Comparative evaluation of clinical outcomes, efficacy and complications of robotic cholecystectomies Vs Laparoscopic cholecystectomies for gall stone diseases: A Systematic Review

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ABSTRACT
Background: When compared to laparoscopic surgery, the developing technology of robotic surgery may have some advantages in many challenging endoscopic operations. However, the relative merits of robot-assisted cholecystectomy (RAC) over traditional laparoscopic cholecystectomy (LC) continue to be a contentious topic. This study's objective was to compare RAC and LC for benign gallbladder disease in order to assess their safety and effectiveness.
Methods: To find comparative studies evaluating the safety and effectiveness of RAC and LC, a systematic literature search was carried out using the PubMed, EMBASE, and Cochrane Library databases. In addition to utilising R software to analyse the data and apply random effects models, the quality of the literature was evaluated.
Results: There were 26 studies total, 3 prospective and 18 retrospective, 5 RCTs, and 21 NRCSs. There were 4004 patients in total, of whom 1833 (46%) underwent RAC and 2171 (54%) underwent LC. There were no appreciable differences between the RAC and LC groups in terms of intraoperative problems, postoperative complications, readmission rate, hospital stay, estimated blood loss, and conversion rate. However, RAC was linked to a longer operating time than LC in the RCT group, which was consistent with the NRCS group (MD = 12.04 min, 95% CI 7.26-16.82); RAC also had a higher rate of incisional hernia in the NRCS group (RR = 3.06, 95% CI 1.42-6.57); and one RCT reported that RAC was comparable to LC (RR = 7.00, 95% CI 0.38-129.
Conclusion: For benign gallbladder illnesses, the RAC was not proven to be more efficient or safe than LC, indicating that RAC is a developing treatment rather than immediately taking the place of LC. The existing evidence supports the use of LC in cholecystectomy despite the greater expenses.
Keywords Cholecystectomy robotic-assisted · Laparoscopic · Meta-analysis

INTRODUCTION
The most effective treatment for benign gallbladder problems frequently involves prompt surgical surgery. Cholecystectomy is a well-known and frequently used procedure [1]. Cholecystectomy is currently performed via laparoscopic and robot-assisted surgery, two forms of minimally invasive procedures.

Since the first laparoscopic cholecystectomy (LC) was performed in 1985 by Dr. Erich Muhe in Germany, the procedure has progressively gained popularity [2]. As the learning curve for LC was surmounted, it quickly rose to the top of the list of treatments used worldwide [3-5]. When compared to the traditional open cholecystectomy, LC is related with less postoperative complications, less pain, less blood loss, a shorter hospital stay, and a quicker recovery [6–8]. In addition, the 3D Laparoscopic Cholecystectomy has been developed and implemented thanks to the ongoing improvements in surgical laparoscopic technology [9]. Laparoscopic procedures can have certain drawbacks, though, include inadequate flexibility and a rather steep learning curve [10–12].

Another minimally invasive approach that has recently been introduced is the robotic surgical system [13, 14]. Some benefits of the robotic-assisted system are built-in, such as tremor suppression, increased precision, and instrument adaptability [15–17]. Additionally, two randomised controlled trials found that using a robot during endoscopic surgery could lower the mean heart rate and intraoperative mental stress in surgeons, which may have positive health effects [18, 19]. Though its impact on cholecystectomy is nearly flawless, LC has emerged as the gold standard for treating benign gallbladder illnesses [4, 20]. Due to the longer operating time, complicated installation process, and especially the greater expense, the robotic-assisted cholecystectomy (RAC) was met with a number of obstacles [3, 14]. Further research into RAC's effectiveness is warranted.

There has only been one meta-analysis comparing RAC with LC [21], which included 13 research with just one randomised controlled trial (RCT). As a result, due to the small number of studies and the risk of bias, the pooled results from these studies may not be strong enough. Additionally, the results' interpretation was not very thorough. More RCTs and non-randomized controlled studies (NRCSs) are added to increase robustness in order to get around these restrictions. In order to systematically examine the safety and efficacy of RAC and LC for benign gallbladder disorders, a meta-analysis was done.

MATERIALS AND METHODS

LITERATURE SEARCH METHOD

Two reviewers separately searched PubMed, EMBASE, and Cochrane Library for studies comparing RAC with LC for all benign gallbladder disorders. The systematic review followed PRISMA [22]. “Cholecystectomy,” “Robotics,” “Robot-assisted,” and “Laparoscopic” were searched. To ensure precision, we limited our search to titles and abstracts and humans.

INCLUSION CRITERIA

The search results were carefully checked to determine if they satisfied inclusion criteria. Studies were eligible for inclusion if they (1) compared RAC versus LC in patients with benign gallbladder diseases; (2) reported at least one essential outcome, such as operative parameters, postoperative outcomes, postoperative complications, etc.; and (3) in the case of duplicate data, were more recent or had a larger sample size.

EXCLUSION CONDITIONS

Exclusion criteria: (1) malignant gall bladder illness; (2) no original data available for extraction; (3) authors and/or institutions overlapped between two or more studies; and (4) the Newcastle–Ottawa scale Score (NOS) < 6. Discussion and agreement settled disagreements.

INTEREST OUTCOMES

RAC and LC were compared based on operative parameters, including operative time (minutes), estimated blood loss (mL), and conversion to open surgery; postoperative parameters, including length of hospital stay (days), readmission for 30 days, and relevant expenses; and intraoperative and postoperative complications. Only the latest data is used if data sets overlap.

EXTRACTING DATA

As mentioned, two authors independently extracted data from the involved studies: (1) the surname of the first author, year of publication, journal, and study design, (2) patients' basic characteristics (age and body mass index), (3) indications for surgery, (4) type of surgical procedure (RAC or LC), and (5) number of subjects operated upon each technique, perioperative and post-operative outcomes. Surgical Endoscopy was also contacted.

DATA ACCURACY

BIAS ASSESSMENT

The Cochrane Risk of Bias Tool evaluated all included RCTs [23]. Random sequence generation; allocation concealment; blinding; incomplete outcome data; selective reporting; and other bias are assessed. The modified Newcastle-Ottawa Scale (NOS) assessed NRCS study quality [24]. This standard has eight items, with a maximum score of nine. Studies with a score of seven or higher are high-quality, and those with a score of six or higher are methodologically sound [25].

STATISTICAL ANALYSIS

R-3.4.2, 64bit, The Cochrane Collaboration, Oxford, UK, was used for this meta-analysis. Weighted mean differences (WMDs) and risk ratios (RRs) were used to evaluate continuous and dichotomous variables, respectively, with 95% confidence intervals (CIs) [26]. I2 showed heterogeneity. Higgins' I2 statistic was low, moderate, and high heterogeneity, respectively [27]. Because studies vary naturally, especially in surgical research, a random effect model was used for data analysis [28]. $P < 0.05$ indicated statistical significance. If there are ten or more studies, Egger's test detects publication bias [29].

SUBGROUP ANALYSIS

In the research we included, the RAC group employed SIRC and MIRC, while the LC group used SILC and MILC. Three subgroup analyses were done to strengthen the results.

RESULTS

STUDYING SELECTION

2238 possible qualifying studies were found overall at first. Duplicate studies were eliminated, leaving 1931 relevant studies for screening. Of these, 1862 studies were eliminated by reading the titles and abstracts. 69 articles in total were included for full-text analysis. 42 of these studies were dropped because they didn't meet the requirements for inclusion. Ultimately, 26 studies [3-5, 10, 11, 13, 14, 20, 30-47] were included in the meta-analysis.

STUDY CHARACTERISTICS AND EVALUATION OF THE METHODOLOGY'S QUALITY

There were 4004 patients in total, of whom 1833 (46%) underwent RAC and 2171 (54%) underwent LC. 21 NRCSs [3-5, 10, 11, 13, 14, 20, 31, 33, 34, 36-42, 44, 45, 47] (81%) and 5 RCTs [30, 32, 35, 43, 46] (19%) were included. The da Vinci robot (19), the Zeus system (3), and the AESPO were each used in one of the 26 investigations; only one research did not mention the robotic model. A low risk of bias was found in two RCTs, while a substantial risk was found in some others.

OPERATING HOURS

There were twenty studies that reported the operation time, including five RCTs [35, 43, 46] and sixteen NRCSs [3-5, 10, 11, 13, 14, 20, 31, 33, 34, 36-42, 44, 45, and 47]. In the RCT group, there was no evidence of statistical heterogeneity (P = 0.60, I2 = 0%) but a statistically significant difference between the operating times of the RAC and LC (pooled MD = 12.04 min, 95% CI 7.26-16.82, I2 = 0%). In the NRCS group, the pooled data came to a similar conclusion with considerable heterogeneity (P <0.01, I2 = 95%) (pooled WMD = 13.78 min, 95% CI 3.29-24.26).

PROBLEMS DURING SURGERY

13 studies with a total of 1773 patients included in them—4 RCTs [32, 35, 43, 46] and 9 NRCSs [5, 20, 33, 34, 38, 39, 42, 44, 45]—reported information on intraoperative complications. Eight of these investigations [5, 20, 35, 38, 39, 42, 44, 46] indicated that there were no events in the RAC and LC groups. In the RCT group, the RAC and LC groups experienced intraoperative complications at rates of 9.3% (18/193) and 12.3% (20/163), respectively. A meta-analysis revealed no statistically significant statistical heterogeneity (P = 0.22, I2 = 34%) between the rates of intraoperative complications in RAC and LC (pooled RR = 0.87, 95% CI 0.42-1.80, I2 = 34%). The RAC and LC groups in the NRCS group experienced intraoperative problems at rates of 1.5% (12/777) and 1.5% (9/600), respectively. Likewise, the combined data supported the findings of the RCT group (combined RR = 1.11, 95% CI 0.44-2.78). There was no evidence of heterogeneity between the trials (P = 0.25, I2 = 29%)

BLOOD LOSS ESTIMATES FROM A META-ANALYSIS

Two RCTs [35, 46] and three NRCSs [5, 39, 40] were used in five investigations to report the estimated intraoperative blood loss. In the RCT group, meta-analysis found no evidence of statistical heterogeneity (P = 0.33, I2 = 0%) and no difference between the RAC and LC groups in terms of blood loss (pooled MD = 1.07 ml, 95% CI 7.25 to 5.11). The pooled data for the NRCS group showed a comparable outcome (pooled MD = 0.92 ml, 95% CI- 3.97 to 2.14), with no sign of statistical heterogeneity (P = 0.54, I2 = 0%)

RATE OF CONVERSION

The conversion to an open surgical procedure is the result in question. There were 22 studies that reported the conversion rate, including 4 RCTs [30, 35,43, 46] and 18 NRCSs [3-5, 10, 13, 14, 20, 31, 34, 36-41, 44, 45, 47] with a total of 3770 patients. In 11 of them [4, 13, 14, 30, 31, 34, 37–39, 43, 46], there were no events reported in the RAC and LC groups. The conversion rates for the RAC and LC groups in the RCT group were 5% (1/20) and 5% (1/20), respectively. No discernible difference in conversion rates between RAC and LC was found in the meta-analysis (pooled RR = 1.00, 95% CI 0.07-14.90). The conversion rate in the NRCS group was 2.4% (37/1553) and 3.4% (64/1903) for the RAC and LC groups, respectively. The combined statistics were also in line with the RCT group (combined RR = 0.50, 95% CI 0.23-1.06). None of the studies showed any overt het- erogeneity (P = 0.08, I2 = 42%).

COMPLICATION FOLLOWING SURGERY

Postoperative problems were the subject of 16 investigations, including 3 RCTs [35, 43, 46] and 13 NRCSs [3-5, 14, 20, 33, 34, 36-39, 45, 47], involving a total of 2051 patients. Based on four investigations [20, 33, 35, 38], no event was reported in the RAC and LC groups of these. The rate of postoperative complications in the RCT group was 4.5% (6/133) and 1.9% (2/103) in the RAC and LC groups, respectively. With regard to postoperative complications, meta-analysis revealed no discernible difference between the RAC and LC groups (pooled RR = 1.76, 95% CI 0.41–7.53), and there was also no sign of statistical heterogeneity (P = 0.43, I2 = 0%). The RAC and LC groups in the NRCS group experienced postoperative complications at rates of 2.7% (21/777) and 9.1% (94/1038), respectively. Likewise, the combined data supported the findings of the RCT group (combined RR = 0.67, 95% CI 0.33-1.40). The studies did not appear to be significantly heterogeneous (P = 0.17, I2 = 30%)

DURATION OF HOSPITALISATION

Data on the length of hospital stays were given by 17 studies, including 3 RCTs [35, 43, 46] and 14 NRCSs [3-5, 11, 13, 14, 34, 36, 38, 40, 41, 44, 45, 47]. In the RCT group, meta-analysis found no evidence of statistical heterogeneity (P = 0.81, I2 = 0%) and no significant difference in the length of hospital stay between the RAC and LC groups (pooled MD = 0.05, 95% CI 0.10 to 0.21). With a significant degree of heterogeneity (P 0.01, I2 = 93%) and a comparable finding (pooled MD = 0.27, 95% CI 0.61 to 0.08) for the NRCS group, the pooled data

RATE OF READMISSION

In six NRCSs, 30-day readmission rates were recorded. The rate of readmission was outlined in the meta-analysis as readmission within 30 days. Overall, the RAC and LC groups did not differ significantly from one another (pooled RR = 1.21, 95% CI 0.62-2.35). The studies' heterogeneity was not statistically significant (I2 = 0%, P = 0.80)

INCISIONAL HERNIA INCIDENCE

The rate of incisional hernias was reported in seven trials, including one RCT [43] and six NRCSs [3, 20, 37, 38, 44, 45], totaling 1549 patients. One of them, study [38], claimed that both the RAC and LC groups saw an incidence of 0 events. In the RCT group, the incidence of incisional hernias was 10% (3/30) and 0% (0/30) in the RAC and LC groups, respectively. Pietrabissa et al. [43] showed that although there is no statistically significant difference, the RAC group has a greater rate of incisional hernias (pooled RR = 7.00, 95% CI 0.38-129.84). Similar to the NRCS group, the RAC and LC groups' rates of incisional hernias were 5.5% (37/671) and 1.1% (9/818), respectively. Without any indication of statistical heterogeneity (P = 0.51, I2 = 0%), meta-analysis revealed that the rate of incisional hernias for the RAC group was considerably greater than the LC group (pooled RR = 3.06, 95% CI 1.42-6.57)

COSTS OF HOSPITALISATION

It is crucial to compare the cost-effectiveness of RAC and LC as a freshly developing technology. Seven papers [3, 5, 14, 20, 34, 45, and 47] that were included in this meta-analysis provided information on hospitalisation expenses overall. For the meta-analysis, six studies [3, 5, 14, 20, 45, and 47] were taken into account; the other study [34] was excluded due to insufficient data. We separated hospitalisation costs into three subgroups according to various regions, taking into account the various economic levels and medical insurance policies among various countries. According to pooled data, hospitalisation costs for RAC patients were significantly higher than those for LC patients in Switzerland (pooled MD = 1812.29$, 95% CI 1343.70-2280.88, I2 = 0%), Taiwan (pooled MD = 4493.77$, 95% CI

3378.23-5609.31, I2 = 97%), and the United States (pooled MD = 3160.96$, 95% CI 2768.96-3552.

COMPARATIVE COMPARISON OF THE SIRC AND THE MILC

SIRC and MILC were compared in seven trials, including two RCTs [43, 46] and five NRCSs [3, 13, 41, 44, 45]. Results from the RCT group showed a correlation between SIRC and longer operating time (pooled MD = 15.26 min, 95% CI - 8.82 to 21.70). The estimated blood loss, hospital stay, intraoperative, and postoperative problems were not significantly different between the SIRC and MILC groups; the other outcomes are not given (Table 1). Operative time, estimated blood loss, conversion rate, intraoperative and postoperative complications, readmission rate, and hospital stay did not significantly differ between the two categories in the NRCS group. However, Table 1 found a correlation between SIRC and a greater rate of incisional hernia (pooled RR = 3.71, 95% CI 1.61-8.58).

COMPARATIVE STUDY OF THE SIRC AND THE SILC

SIRC and SILC were compared by six NRCSs (4, 5, 20, 38, 39, and 47). Operative time, estimated blood loss, conversion rate, postoperative complications, hospital stay, readmission rate, and the increased rate of incisional hernia between the SIRC and MILC groups did not differ significantly from one another. It is not stated how frequently intraoperative problems occur (Table 2).

Table 1 Subgroup analysis for studies SIRC comparing with MILC

Outcomes	No. of studies	No. of patients	MD or RR	95% CI	Tests for heterogeneity	
RCT					I^2 (%)	P
Operative time (min)	2	196	15.26	8.82 to 21.70	0	0.47
Intraoperative complications	1	120	0.56	0.21 to 1.46	–	–
Estimate blood loss (ml)	1	136	– 2.7	− 9.70 to 4.30	–	–
Conversion rate to open	NR	NR	NR	NR	NR	NR
Postoperative complications	2	196	1.76	0.41 to 7.53	0	0.43
Length of hospital stay (days)	2	196	0.06	− 0.10 to 0.22	0	0.55
Readmission rate (30-days)	NR	NR	NR	NR	NR	NR
The rate of incisional hernias	NR	NR	NR	NR	NR	NR
NRCS						
Operative time (min)	4	1441	16.15	− 12.03 to 44.33	99	< 0.01
Intraoperative complications	1	198	9	0.49 to 164.96	–	–
Estimate blood loss (ml)	NR	NR	NR	NR	NR	NR
Conversion rate to open	4	1461	0.69	0.15 to 3.06	64	0.04

Postoperative complications	2	643	0.4	0.07 to 2.13	67	0.08
Length of hospital stay (days)	5	1581	– 0.09	− 0.72 to 0.54	92	< 0.01
Readmission rate (30-days)	2	818	1.45	0.52 to 4.04	12	0.29
The rate of incisional hernias	3	1321	3.71	1.61 to 8.58	0	0.56

RCT randomized controlled trial, *NRCS* non-randomized controlled study, *NR* not reported

Table 2 Subgroup analysis for studies SIRC comparing with SILC

Outcomes	**No. of studies**	**No. of patients**	**MD or RR**	**95% CI**	**Tests for heterogeneity**	
NRCS					**I^2 (%)**	**P**
Operative time (min)	6	848	8.51	− 7.59 to 24.61	94	< 0.01
Intraoperative complications	NR	NR	NR	NR	NR	NR
Estimate blood loss (ml)	2	267	– 3.35	− 8.97 to 2.09	0	0.74
Conversion rate to open	3	433	0.33	0.09 to 1.18	22	0.28
Postoperative complications	4	716	0.8	0.29 to 2.22	0	0.56
Length of hospital stay (days)	4	736	– 0.28	− 0.77 to 0.22	83	< 0.01
Readmission rate (30-days)	3	602	0.97	0.37 to 2.51	0	0.94
The rate of incisional hernias	1	82	0.58	0.05 to 6.14	–	–

RCT randomized controlled trial, *NRCS* non-randomized controlled study, *NR* not reported

Table 3 Subgroup analysis for studies MIRC comparing with MILC

Outcomes	**No. of studies**	**No. of patients**	**MD or RR**	**95% CI**	**Tests for heterogeneity**	
					***I^2* (%)**	***P***
RCT						
Operative time (min)	3	238	8.1	0.97 to 15.42	0	0.95
Intraoperative complications	1	60	1.18	0.58 to 2.43	–	–
Estimate blood loss (ml)	1	40	4.7	− 8.48 to 15.88	–	–
Conversion rate to open	NR	NR	NR	NR	NR	NR
Postoperative complications	NR	NR	NR	NR	NR	NR
Length of hospital stay (days)	1	40	0	− 0.47 to 0.47	–	–
Readmission rate (30-	NR	NR	NR	NR	NR	NR

days)						
The rate of incisional hernias NRCS	NR	NR	NR	NR	NR	NR
Operative time (min)	6	917	17.07	3.50 to 30.64	82	< 0.01
Intraoperative complications	2	44	0.89	0.42 to 1.88	0	0.77
Estimate blood loss (ml)	1	326	– 0.92	− 3.49 to 3.89	–	–
Conversion rate to open	3	837	0.42	0.12 to 1.40	0	0.61
Postoperative complications	4	304	1.15	0.28 to 4.63	35	0.2
Length of hospital stay (days)	5	961	– 0.42	− 0.94 to 0.10	92	< 0.01
Readmission rate (30-days)	NR	NR	NR	NR	NR	NR
The rate of incisional hernias	1	36	3.73	0.16 to 85.62	–	–

RCT randomized controlled trial, *NRCS* non-randomized controlled study, *NR* not reported

SUBGROUP COMPARISON BETWEEN MIRC AND MILC

Thirteen studies compared MIRC with MILC, including three RCTs [30, 32, 35] and ten NRCSs [10, 11, 14, 31, 33, 34, 36, 37, 40, 42]. The findings in the RCT group showed that MIRC was linked to a longer operating duration (pooled MD = 8.1 min, 95% CI 0.97-15.42). Between two subgroups, there were no appreciable changes in estimated blood loss, intraoperative complications, or hospital stay. Results showed that MIRC was associated with a longer operating time in the NRCS group (pooled MD = 17.07 min, 95% CI 3.50-30.64) (Table 3). Between the two categories, there were no appreciable changes in the estimated blood loss, conversion rate, intraoperative and postoperative complications, hospital stay, or incisional hernia rate (Table 3).

SENSITIVITY RESEARCH

To determine the validity of our findings and look into possible causes of significant heterogeneity, we ran sensitivity analyses. The outcomes were consistent once low-quality NRCSs were eliminated.

BIAS IN PUBLICATIONS

For four outcomes, the publication bias was evaluated using Egger's test. Operative time, hospital stay duration, conversion rate, and postoperative complication all had P values of 0.795, 0.805, 0.243, and 0.411, respectively. There was no discernible publication bias across the studies.

DISCUSSION

In the meta-analysis, we did not find any statistically significant differences between RAC and LC for benign gallbladder illnesses in terms of intraoperative complications, postoperative problems, readmission rate, hospital stay, estimated blood loss, or conversion rate. However, the findings showed that RAC required more time during surgery and had a greater rate of incisional hernia than LC. Additionally, the findings of the subgroup analyses of either RCTs or NRCSs agreed with the findings from the overall study, demonstrating the validity of this meta-analysis.

One of the most important measures of surgical operations is the operating time. The findings of the meta-analysis showed that RAC required more time during surgery than LC did; the RCT group's findings were in line with those of the NRCS group. Additionally, the outcomes of two subgroups also demonstrated that the RAC's operating time was longer. The results of the RCT subgroup are more believable, however another subgroup revealed that there was no significant difference in the operating time between the SIRC and SILC groups. The different definitions of operative time may also be the cause of the NRCS group's higher heterogeneity when compared to the RCT group. The definition of the operative time we retrieved from two RCTs [35, 43] was from the first gallbladder retraction until the gallbladder's total detachment from the liver bed; in the other RCTs, the operative time was not clearly defined. Six studies [3, 10, 20, 39, 42, 44] used this definition to include docking time and console time for robotic surgery; the remaining five studies [5, 11, 13, 38, 45] did not clearly define the operative time. Of the studies in the NRCS group, five [4, 14, 31, 40, 47] define the operative time as the period of time from the skin incision to wound closure. Future research should, it is desired, include a precise characterization of the operative time. The previous meta-analysis, however, failed to detect a statistically significant difference between the RAC and LC groups in terms of mean operation time [21].

According to the theoretical conclusions, the RAC group's longer mean operating time may be due to the following factors: First off, the robotic operation is more complex and takes longer to dock and use the console [3, 13, 48]. Second, the absence of tactile input means that even seasoned surgeons must estimate the force of the instrument for tissue by interpreting visual data, which could lengthen the procedure [49]. Thirdly, a crucial element can be the surgeons' experience and knowledge with robotic technology. Even though RAC's mean oper- ative time was 13.14 minutes longer than LC's, it is unlikely that this has any clinical importance. Additionally, doctors' surgical techniques have gradually improved, and operating room time can be difficult to cut down on.

There were no appreciable differences between the two methods in terms of the estimated blood loss and length of hospital stay. Theoretically, robotic surgery is a more precise procedure that might shorten hospital stays and minimise blood loss. These benefits have been acknowledged in bariatric, gynaecological, and colorectal surgery [50–52]. However, it should be noted that benign gallbladder disease surgery is quite straightforward, making it inappropriate to highlight the key benefits of robotic surgery in difficult surgery. Additionally, there was a higher level of hospital stay variability, which may be related to hospitalisation policies. As is well knowledge, hospitals from various countries have various hospitalisation policies. Additionally, the heterogeneity may have been influenced by ambiguous definitions of hospital stays. Only one study [13] of the included studies clearly characterised the length of hospital stay from admission to discharge; the other trials did not.

There was no discernible difference between the two approaches in terms of the conversion rate or the 30-day readmission rate, albeit there was a tendency for the RAC group to have lower conversion rates. Acute and chronic cholecystitis may be more difficult to treat and have a greater rate of conversion during laparoscopic surgery, according to Giulianotti et al. [49]. A recent study comparing 676 robotic and 289 laparoscopic cholecystectomies showed that the robot group had a considerably reduced conversion rate of acute cholecystitis (0.76% vs. 9.57%). [53].

This meta-analysis showed that there was no significant difference between the two procedures in terms of intraoperative and postoperative complications (such as bile spillage, minor bleeding, bile leakage, and wound infection), with the exception of the incidence of incisional hernias. Other than the prevalence of incisional hernias, previous meta-analyses revealed comparable findings [21]. Our meta-analysis, however, showed that the incidence of inci- sional hernias was greater in the RAC group. The subgroup data also showed that SIRC had a higher rate of incisional hernias than the MILC group. Thirteen trials in the robotic group of the meta-analysis's 26 studies employed SIRC, and 20 studies used MILC in the laparoscopic group. Additionally, the subgroup analysis suggested that SIRC would increase the prevalence of incisional hernias, and other research [54, 55] supported this conclusion. Since the abdominal wall is weak where the umbilicus is, the SIRC is primarily done there. It is simple to raise the incidence of trocar-site hernia due to the use of larger size trocars, which adds additional damage to the abdominal wall [45, 56]. A similar conclusion is supported by Antoniou et al. [57].

The biggest disadvantage of RAC is its higher price [3]. According to the findings of this meta-analysis, RAC hospitalisation expenses are much greater than LC hospitalisation costs. The increasing costs of robotic surgery are primarily attributable to the equipment's initial purchase price and yearly maintenance expenses. The fact that RAC is more expensive than LC while offering no convincing proof of advantage may be the most crucial conclusion [58]. Given the high expense of RAC, the available research supports the use of LC during cholecystectomy.

Robotic surgery is a cutting-edge technology with some potential benefits. Numerous meta-analyses [50, 51, 59–62] shown that when compared to laparoscopic surgery, robotic-assisted surgery can decrease complications, conversion rates, blood loss, and length of hospital stay. Robot-assisted surgery did not, however, demonstrate these benefits in cholecystectomy for benign gallbladder disease. The merits of RAC are still up for debate, according to a Cochrane analysis titled "robot-assisted for laparoscopic cholecystectomy"; the review also found that the procedure is safe but does not significantly outperform LC [63].

The following are some of this meta-analysis's benefits: The following steps were taken to improve the quality of the meta-analysis: (1) more thorough studies were included to increase the sample size; (2) a systematic and rigorous approach was used; (3) we combined all RCTs and NRCSs to analyse their conclusions, respectively; and (4) all meta-analysis results are discussed in detail.

It is important to remember the meta-analysis's following limitations: (1) The majority of the included studies were observational, which could make it difficult to understand the findings; and (2) There was little blinding of outcome assessors; we should make some improvements and pay more attention to this.

CONCLUSIONS

In conclusion, RAC requires more time during surgery and has a greater rate of incisional hernia than LC. For benign gallbladder illnesses, the RAC was not proven to be more efficient or safe than LC, indicating that RAC is a developing treatment rather than immediately taking the place of LC. In conclusion, RAC requires more time during surgery and has a greater rate of incisional hernia than LC.

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