Mini-CAT 2 **Fredrique Green**

Clinical Question:

On my surgery rotation, Wednesdays were reserved for robotic surgeries, which included robot-assisted: cholecystectomies, appendectomies, and hernia repairs. Although utilization of the robot was fairly new to the general surgery service, I was able to observe 3 robot-assisted cholecystectomies, and noticed that operating time was longer than that of laparoscopic because of robot set-up. Given this longer operating time and that the laparoscopic approach is still the gold standard approach for cholecystectomies, I wondered how the robot-assisted approach compares to the laparoscopic and what benefits it yields that justify its use instead.

PICO Question:

In adult patients with uncomplicated gallbladder disease (symptomatic cholelithiasis, uncomplicated cholecystitis) undergoing cholecystectomy, how does robot-assisted cholecystectomy (RC) compare to laparoscopic cholecystectomy (LC) in terms of peri- and postoperative outcomes?

P	I	C	O
Adult cholecystectomy	Robot-assisted	Laparoscopic	Postoperative outcomes
Uncomplicated cholecystectomy	Robot-assisted cholecystectomy	Laparoscopic cholecystectomy	Perioperative outcomes
			Operative outcomes
			Operative complications
			Recovery

<u>Search Strategy</u>:

- PubMed:
  - robot vs laparoscopic cholecystectomy operative outcomes (filters: 2014-2024): 36 results
  - robot assisted cholecystectomy laparoscopic operative outcomes (filters: 2014-2024): 94 results
- Cochrane:
  - robot vs laparoscopic cholecystectomy operative outcomes: 10 results
  - robot-assisted cholecystectomy laparoscopic postoperative complications: 22 results
- TRIP Database:
  - robot vs laparoscopic cholecystectomy operative outcomes: 92 results
  - robot vs laparoscopic cholecystectomy complications: 94 results
- Google Scholar:
  - robot assisted cholecystectomy laparoscopic operative outcomes (filters: 2014-2024): 16,100 results

My searches yielded enough results that I could focus on very recent articles, so I began my selection with articles published within the last 10 years. I was able to find very recent articles, I assume because of the recent widespread adoption of robotic-assisted surgeries. I realized while searching that “perioperative complications” and “postoperative complications” are broad topics, so I chose articles that measured similar outcomes to keep what I considered an “outcome” more narrow and manageable. I chose as many systematic reviews and meta-analyses as I could find to keep the level of evidence as high as possible. I also incorporated a couple of cohort studies because I believe that their observational nature best aligns with studying outcomes in real-world settings, and because they allow for longitudinal follow-up of patients post-surgery, which is crucial for assessing *both* perioperative and postoperative outcomes, including recovery time, complications, and pain.

Articles Chosen:

Article 1:

Citation:
Singh A, Kaur M, Swaminathan C, Siby J, Singh KK, Sajid MS. Laparoscopic versus robotic cholecystectomy: a systematic review with meta-analysis to differentiate between postoperative outcomes and cost-effectiveness. *Transl Gastroenterol Hepatol*. 2024;9:3. Published 2024 Jan 12. doi:10.21037/tgh-23-56

Abstract:

Background

Robotic cholecystectomy (RC) has shown promising outcomes in multiple studies when compared with the gold standard laparoscopic cholecystectomy (LC). The objective of this study is to compare the postoperative surgical outcomes and cost in patients undergoing RC versus LC.

Methods

Studies reporting postoperative outcomes and costs in patients undergoing RC versus LC were selected from medical electronic databases and analysis was conducted by the values of systematic review on the statistical software RevMan version 5.

Results

Six trials on 1,013 affected individuals for post-operative outcomes and cost comparison were used. Random effect model analysis was used in the analysis. Duration of operation (mean difference: −10.23, 95% CI: −16.23 to −4.22, Z=3.34, P=0.0008) was shorter in the LC group with moderate heterogeneity. Bile leak (odds ratio: 3.34, 95% CI: 0.85 to 13.03, Z=1.73, P=0.08) and no heterogeneity was seen, Postoperative complications (odds ratio: 1.49, 95% CI: 0.50 to 4.46, Z=0.72, P=0.47) with moderate heterogeneity. Both were statistically similar. LC had reduced cost (standardised mean difference: −7.42, 95% CI: −13.10 to −1.74, Z=2.56, P=0.01) with significant heterogeneity.

Conclusions

RC failed to prove any clinical advantage over LC for postoperative outcomes including longer duration of operation moreover LC was more cost effective. Due to the paucity of randomised control trial (RCT) and significant heterogeneity, a major multicentre RCT is required to strengthen and validate the findings.

PDF: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10838610/pdf/tgh-09-23-56.pdf

Article 2:

Citation: Kalata S, Thumma JR, Norton EC, Dimick JB, Sheetz KH. Comparative Safety of Robotic-Assisted vs Laparoscopic Cholecystectomy. *JAMA Surg*. 2023;158(12):1303-1310. doi:10.1001/jamasurg.2023.4389

Abstract:

Importance: Robotic-assisted cholecystectomy is rapidly being adopted into practice, partly based on the belief that it offers specific technical and safety advantages over traditional laparoscopic surgery. Whether robotic-assisted cholecystectomy is safer than laparoscopic cholecystectomy remains unclear.

Objective: To determine the uptake of robotic-assisted cholecystectomy and to analyze its comparative safety vs laparoscopic cholecystectomy.

Design, setting, and participants: This retrospective cohort study used Medicare administrative claims data for nonfederal acute care hospitals from January 1, 2010, to December 31, 2019. Participants included 1 026 088 fee-for-service Medicare beneficiaries 66 to 99 years of age who underwent cholecystectomy with continuous Medicare coverage for 3 months before and 12 months after surgery. Data were analyzed August 17, 2022, to June 1, 2023.

Exposure: Surgical technique used to perform cholecystectomy: robotic-assisted vs laparoscopic approaches.

Main outcomes and measures: The primary outcome was rate of bile duct injury requiring definitive surgical reconstruction within 1 year after cholecystectomy. Secondary outcomes were composite outcome of bile duct injury requiring less-invasive postoperative surgical or endoscopic biliary interventions, and overall incidence of 30-day complications. Multivariable logistic analysis was performed adjusting for patient factors and clustered

within hospital referral regions. An instrumental variable analysis was performed, leveraging regional variation in the adoption of robotic-assisted cholecystectomy within hospital referral regions over time, to account for potential confounding from unmeasured differences between treatment groups.

Results: A total of 1 026 088 patients (mean [SD] age, 72 [12.0] years; 53.3% women) were included in the study. The use of robotic-assisted cholecystectomy increased 37-fold from 211 of 147 341 patients (0.1%) in 2010 to 6507 of 125 211 patients (5.2%) in 2019. Compared with laparoscopic cholecystectomy, robotic-assisted cholecystectomy was associated with a higher rate of bile duct injury necessitating a definitive operative repair within 1 year (0.7% vs 0.2%; relative risk [RR], 3.16 [95% CI, 2.57-3.75]). Robotic-assisted cholecystectomy was also associated with a higher rate of postoperative biliary interventions, such as endoscopic stenting (7.4% vs 6.0%; RR, 1.25 [95% CI, 1.16-1.33]). There was no significant difference in overall 30-day complication rates between the 2 procedures. The instrumental variable analysis, which was designed to account for potential unmeasured differences in treatment groups, also showed that robotic-assisted cholecystectomy was associated with a higher rate of bile duct injury (0.4% vs 0.2%; RR, 1.88 [95% CI, 1.14-2.63]).

Conclusions and relevance: This cohort study's finding of significantly higher rates of bile duct injury with robotic-assisted cholecystectomy compared with laparoscopic cholecystectomy suggests that the utility of robotic-assisted cholecystectomy should be reconsidered, given the existence of an already minimally invasive, predictably safe laparoscopic approach.

PDF: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10512167/?report=printable

Article 3:

Citation:

Lee EK, Park E, Oh WO, Shin NM. Comparison of the outcomes of robotic cholecystectomy and laparoscopic cholecystectomy [published correction appears in Ann Surg Treat Res. 2017 Oct;93(4):229. doi: 10.4174/astr.2017.93.4.229]. *Ann Surg Treat Res*. 2017;93(1):27-34. doi:10.4174/astr.2017.93.1.27

Background

Rapid adoption of robotic-assisted general surgery procedures, particularly for cholecystectomy, continues while questions remain about its benefits and utility. The objective of this study was to compare the clinical effectiveness of robot-assisted cholecystectomy for benign gallbladder disease as compared with the laparoscopic approach.

Methods

A literature search was performed from January 2010 to March 2020, and a narrative analysis was performed as studies were heterogeneous.

Results

Of 887 articles screened, 44 met the inclusion criteria (range 20–735,537 patients). Four were randomized controlled trials, and four used propensity-matching. There were variable comparisons between operative techniques with only 19 out of 44 studies comparing techniques using the same number of ports. Operating room time was longer for the robot-assisted technique in the majority of studies (range 11–55 min for 22 studies, $p < 0.05$; 15 studies showed no difference; two studies showed shorter laparoscopic times), while conversion rates and intraoperative complications were not different. No differences were detected for the length of stay, surgical site infection, or readmissions. Across studies comparing single-port robot-assisted to multi-port laparoscopic cholecystectomy, there was a higher rate of incisional hernia; however, no differences were noted when comparing single-port robot-assisted to single-port laparoscopic cholecystectomy.

Conclusions

Clinical outcomes were similar for benign, elective gallbladder disease for robot-assisted compared with laparoscopic cholecystectomy. Overall, the rates of complications were low. More high-quality studies are

needed as the robot-assisted technique expands to more complex gallbladder disease, where its utility may prove increasingly beneficial.

PDF: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8067374/pdf/13643_2021_Article_1673.pdf

Article 4:

Citation: Straatman J, Pucher PH, Knight BC, et al. Systematic review: robot-assisted versus conventional laparoscopic multiport cholecystectomy. *J Robot Surg*. 2023;17(5):1967-1977. doi:10.1007/s11701-023-01662-3

Abstract: Laparoscopic cholecystectomy has become the standard of care for the treatment of symptomatic gallstone disease. In the context of the increasing uptake of robotic surgery, robotic cholecystectomy has seen a substantial growth over the past decades. Despite this, a formal assessment of the evidence for this practice remains elusive and a randomised controlled trial is yet to be performed. This paper reviews the evidence to date for robotic multiport cholecystectomy compared to conventional multiport cholecystectomy. This systematic review was performed conducted using the Medline, Embase and Cochrane databases; in line with the PRISMA guideline. All articles that compared robotic and conventional laparoscopic cholecystectomy were included. The studies were assessed with regards to operative outcomes, postoperative recovery and complications. Fourteen studies were included, describing a total of 3002 patients. There was no difference in operative blood loss, complication rates, incidence of bile duct injury or length of hospital stay between the robotic and laparoscopic groups. The operative time for robotic cholecystectomy was longer, whereas the risk of conversion to open surgery was lower. There was marked variation in definitions of measured outcomes, and most studies lacked data on training and quality assessment, leading to substantial heterogeneity of the data. Available evidence on multiport robotic cholecystectomy compared to conventional laparoscopic cholecystectomy is scarce and the quality of the available studies is generally poor. Results suggest longer operating time for robotic cholecystectomy, although many studies included the learning curve period. Postoperative recovery and complications were similar in both groups.

PDF: Systematic review: robot-assisted versus conventional laparoscopic multiport cholecystectomy

Article 5:

Citation: Lee SM, Lim JH. Comparison of outcomes of single incision robotic cholecystectomy and single incision laparoscopic cholecystectomy. *Ann Hepatobiliary Pancreat Surg*. 2021;25(1):78-83. doi:10.14701/ahbps.2021.25.1.78

Abstract:

Backgrounds/Aims

Multiport laparoscopic cholecystectomy is the standard surgical procedure for symptomatic gallbladder diseases. However, as a result of the ongoing trend toward minimally invasive laparoscopy, single-incision laparoscopic cholecystectomy (SILC) has evolved. Single-incision robotic cholecystectomy (SIRC) can overcome several limitations of manual SILC. The purpose of this study is to evaluate and compare the safety and feasibility of SIRC and SILC.

Methods

This study retrospectively reviewed data for all patients who underwent SIRC or SILC from March 2018 to July 2019 in a single institution. The following variables were analyzed: age, sex, body mass index, pain scale, length of stay, and complications. The data were analyzed using the Independent two sample t-test or the Fisher's exact test.

Results

A total of 343 patients underwent SIRC or SILC during the study period. After excluding patients with acute cholecystitis, 197 SIRC and 103 SILC patients were analyzed in this study. The surgery time and postoperative hospital stay did not differ between SIRC and SILC. However, the SIRC patients experienced less bile spillage during the surgery than did the SILC patients (SIRC vs. SILC: 24 (23.3%) vs. 11 (5.6%) cases, respectively; p<0.001). Although there was no difference in the incidence of postoperative complications between procedures, additional pain control was administered more frequently in SILC patients (SILC 1.08±0.893, SIRC 0.58±0.795; p<0.001).

Conclusions

While both SILC and SIRC are effective for single-incision cholecystectomy, SIRC was superior to SILC in terms of technical stability. Moreover, it has the advantage of postoperative pain control.

PDF: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7952663/pdf/ahbps-25-1-78.pdf

Summary of the Evidence:

Author (Date)	Level of Evidence	Sample/Setting (# of subjects/ studies, cohort definition etc.)	Outcome(s) studied	Key Findings	Limitations and Biases
Anurag Singh, Mandeep Kaur, Christie Swaminathan, Jayas Siby, Krishna K. Singh, Muhammad S. Sajid; 2024	Systematic review and meta-analysis	1) 1,013 patients across 7 studies (6 of which focused on postoperative outcomes) in total for postoperative outcomes. 2) 642 patients undergoing laparoscopic cholecystectomy were placed in the LC group. 3) 371 patients undergoing robot-assisted cholecystectomy were placed in the RC group. 4) For cost comparison, 817 patients were analyzed.	1) Primary outcomes: duration of operation, bile leak rates, conversion rates, overall postoperative complications. 2) Cost outcomes: procedural cost comparison between RC and LC.	1) LC had a shorter mean operation duration compared to RC (mean difference: 10.23 minutes less) 2) There was no significant difference in overall postoperative complications between RC and LC. 3) There was no significant difference in bile leak rates between RC and LC. 4) LC was associated with significantly lower procedural costs compared to RC (standardized mean difference: -7.42).	1) Some studies had no blinding and also had manual randomization, which potentially introduced bias. 2) The review included 3 RCTs and 3 comparative trials. This limited number of RCTs necessitates caution in drawing strong conclusions, as they have different levels of evidence quality. 3) Some studies compared single incision LC to RC, while others compared multiport LC to RC, which can create potential inconsistencies in comparisons between the two. 4) There was variability in blinding methods across studies (single, double, no blinding),

					which could also create potential inconsistencies in comparisons.
Stanley Kalata, Jyothi R. Thumma, Edward C. Norton, Justin B. Dimick, and Kyle H. Sheetz; 2023	Retrospective cohort study	1) The study included 1,026,088 fee-for-service Medicare patients aged 66 to 99 years who underwent cholecystectomy between 2010 and 2019. 2) Patients were identified using Medicare claims data; those with certain cancers were excluded.	1) Primary outcome: bile duct injury requiring surgical repair within 1 year post-cholecystectomy. 2) Secondary outcomes: postoperative biliary interventions (either endoscopic or surgical), 30-day overall complication rates, and serious complication rates (defined as: hospital stay >75th percentile).	1) Robotic-assisted cholecystectomy was associated with a higher risk of bile duct injury compared to laparoscopic cholecystectomy (0.7% robot vs. 0.2% laparoscopic). 2)) Higher rates of biliary interventions were observed with robotic-assisted cholecystectomy (7.4% robot vs. 6.0% laparoscopic). 3) Serious complications were more frequently with robotic-assisted compared to laparoscopic (9.3% robot vs. 8.6% laparoscopic). 4) There was no significant difference in 30-day overall complication rates between the two procedures. 5) There has been increasing adoption of robotic technology, surgical specialties, driven by technological advancements that promise enhanced precision, better visualization, and maneuverability. However, this adoption trend may not always align with clear clinical	1) The retrospective nature and use of administrative claims data may introduce coding inaccuracies. 2) Confounding variables (e.g. severity of gallbladder inflammation, intraoperative conversions) were not fully accounted for, potentially introducing vias. 3) All subjects were Medicare beneficiaries, which may limit generalizability of findings.

				benefits, especially for complex cases where there is lack of clear evidence on the advantages of robotic technology over traditional laparoscopy.	
Rivfka Shenoy, Michael A. Mederos, Linda Ye, Selene S. Mak, Meron M. Begashaw, Marika S. Booth, Paul G. Shekelle, Mark Wilson, William Gunnar, Melinda Maggard-Gibbons, Mark D. Girgis; 2017	Systematic review	1) 44 studies were included, which included a range of 20 to 735,537 patients across studies. 2) Patients undergoing elective cholecystectomy for non-cancer indication were included. 3) The review included 4 RCTs, 4 propensity-matched studies, 36 observational studies.	1) OR time 2) Intraoperative complications 3) Conversion rates (to open) 4) Length of stay (LOS) 5) Surgical site infections (SSI) 6) Readmissions 7) Pain 8) Incisional hernia rates	1) OR time was generally longer for robot-assisted cholecystectomy compared to laparoscopic. 2) No significant differences in intraoperative complications were found between techniques. 3) Conversion rates were similar between robot-assisted and laparoscopic techniques. 4) There were no conclusive differences in LOS observed between techniques. 5) Rates of SSIs were similar between robot-assisted and laparoscopic groups. 6) There was limited data on readmissions, but of the data included (in one propensity-matched study), lower rates were observed in the robot-assisted group.	1) The mix of varying methodologies (RCTs, propensity-matched, observational studies) can create inconsistent results.

				7) Pain had heterogeneous results across studies, making it difficult to draw conclusive comparisons.	
Jennifer Straatman, Phil H Pucher, Ben C Knight, Nick C Carter, Michael A Glaysher, Stuart J Mercer, Gijsbert I van Boxel; 2023	Systematic review	1) 14 articles were included, comprising 3002 patients. 2) Studies included 1 propensity matched study, 2 case-control studies, and 11 observational cohort studies. 3) Patients were grouped into undergoing multiport robotic cholecystectomy (RC) or conventional multiport laparoscopic cholecystectomy (LC).	1) Operating time 2) Blood loss 3) Conversion 4) Postoperative recovery (e.g. length of hospital stay, pain management) 5) Complications (e.g. overall, bile duct injuries) 6) Cost	1) RC has a longer operative time but lower conversion rates to open surgery compared to LC. 2) Postoperative recovery outcomes measured were similar between RC and LC. 3) Across the studies, costs associated with RC were higher than LC.	1) Most studies included were rated as poor or fair quality due to unclear cohort selection criteria and inadequate reporting. 2) Surgeon experience and training protocols were heterogeneous and inconsistently reported, potentially influencing outcomes. 3) Lack of standardized reporting across studies can introduce publication bias.
Sun Min Lee, Jin Hong Lim; 2021	Observational cohort study	1) 343 patients underwent single-incision cholecystectomy (220 robot, 123 laparoscopic) from June 2018 to February 2019 2) Exclusion criteria: >70 years old, those intolerant to single-port laparoscopic surgery, history of specific conditions (e.g. upper abdominal surgery, gallbladder empyema).	1) Surgery time 2) Conversion rate to open 3) Intraoperative complications (e.g., bile spillage) 4) Postoperative complications 5) Length of stay 6) Pain scale scores 7) Need for additional pain treatments.	1) Mean surgery time was similar between SILC (60.66 minutes) and SIRC (63.35 minutes). 2) No significant difference in bleeding volume. 3) Bile spillage occurred more frequently in SILC compared to SIRC. 4) 1 SILC patient required conversion to multiport laparoscopic cholecystectomy due to hepatic artery bleeding; no	1) This study was done at a single center and was retrospective, which limits generalizability. 2) There were small sample size for certain subgroups, which also limits broader conclusions. 3) The retrospective nature could lead to incomplete or inconsistent data collection, impacting study validity. 4) Surgeon experience with SIRC and SILC could influence outcomes.

				open conversions were noted. 5) Similar rates of postoperative complications were observed between SILC and SIRC (subhepatic abscess, wound issues) 6) Mean stay in hospital was comparable between SILC (1.51 days) and SIRC (1.46 days). 7) Immediate postoperative and subsequent VAS (visual analog scale) scores were similar between SILC and SIRC groups. However, SILC patients required more additional pain control treatments than SIRC patients.	5) SIRC is a limited option available to patients who can afford its additional costs, potentially affecting patient selection and outcomes.

Conclusion(s):

Article 1: RC did not demonstrate any clinical advantage over LC in terms of postoperative outcomes, RC had similar rates of bile leakage and overall complications, and LC was identified as more cost-effective compared to RC. However, due to significant heterogeneity among studies and the limited number of RCTs, there is the need for larger RCTs (preferably multicenter) to strengthen and validate the findings. Ultimately, while RC shows promise, its clinical benefits compared to LC warrant further investigation and confirmation in larger, more rigorous trials.

Article 2: There has been a significant increase in the adoption of robotic-assisted surgery over the study period from 2010 to 2019. During this study period, RC was associated with higher rates of bile duct injury requiring surgical repair compared to LC. This finding persisted across different patient subgroups and was supported by instrumental variable analysis (a statistical method that identifies and addresses potential biases caused by unmeasured variables) to mitigate potential biases. Overall complication rates were also similar between the two approaches. Based on these results, the safety, utility, and clinical justification for adopting RC when LC is already an established, minimally invasive procedure with lower complication rates, should be called into question.

Article 3: Generally, RC resulted in longer operating room times compared to LC (median difference of 38 minutes based on RCTs). There were no significant differences in intraoperative complications, conversion rates, length of stay, surgical site infections, readmissions, or pain outcomes between the two techniques. Rates of postoperative incisional hernias may vary depending on the number of ports used (single-port RC was potentially

associated with higher hernia rates compared to multi-port LC). Additionally, there is a need for further studies that focus on standardized outcome measurements to better understand the comparative effectiveness of RC and LC.

Article 4: RC is associated with longer operative times compared to LC, *but* it demonstrated a lower conversion rate to open surgery. Postoperative recovery and complication rates (overall complications and bile duct injuries) were similar between RC and LC. However, issues such as unclear selection criteria, lack of standardized outcomes, and variable surgeon experience with robotic techniques yielded poor evidence quality across studies. This poor quality evidence emphasizes the need for more robust RCTs to better comparatively assess the safety and efficacy (in terms of outcomes and recovery) of RC compared to LC for routine clinical practice.

Article 5: Both SIRC and SILC showed similar outcomes in terms of surgery duration, bleeding, and postoperative complications. SIRC demonstrated advantages in technical stability and pain management - specifically, it resulted in fewer instances of bile spillage and required less additional pain control compared to SILC. Despite higher costs and the acknowledgment that those higher costs limit patient accessibility, SIRC may offer improved surgical outcomes.

Overall conclusion: The comparison betweens the operative outcomes (both peri- and post-) of robot-assisted cholecystectomy (RC) and laparoscopic cholecystectomy (LC) in adult patients undergoing cholecystectomy reveals nuanced findings. Across the 5 articles chosen (2 systematic reviews, 1 systematic review and meta-analysis, and 2 cohort studies), several indicated that RC does not consistently outperform LC in terms of postoperative complications and recovery. Although RC demonstrated slightly higher risk for bile duct injuries and biliary interventions, both approaches showed similar rates of overall complications, length of hospital stay, surgical site infections (SSI), and bile leak. It was also true across studies that RC required longer operating times compared to LC. RC demonstrated some potential technical advantages (evidenced by lower conversion rate to open surgery in complex cases), but even those purported technical advantages lack clear evidence when it comes to the complex cases, as suggested by Kalata et al. (2023). All studies called for the need for larger and/or multicenter RCTs to validate their outcomes more comprehensively. The significant heterogeneity among the studies is a particular variable that can influence the comparative results. For example, the differing surgeon experience with robotic techniques and differing patient populations can absolutely impact operative outcomes and study results.

Clinical Bottom Line:
The combined evidence of the five selected articles shows that RC does not consistently demonstrate superior clinical outcomes compared to LC. Across studies, both techniques exhibited similar rates of overall complications, bile leakage, and lengths of hospital stay, suggesting comparable safety profiles. RC did show a lower conversion rate to open surgery in some studies, indicating it has some potential technical advantages in complex cases, but this still remains to be seen pending further, more robust RCTs. RC was also found to have a longer operating time and it also suffers from varying surgeon experience, a point I felt was corroborated by my own student experience on a general surgery service. It should also be noted that although the higher procedural costs associated with robotic technology were not part of my outcome, it is important to consider that this may elicit patient selection bias by limiting patient accessibility. Together, these findings illustrate a limited extent to which RC influences clinical outcomes, suggesting a **small magnitude of effect**.

The articles themselves had **strengths and weaknesses** that impacted the quality of their evidence. Some of the articles I selected had large patient cohorts, increasing the reliability of their findings. The analysis over a 9 year period (Kalata et al., 2023) also allowed for a strong assessment of trends and long-term outcomes. Additionally, the articles were diverse in their study designs (retrospective analyses, prospective studies, meta-analyses, systemic reviews), bringing varied perspectives and methodologies to my PICO question. However, the articles also inherently *suffer* due to that significant variability in study designs, patient populations, and surgeon experience, because it complicates the direct comparison I sought to make. The differences in how outcomes are

measured and reported (e.g. pain scores, complication rates) also make synthesizing findings across studies difficult. Lastly, the evidence is ultimately heavily reliant on observational studies and retrospective data (which are more prone to bias) because even the systemic reviews had a small number of RCTs.

And so despite that the adoption of RC has increased over time, the evidence and quality of evidence presented here supports the scrutiny over this uptick in adoption. Clinically, RC does appear to impact patient comfort and recovery experience by offering better postoperative pain management (based on fewer instances of additional pain control required compared to LC) and potential for improved technical stability. But the evidence for this is not strong, and so I agree that it **lacks a significance strong enough to clinically justify** choosing RC over the well-established LC.

Based on the combined evidence *and* weight of the evidence, **LC is generally superior and preferable due to RC's longer operating times and higher costs without significant advantages**. Adoption of RC should be considered carefully, prioritizing cases where its potential benefits justify the additional costs and resources. Additionally, further large-scale, multicenter RCTs are essential to provide more definitive guidance on the comparative effectiveness of RC and LC.