD= 0.21 (0.02, 0.04)	P=0.03	Laparoscopy	0%
(Ali 2022)	N=11	1468	3257		MD =0.13 (-0.05, 0.32)	P=0.15	NS	80%
(Gong 2022)	N=6	1176	1614		MD= -0.08 (-0.42, 0.25)	P=0.63	NS	66%
(Jin 2022)					MD= -0.57 (-0.97, -0.20)	P=0.03	**Robot**	52%

CI confidence interval; MD mean difference; NR not reported; NS not significant; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				

5-year overall survival rate								
(Pan 2017)	n=3	NR	NR	NR	HR=1.32 (0.94, 1.87)	P=0.11	NS	0%
(Ai 2019)	n=3	393/495	549/645		OR=0.54 (0.22, 1.33)	P=0.18	NS	79%
(Bobo 2019)	n=3	NR	NR	NR	HR=1.15 (0.51, 2.59)	P=0.73	NS	0%
(Liao 2019)	n=8	NR	NR	NR	HR= 0.98 (0.80, 1.20)	P=0.81	NS	0%
(Ma 2020)	n=6	890	1498		LG vs RG HR=0.95 (0.76, 1.18)	P=0.64	NS	0%
(Feng 2021)	N=7	3475	4106		OR=0.96 (0.86, 1.07)	P=0.50	NS	0%
(Wu 2021)	N=11				HR= 0.97 (0.80, 1.19)	P=0.80	NS	0%
(Baral 2022) (3 year)	N=12	1665/1926	3854/4857		OR= 1.19 (0.70, 2.20)	P=0.52	NS	88%
(Jin 2022) (3 year)					OR= 0.10 (0.78, 1.35)	P=0.83	NS	1.2%

CI confidence interval; NR not reported; NS not significant; HR hazard ratio; OR odds ratio; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

Outcome	**Studies included, n**	**Participant, N**			**Pooled effect (95%CI)**	**P-value**	**Favours**	**I^2**
		Robot	Laparoscopy	Open				
5-year disease-free survival rate								
(Pan 2017)	n=2	NR	NR	NR	HR 1.57 (0.82, 3.00)	P=0.17	NS	0%
(Ai 2019)	n=2	328/362	341/369		OR=0.79 (0.47, 1.33)	P=0.38	NS	0%
(Bobo 2019)	n=2	NR	NR	NR	HR=2.24 (0.79, 6.35)	P=0.13	NS	0%
(Liao 2019)*	n=8	NR	NR	NR	HR=0.92 (0.72, 1.19)	P=0.53	NS	0%
(Ma 2020)*	n=3	586	586		LG vs RG HR=0.91 (0.69, 1.21)	P=0.53	NS	0%
(Feng 2021) *	N=5	2732	2732		OR= 0.98 (0.80, 1.21)	P=0.85	NS	0%
(Wu 2021)	N=6				HR= 0.94 (0.72, 1.23)	P=0.65	NS	0%

CI confidence interval; NR not reported; NS not significant; HR hazard ratio; OR odds ratio; RG robotic gastrectomy; LG laparoscopic gastrectomy; OG open gastrectomy

*Relapse-free survival (RFS)

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