REVIEW ARTICLE

Robotic Surgery: A New Era in Gall Bladder Surgery

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Abstract:

Robotic cholecystectomy (RC), particularly single-port robotic cholecystectomy (SRC), is emerging as a refined alternative to conventional laparoscopic cholecystectomy (CLC) in gallbladder surgery. It addresses the ergonomic and technical limitations of multi-port and single-port laparoscopic approaches through enhanced visualization, dexterity, and precision. Despite initial concerns over operative time and cost, SRC demonstrates reduced complications, improved cosmesis, less pain, quicker recovery, and higher patient satisfaction. Technological innovations like the da Vinci Single-Site Surgical Platform have propelled its feasibility and safety, showing promise even in the pediatric population. While initial learning curves and infrastructure requirements remain challenges, growing familiarity among surgical teams may soon reduce operative duration and financial barriers. Comparative analyses, however, must be cautiously interpreted due to retrospective designs and potential biases. Overall, SRC reflects a significant shift toward improved clinical outcomes in minimally invasive gallbladder surgery, warranting further validation through randomized controlled trials and large-scale studies.

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Introduction:

Laparoscopic cholecystectomy (LC) is one of the most common procedures in general surgery and currently the standard of care for gallstone diseases.[1] The most recent technological innovation in minimally invasive gallbladder surgery is Robotic cholecystectomy (RC).[2]

LC was first introduced in 1985, as a viable replacement for open cholecystectomy.[3] Due to it's many advantages over Open Cholecystectomy (OC), the technique of Multi-port Laparoscopic Cholecystectomy (MLC) soon evolved to become the gold standard for the treatment of symptomatic gallbladder disease. But when first introduced in 1985, MLC was met with questions of technical feasibility and effectiveness. Now those same concerns and questions afflict the introduction of a newer technology, Single-port Robotic Cholecystectomy (SRC), to further improve upon the advantages of minimally invasive surgery of the gallbladder. [4]

Since the introduction of Conventional Laparoscopic Cholecystectomy (CLC) using multiple ports, continuous trials for less invasive approaches by reducing the number and size of ports have been attempted by many researchers[5]. In this context, Navarra et al. introduced Single port Laparoscopic Cholecystectomy (SLC) in 1995.[6] But multiple problems including crowding of instruments within the port, reduced triangulation, poor surgical ergonomics have invalidated its prevalent use in teaching hospitals.[7, 8] Single Port Laparoscopic Cholecystectomy (SLC) also led to inadequate traction of the gallbladder during a dissection of Calot's triangle and have a difficulty in obtaining the "critical view of safety" [9] resulting in increased risk of bile duct injury or bile spillage.[10,11]

In 2011, the novel da Vinci Single-Site Instrumentation and Accessories (Intuitive Surgical, Inc., Sunnyvale, CA, USA) system was developed to overcome these limitations.[12] When they reported the results from a First Human Use Clinical Study of the New da Vinci Single-Site Surgical Platform, it brought a new revolution in the field of minimal invasive gall bladder surgery.

Single-port Robotic Cholecystectomy (SRC) offers a way to offset the limitations of both Multi-port laparoscopic cholecystectomy (MLC) and single-site laparoscopic cholecystectomy (SLC). RC has perceived benefits, including enhanced tactile feedback, better exposure, easier manipulation of the instruments, greater magnification than that previously available, high-definition three-dimensional visualization, and prevents instrument collisions.[13,14] Fingertip controls allow precise and delicate movement of instruments while filtering out hand tremors. At the fascia level, the instruments are crossed and reassigned to the opposite hand by robotic software, which allows better hand–eye coordination and ability to perform very small movements, [12,15-17] making fine dissection possible.[18] Conversion rate is also lower [19] while also maintaining the benefits of single-port operations which include improved cosmesis, minimize scarring, decreased blood loss, decrease postoperative

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pain, quicker healing times, less hospital stay for the patient[20], which provide greater patient satisfaction.[21] SSRC has also been shown to reduce musculoskeletal strain on the surgeon, allowing the surgeon to work in a more ergonomically advantageous workstation by enabling to operate the endoscope while seated at the console, away from the sterile field.[14]

Many previous studies have demonstrated the benefits of robotic cholecystectomy and suggested that da Vinci single-site technology for cholecystectomy is safe, feasible, and results in a shorter learning curve than that of conventional LC. [22-25]. More-over, postoperative complication was significantly lower in the RC group, than in the LC group while the cost was higher in the RC group.[1] Adoption of robotic surgery in the pediatric population has been limited in part because of instrumentation size and lack of surgical domain with respect to younger patients.[26]

The aim of this research was to evaluate the, safety and efficacy, both short term and long term outcome of SRC compared to MLC in perioperative and postoperative settings, and we also assessed and compared medical resource utilization for the two operative procedures.

Methods and Materials:

Literature Search:

In this review article I have tried to identify the medical records that are relevant randomized control trails (RCTs) and comparative studies about SRC and MLC which compared and analyzed the outcomes between two techniques. To find relevant studies, the electronic databases PubMed, MEDLINE, online journals , including Literature in the English from January 2010 to 2022 had been searched to seek information. As robot-assisted procedures were not widely being performed prior to 2010[27] we included studies that published after 2010. We tried to include both randomized controlled trials (RCTs) and observational studies that compared and measured intraoperative, perioperative, or postoperative outcomes between robotic and laparoscopic approach.

For online literature search The search terms useded "single-site robotic cholecystectomy" (SSRC) or "single incisional robotic cholecystectomy"(SIRC) or Single-port Robotic Cholecystectomy (SRC) and "Multi-port laparoscopic cholecystectomy" (MLC) or "multi incisional laparoscopic cholecystectomy" or "conventional laparoscopic cholecystectomy" (CLC) or "laparoscopic cholecystectomy" (LC).

Surgical Technique:

All surgeries usually perform under general anesthesia with the patient in the supine position. In the SIRC group, the da Vinci Single Port (Sp) surgical system is use to perform cholecystectomy while in MLC group 4 ports are use to perform cholecystectomy

·The da Vinci SP robotic surgical system

The latest addition to the da Vinci surgical system is The da Vinci SP robotic surgical system which consists of a

Figure 1: *Da Vinci Sp Surgical System- (left to right) A. Surgeon's Console, B. Patient's-side cart, C. Vision Cart (Image: Dr Jhinuk, Korea University Anam Hospital)*

Patient-side cart, Vision Cart and a Surgeon's console. [19] The patient-side cart has 1 major arm which harbors 4 arms with the corresponding instruments that are parallel to each other. [19] A boom that can rotate 360°, is connected to the 4 arms adding to the degree of freedom of movement. [19] The da Vinci SP system has the multi-joint capability of its instruments and endoscope, made possible by elbow and wrist motion. [19] It consists of a 2.5-cm diameter pure SP with 4 lumens that accommodates the endoscope and 3 instruments (Fig. 1). [19] No extra port is used for assistant surgeon and Insufflation is done via an adaptor attached to the side of the SP. For all the 4th generation platforms surgeon console and the vision cart are universl and thus, it can be used in Si, Xi, and SP patient side cart models. [19]

Procedure:

Single-site robotic cholecystectomy

After induction of general anesthesia, placement of a urinary catheter, and administration of pre-incision antibiotics patient bed usually placed into 12° to 15° of reverse Trendelenburg position and the da Vinci Si Surgical System is brought in over the patient's right shoulder.[12]

A single 2- 2.5 cm trans-umbilical incision is made through the midpoint of the umbilicus and the fascia is entered sharply and deepened into the peritoneum from where The da Vinci multi channel single-site access port is inserted and the abdomen is insufflated to 15 mm Hg via the port insufflation catheter. [12] Through the access port he 8.5-mm camera trocar and camera are inserted first and each of the curved cannulae is placed under direct vision to locate the remote centers in the middle of the access port and then docked to the 2 robotic arms.[12]

When the camera arm is docked , the 5-mm bedside assistant trocar is placed through the access port. [12] The operating surgeon then move to the console and the bed side assistant surgeon grasped the dome of the gallbladder using a bariatric length grasper (to increase distance from the robotic arms) and retract the gallbladder cephalad to expose the infundibulum. . [12] Then a standard cholecystectomy, using the critical view method is perform by using the Single-site instruments (Maryland dissector, Cadiere grasper, monopolar curved scissors, Hem-O-Lok clip applier [Weck Closure Systems, Research Triangle Park, NC], monopolar cautery hook, and suction irrigator). [12]

The dissection of Calot's triangle performs by using grasper with the left hand and Maryland robotic forceps on right hand to skeletonize the cystic duct and cystic artery[28] Robotic hemolok-o-clips are used to secure the cystic duct and artery, transection is performed, and the gallbladder is detached from the hepatic bed with Robotic hook cautery [18, 28] After dissection off the liver bed, the gallbladder is placed in an extraction bag and remove with the access port device.[12] After that instruments and trocars removes. the fascia of the umbilical site closes with 0-Vicryl suture in an interrupted figure of eight fashion. [29] The 4-0 Monocryl interrupted suture is given in a sub-cuticular fashion and skin glue (Surgicel) is used to skin[29] Patients are then transported to the recovery unit.

Multi-port laparoscopic cholecystectomy (4 ports are used)

A 5-mm incision is made at the umbilicus, and A 5-mm trocar is then placed using a Visiport. [29] After establishing Pneumoperitoneum diagnostic laparoscopy is performed. [29] An 11-mm port is then placed at the sub-xiphoid region and two more 5 mm ports then placed : one at the subcostal region and another in the anterior axillary line, in line with the umbilicus for retraction. [29] Next steps of dissection of Calot's triangle are almost the same as in robotic surgery. Specimen is then removed from the sub-xiphoid port in a specimen retrieval bag and sequentially umbilical and sub-xiphoid ports are closed with size 1-Vicryl suture in a figure of eight fashion (Fig. 2).[29] Finally skin was closed by subcuticular suture.

Figure 2: *Patient side cart- 360 ^{0} rotating Boom with 4 arms (Intuitive image)*

Review of medical records

The articles and literatures that reported on medical records of the patients who underwent robotic-assisted and laparoscopic cholecystectomy and compared the outcomes between two techniques were reviewed in this study. Nowadays it is thought that robotic surgery is one of the tool options in achieving the goal of minimally invasive reduced-port surgery and becoming more

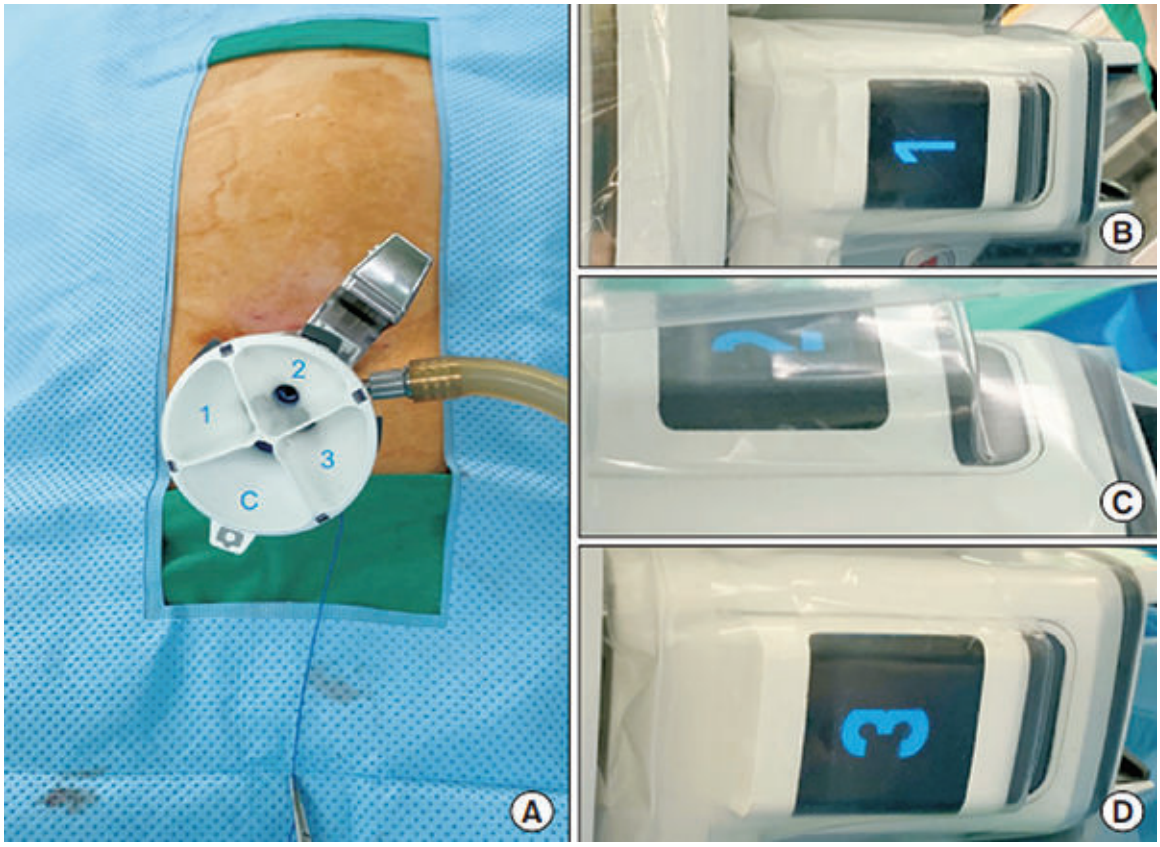

Figure 3: *Trocar system of the robotic SP cholecystectomy. (A) SP robotic system has pure single port with 4 lumens. Flexible scope and 3 individual instruments can be simply docked to the system (B–D).*[19]

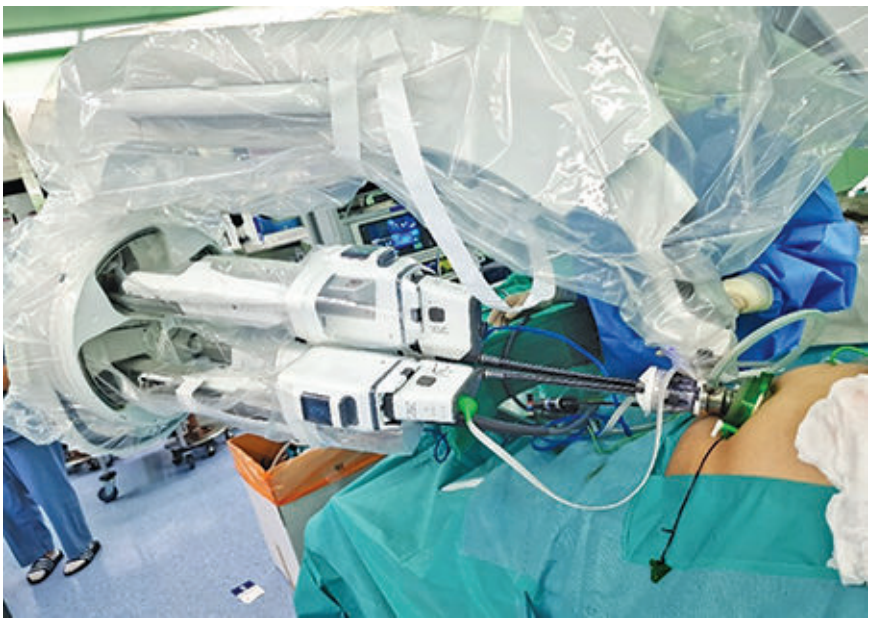

Figure 4: *The robotic ports are docked with their appropriate instrument arms (image: Dr. Jhinuk, at Korea University Anam Hospital)*

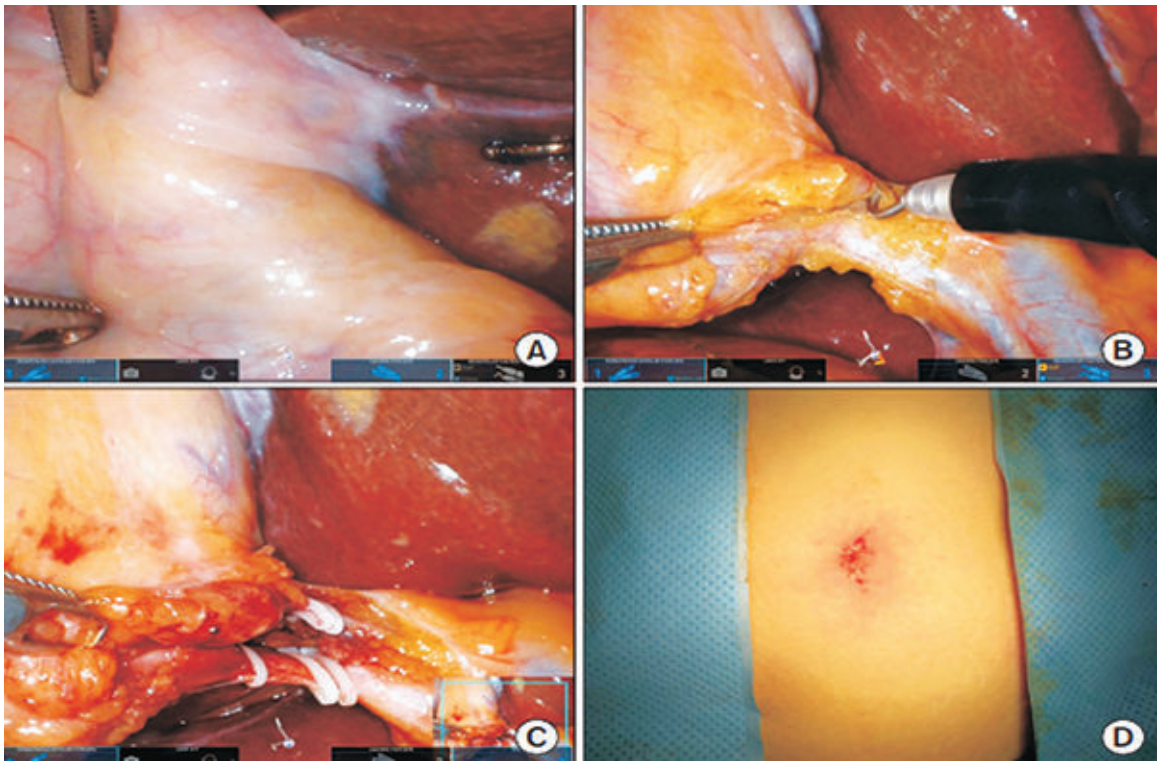

Figure 5: *Procedure description of the robotic SP cholecystectomy. With effective gallbladder retraction (A), calot trianlge is dissected by using remaining two robotic artms (B). (C) Cystic duct and artery are clipped under magnified operation field. (D) Final postoperative wound.*[19]

popular day by day. Patients are expected to be explained about each surgical technique, advantages and disadvantages of conventional laparoscopic and robotic approach for minimally invasive cholecystectomy.[30] Therefore, I tried to compare the currently available surgical options with Robotic technique to analyse their outcomes to provide better options to the patients so that they can chose the surgical option that is regarded as most appropriate for them.

In this article I have tried to review the medical records of different articles which analysed OR time, conversion to an open procedure, bile duct injury, blood loss, length of surgery and hospital stay, readmissions, post-operative complications, need for reoperation, and operative and hospital costs between those patients groups who underwent either RC (robotic cholecystectomy) or conventional LC (laparoscopic Cholecystectomy).

Comparison of intraoperative outcomes

I reviewed three intraoperative outcomes: OR time, intraoperative complications, and conversion rates.

Operation time

On 2017 in a comparative study it was showed that RC group patients took significantly longer average operation time than that of LC group (75.7 ± 31.3 minutes vs. 64.37 ±30.61 minutes, p Z 0.035).[1] Another comparative analysis in pediatric patients showed significant difference in the median operative time between LC and RC group which was 79 min (IQR 57 – 101) and 98 min (IQR 78.5 – 117.5) for LC and RC, respectively ($p<0.001$)[31] Lana Aleuy et al., (from Dec. 2017 to Sept. 2021) included 14 studies in their metaanalysis where they found that RC had longer operative time compared to LC (MD= 18.86 min, $p=0.007$).[32]

Recently on 2021 Rivfka Shenoy and Michael A. Mederos in their review found that two of the four RCTs and two of the three propensity matched studies reported that OR time is statistically longer for robot-assisted cholecystectomy [27], Kudsi et al.[33] showed that on average, the robot-assisted approach took 17 min

longer than the laparoscopic approach (61 ± 27.5 min. vs. 44 ± 19.9 min., p < 0.05). David S Strosberg et al also found the similar result [30] William J. Kane et al. on 2020 also reported greater operative duration (total time in the operating room) for patients undergoing robotic-assisted cholecystectomy (Robot: 185 [175–195] vs. Lap: 160 [135–175] min, p < 0.0001,).[34]

On the other hand, Sherry M. Wren, et al. on 2011 found that the mean (SD) total operative time was 105.3 (18.32) minutes (range, 82-139 minutes) in RC group which was 106.1 (23.53) minutes (range, 70-142 minutes) in LC group and they found no significant difference in operative times between the 2 groups (P=.93).[12] Banujan Balachandran1 and Theadore A et al. on (2017) performed a comparative study and did not find any significant difference in the total operative times between the two groups [29] Ning Sun et al., on 2018 evaluated two RCTs and five comparative studies, and revealed similar operative time between SSRC and MLC groups (MD ¼ 3.06, 95% CI: 7.61-1.49, p ¼ 0.19) [31].

On 2021 Sun Min Lee and Jin Hong Lim analysed the data from 300 patients who underwent single incision robotic cholecystectomy (197 SIRC) and single incision laparoscopic cholecystectomy (103 SILC) to compare the outcomes and found no difference in the total operating time between SILC and SIRC (p=0.526.[28]

However, Chung Hyeun Ma et al. on 2020 found that the total operation time of RSSC was 41.9±11.2 minutes, which was significantly shorter than 52.4±16.6 minutes for SSLC.[18] The RCT by Grochola et al.[22] did not find statistically significant differences but in two studies OR time was found statistically shorter for the robot-assisted cholecystectomy which were observational and not propensity matched [35,36]

Intraoperative complications

No intraoperative complications were reported by Banujan Balachandran1 and Theadore A et al. on (2017) in their study but two cases of postoperative bile leak within the laparoscopic group and one in the robotic group were seen at follow-up. [29]

Chung Hyeun Ma et al. on 2020 in their analysis found that Intraoperative bile spillage occurred in 9.5% of the patients in the SSLC group and in 3.1% in the RSSC group.[18] Sun Min Lee and Jin Hong Lim 2021, in their study reported that there was no difference in the amount of bleeding between SILC (13.98±65.543 [range, 0-400] ml) and SIRC (13.48±52.921 [range 0-600] ml, respectively, p=0.954). (28) Bile spillage during the surgery occurred more often with SILC (23.30%) than with SIRC (5.6%) (p“ÿ0.001). [28]

Rivfka Shenoy and Michael A. Mederos on 2021 ,in their review showed that three RCTs found no intraoperative complications (i.e., bleeding, bile duct spillage) difference between techniques [27]; however, Grochola et al.[22] shows more than 30% reduction in complications for the robotic arm. Twelve observational studies, showed similar intraoperative complication rates between techniques although one study demonstrated higher complication rates in the laparoscopic arm [27].

Afif N. Kulaylat a., Holden Richards et al 2021 found no differences in intraoperative or postoperative complications (LC 4.1% vs. RC 7.6%) [26] Ning Sun et al in their meta analysis found two studies reported bleeding during operation. and three studies evaluated the bile leakage but there was no significant difference in the incidence rate of bleeding or bile leakage between SSRC and MLC groups [31] A systemic review by Lana Aleuy, Oluwaferanmi Akande & Aliu Sanni, also reported no significant difference in operative complications (p= 0.57), and bile leak (p= 0.10) between LC and RC [32]

In the review report by David S Strosberg et al. found lower rates of intraoperative cholangiography (p=0.0008), and blood loss (p=0.012), for robotic cholecystectomy but no bile duct injuries were detected in either group and there was no significant difference was found in bile leak rates (p=0.6311) or need for reoperation (p=1.000). [30]

Conversion rates

David S Strosberg et al. in their review report showed that the rate of conversion to an open procedure (p=0.0238), was lower for robotic cholecystectomy. [30]

However, Banujan Balachandran1 and Theadore A et al. on (2017) in their study reported that the total rate of LC conversion or open conversion between the two groups was not statistically significant (6.1 vs. 4.9%; p = 0.551) [29]. Lana Aleuy , Oluwaferanmi Akande & Aliu Sanni, also reported no significant difference in conversions (p= 0.14), between LC and RC [32] Rivfka Shenoy and Michael A. Mederos on 2021 ,in their review showed that, all four RCTs and one propensity matched

study [27] found no significant differences between techniques. Most of the other observational studies showed no differences in conversion rates [27]. Ning Sun et al in their meta analysis found six studies reported about conversion rate and no significant difference between SSRC and MLC groups was found by the fixed effects model (OR ¼ 1.30, 95% CI: 0.71e2.37, p ¼ 0.40) [31].

Comparison of short-term outcomes

I reviewed four short-term outcomes : length of stay (LOS), surgical site infection (SSI), readmissions, and pain.

Length of stay (LOS),

Chung Hyeun Ma et al. on 2020 in their analysis found that The length of hospital stay was shorter in the RSSC group compared to SSIC group (RSSC, 3.2±1.2 days; SSLC, 4.0±1.8 days) respectively.[18] William J. Kane et al. on 2020 found similar result. (Robot: 0.1±0.7 vs. Lap: 0.8±1.9, p < 0.0001) [34] Lana Aleuy et al. [32] and David S Strosberg et al. [30] in their report also demonstrated that there were lower rates of hospital stay (p=0.009 and p=0.0001 respectively), for robotic cholecystectomy. [30]

On the other hand, In the comparative analysis in pediatric patients, Afif N. Kulaylat a," , Holden Richards et al 2021 reported that Median hospital length of stay was similar (22 h) between LC and RC groups for both simple and complex cases. [26]

Sun Min Lee and Jin Hong Lim on 2021 found no difference in the average length of the postoperative hospital stay in their comparative study between SILC and SIRC which was (1.51± 0.989 [range 1-7] days compared to 1.46±0.866 [range 1-7] days, respectively, p=0.635).[28].

Rivfka Shenoy and Michael A. Mederos on 2021 ,in their meta analysis demonstrated that, only one of the three RCTs reported a shorter stay for the robot-assisted cholecystectomy [22]. The majority of other observational studies in their review showed similar length of stays between techniques (17 of 24 studies), and in general, all studies reported that patients were discharged within 1–2 days.[27]

Ning Sun et al in their meta analysis also found that the length of hospital stay were similar between SSRC and MLC groups (MD ¼ 0.02, 95% CI: 0.60 - 0.57, p ¼ 0.96) [31].

Surgical site infection (SSI),

Altyhough Yu-Pei Li et al (2017) in their study found better clinical outcomes in the RC group. (1) Postoperative complications were developed in 75 patients (20.4%) in the CLC group while in three patients (3.8%) in the RC group which was statistically significant (p Z 0.001).[1]

Chung Hyeun Ma et al. on 2020 in their analysis found no critical complications between RSSC and SSIC group .(18) Afif N. Kulaylat et al 2021 also reported no differences in intraoperative or postoperative complications between two techniques (LC 4.1% vs. RC 7.6%) [26] Ning Sun et al in their meta analysis found no significant difference between SSRC and MLC groups in postoperative complications and for the risk of wound infection [31] Lana et al. in their systemic review also reported that there was no significant difference in operative complications (p= 0.57),) between LC and RC. [32]

On the other hand, Banujan Balachandran1 and Theadore A et al. on (2017) in their comparative study reported that wound infections (3.9 vs. 1.1%; p = 0.037) were seen more commonly in SSRC group,[29]

Rivfka Shenoy and Michael A. Mederos on 2021, in their meta analysis found that none of the RCTs reported SSI rates statistically significant difference between LC and RC groups but only one observational study demonstrated a statistically significant higher SSI rate for robotassisted arm [27]

Readmissions,

In the comparative analysis by Afif N. Kulaylat et al 2021, no differences were detected in hospital readmission rates between LC nd RC groups (LC 4.5% compared to RC 5.1%). [26]

On the other hand, Rivfka Shenoy and Michael A. Mederos on 2021 ,in their meta analysis showed that, only propensity-matched study reported a lower rate of readmissions for the robot-assisted group (0% vs. 4.1%, p < 0.05) [27]. However, four other observational studies demonstrated that the robot-assisted approach had lower rates of readmissions [27]. William J. Kane et al. on 2020 in their analysis also demonstrated that patients who underwent robotic cholecystectomy had lesser rates of 90-day readmission (Robot: 0% [0], Lap: 4.1% [43], p = 0.035, [34] David S Strosberg et al. also reported that readmission rate was lower (p=0.033), for robotic cholecystectomy. [30]

Although Banujan Balachandran1 and Theadore A et al. on (2017) in their comparative study reported that mean length of follow-up was 2.5 months in the SSRC group and 3.3 months in the LC group (p = 0.12). [29] , Yu-Pei Li et al (2017) in their study showed that patients in the CLC group had more frequency of OPD visits and received OPD care, although the difference was not significant (p Z 0.131, 0.143, respectively). [1]

Pain.

Chung Hyeun Ma et al. on 2020 in their analysis found no significant difference in the postoperative pain score between RSSC and SSIC group .[18] Afif N. Kulaylat et al on 2021 reported postoperative analgesic use was similar between both LC and RC groups (LC 13 mg vs. RC 12 mg [morphine equivalent]). [26]

However, Sun Min Lee and Jin Hong Lim on 2021 reported that additional pain control was administered more frequently in SILC patients than in SIRC patients. (SILC 1.08±0.893 vs. SIRC 0.58±0.795, p"ÿ0.001). [28] Banujan Balachandran1 and Theadore A et al. on (2017) in their comparative study reported that abdominal pain (8.4 vs. 4.2%; p = 0.032) were more frequently seen in SSRC group,[29] Yu-Pei Li et al (2017) in their study found That the period of analgesics requirement was significantly longer in the CLC group (p Z 0.023) which may indicate that prolonged postoperative pain were experienced by CLC group patients. [1]

Comparison of long-term outcomes

The main long-term outcome we reviewed was the rate of incisional hernias. We also reviewed the overall total cost between two techniques.

Follow up complications and incisional hernias

Sherry M. Wren, MD; Myriam J. Curet, on 2011 in their study reported that there were no late complications in single-port cholecystectomy within the 30-day postoperative period, and no new complications related to the surgery were detected in a mean follow-up of 201 days (range, 151-291 days).[12] Afif N. Kulaylat et al on 2021 found no differences in postoperative complications between two techniques(LC 4.1% compared to. RC 7.6%) [26] Banujan Balachandran et al. on (2017) showed that mean length of follow-up was 2.5 months in the SSRC group and 3.3 months in the LC group (p = 0.12). [29]. However, they also reported that at the time of last follow-up, the rate of incisional hernias was higher in SSRC group as compared to LC group (6.5 vs 1.9%; p = 0.006) [29]

Rivfka Shenoy and Michael A. Mederos on 2021 ,in their meta analysis found that 12 studies including two RCTs and one propensity-matched study reported that the single-port approach (robot-assisted) had higher rates of incisional hernia compared to multi-port approach (laparoscopic).[27] Hagen et al. [37] reported that seven patients (7.1%) undergoing single-port robot assisted technique required a follow-up incisional hernia repair, while in the multi-port laparoscopic arm group no patients required follow up repair (p < 0.05) . Ning Sun et al in their meta analysis showed that incidence rate of incisional hernia in SSRC group was 5.8% which was significantly higher than MLC group (0.9%). [31]

However, Yu-Pei Li et al (2017) in their study found that CLC group patients two cases (0.55%) of incisional hernia required open repair while One case (1.28%) of umbilical hernia was reported in the RC group. [1]

Cost:

Afif N. Kulaylat et al 2021 in their comparative analysis reported that in the robotic cholecystectomy groups total hospital costs were higher (multi-port $17,340, single-site $15,519) compared to the laparoscopic cholecystectomy group ($11,197), which were considered primarily by higher perioperative costs [26] William J. Kane et al. on 2020 in their analysis demonstrated similar results (Robot: $6611 [$5484-8098] vs. Lap: $4930 [$4051-6865], p < 0.0001) [34] Ning Sun et al in their meta analysis also showed that the total costs (USD, Thousand) was higher in the SSRC group than MLC group (MD ¼ 3.51, 95% CI: 0.31-6.71, p ¼ 0.03) [31]

In a comparative study of medical resource utilization and clinical outcomes between Robotic versus conventional laparoscopic cholecystectomy by Yu-Pei Li et al. on 2017, showed that the patients in the RC group consumed more medical resources. and significantly higher average hospital charge (NTD204125 47037.03 compared to NTD49218 15324.59, p Z 0.001). [1]

However, S Strosberg et al. in their retrospective comparison study analysed the cost of RC and LC but found no difference in total direct operative and hospital costs (p=0.365) between two technioques [30]

Should Robotic Surgery be performed for cholecystectomy?

Gallbladder disease still considered as the most common medical problems leading to surgical intervention and an ideal arena to test and compare new and innovative surgical techniques with current routine practices. [29]. Although conventional laparoscopic cholecystectomy is considered the standard treatment for gallbladder diseases, single incision surgery is the latest evolution in cholecystectomy. [31] Since its establishment , single incision laparoscopic cholecystectomy has become popular due to its better cosmetic outcomes, and trends seems that it may replace conventional multi-port laparoscopic cholecystectomy.[28] But there are significant limitations found to be associated with manual SILS, including visualization, triangulation of target anatomy, and ergonomics.[12]. Recently, single incision robot assist cholecystectomy (the da Vinci Single-site Surgical System) has been developed to overcome the limitations of SILC.[28]

Robotic single-port system provides a 10 times magnified, stable and high definition 3- dimensional images, and tremor suppression, which avoid biliary and artery damage during operation. [31]

Moreover, in the robotic surgery surgeon can associate their hands with the instrument tips regardless of the robotic arm holding the instruments. [31] The curved cannulae allow the robotic arms to spread out, and helps to minimize collisions and enable instrument triangulation with coordination of instrument handedness and screen view [12]. The presence of a bedside-assistant port also enables dynamic traction which facilitates safe dissection. [12] The 3-dimensional endoscope allows exquisite visualization and eliminates collisions either with the bedside surgeon or intra-abdominal instruments, and high-definition camera provides an excellent view during dissection [12]. Moreover robotic technique provides a better ergonomic comfort for the surgeon when seated at the console. [12]

Many surgeons reported that in the robotic surgery cystic artery and duct dissection, ligation, and transection were more easier and safer to perform than with multi-port or single-port laparoscopy cholecystectomy.[31] and there were many surgeons who thought robotic assisted minimally invasive surgery is a reality and may become the surgical procedure of the future.[31] Robotic-assisted operations are now common in certain gastrointestinal procedures, including colorectal surgery [34] as robot assist surgery has been reported to provide better visualization, dexterity, and instrumentation in minimal accesssurgery.[34] . Although , surgeons have begun to use the robot to perform cholecystectomy , however there has been minimal evidence to suggest improved clinical outcomes [34] .Grochola et al.[22] reported that single incision robot cholecystectomy provides significant benefits to surgeon's in the term of reducing stress load, but they failed to show a patient advantage [28] Although the popularity and use of SSRC is increasing, but few studies have been published comparing SSRC with MLC. However, there are also only a few studies that compared SILC with SIRC.

After review of the different medical records the present research clearly identified that the robotic approach to be associated with greater operative time[1,27,30,31, 32,34] and greater hospital charges and cost[1,26,31,34] compared to laparoscopic repairs. But by contrast, In robot assist cholecystectomy pre and postoperative complications[18, 27, 28, 29] were apparently low, less chance of biliary duct or hepatic artery injury, bile leak, reoperation, and less chance of inadvertent injuries to the surrounding structure or mortality.

Bile spillage can be an indicator of surgical stability, so care should be taken to avoid perforating the gallbladder during cholecystectomy.[28] Bile spillage during laparoscopic cholecystectomy may provoke tumor recurrence with a hidden malignancy of the gallbladder.[28] and negatively affects progression free survival in patients with incidental gallbladder cancer discovered during laparoscopic cholecystectomy [28] Moreover, bile spillage is a potential risk for developing surgical site infection [28]. Peponis et al [38] reported that patients with bile spillage have over two times more chance to develop surgical site infection. Rice et al. [39] also reported that intraperitoneal bile spillage was associated with intra-abdominal abscesses.

Robotic cholecystectomy is also associated with a lesser rate of conversion to open procedure. [1,18,30] Moreover, there is significantly lower pain scale score[1,28,29] in the RC group when compared to single-incision LC.

Major disadvantages for RC surgery is time, cost and post operative complication like incisional hernia. [27,29,31]Previously published data shows that , the

docking time initially which had an average learning curve period of about 10 minutes was recently reduced to an average of less than three minutes [40]. Thus, we can markedly shortened the robotic surgery time [41] after mastering the learning curve.

We found that Hospital cost was greater for robotic-assisted cholecystectomy but eventually If robotic surgery is more widely adopted and performed routinely, costs will decrease over time. However a clinical benefit should be present to justify the use of a new costlier technology. Our finding is that readmission rate is lower and follow up OPD visit is less frequent in RC group [1,27,30,34].

The umbilical wound is always larger in RC than MLC's. The periumbilical area is inherently weak anatomically and the higher rate of incisional hernia in SSLC has been ascribed to local ischemia induced by placement of a single large port or multiple ports at a single site, which could potentially weaken the fascia [29]. which increased the risk of incisional hernia. [31] Similarly, potential ischemia combined with the fact that the fascial incision for SSRC represents a 400% increase in the length of incision as compared to LC (20 vs. 5 mm) could contribute to the higher incidence of wound infection and subsequent incisional hernia following SSRC. [29]

Although there is a potential risk of developing incisional hernia in RC group[27,29,31], others postoperative complication was significantly higher in the CLC group than in the RC group, seems the surgical value higher in the CLC group in the index hospitalization. However, the postoperative complications may cause poor quality of life and the treatment for postoperative complications for CLC may consume more medical resources than for RC be associated with increased cost. [1] Thus the surgical value should be carefully evaluated in every aspect of perioperative and postoperative factors.[1] Moreover, the frequency of additional pain treatment may be an alternative method for assessing the effectiveness of surgery [28]

Conclusion

The potential benefits of robot assist surgery include decreased pain, improved cosmesis, shorter recovery, and higher patient satisfaction. These benefits proves that RC carried better clinical outcomes.

This review is to suggest that a robotic cholecystectomy may provide better clinical outcomes for patients. Although longer operative duration was demonstrated in robotic technique, but when surgeons and other operating room staff will continue to use the robot and become more efficient, operative times should be shortened. Hospital costs were higher in robotic-assisted cholecystectomy, but this could be offset when considering the added cost of post operative complications and the greater number of readmissions seen in the laparoscopic group. Bedeir et al. [42] reported that in a hospital which already acquired the infrastructure for robotic surgery, procedure costs for robotic surgery were even lower than for LC. [1]

The disadvantages of longer operative time and higher cost—have the potential to improve with time when robotic surgery will be in regular practice. Although many previous reports showed that the clinical outcomes were comparable between RC and CLC, although the difference did not reach statistical significance. however, those meta-analyses were based primarily on retrospective observational studies and therefore must be interpreted with caution due the presence of confounders, selection bias, and differences in study design. While robotic surgery has already been established n surgical oncology [34], I hope the findings of this review will help to further support the use of robotic-assistance in non-cancer-related, minimally-invasive surgery like cholecystectomy. Further large dataset analyses or randomized controlled trials are needed to understand the long-term implications of robotic technology and its role in minimally invasive surgery.

Conflict of interest: None

References:

1. Yu-Pei Li, Shen-Nien Wang, King-The Lee. (2017). Robotic versus conventional laparoscopic cholecystectomy: A comparative study of medical resource utilization and clinical outcomes . KJMS (2017), vol 33, 201- 206 https://www.clinicalkey.com.au/#!/content/journal/1-s2.0-S1607551X1630506X#refInSitubib18
2. Emily N. Kirkham et al. (2022). Quality of reporting of robot-assisted cholecystectomy in relation to the IDEAL recommendations: systematic Review. Oxford BJS Open, 2022, Vol. 6, No. 5. https://academic.oup.com/bjsopen/article/6/5/zrac116/6770691?login=true
3. Reynolds W Jr (2001) The first laparoscopic cholecystectomy. J Soc Laparoendosc Surg 5:89–94. https://pubmed.ncbi.nlm.nih.gov/11304004/
4. Paul, Curcillo, Podolsky et al (2010) Single-port-access (SPA) cholecystectomy: a multi-institutional report of the

first 297 cases. Surg Endosc 24:1854–1860. https://vincerainstitute.com/why-vincera/news-articles/files/017-2010 Curcillo_Wu_Podolsky_Mouhlas_Poor-Single-Port-Access-SPA-cholecystectomy-a-multi-institutional-report-of-the-first-297-cases.pdf

5. Pan MX, Jiang ZS, Cheng Y, et al. Single-incision vs three-port laparoscopic cholecystectomy: prospective randomized study. World J Gastroenterol 2013;19:394-398
6. Navarra G, Pozza E, Occhionorelli S, Carcoforo P, Donini I. Onewound laparoscopic cholecystectomy. Br J Surg 1997;84:695.
7. Mutter D, Callari C, Diana M, Dallemagne B, Leroy J, Marescaux J (2011) Single port laparoscopic cholecystectomy: which technique, which surgeon, for which patient? A study of the implementation in a teaching hospital. J Hepato-Biliary-Pancreat Sci 18:453–457
8. Prasad A, Mukherjee KA, Kaul S, Kaur M (2011) Postoperative pain after cholecystectomy: conventional laparoscopy versus single-incision laparoscopic surgery. J Minim Access Surg 7:24–27
9. Kee-Hwan Kim (2018) Comparison of Single-Incision Robotic Cholecystectomy, SingleIncision Laparoscopic Cholecystectomy and 3-Port Laparoscopic Cholecystectomy -Postoperative Pain, Cosmetic Outcome and Surgeon's Workload. Journal of Minimally Invasive Surgery Vol. 21. No. 4, 2018. https://www.e-jmis.org/journal/view.html?doi=10.7602/jmis.2018.21.4.139
10. Joseph M, Phillips MR, Farrell TM, Rupp CC. Single incision laparoscopic cholecystectomy is associated with a higher bile duct injury rate: a review and a word of caution. Ann Surg. 2012;256(1):1e6.
11. Garg P, Thakur JD, Singh I, Nain N, Mittal G, Gupta V. A prospective controlled trial comparing single-incision and conventional laparoscopic cholecystectomy: caution before damage control. Surg Laparosc Endosc Percutaneous Tech. 2012;22(3):220e225.
12. Serry,Wren SM, Curet MJ. Single-port robotic cholecystectomy: results from a first human use clinical study of the new da Vinci single-site surgical platform. Arch Surg. 2011;146(10):1122-1127.
13. Barrera K, Chung P, Sugiyama G. Robotic approach to cholecystectomy, updates in gallbladder diseases. In: Abdeldayem H (ed.), Updates in Gallbladder Diseases. London: IntechOpen, 2017, page numbers 9
14. Kroh M, El-Hayek K, Rosenblatt S, Chand B, Escobar P, Kaouk J et al. First human surgery with a novel single-port robotic system: cholecystectomy using the Da Vinci single-site platform. Surg Endosc 2011;25:3566–3573
15. Allemann P, Leroy J, Asakuma M, Al Abeidi F, Dallemagne B, Marescaux J (2010) Robotics may overcome technical limitations of single-trocar surgery: an experimental prospective study of Nissen fundoplication. Arch Surg 145:267–271
16. Pietrabissa A, Sbrana F, Morelli L, Badessi F, Pugliese L, Vinci A, Klersy C, Spinoglio G (2012) Overcoming the challenges of single-incision cholecystectomy with robotic single-site technology. Arch Surg 147:709–714
17. Miller DW, Schlinkert RT, Schlinkert DK (2004) Robot-assisted laparoscopic cholecystectomy: initial Mayo clinic Scottsdale experience. Mayo Clin Proc 79:1132–1136
18. Chung Hyeun Ma, Hyo Seon et al (2020) Surgical Outcomes of Robot vs. Laparoscopic Single-site Cholecystectomy: Single Surgeon's Experience. Ann Robot Innov Surg. 2020 Feb;1(1):40-48. https://doi.org/10.37007/aris.2020.1.1.40 pISSN 2635-6678·eISSN 2635-666X
19. Charles Jimenez , Frederick Huynh et al (2021). Initial experiences of robotic SP cholecystectomy: a comparative analysis with robotic Si single-site cholecystectomy
20. Ross SB, Sawangkum P, de La Vega KA, Teta A, Luberice K, Rosemurgy AS (2013) Single-site robotic cholecystectomy (SSRC): an initial review of safety and feasibility. Minerva Chir 68:435–443 1252 World J Surg (2017) 41:1246–1253 123
21. Lanfranco AR, Castellanos AE, Desai JP, Meyers WC (2004) Robotic surgery: a current perspective. Ann Surg 239:14–21
22. Grochola LF, Soll C, Zehnder A, Wyss R, Herzog P, Breitenstein S. Robot-assisted single-site compared with laparoscopic single-incision cholecystectomy for benign gallbladder disease: protocol for a randomized controlled trial. BMC Surg 2017; 17:13. PUBMED | CROSSREF
23. Lee EK, Park E, Oh WO, Shin NM. Comparison of the outcomes of robotic cholecystectomy and laparoscopic cholecystectomy. Ann Surg Treat Res 2017; 93:27-34. PUBMED | CROSSREF
24. Escobar-Dominguez JE, Hernandez-Murcia C, Gonzalez AM. Description of robotic single site cholecystectomy and a review of outcomes. J Surg Oncol 2015; 112:284-8. PUBMED | CROSSREF
25. Gonzalez A, Murcia CH, Romero R, et al. A multicenter study of initial experience with single-incision robotic cholecystectomies (SIRC) demonstrating a high success rate in 465 cases. Surg Endosc 2016; 30:2951-60. PUBMED | CROSSREF
26. Afif N. Kulaylat, Holden Richards et al (2021) Comparative analysis of robotic-assisted versus laparoscopic cholecystectomy in pediatric patients. Journal of Pediatric Surgery 56 (2021) 1876–1880 https://pubmed.ncbi.nlm.nih.gov/33276970/
27. Rivfka Shenoy, Michael A , Linda Ye et al (2021). Intraoperative and postoperative outcomes of robot-assisted cholecystectomy: a systematic review. BMC (Bio-Medi-Central) Shenoy et al. Systematic Reviews (2021) 10:124, https://doi.org/10.1186/s13643-021-01673-x

28. Sun Min Lee and Jin Hong Lim (2021) Comparison of outcomes of single incision robotic cholecystectomy and single incision laparoscopic cholecystectomy. Ann Hepatobiliary Pancreat Surg 2021;25:78-83 https://doi.org/10.14701/ahbps.2021.25.1.78

29. Banujan, Theadore A. Hufford,Joubin Khorsand et al (2017) A Comparative Study of Outcomes Between Single-Site Robotic and Multi-port Laparoscopic Cholecystectomy: An Experience from a Tertiary Care Center. World J Surg (2017) 41:1246–1253 DOI 10.1007/s00268-016-3799-0

30. David S Strosberg, MD1 , Michelle C Nguyen, MD1 , Peter Muscarella II, MD2 , Vimal K Narula, MD1. A RETROSPECTIVE COMPARISON OF ROBOTIC CHOLECYSTECTOMY VS. LAPAROSCOPIC CHOLECYSTECTOMY: OPERATIVE OUTCOMES AND COST ANALYSIS LINK: HTTPS://WWW.SAGES.ORG/MEETINGS/ANNUAL-

31. Ning Sun, Jialin Zhang, Chengshuo Zhang, Yue Shi (2018) Single-site robotic cholecystectomy versus multi-port laparoscopic cholecystectomy: A systematic review and meta-analysis. The American Journal of Surgery 216 (2018) 1205-1211, https://pubmed.ncbi.nlm.nih.gov/29866396/

32. Lana Aleuy 1, Oluwaferanmi Akande2 & Aliu Sanni, MD3. Robotic versus Laparoscopic Cholecystectomy: A Meta-Analysis. email: la7864@pcom.edu. Chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://digitalcommons.pcom.edu/cgi/viewcontent.cgi?article= 1628&context=research_day

33. Kudsi OY, Castellanos A, Kaza S, McCarty J, Dickens E, Martin D, et al. Cosmesis, patient satisfaction, and quality of life after da Vinci Single-Site cholecystectomy and multiport laparoscopic cholecystectomy: short-term results from a prospective, multicenter, randomized, controlled trial. Surg Endosc. 2017;31(8):3242–50. https://doi.org/10.1007/s00464-016-5353-4

34. William J. Kane, MDa, Eric J. Charles, MD PhDa, J. Hunter Mehaffey, MD MSca, Robert B. Hawkins, MD MSca, Kathleen B. Meneses, MScb, Carlos A. Tache-Leon, MDa, Zequan Yang, MDc. ROBOTIC COMPARED WITH LAPAROSCOPIC CHOLECYSTECTOMY: A PROPENSITY MATCHED ANALYSIS Surgery. 2020 February ; 167(2): 432–435. doi:10.1016/j.surg.2019.07.020

35. Spinoglio G, Lenti LM, Maglione V, Lucido FS, Priora F, Bianchi PP, et al. Single-site robotic cholecystectomy (SSRC) versus single-incision laparoscopic cholecystectomy (SILC): comparison of learning curves. First European experience. Surg Endosc. 2012;26(6):1648–55. https://doi.org/10.1 007/s00464-011-2087-1.

36. Lee JH, Song KB, Shin SH, Kim SC, Lee YJ, Park KM. Robotic singlesite cholecystectomy of 520 cases: surgical outcomes and comparing with laparoscopic single-site procedure. Surg Endosc. 2018;32(1): S351

37. Hagen ME, Balaphas A, Podetta M, Rohner P, Jung MK, Buchs NC, et al. Robotic single-site versus multiport laparoscopic cholecystectomy: a casematched analysis of short- and long-term costs. Surg Endosc. 2018;32(3): 1550–5. https://doi.org/10.1007/s00464-017-5843-z.

38. Peponis T, Eskesen TG, Mesar T, Saillant N, Kaafarani HMA, Yeh DD, et al. Bile spillage as a risk factor for surgical site infection after laparoscopic cholecystectomy: a prospective study of 1,001 patients. J Am Coll Surg 2018;226:1030-1035. 22.

39. Rice DC, Memon MA, Jamison RL, Agnessi T, Ilstrup D, Bannon MB, et al. Long-term consequences of intraoperative spillage of bile and gallstones during laparoscopic cholecystectomy. J Gastrointest Surg 1997;1:85-90; discussion 90-91.

40. Lim JH, Lee WJ, Choi SH, Kang CM. Cholecystectomy using the Revo-i robotic surgical system from Korea: the first clinical study. Updates Surg 2020. doi: 10.1007/s13304-020-00877-5. [in press] 27.

41. Posada Calderon L, Al Hussein Al Awamlh B, Shoag J, Patel N, Nicolas JD, Scherr DS. The role of surgical experience in patient selection, surgical quality, and outcomes in robot-assisted radical cystectomy. Urol Oncol 2021;39:6-12.

42. Bedeir K, Mann A, Youssef Y. Robotic single-site versus laparoscopic cholecystectomy: Which is cheaper? A cost report and analysis. Surg Endosc 2016;30:267e72.