APPENDIX A. SEARCH STRATEGIES

CHOLECYSTECTOMY

DATABASE SEARCHED & TIME PERIOD COVERED:
Pubmed – 2010-2020

"Robotic Surgical Procedures"[Mesh] OR robotics[mh] OR robot-assisted OR robot*[tiab] OR robot*[ot]
AND
cholecystectomy[tiab]OR cholecystectomies[tiab])) OR cholecystectomy[MeSH]
AND
"2010"[Date - Publication] : 2020[Date - Publication]

DATABASE SEARCHED & TIME PERIOD COVERED:
EMBASE – 2010-2020

'robot assisted surgery'/exp OR 'robot assisted surgery' OR 'robot assisted' OR robot*
AND
Cholecystectomy/exp OR Cholecystectomy OR Cholecystectomies
AND
Publication years 2010-2020

DATABASE SEARCHED & TIME PERIOD COVERED:
Cochrane 2010-2020

Robotic assisted surgical procedures OR robotics OR (MESH descriptor)Robotic Surgical Procedures/exp OR (MESH descriptor)Robotics/exp
AND
(MESH Descriptor)Cholecystectomy/exp OR (Cholecystectomy OR Cholecystectomies)ti,ab,kw
AND
Publication years Jan 2010-Dec 2020

INGUINAL HERNIA

DATABASE SEARCHED & TIME PERIOD COVERED:
PUBMED – 2010-2020

"Robotic Surgical Procedures"[Mesh] OR robotics[mh] OR robot-assisted OR robot*[tiab] OR robot*[ot]
OR
surgical mesh or open surgical technique* or open operative technique* or open suture repair* or mesh repair*
OR
"Abdominal Wall/surgery"[Mesh] OR "Hernia, Ventral/surgery"[Mesh]

AND

Hernia, Inguinal[MESH] OR “inguinal hernia” OR “inguinal hernias” OR Groin[MESH] OR Groin or groins

AND
(limit) Humans
AND
(limit) adult
AND

"2010"[Date - Publication] : "2020"[Date - Publication]

DATABASE SEARCHED & TIME PERIOD COVERED:
EMBASE – 2010 - 2020

'robot assisted surgery'/exp OR 'robot assisted surgery' OR 'robot assisted' OR robot*
AND
‘inguinal hernia/exp OR inguinal region/exp OR “inguinal hernia” OR “inguinal hernias” OR groin OR groins
AND
Human/de
AND
adult/lim OR aged/lim OR very elderly/lim
AND
Publication years 2010-2020

DATABASE SEARCHED & TIME PERIOD COVERED:
COCHRANE Reviews – 2010- Dec 2020

Robotic assisted surgical procedures OR robotics OR (MESH descriptor) Robotic Surgical Procedures/exp OR (MESH descriptor)Robotics/exp

AND

1. explode inguinal hernia (MeSH)
2. inguinal herni* ti,ab,kw
3. shouldice. ti,ab,kw
4. bassini. ti,ab,kw
5. mcvay. ti,ab,kw
6. stoppa.t ti,ab,kw
7. (laparoscop* NEAR25 herni*) ti,ab,kw
8. (tension-free NEAR25 herni*) ti,ab,kw
9. (conventional NEAR25 herni*). ti,ab,kw
10. (open NEAR25 herni*). ti,ab,kw
11. (darn NEAR25 herni*). ti,ab,kw
12. (mesh NEAR25 hern*). ti,ab,kw
13. (traditional NEAR25 herni*) ti,ab,kw
14. (plug NEAR25 herni*).t ti,ab,kw

15.(lichtenstein NEAR25 herni*).tw
16. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15

AND

Publication years Jan 2010- Dec2020

Notes on ENL:
Created separate ENL for Cochrane which was deduped and then copied into other ENL
keyword: child, manually reviewed and deleted records

DATABASE SEARCHED & TIME PERIOD COVERED:
OVID MEDLINE & Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily - 1946 to March 26, 2020)

1. exp Hernia, Ventral/su [Surgery]
2. Abdominal Wall/su [Surgery]
3. (surgical mesh or open surgical technique* or open operative technique* or open suture repair* or mesh repair*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
4. 1 or 2 or 3
5. Hernia/
6. exp Hernia, Inguinal
7. Groin/
8. inguinal hernia or inguinal hernias or groin or groins
9. 5 or 6 or 7 or 8
10. 4 and 9

Limit – humans, 2010-2020, young adult, adult, middle age, middle aged, all aged

<u>VENTRAL HERNIA</u>

DATABASE SEARCHED & TIME PERIOD COVERED:
PUBMED – 2010-2020

"Robotic Surgical Procedures"[Mesh] OR robotics[mh] OR robot-assisted OR robot*[tiab] OR robot*[ot]
AND
“surgical mesh” or “open surgical technique*” or “open operative technique*” or “open suture repair*” or “mesh repair*”
OR
"Abdominal Wall/surgery"[Mesh] OR "Hernia, Ventral/surgery"[Mesh]

AND

"ventral hernia" OR "incisional hernia"
OR
ventral hernia or incisional hernia
OR
"Hernia"[Mesh])
OR
“Hernia, Ventral"[Mesh]

AND
(limit) Humans
AND
(limit) adult
AND
"2010"[Date - Publication] : "3000"[Date - Publication]

DATABASE SEARCHED & TIME PERIOD COVERED:
EMBASE - 2010-2020

'robot assisted surgery'/exp OR 'robot assisted surgery' OR 'robot assisted' OR robot*
AND
Abdominal wall hernia/exp OR incisional hernia/exp OR umbilical hernia/exp OR epigastric hernia/exp OR 'incisional hernia' OR 'incisional hernias' OR 'ventral hernia' OR 'ventral hernias' OR 'umbilical hernia' OR 'umbilical hernias' OR 'epigastric hernia' OR 'epigastric hernias'
AND
Human/de
AND
adult/lim OR aged/lim OR very elderly/lim
AND
Publication years 2010-2020

DATABASE SEARCHED & TIME PERIOD COVERED:
COCHRANE – Jan 2010 – Dec 2020

Robotic assisted surgical procedures OR robotics OR (MESH descriptor) Robotic Surgical Procedures/exp OR (MESH descriptor)Robotics/exp
AND
Incisional hernia(Mesh descriptor)/exp OR Hernia, ventral(Mesh descriptor)/exp OR Hernia, umbilical (Mesh descriptor)/exp OR “incisional hernia” OR “Incisional hernias” OR “ventral hernia” OR “ventral hernias” OR “umbilical hernia” OR “umbilical hernias” OR “epigastric hernia” OR “epigastric hernias”:ti,ab,kw
AND
Publication years Jan 2010- Dec2020
NB: results reviewed for animal and children exclusion

DATABASE SEARCHED & TIME PERIOD COVERED:
OVID MEDLINE & Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily (1946 to March 26, 2020) –

1. exp Hernia, Ventral/su [Surgery]
2. Abdominal Wall/su [Surgery]
3. (surgical mesh or open surgical technique* or open operative technique* or open suture repair* or mesh repair*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
4. 1 or 2 or 3
5. Hernia/
6. exp Hernia, Ventral/

(ventral hernia or incisional hernia).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

8. 5 or 6 or 7
9. 4 AND 8

AND
Humans (limit)
AND
Young adult OR adult Or middle age OR middle aged or all aged OR aged (limit)
AND
2010-1091 (limit)

APPENDIX B. PEER REVIEWER COMMENTS AND RESPONSES

Reviewer comment	Authors Responses
	Note to the reviewers, we updated our search through April 2020. This added a handful of studies (5 cholecystectomy; 4 inguinal hernia repair; 4 ventral hernia repair). 1 inguinal study is an RCT. These did not change our main conclusions.
Yes - Throughout this very well written manuscript there is a biased assumption that the capabilities of surgeons operating laparoscopically and robotically are similar. This would be the majority view but I strongly believe that it is incorrect. Robotic instruments and integrated real 3 dimensional vision generated by 2 cameras, 1 for each eye is vastly different than laparoscopy. Could robotic procedures be longer because surgeons are seeing better and working safer? Could robotic procedures take longer because more complex cases are being performed? Are robotic procedures taking longer because the staff are less experienced? Where are robotic surgeons in their learning curves within all of these studies? Laparoscopy has been main stream for more than 30 years so the experience of surgeons with laparoscopy would have to be significantly higher.	Yes. We agree that the robot offers clear advantages and have added comments about these to the Discussion. Thanks for your other comments. We expanded our Discussion section on: increased OR time/ safer; complexity of cases; learning curves.
Yes - As the authors know, the topic of robotic use in General Surgery is a very fluid and hot topic. Because the literature is continually changing with new studies, albeit, not RCTs, it is really difficult to make definitive conclusions. There was a recent study in the last 6 months comparing robotic and laparoscopic ventral hernia repair and concluded no difference in outcomes studied. The outcome that is not typically included in most studies is postoperative pain for all 3 procedures. Many experts feel the major benefit of robotic repair of both incisional and inguinal hernias is the avoidance of using tacks. The ability to use intra-corporal sewing with the robot for securing mesh with ventral hernias and avoiding tacks does reduce postop pain. Similarly, the use of mesh that eliminates the need for sutures for robotic inguinal hernia repair definitely reduces acute and chronic pain for these patients. So perhaps comments in these 2 areas would be helpful for the reader. I agree with the authors that it is really hard to justify by any outcome that there is a benefit to using a robot for cholecystectomy.	Yes. Thank you for your suggestion. We added comments to our Discussion about 1) benefit of robotic approach for hernia repairs as tacks aren't used; 2) sutureless mesh. Thank you for this comment. We are working several manuscripts to submit.

Compliments to the authors for an excellent review. Suggest you convert this into a manuscript that could be published in a surgical journal.	
Edits recommended as below: Page 4, Lines 32-40: Degrees/titles edited; recommend deletion of mailstops (10NC2) Mark A. Wilson, MD, PhD National Director of Surgery (10NC2) Department of Veterans Affairs William Gunnar, MD Executive Director, National Center for Patient Safety Former National Director of Surgery (10NC2) Department of Veterans Affairs	Thank you for your edits. These corrections were made.
Page 6, Lines 25-44: Capitalization is not consistent. Standardize terminology to robot-assisted for all uses. RESULTS .... 19 Key Question 1A – Cholecystectomy: What is the clinical effectiveness of robot-assisted surgery compared to conventional laparoscopic surgery for cholecystectomy?...................... 23 Key Question 2A – cholecystectomy: what is the cost-effectiveness of robot-assisted surgery compared to conventional laparoscopic surgery for cholecystectomy? .... 30 Key Question 1B – inguinal hernia surgery: What is the clinical effectiveness of robot-assisted surgery compared to conventional laparoscopic or open surgery for inguinal hernia repair? 38 Key Question 2B – Inguinal Hernia Surgery: what is the cost-effectiveness of robotic-assisted surgery compared to conventional laparoscopic OR open surgery for inguinal hernia repair? .... 47 Key Question 1C – VentraL hernia surgery: What is the clinical effectiveness of robotic assisted surgery compared to conventional laparoscopic or open surgery for ventral hernia repair?.. 49 Key Question 2C – Ventral Hernia Surgery: what is the cost-effectiveness of robot-assisted surgery compared to conventional laparoscopic OR open surgery for ventral hernia repair? 59	These corrections were made.

Page 8, Lines 39-33: Delete mailstops (10NC2); add current title for Dr. Gunnar as below: This topic was developed in response to a nomination by Dr. Mark Wilson, National Director of Surgery (10NC2), and Dr. William Gunnar, Executive Director, National Center for Patient Safety and former National Director of Surgery (10NC2). Key questions were then developed with input from the topic nominator, the ESP coordinating center, the review team, and the technical expert panel (TEP).	
Very nice review. I have a couple minor edits/suggestions. Page 7, line 42 would add ….We assessed robotic and laparoscopic approach for cholecystectomy, as open cholecystectomy is typically performed for cancer pathology or in the setting of significant inflammation or adhesive disease. page 7 line 49 ,...in order (to) lessen confounding factors page 8 line 20. not sure what is meant by "technique factors".... page 41 line 11 - I think there are extra tick marks for length of stay. I suspect that the learning curve of robotic general surgery played a large part in increased operative times. Most of the studies compared early surgeon experience with the robot compared with years of experience laparoscopically. Perhaps a reference about learning curve and robotic surgery could be included. Inguinal hernia repairs and cholecystectomies rarely require inpatient hospitalization. This should be noted.	Requested edits were made to pages 7-8. For page 41 comment: These studies reported inpatient and outpatient LOS so both were listed. We now display only outpatient values which generalizes better to how most are done. We added a clarification that inguinal hernias and cholecystectomy are mainly outpatient procedures.
Robotic surgery is an exciting field with more advanced procedures being performed daily. Although the technology has been available for years there is still a learning curve for the surgeon and may be reflected by longer case times initially. As it becomes more integrated into practice I foresee the benefits will rise. This review is a great resource for those interested in robotic general surgery and how it compares to laparoscopic and open surgery. The authors skillfully reviewed many studies and have	Thanks for the comments. We added to the Discussion more specifics about the potential learning curve. It is possible that more complex gallbladder cases are preferentially done with the robot, but this was hard to assess with the studies as case complexity wasn't defined well for the benign disease. RCTs for cholecystectomy should control reasonably well for this potential difference. We also added comments

put together a comprehensive overview of the data we have thus far. Thank you for acknowledging the limitations of all these heterogenous studies. Page numbers based on pdf document, not those printed on the text. Cholecystectomy: Did the studies look at difficulty of gallbladder surgery? *Ie* were the robotic gallbladders done because of an expected difficult surgery vs laparoscopic technique? This is alluded to further in the discussion as a selection bias. Inguinal hernias: Pg 11: Again was the difficulty of the hernias looked at in the demographics and case matching? I would always choose a robotic repair over laparoscopic if expected to be difficult (patient obesity, size of hernia defect, incarceration, bowel involvement). Since the cost effectiveness sections all came to the same conclusions perhaps they could be condensed into 1 section. Discussion: Differences in OR time across studies is possibly due to docking time of the robot but an efficient team can do this in 10 minutes or less. I would also be careful placing a lot of weight on the differences in OR time especially if not a great time difference between technique. Faster is not necessarily better for the patient. I think a lot of the difference is due to the learning curve with starting robotic surgeries, the efficiency of the OR team and mostly the difficulty of the case. When choosing a surgical technique for hernia or gallbladder I always consider the robot when I anticipate a case to be more difficult. *Ie* larger hernia, incarcerated bowel, recurrence hernia, chronic cholecystitis with PCT. These cases will always take me longer because of the difficulty not because of the robot. The LOS is a hard measure to compare as most of these cases are done outpatient regardless of technique. Again I don't think there is a big clinical impact here but all the studies mention it. As for the cost I agree that no conclusions can be made based on the evidence. These sections could be condensed into 1 for cholecystectomy and hernias. Does the VA have any cost data to look at internally? "Urologic surgery has been widely adopted in the VA, so this experience for the staff may translate into an easy implementation to	about use of robot for more complex cases including cancer in the Discussion. We added more cost data and have chosen to present them by the individual procedures. Cost range is quite different between these groups so it seems better to keep them separate. Differences between study arms for hernias were multi-factorial. Sometimes matching was on patient factors, but not for hernia size or complexity. And sometimes visa versa. Standardized matching across studies on the most pertinent factors would be very useful. Studies typically matched based on the available variables available in their dataset. This comment was added to our Discussion as well. We added comments to address your points – gallbladder difficulty was poorly assessed for observational studies. Yes. The difficulty of cases for inguinal hernias was also hard to assess. Particularly for inguinal hernias, there were gaps in reported information to assess. We did our best to control for laterality (unilateral, bilateral) as this would greatly impact outcomes we were interested in. Unfortunately, we are not aware of any cost data within the VA. We are in the process of accessing VA utilization data on robotic surgery. A comment on this was added to the Discussion section.

the robotic general surgery field." I agree with this statement. Most OR staff is familiar with robotic surgery and adept at use. Research Gaps: Agree with surgeon learning curve affecting outcomes of studies. Additionally the difficulty of cases effects outcomes. Agree with need for long term follow up to prove hernia recurrence is lower or higher for each technique. Cholecystectomy for cancer should be considered on its own for clinical effectiveness. This operation may involve a partial hepatectomy depending on pathology. Additionally studies need to clearly compare cases based on the difficulty as I mentioned earlier. A small ventral hernia with no adhesions or bowel involvement can be done in 1-2 hours, whereas a larger ventral hernia with need for adhesiolysis and component release will take 3-5 hours. Surgeon experience is a critical component in deciding which technique to use. At the end of the day the best operation for the patient is the 1 the surgeon is most experienced with. I do not foresee many RRT being done for robotic vs laparoscopic vs open surgery in the future. The robotic surgery platform is taking off and has been proving itself without these trials.	
This is an exhaustive review and is balanced well with the exception of the bias that I perceive as described above. It is clear that the authors have worked very dilligently to use language that avoids this bias against robotics but I would consider adding a section related to the expanded capabilities that robotic surgery has offered. For example lap inguinal hernias nation wide never exceeded 20% of total cases. However, with the addition of robotically trained inguinal hernia surgeons large markets, not just individual surgeons, now are able to offer minimally invasive inguinal hernia surgery to greater than 40% of an entire market. Personally, I saw my busy inguinal practice go from 60%mis 40%open to 95%MIS vs 5%open with the addition of the robotic platform to my armamentarium of procedures that I may thoughtfully offer to patients. The end result is that more patients are able to have an MIS hernia repair and this increased cost is worth it to each patient that has shorter times of lifting restrictions, less opioid utilization, earlier return to full activity, and earlier return to work.	Thanks for the comment. We added text about the expanded capabilities of robotic surgery to the Discussion section. We added to the Discussion the importance of balancing added cost with potential benefits to the patient.

The authors should be commended for synthesizing a large amount of data that stems from very disparate data sources with variable methodologies and end points. The authors appropriately used the GRADE methodology to rate the quality of the evidence. They also appropriately noted that data was too heterogenous to allow for meta-analysis and instead presented this as a systematic narrative review of the evidence. The authors clearly delineated their search strategy and analytic framework. They also note limitations in the study, including the learning curve effect of robotic surgery as the newer technology which may predispose towards higher costs and longer operative times for the newer procedures. The authors do address risk of bias in the published data but primarily discuss this in terms of publication bias and not selection or author bias. There is excellent literature that suggests that there is significant bias in published reports of robotic surgery, and specifically that studies with unreported Conflict of Interest are significantly more favorable towards robotics (example: https://www.ncbi.nlm.nih.gov/pubmed/28700443)	Excellent point, we have added a sentence about the evolution of the robotic platform to other companies and types of technology. Thank you for your comment. We have added these additional gaps in the Discussion. We added several additional research gaps to the Discussion, including the ones listed here: surgeon ergonomics, surgical education, learning curve, and anticipated new robotic platforms.
The data seems clear that robotic surgery takes longer. There are some limited indications that a few selected patient outcome metrics are improved with robotics compared to open surgery and that conversion to open surgery may be less often needed in robotics compared to laparoscopy. There is 1 area were robotic surgery seems to be have clinically worse outcomes, notably single port robotic surgery leading to higher incisional hernia rates compared to multiple port laparoscopy. Because the studies were selected as RCTs or case comparisons, the data sources are unable to answer an important question of whether robotics allows some cases to be done via a minimally invasive approach as opposed to an open approach. Robotic advocates often claim that the robot allows some procedures to be done minimally invasively instead of open, but some market data in hernia surgery suggests that more cases seem to be converting from laparoscopic to robotic, as opposed to open cases transitioning to robotic. Studies looking at market adoption of robotic surgery could help answer this question, but would require an additional avenue of analysis. Costs seem to be higher in robotics, but due to limitations in data and methodology this is less certain, and likely varies depending on the particulars of an operation and the method of accounting. For example, the costs of robotic acquisition are	

handled variably across studies, as is the cost of length of stay data.

The authors use their systematic review to identify 4 areas with a research gap as a guide to future research. These areas are well considered and are all worthy of future study. Because the literature review focused on patient outcomes and cost, the identified research gaps are obviously focused on these areas. There are several major research gaps not identified in this review as they do not directly arise in the types of studies considered in this analysis:
1) Surgeon ergonomics and workload. Surgeons have a very high rate of musculoskeletal disorders due to the ergonomic challenges of both open and laparoscopic surgery. Advocates for robotic surgery often allege that ergonomics are improved and surgeon stress/workload/fatigue is decreased with robotic adoption, and postulate that this will result in improved surgeon longevity. Although data in this area is sparse, it would be a valuable additional area for future research.
2) Surgical education and learning curve. Robotics is a new and evolving technology. This is creating major issues in surgical education - both in education of surgical trainees and also in education of surgeons in practice who are learning new approaches. The advent of laparoscopy more than 20 years ago showed the importance of education and learning curves, as patient injury rates skyrocketed during the early years of laparoscopic surgery.
3) Future innovation in surgical robotics. Although not discussed in the review, all of the studies addressed here are using the da Vinci system from Intuitive. There are several new robotic platforms that will soon be available, and these will come with new opportunities and challenges with regard to technical issues, patient outcomes, and costs. Additionally, robotic platforms offer the potential for new advances in computer vision, machine learning, and automation that may transform the surgical landscape. These are areas rife with research opportunities.

APPENDIX C. COCHRANE RISK OF BIAS TOOL

The Cochrane Collaboration's Tool for Assessing Risk of Bias*

Domain	Support for judgement	Review authors' judgement
Selection bias.		
Random sequence generation.	Describe the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.	Selection bias (biased allocation to interventions) due to inadequate generation of a randomised sequence.
Allocation concealment.	Describe the method used to conceal the allocation sequence in sufficient detail to determine whether intervention allocations could have been foreseen in advance of, or during, enrolment.	Selection bias (biased allocation to interventions) due to inadequate concealment of allocations prior to assignment.
Performance bias.		
Blinding of participants and personnel *Assessments should be made for each main outcome (or class of outcomes).*	Describe all measures used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.	Performance bias due to knowledge of the allocated interventions by participants and personnel during the study.
Detection bias.		
Blinding of outcome assessment *Assessments should be made for each main outcome (or class of outcomes).*	Describe all measures used, if any, to blind outcome assessors from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.	Detection bias due to knowledge of the allocated interventions by outcome assessors.
Attrition bias.		
Incomplete outcome data *Assessments should be made for each main outcome (or class of outcomes).*	Describe the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. State whether attrition and exclusions were reported, the numbers in each intervention group (compared with total randomized participants), reasons for attrition/exclusions where reported, and any re-inclusions in analyses performed by the review authors.	Attrition bias due to amount, nature or handling of incomplete outcome data.
Reporting bias.		
Selective reporting.	State how the possibility of selective outcome reporting was examined by the review authors, and what was found.	Reporting bias due to selective outcome reporting.
Other bias.		
Other sources of bias.	State any important concerns about bias not addressed in the other domains in the tool. If particular questions/entries were pre-specified in the review's protocol, responses should be provided for each question/entry.	Bias due to problems not covered elsewhere in the table.

* http://handbook.cochrane.org/ in Table 8.5.a

APPENDIX D. RISK OF BIAS IN NON-RANDOMISED STUDIES – OF INTERVENTIONS (ROBINS-I)

Bias domains included in ROBINS-I[10]

Pre-intervention	Risk of bias assessment is mainly distinct from assessments of randomised trials
Bias due to confounding	Baseline confounding occurs when 1 or more prognostic variables (factors that predict the outcome of interest) also predicts the intervention received at baseline ROBINS-I can also address time-varying confounding, which occurs when individuals switch between the interventions being compared and when post-baseline prognostic factors affect the intervention received after baseline
Bias in selection of participants into the study	When exclusion of some eligible participants, or the initial follow-up time of some participants, or some outcome events is related to both intervention and outcome, there will be an association between interventions and outcome even if the effects of the interventions are identical This form of selection bias is distinct from confounding—A specific example is bias due to the inclusion of prevalent users, rather than new users, of an intervention
At intervention	Risk of bias assessment is mainly distinct from assessments of randomised trials
Bias in classification of interventions	Bias introduced by either differential or non-differential misclassification of intervention status Non-differential misclassification is unrelated to the outcome and will usually bias the estimated effect of intervention towards the null Differential misclassification occurs when misclassification of intervention status is related to the outcome or the risk of the outcome, and is likely to lead to bias
Post-intervention	Risk of bias assessment has substantial overlap with assessments of randomised trials
Bias due to deviations from intended interventions	Bias that arises when there are systematic differences between experimental intervention and comparator groups in the care provided, which represent a deviation from the intended intervention(s) Assessment of bias in this domain will depend on the type of effect of interest (either the effect of assignment to intervention or the effect of starting and adhering to intervention).
Bias due to missing data	Bias that arises when later follow-up is missing for individuals initially included and followed (such as differential loss to follow-up that is affected by prognostic factors); bias due to exclusion of individuals with missing information about intervention status or other variables such as confounders
Bias in measurement of outcomes	Bias introduced by either differential or non-differential errors in measurement of outcome data. Such bias can arise when outcome assessors are aware of intervention status, if different methods are used to assess outcomes in different intervention groups, or if measurement errors are related to intervention status or effects
Bias in selection of the reported result	Selective reporting of results in a way that depends on the findings and prevents the estimate from being included in a meta-analysis (or other synthesis)

APPENDIX E. QUALITY ASSESSMENT FOR INCLUDED RCT STUDIES

CHOLECYSTECTOMY

Author, year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias
Grochola, 2019[13] Intraop Patient measures	○ ○	◒ ◒	● ○	◒ ○	○ ○	○ ○	○ ○
Heemskerk, 2014[14]	◒	◒	◒	◒	○	○	●
Kudsi, 2017[15]	○	○	◒	●	○	○	○
Pietrabissa, 2016[16]	○	○	○	○	○	○	○

○= low risk of bias ● = risk of bias ◒ = unknown

INGUINAL HERNIA REPAIR

Author, year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias
Prabhu 2020[63]	○	◒	● Single-blinded	◒	○	○	● Intuitive funded institutional research grant to 1st author; 6 authors received honoraria from Intuitive (including 1st author)

○ = low risk of bias ● = risk of bias ◒ = unknown

APPENDIX F. QUALITY ASSESSMENT FOR INCLUDED OBSERVATIONAL STUDIES

CHOLECYSTECTOMY

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
Abel, 2019[32]	Serious: not discussed	Serious: unknown how offered	Low	Low	No information	Low	Low	n/a
Aggarwal, 2020[22]	Low: no serious demographic differences	Low: surgical method based on scheduled surgery date	Low	Low	Low (short follow-up)	Low	Low	n/a
Albrecht, 2017[17]	Low: matched	Moderate: unknown how offered	Low	Low	No information	Moderate: patient-reported pain scores	Low	n/a
Altieri, 2016[45]	Low: propensity matching	Serious: unknown how offered, database	Low	Low	No information	Low	Low	n/a
Aragon, 2014[44]	Moderate: differences in weight	Serious, unknown how offered	Low	Low	Low: no missing data	Low	Low	n/a
Autin, 2015[39]	Serious: not discussed	Serious, unknown how offered	Low	Low	No information	Low	Moderate	n/a

Balachandran, 2017[23]	Moderate: sig differences in gender, BMI, comorbidities, previous abdominal surgeries and diagnosis	Serious: unknown who was offered robotic vs lap	Low	Low	Low: excluded missing data	Low	Low	n/a
Buzad, 2013[33]	Moderate: sig differences in gender	Serious for SILC: don't know how they retrospectively chose cases Low for SSRC: consecutive cases in that time frame	Low	Low	Low: no missing data	Low	Low	
Calatayud, 2012[116]	Low: similar groups	Serious: unknown who was offered robotic vs lap	Low	Low	No information	Low	Low	n/a
Chung, 2015[24]	Moderate: sig differences in age, BMI, elective nature, ASA classification, hypertension	Moderate: unknown whether it was consecutive or all cases, unclear how offered	Low	Low	Low: excluded missing data	Low	Low	n/a
Eid, 2020[21]	Serious: acuity of surgeries significantly diff between groups	Serious: unknown how offered	Low	Low	Low (short follow-up)	Low	Low	n/a
Farnsworth, 2018[46]	Moderate: significant differences in primary diagnoses	Serious: prospectively collected ACS registry but don't know	Low	Low	No information	Low	Low	n/a

		how people were offered						
Farukhi, 2017[52]	Serious: not discussed	Serious: unknown how offered	Low	Low	No information	Low	Low	n/a
Gonzalez, 2013[34]	Moderate: sig differences in age and ASA score	Moderate: ALL robotic cases compared to first, consecutive 166 lap cases, but don't know how offered	Low	Low	Low: account for missing data	Low	Low	n/a
Gustafson, 2016[36]	Moderate: BMI and prior abd surgeries significantly diff	Moderate: consecutive cases but don't know how offered	Low	Low	Low: no missing data	Moderate: pt reported outcomes	Low	n/a
Hagen, 2017[25]	Low: patients matched by characteristic	Moderate: don't know how offered but matched	Low	Low	Low: no missing data	Low	Low	n/a
Hagen, 2017[30]	Low: case-matched analysis	Moderate, unknown how offered	Low	Low	No information	Low	Low	n/a
Hawasli, 2016[55]	Moderate: age didn't differ but didn't discuss other sources of bias	Moderate: all cases in time period but didn't discuss how offered	Low	Low	No information	Low	Low	n/a
Higgins, 2017[61]	Serious: don't discuss	Serious: unknown who was offered robotic vs lap	Low	Low	No information	Low	Low	n/a

Jang, 2019[40]	Serious: gender, age, BMI and ASA score differences	Serious, unknown how offered	Low	Low	No information	Moderate: unknown who measured pain scale	Low	n/a
Kaminski, 2014[58]	Moderate: shown but not analyzed differences in age, gender, race. Unsure of significant differences	Serious: unknown who was offered robotic vs lap	Low	Low	Low: excluded missing for outcomes of interest	Low	Low	n/a
Kane, 2020[57]	Low, propensity-matched	Serious: unknown how offered	Low	Low	No information	Low	Low	n/a
Khorgami, 2019[49]	Moderate: no differences, but lumped all surgeries together, no sub-analysis of just cholecystectomy	Serious: unknown who was offered robotic vs lap	Low	Low	No information	Low	Low	n/a
Lee, 2017[26]	Moderate	Moderate: unknown who was offered robotic vs lap	Low	Low	Low	Moderate: patient-reported questionnaire	Low	n/a
Lee, 2018[41]	Moderate: BMI, sex and indication differences	Serious: consecutively performed but unknown how offered	Low	Low	No information	Low	Low	n/a
Lee, 2019[27]	Moderate: differences in age, ASA status, preop and pathologic diagnosis	Moderate: patient decided robot vs lap	Low	Low	No information	Low	Low	n/a

Lescouflair, 2014[42]	Low: matched pts	Serious: consecutively performed but unknown how offered	Low	Low	No information	Moderate: pain measurements	Low	n/a
Li, 2017[28]	Low: similar groups	Serious: unknown who was offered robotic vs lap	Low	Low	No information	Low	Low	n/a
Main, 2017[18]	Moderate: propensity matched analysis, but differences in indication	Serious: unknown who was offered robotic vs lap	Low	Low	No information	Low	Low	n/a
Mitko, 2016[20]	Moderate: indication different	Serious: reviewed all performed but unknown how offered	Low	Low	No information	Low	Low	n/a
Moore, 2016[43]	Moderate: age different	Serious: consecutively performed but unknown how offered	Low	Low	No information	Low	Low	n/a
Pokala, 2019[56]	Serious: groups sig diff in age and race	Serious: unknown how offered (database)	Low	Low	Low (short follow-up)	Low	Low	n/a
Rosemurgy, 2015[50]	Serious: don't discuss	Serious: unknown who was offered robotic vs lap	Low	Low	No information	Low	Low	Didn't report surgical indication/ diagnosis
Ross, 2014[53]	Serious: no discussion	Serious: unknown how offered	Low	Low	No information	Low	Low	n/a

Spinoglio, 2012[37]	Low, similar groups	Low, consecutive cases that matched inclusion criteria matched to 25 consecutive lap cases	Low	Low	Low: no missing data	Low	Low	n/a
Strosberg, 2017[51]	Moderate: differences in BMI, comorbidities and indication	Serious, unknown how offered	Low	Low	Low: no missing data	Low	Low	n/a
Strosberg, 2017[51]	Serious: BMI, comorbidities, indication different	Serious: unknown how offered	Low	Low	No information	Low	Low	n/a
Su, 2017[38]	Low: similar groups	Serious, unknown how offered	Low	Low	Low: no missing data	Moderate: unknown who measured pain scale	Low	n/a
Teoh, 2017[31]	Moderate: similar groups but not addressed what was measured	Serious: unknown how offered	Low	Low	No information	Moderate: unknown who measured pain scale	Low	n/a
Wren, 2011[29]	Low: average age and BMI not significantly different	Moderate: robot offered to all who met inclusion/exclusion criteria and compared to previous sequential lap cases	Low	Low	Low: no missing data	Moderate: pain measurement	Moderate: excluded 1 patient who had conversion	n/a

INGUINAL HERNIA REPAIR

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
Abdelmoaty, 2018[75]	Serious: no baseline characteristics reported	Low: database	Low	Low	Low	Low	Low	1 author is a surgical proctor for Intuitive
AlMarqoozi, 2019[71]	Low: similar baseline characteristics and laterality except for age; non-propensity matched	Low: database	Low	Low	Serious: Low 1-yr f/u (6-9%)	Low: complications Moderate: QOL	Low	2 authors (including senior author) receive grants from Intuitive
Bittner, 2018[12]	Moderate: cohorts differed by age, type of job, history of IHR, and use of preop pain meds; BMI not reported but propensity matched	Serious: random consumer sample with, only includes those with survey completion	Serious: recall bias due to study design	Low	Serious: low survey response rate (6%)	Serious: narcotic use, RTW, pain	Low	Study funded by Intuitive; 2 authors (including senior author) employed by Intuitive; 1 author receives consulting fees from Intuitive
Charles, 2018[68]	Moderate: similar baseline characteristics except ASA; non-propensity matched	Low: database	Low	Low	Low	Low: complications, OR times	Low	1 author with grant and travel expenses for educational course from Intuitive
Gamagami, 2018[69]	Low: similar baseline characteristics; propensity matched	Low: consecutive series	Low	Low	Low	Low: complications Moderate: pain not well-defined	Low	Study sponsored by Intuitive; statistical analysis performed by Intuitive; all authors received research grants from Intuitive; 4 authors received

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
								consulting and education fees from Intuitive
Holcomb, 2019[84]	Serious: most demographic data not displayed; non-propensity matched	Low: database	Low	Low	Low	Low: complications	Low	
Huerta, 2019[70]	Serious: differs in laterality and hernia complexity; non-propensity matched	Moderate: patients chosen by surgeon expertise	Low	Low	Low	Low: inguinodynia, complications	Low	
Janjua, 2020[77]	Low: differences in age, gender, comorbidities, and laterality; propensity matched	Low: database	Low	Low	Low	Low: LOS	Low	
Kakaishvili, 2018[72]	Serious: baseline characteristics not specified, laterality differs; non-propensity matched	Serious: not specified if consecutive series	Low	Low	Low	Low: OR times, complications Moderate: pain	Low	
Khoraki, 2019[78]	Low: similar baseline characteristics; non-propensity matched	Low	Low	Low	Low	Low: complications	Low	
Knott, 2017[80]	Serious: not propensity matched, adjusted for patient	Low: database	Low	Low	Moderate: unknown follow-up	Low	Low	

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
	characteristics but not displayed							
Kolachalam, 2017[66]	Low: similar characteristics, propensity matched	Low: consecutive series for robotic group Moderate: open group patients prior to study initiation	Low	Low	Low	Low	Low	Study sponsored by Intuitive; statistical analysis performed by Intuitive biostatistician; all authors received research grants from Intuitive; 4 authors received consulting and education fees from Intuitive
Kosturakis, 2018[67]	Serious: baseline characteristics differ in hernia laterality and ASA; non-propensity matched	Low: consecutive series	Low	Low	Moderate: unknown follow-up	Low	Low	
Kudsi, 2017[74]	Serious: similar baseline characteristics and laterality except gender and ASA; non-propensity matched	Low: consecutive series	Low	Low	Moderate: missing some data in robot group at f/u	Low: complications, inguinodynia	Low	1st author is consultant for Intuitive
Lammers, 2019[83]	Serious: similar baseline characteristics but not reported; non-propensity matched	Low: consecutive series	Low	Low	Low	Low: OR times, complications	Moderate: spread not reported	

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
Macias, 2017[81]	Serious: baseline characteristics and laterality not reported	Serious: not specified if consecutive series	Low	Low	Moderate: unknown follow-up	Low: OR times, inguinodynia	Moderate: limited perioperative and long-term outcomes reported	
Muysoms, 2018[73]	Moderate: similar patient characteristics except baseline QOL, laterality analyzed in subgroups; non-propensity matched	Low: consecutive series for robot Moderate: lap patients from previously published studies	Low	Low	Low	Low: OR times, complications Moderate: QOL/pain	Low	1st author receives consultant fees from Intuitive
Pokala, 2019[82]	Serious: baseline characteristics not completely reported; robot patients more male; non-propensity matched	Moderate: database, severe severity excluded	Low	Low	Low	Low: complications, pain	Low	
Sheldon, 2019[79]	Moderate: similar baseline characteristics except for laterality, other characteristics not reported; non-propensity matched	Serious: institutional data, not stated if consecutive series; patients with intraoperative conversions of approach excluded	Low	Low	Low	Low: narcotic use	Low	
Switzer, 2019[64]	Serious: similar baseline demographics, baseline QOL scores, laterality, but not explicitly reported; non-	Serious: database; excluded patients without 6-mo EuraHS	Low	Low	Low	Low: complications, readmissions, recurrences Moderate: EuraHS QOL	Moderate: complications not specified	

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
	propensity matched							
Waite, 2016[65]	Low: similar baseline characteristics, laterality	Low: consecutive series	Low	Low	Low	Low: OR times Moderate: pain scale	Low	1 author became a consultant for Intuitive following preparation of manuscript
Zayan, 2019[76]	Serious: differ by gender, smoking status, co-morbidities, and laterality; non-propensity matched	Serious: not stated if consecutive series, selected based on availability to complete 1-yr f/u survey	Low	Low	Low	Low: LOS, OR times, complications Moderate: QOL	Moderate: limited reporting of complications	

VENTRAL HERNIA REPAIR

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
Altieri, 2018[99]	Moderate: differences in ethnicity, gender, BMI; propensity matched but characteristics not reported	Low: database	Low	Low	Low	Low: complications	Moderate: matched outcomes poorly reported and inconsistent with tables	
Armijo, 2018[104]	Moderate: similar characteristics except gender and co-morbidities; non-propensity matched	Low: database	Low	Low	Low	Low: narcotic use, complications	Low	
Bittner, 2018[86]	Serious: differences in co-morbidities, smoking status,	Low	Low	Low	Low	Low: complications	Moderate: no data on	1st author is consultant for Intuitive

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
	gender, hernia size; non-propensity matched						recurrences at 90 days	
Carbonell, 2018[90]	Low: similar characteristics, including proportion of TARs performed; propensity matched	Low: database	Low	Low	Low	Low: complications	Low	6 authors (including 1st author) received honoraria from Intuitive; 2 authors received educational funds from Intuitive
Chen, 2016[100]	Moderate: similar characteristics except for gender; non-propensity matched	Low	Low	Low	Low	Low: complications, recurrence	Low	
Coakley, 2017[98]	Low: similar baseline characteristics; non-propensity matched	Low: database	Low	Low	Low	Low: complications	Low	
Gonzalez, 2015[95]	Low: similar baseline characteristics; non-propensity matched	Low	Low	Low	Moderate: unknown follow-up	Low: complications, recurrence	Low	
Guzman-Pruneda, 2020[91]	Serious: large difference in gender, smoking status, hernia size; non-propensity matched	Low: database	Low	Low	Low	Low: complications, recurrence Moderate: QOL	Low	Operative techniques (*eg* drain placement) were significantly different between comparison groups
Khorgami, 2018[94]	Serious: unable to assess characteristics, as data was pooled for multiple procedures; non-propensity matched	Low: database	Low	Low	Low	Low: LOS	Serious: no other outcomes besides LOS	

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
Lu, 2019[93]	Moderate: similar baseline characteristics except for gender and co-morbidities; non-propensity matched	Low	Low	Low	Serious: large difference in 1-year follow-up rates between groups	Low: complications, recurrence	Low	Senior author has received honoraria for speaking engagements and consulting for Intuitive
Martin-del-Campo, 2018[87]	Low: similar baseline characteristics except ASA; propensity matched for hernia size	Low	Low	Low	Low	Low: complications	Low	2 authors are consultants for Intuitive
Mudyanadzo, 2020	Serious: baseline characteristics not reported; non-propensity matched	Serious: institutional data, not stated if consecutive series	Low	Low	Low	Low: pain, narcotic use	Low	
Nguyen, 2017[88]	Moderate: similar characteristics except hernia size; non-propensity matched	Serious: institutional data, not stated if consecutive series	Low	Low	Low	Low: complications	Low	
Prabhu, 2017[96]	Low: similar baseline characteristics; propensity matched	Low: database	Low	Low	Low	Low: complications	Low	1st and senior authors receive grant money from Intuitive
Roberts, 2019[92]	Serious: significantly different hernia defect size, other baseline characteristics not reported; non-propensity matched	Low: database	Low	Low	Low	Low: pain, complications	Low	
Song, 2017[103]	Moderate: characteristics not	Low: database	Low	Low	Low	Low: complications, narcotic use	Low	

Author, year	Confounding	Selection bias	Bias in measurement classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Other source of bias
	explicitly reported; propensity matched							
Switzer, 2017[89]	Moderate: similar age, gender, hernia size, other characteristics not explicitly reported; propensity matched	Low: database	Low	Low	Moderate: unknown follow-up	Low: complications, recurrence Moderate: QOL	Moderate: complications outcomes not defined or reported	
Walker, 2018[97]	Moderate: similar baseline characteristics except gender; propensity matched except for gender, and matched characteristics not reported	Serious: institutional data, not stated if consecutive series	Low	Low	Moderate: unknown follow-up	Low: complications, recurrence	Moderate: matched outcomes only selectively reported	2 authors (including senior author) receive honoraria to proctor for Intuitive
Warren, 2016[101]	Serious: similar characteristics except gender, recurrent hernia, and whether TAR performed concurrently; non-propensity matched	Low: database	Low	Low	Low	Low: narcotic use, complications	Low	1st and senior authors are speakers for Intuitive
Zayan, 2019[76]	Serious: difference in gender, BMI, smoking status, baseline QOL; non-propensity matched	Serious: institutional data, not stated if consecutive series	Low	Low	Moderate: unknown follow-up	Low: recurrence Moderate: QOL	Moderate: no outcomes relating to other complications	

APPENDIX G. EVIDENCE TABLES

CHOLECYSTECTOMY

Demographics and Pre-operative Factors

Author Year Population Study Design US (y/n) VA (y/n)	**# Institutions/ Surgeons**	**Propensity Matching**	**Patient Characteristics Preop** N Age, mean yr (SD) Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % Male, % BMI, mean (SD) ASA class, mean (SD) Diabetes, % Indication for surgery Acute Chole, N (%) Symptomatic Cholelithiasis, N (%) (*ie*, biliary colic, sludge, chronic cholecystitis) Other, N (%) (*ie*, cancer, polyps, choledocholithiasis, gallstone pancreatitis, *etc*) Elective operation, %								
			Total	**Single-Port Robot**	**Single-Port Lap**	**Multi-Port Robot**	**Multi-Port Lap**	**Unspecified Robot**	**Unspecified Lap**	**Specified combined single and multi- port Robot**	**Specified combined single and multi-port Lap**
Abel S 2019[32] Retrospective cohort Y N	NR/NR	No	N: 584	N: 296 BMI: 32			N: 288 BMI: 31				
Aggarwal R 2020[22] Retrospective cohort N N	Single institution/ Single surgeon	No	N: 40			N: 20 Age: 45.9 (13) Male: 3 (15%) BMI: 28.5 (4.4) ASA 1: 9 (45%) ASA 2: 10 (50%) ASA 3: 1 (5%) Cholecyst: 3 (15%) Biliary colic: 16 (80%) GB polyp: 1 (5.0%) Previous abdominal	N: 20 Age: 48.4 (12.2) Male: 3 (15%) BMI: 31.3 (6.2) ASA 1: 8 (40%) ASA 2: 12 (60%) ASA 3: 0 (0%) Cholecyst: 7 (35%) Biliary colic: 13 (65%) GB polyp: 0 (0%) Previous abdominal surgery: 3 (15%)				

						surgery: 7 (35%)					
Albrecht R 2017[17] Retrospective (matched-pair analysis) N N	Multi- institutional		N: 70			N: 35 Age: 55.5 (17.3) Men: 13 (37.1%) BMI: 28.3 (5.7) ASA I: 10 (28.6%) ASA II: 22 (62.9%) ASA III: 3 (8.6%) Elective: 32 (91.4%)	N: 35 56.9 (16.7) Men: 13 (37.1%) 30.0 (5.2) BMI >30: 14 ASA I: 12 (34.3%) ASAII: 19 (54.3%) ASA III: 4 Elective: 30 (85.7%)				
Altieri MS 2016[45] SPARCS database Prospective cohort Y N	Not reported	Yes	N: 110052					N: 186 NH-W: 69.35% NH-Black: 6.99% NH-Asian: 2.69% Hispanic: 12.37% Male: 34.41% Diabetes: 17.74%	N: 109,866 NH-W: 58.54% NH- Black: 10.95% NH-Asian: 2.89% Hispanic: 18.64% Male: 35.42% Diabetes: 16.48%		
Aragon RJ 2014[44] Prospective observational study Y N	1 institution	No	N: 330 Age: 45 (14) Male: 27% Weight: 88.3 (24.1) Sympt cholelithiasis: 79.1% Acute cholecyst: 13.64% Other: 7.3%	N: 132 Weight: 86.2 (23.6)	N: 36 Weight: 74.4 (15.8)	N; 162 Weight: 93.1 (24.7)					
Autin RL 2015[39] Retrospective analysis Y N	1 institution	No	N: 54	N: 27	N: 27						
Balachandran B 2017[23] Retrospective cohort	1 Surgeon, 1 Institution	No	N: 678 Age: 54.8 (18.6) Male: 209 (30.8%) BMI: 29.6 (6.9) ASA I: 21%	N: 415 Age: 54.1 (18.7) Male: 111 (26.7%) BMI: 29 (6.1) ASA I: 21.5% ASA II: 54.8%			N: 263 Age: 55.8 (18.4) Male: 98 (37.3%) BMI: 30.5 (7.8) ASA I: 20.4% ASA II: 47.8%				

Y N			ASA II: 51.9% ASA III: 25.1% ASA IV: 0% ASA V: 2.0% Diabetes: 112 (16.5%) Acute cholecyst: 173 (25.5%) Chronic cholecyst: 505 (74.5%)	ASA III: 21.8% ASA IV: 0% ASA V: 1.9% Diabetes: 61 (14.9%) Acute cholecyst: 76 (18.3%) Chronic cholecyst: 339 (81.7%)			ASA III: 29.6% ASA IV: 0% ASA V: 2.2% Diabetes: 51 (19.4%) Acute cholecyst: 97 (36.9%) Chronic cholecyst: 166 (63.1%)				
Buzad FA 2013[33] Prospective cohort with historically (retrospective) matched pairs Y N	1 institution/ 1 surgeon	No	N: 30	N: 20 Age: 47.8 (14.9) NH White: 70% (14) Hispanic: 25% (5) Other: 5% (1) Male: 35% (7) BMI: 27.1 (4.7) ASA I: 20% (4) ASA II: 80% (16) Acute cholecyst: 10% (2) Other: 18 (90%)	N: 10 Age: 43.3 (13.7) NH White: 80% (8) Hispanic: 20% (2) Other: 0 Males: 0% (0) BMI: 28.4 (6.2) ASA I: 50% (5) ASA II: 50% (5) Acute cholecyst: 0 Other: 10 (100%)						
Calatayud D 2012 [116] Retrospective analysis Y N	1 Institution	No	N: 187			N: 119 Age: 43.67 Male: 22% BMI: 32.8	N: 68 Age: 44.6 Male: 23.5% BMI: 32.8				
Chung PJ 2015[24] Retrospective cohort Y N	1 Institution/ N/R	No	N: 140	N: 70 Age: 40.3 (15.2) White: 15% Black: 53% Asian-Pacific: 2.0% Male: 14.3% (10) BMI: 29.5 (6.2) ASA I: 11.4% (8) ASA II: 65.7% (46) ASA III: 20% (14) ASA IV: 0 Diabetes: 10% Elective: 46%			N: 70 Age: 47.6 (17.2) White: 59% Black: 9% Asian-Pacific: 1% Male: 18.6% (13) BMI: 32.4 (7.4) ASA I: 4.3% (3) ASA II: 52.9% (37) ASA III: 41.4% (29) ASA IV: 1.4% (1) Diabetes: 19% Elective: 20%				
Eid JJ 2020[21] Retrospective cohort	Single institution/ Multiple surgeons	No	N: 90			N: 20 Age: 44.1 (15.4) Caucasian: 5	N: 70 Age: 42.3 (17) Caucasian: 10 (14.3%)				

Y N						(25%) African-American: 14 (70%) Other/ Decline: 1 (5%) Male: 2 (10%) BMI: 35.7 (9.4) ASA I: 2 (10%) ASA II: 10 (50%) ASA III: 8 (40%) ASA IV: 0 (0%) Diabetes: 2 (10%) Acute cholecyst: 5 (25%) Biliary colic: 12 (60%) Choledocholithiasis: 3 (15%) Biliary dyskinesia: 0 (0%) Outpatient: 19 (95%) ER admission: 1 (5%)	African-American: 58 (82.9%) Other/ Decline: 2 (2.9%) Male: 10 (14.3%) BMI: 34.3 (8.2) ASA I: 6 (8.6%) ASA II: 44 (62.9%) ASA III: 20 (28.6%) ASA IV: 0 (0%) Diabetes: 7 (10%) Acute cholecyst: 26 (37.1%) Biliary colic: 30 (42.9%) Choledocholithiasis: 13 (18.6%) Biliary dyskinesia: 1 (1.4%) Outpatient: 12 (17.1%) ER admission: 58 (82.9%)				
Farnsworth J 2018[46] Observational (prospectively collected registry) Y N	1 institution/ 2 surgeons	No	N: 51					N: 14	N: 37		
Farukhi MA 2017[52] Case control retrospective analysis Y N	1 institution	No	N: 139					N: 69 Morbidly obese: 42	N: 70 Morbidly obese: 19		
Gonzalez AM 2013[34] Retrospective cohort Y N	1 institution (3 hospitals)/ 3 surgeons	No	N: 498	N: 166 Age: 51.6 (15.9) Male: 21.1% (35) BMI: 29.4 (6.2) Mean ASA: 1.84 (0.73) Acute cholecyst: 12% (20)	N: 169 Age: 44.5 (14.3) Male: 23.7% (40) BMI: 29.1 (5.6) Mean ASA: 1.72						

				Sympt cholelithiasis: 76.5% (127) Other: 19 (11.4%)	(0.64)Acute cholecyst: 6.5% (11) Sympt cholelithiasis: 78.7% (133) Other: 11 (6.5%)						
Grochola LF 2019[13] RCT No (Switzerland) No	1 institution/ 3 surgeons	No	N: 60	N: 30 Age: 52.4 (26-82) Race/ethnicity: N/R Male: 10 (33.3%) BMI: 27.3 (3.9) ASA class: N/R Diabetes: n/R Sympt Cholelithiasis: 96.7% (29) Other: 3.3% (1) Elective: 100%	N: 30 Age: 51.5 (30-78) Race/ ethnicity: N/R Male: 14 (46.7%) BMI: 27.3 (4.2) ASA class: N/R Diabetes: N/R Sympt cholelithiasis: 96.7% (29) Other 3.3% (1) Elective: 100%						
Gustafon M 2016[36] Observational (retrospective analysis of prospective database) Y N	1 institution/ 1 surgeon	No	N: 82	N: 38 Age: 48 (14) Race: N/R Male: 21% BMI: 30 (5) ASA mean: 1.5 (1-3) Diabetes: N/R Indication: N/R Elective: N/R	N: 44 Age: 45 (15) Race: n/r Male: 23% BMI: 26 (4) ASA mean: 1.6 (1-3) Diabetes: n/r Indication: n/r Elective: n/r						
Hagen ME 2018[25] Retrospective cohort, matched pair N N	1 Institution	Yes	N: 198	N: 99 Age: 47.4 (12.6) Race: N/R Male: 27.3% (27) BMI: 26.2 (4.2) ASA I and II: 96% (95) III and IV: 4% (4) Diabetes: N/R Sympt cholelithiasis: 100% Elective: N/R			N: 99 Age: 47 (14) Race: N/R Male: 27.3% (27) BMI: 26.3 (4.9) ASA I and II: 96% (95) ASA III and IV: 4% (4) Diabetes: N/R Sympt cholelithiasis: 100% Elective: N/R				
Hagen ME 2018 [30] Retrospective, case-matched analysis	Not reported	No	N: 156	N: 78			N: 78				

Y N											
Hawasli A 2016[55] Observational (retrospective) Y N	1 institution/ 14 surgeons	No	N: 246 Age: 45.4 (17.1) Male: 15.9% (39)							N: 26 (14 single port robot - 53.8%)) Age: 46.2 (11.2)	N: 220 (8 single port lap - 3.6%) Age: 45.3 (17.6)
Heemskerk J 2014[14] Prospective Randomized Trial N N	1 Institution/ 2 surgeons	No	N: 22			N: 11	N: 11				
Higgins RM 2017[61] Surgical Profitability Compass Procedure Cost Manager System Database Retrospective analysis Y N	Not reported	No	N: 381					N: 38	N: 343		
Jang EJ 2019[40] Retrospective analysis N N	2 institutions/ 2 surgeons (1 for SILC and 1 for RSSC)	No	N: 117 Males: 58 (49.6%) ASA 1: 36 (30.8%) ASA 2: 63 (53.8%) ASA 3: 18 (15.4%) Acute cholecyst: 4 (3.4%) Sympt cholelithiasis: 86 (73.5%) Other: 27 (23.1%)	N: 39 Age: 42.03 (10.72) Male: 14 (35.9%) BMI: 28.17 (2.972) ASA 1: 20 (51.3%) ASA 2: 15 (38.5%) ASA 3: 4 (10.3%) Acute cholecyst: 0 Sympt cholelithiasis: 32 (82.1%) Other: 7 (17.9%)	N: 78 Age: 49.76 (12.949) Male: 44 (56.4%) BMI: 27.17 (2.278) ASA 1: 16 (20.5%) ASA 2: 48 (615%) ASA 3: 14 (17.9%) Acute cholecyst: 4 (5.1%) Sympt cholelithiasis: 54 (69.2%) Other: 20 (25.6%)						
Kaminski JP 2014[58] NIS dataset	Not reported	No	N: 735,537					2010 N: 524 Available	2010 N: 362,971 Available		

Retrospective analysis Y N								observations: 451 Age: 53.3 Male: 26.4% (119) Caucasian: 79.6% (359) African American: 10% (45) Hispanic: 7% (31) Asian: 1.1% (5) Native American: 0% (0) Others: 2.3% (10) DM (with and w/o complication): 13.4% Acute cholecyst: 7.1% <u>2011</u> N: 1084 Available observations: 991 Age: 55.8 Male: 35.3% (350) Caucasian: 68.2% (676) African American: 11.9% (118) Hispanic: 14.3% (141) Asian: 1.9% (19) Native American: 0.5% (5) Others: 1.8% (18) DM (w/ or w/o complication): 21.5% Acute	observations: 327,803 Age: 49.3 Male: 32.9% (107,941) Caucasian: 65.3% (214,074) African American: 10.3% (33,656) Hispanic: 18.6% (60,848) Asian: 2.2% (7,366) Native American: 0.8% (2,501) Others: 2.9% (9,358) DM (w/ or w/o complication): 16.8% Acute cholecyst: 39.2% <u>2011</u> N: 370,958 Available observations: 338,702 Age: 51.1 Male: 34.1% (115,406) Caucasian: 63.7% (215,916) African American: 10.1% (34,072) Hispanic: 20.2% (68,541) Asian: 2.0% (6,685) Native American: 0.7% (2,254) Others: 3.3% (11,234)		

								cholecyst: 10.8%	DM (w/ or w/o complication): 17.6% Acute cholecyst: 41.7%		
Kane WJ 2020[57] Retrospective Cohort Y N	Single institution/ Multiple surgeons	Yes	N: 1066					N: 106 Age: 41.5 (30-56)* White: 80 (75.5%) Male: 30 (28.3%) BMI: 30.1 (26.5-36.4)* Diabetes: 7 (6.6%)	N: 1060 Age: 43 (30-58)* White: 806 (76%) Male: 313 (29.5%) BMI: 30.2 (26.5-35.2)* Diabetes: 79 (7.5%)		
Khorgami Z 2019[49] NIS Retrospective analysis Y N	Not reported	No	N: 70,673					N: 1,271	N: 69,402		
Kudsi OY 2017[15] Randomized controlled trial Mixed (7 institutions in US, 1 in Greece) N	8 institutions/ 10 surgeons		N: 136	N: 83 Age: 46.8 (15.5) Caucasian: 46 (55%) African-American: 9 (11%) Asian: 3 (4%) Hispanic: 25 (30%) Male: 18 (21%) BMI: 30.4 (6.5) ASA I: 17 (20%) ASA II: 52 (63%) ASA III: 13 (16%) ASA IV: 1 (1%) DM: 5 (6%) Acute cholecyst: 0 Sympt cholelithiasis: 69 (83.1%) Other: 14 (16.8%) Elective: 100%			N: 53 46.5 (17.3) Caucasian: 29 (55%) African-American: 7 (13%) Asian: 0 (0%) Hispanic: 17 (32%) Male: 4 (7%) BMI: 31.7 (6.7) ASA I: 11 (21%) ASA II: 34 (64%) ASA III: 8 (15%) ASA IV: 0 (0%) DM: 4 (8%) Acute cholecyst: 0 Sympt cholelithiasis: 47 (86.7%) Other: 7 (13.2%) Elective: 100%				
Lee EK 2017[26] Retrospective analysis		No	N: 120 Male: 42.5%	N: 60 Age: 42.53 (9.92) Male: 28 (46.7%) BMI: 24.45 (3.63) ASA I: 37 (61.7%)			N: 60 Age: 46.58 (12.44) Male: 23 (38.3%) BMI: 24.67				

N N				ASA II: 23 (38.3%) Acute cholecyst: 0 (0%) Sympt cholelithiasis: 13 (15.1%) Other: 73 (84.9%)			(4.01) ASA I: 74 (61.7%) ASA II: 46 (38.3%) Acute cholecyst: 7 (4%) Sympt cholelithiasis: 48 (27.1%) Other: 122 (68.9%)				
Lee JH 2018[41] Retrospective analysis Y N	1 institution/ 2 surgeons	No	N: 630	N: 520 Age: 48 (10.1) Male: 135 (25.9%) BMI: 23.9 (3.6) Sympt cholelithiasis: 72.2%	N: 110 Age: 36.4 (9.6) Male: 8 (7.3%) BMI: 21.8 (2.4) Sympt cholelithiasis: 67.4%						
Lee SR 2019[27] Retrospective analysis N N	1 institution/ 1 surgeon	No	N: 121 Age: 46.8 (11.64) Male: 52 (51.2%) BMI: 25 (3.59) ASA 1: 85 (70.2%) ASA 2: 36 (29.8%) Acute cholecyst: 0 (0%) Sympt cholelithiasis: 69 (57.0%) Other: 38 (43.0%)	N: 61 Age: 42.69 (8.95) Male: 34 (55.7%) BMI: 24.78 (3.62) ASA 1: 38 (62.3%) ASA 2: 23 (37.7%) Acute cholecyst: 0 (0%) Sympt cholelithiasis: 23 (37.7%) Other: 38 (62.3%)			N: 60 Age: 50.33 (12.82) Male: 28 (46.7%) BMI: 25.23 (3.57) ASA 1: 47 (78.3%) ASA 2: 13 (21.7%) Acute cholecyst: 0 (0%) Sympt cholelithiasis: 46 (76.7%) Other: 14 (23.4%)				
Lescouflair T 2014[42] Retrospective review of prospectively maintained database Y N	1 institution/ 1 surgeons		N: 82	N: 41	N; 41						
Li YP 2017[28] Retrospective analysis N N	1 institution/ 2 surgeons	No	N: 445	N: 78 Age: 56.69 (13.35) Male: 37 (48.3%) BMI: 24.17 (3.01) Sympt cholelithiasis: 53 (68%)			N: 367 Age: 51.44 (14.11) Male: 161 (43.9%) BMI: 25.63 (4.13) Sympt				

				Acute cholecyst: 17 (21.8%) Other: 8 (10.3%)			cholelithiasis: 235 (64%) Acute cholecyst: 91 (24.8%) Other: 41 (11.2%)				
Main WPL 2017[18] Retrospective analysis Y N	1 institution	Yes	N: 1133			N: 179 Age: 47.19 (14.92) BMI: 38.85 (7.29) ASA I: 10 ASA II: 107 ASA III: 58 ASA IV: 4	Before propensity score matching N: 1133 Age: 46.38 (16.41) BMI: 36.89 (5.95) ASA I: 46 ASA II: 520 ASA III: 373 ASA IV: 15 After Propensity Score Matching N: 358 Age: 45.91 (15.12) BMI: 38.75 (6.72) ASA I: 25 ASA II: 216 ASA III: 112 ASA IV: 5				
Mitko J 2016[20] Retrospective analysis Y N	1 institution	No	N: 1133			N: 179 BMI: 38.8 Acute cholecyst: 6% Chronic cholecyst: 93%	N: 954 BMI: 36.8 Acute cholecyst: 11.7% Chronic cholecyst: 87%				
Moore MD 2016[43] Retrospective analysis Y N	1 institution/ 2 surgeons	No	N: 50	N: 21 Age: 47 (15) Male: 5 (24%) BMI: 26 (3) ASA 1 : 2 (9.5%) ASA 2: 14 (66.7%) ASA 3 or higher: 5 (23.8%) Acute cholecyst: 2 (9.5%) Sympt cholelithiasis: 17 (80.9%) Other: 2 (9.5%)	N: 29 Age: 37 (15) Male: 3 (10%) BMI: 28 (6) ASA 1: 4 (13.8%) ASA 2: 22 (75.9%) ASA 3 or higher: 3 (10.3%) Acute cholecyst: 5 (17.2%) Sympt cholelithiasis: 21 (72.4%)						

					Other: 3 (2.77%)						
Pietrabissa A 2016[16] Prospective, randomized, double-blind trial N N	1 institution/ 4 surgeons	No	N: 60	N: 30			N: 30				
Pokala B 2019[56] Retrospective analysis of Vizient database Y N	Multi-institution/ multi-surgeons	No	N: 91849					N: 1971 Age 18-30yrs: 215 (10.9%) Age 31-50yrs: 699 (35.5%) Age: 51-64yrs: 531 (26.9%) Age ≧ 65: 526 (26.7%) White: 1317 (67.9%) Black: 334 (17.2%) Other: 288 (14.9%) Male: 660 (33.5%)	N: 89878 Age 18-30yrs: 16144 (17.9%) Age 31-50yrs: 31553 (35.1%) Age: 51-64yrs: 21084 (23.4%) Age ≧ 65: 21197 (23.6%) White: 56553 (65.2%) Black: 10906 (12.6%) Other: 19306 (22.3%) Male: 30194 (33.6%)		
Rosemurgy A 2015[50] Retrospective analysis Y N	1 institution	No	N: 232					N: 31 Elective: 100%	N: 201		
Ross S 2014[53] Retrospective analysis Y N	1 institution	No	N: 232					N: 31	N: 201		
Spinoglio G 2012[37] Retrospective analysis N Y	1 institution/ 1 surgeon	No	N: 50	N: 25 Age: 54.2 (17.1) Male: 5 (20%) BMI: 23.7 (3.9) Sympt cholelithiasis: 23 (92%) Acute cholecyst: 0 Other: 2 (8%) Elective: 100%	N: 25 Age: 52.5 (17.9) Male: 3 BMI: 24.5 (4.7) Acute cholecyst: 0 Elective: 100%						

Strosberg DS 2016[54] Retrospective analysis Y N	1 institution	No	N: 156					N: 142 Sympt cholelithiasis: 92 (64.79%) Acute cholecyst: 1 (0.7%) Other: 27 (19.01%)	N: 114 Sympt cholelithiasis: 54 (47.3%) Acute cholecyst: 14 (12.28%) Other: 9 (7.89%)		
Strosberg DS 2017[51] Retrospective analysis Y N	1 institution/ 1 surgeon	No	N: 237					N: 140 Age 47 (17-94) Male: 44 (32.4%) White: 120 (85.7%) BMI: 30.3 (17.1-68.8) Diabetes: 20 (14.3%) Sympt cholelithiasis: 83 (59.3%)	N: 97 Age: 47 (17-82) Male: 31 (32%) Whit: 82 (84.5%) BMI: 28.8 (18.9-46.4) Diabetes: 16 (16.5%) Sympt cholelithiasis: 52 (53.6%)		
Su WL 2016[38] Retrospective analysis N Y	1 institution	No	N: 114	N: 51 Age: 53.64 (15.54) Male: 18 (35.29%) BMI: 23.6 (3.8) Sympt cholelithiasis: 33 (64.7%) Acute cholecyst: 10 (19.61%) Other: 8 (15.69)	N: 63 Age: 50.94 (13.79) Male: 23 (36.51%) BMI: 246 (3.11) Sympt cholelithiasis: 37 (58.73%) Acute cholecyst: 15 (23.81%) Other: 15 (23.81%)						
Teoh AY 2017[31] Prospective comparative study Not reported N	2 hospitals	No	N: 24	N: 14			N: 10				
Wren SM 2011[29] Prospective analysis of SSRC with retrospective comparison to lap chole	1 institution	No	N: 20	N: 10 Age: 58.1 (15.9) BMI: 27.7 (3.3) Male: 7 (70%) Sympt cholelithiasis: 100%			N: 10 Male: 7 (70%) Age: 61.8 (15.6) BMI: 28.4 (6.2)				

Y Y											

cholecyc = cholecystitis; cholelith = cholelithiasis; sympt = symptomatic

Intra-operative Outcomes

Author **Year** **Population** **Study Design** **US (y/n)** **VA (y/n)**	**Intraoperative Outcomes (<30d)** OR, time, min (SD) EBL, mL (SD) Transfusions, % Conversion To Open, % To Lap, % Major Complications, N (%)							
	Single-Port Robot	**Single-Port Lap**	**Multi-Port Robot**	**Multi-Port Lap**	**Unspecified Robot**	**Unspecified Lap**	**Specified combined single and multi-port Robot**	**Specified combined single and multi-port Lap**
Abel S 2019[32] Retrospective cohort Y N								
Aggarwal R 2020[22] Retrospective cohort N N			OR time: 86.5 (60.5-106.5)* Docking time: 11.5 (9-13)* Console time: 30.8 (23.5-35)* Intraoperative event (bleeding): 1 (5.0%) Conversion to lap: 2 (10%)	OR time: 31.5 (26-41)* Intraoperative event: 0 (0%)				
Albrecht R 2017[17] Retrospective (matched-pair analysis) N N			OR time: 104.2 (44.8) Conversion: 2 Complications: 8 (bleeding: 2, gallbladder opening: 4, other: 2)	OR time: 91.9 (38.5) Conversion: 1 Complications: 3 (bleeding: 1, gallbladder opening: 2)				
Altieri MS 2016[45] SPARCS database Prospective cohort Y N								
Aragon RJ 2016[45] Prospective	OR time: 81.3 (23.3)	OR time: 62.3 (21.6)	OR time: 80.9 (24.8)					

observational study Y N	Case start time: 10.1 (8.7) Setup time: 4.4 (2.7) Robot time: 39.7 (15) Cases "not completed via intended approach": 13 (9.8%) Conversion to lap: 7.6% Conversion to open: 0.7%	Cases "not completed via intended approach": 4 (11.1%) Conversion to lap: 5.6%	Case start time: 17.2 (8.7) Setup time: 6.3 (3.7) Robot time: 38.2 (15.5) Cases "not completed via intended approach": 7 (4.3%) Conversion to lap: 3.7% Conversion to open: 0.6%					
Autin RL 2015[39] Retrospective analysis Y N								
Balachandran B 2017[23] Retrospective cohort Y N	OR time: 89.4 (27.8) Robotic time: 57 (14.7) Docking time: 6.8 (5.2) EBL: Minimal Conversion to Open: 13 (3.2%) Conversion to Lap : 12 (2.9%) Major complications: 0			OR time: 92.6 (31.9) EBL: Minimal Conversion to open: 13 (4.9%) Major complications: 0				
Buzad FA 2013[33] Prospective cohort with historically (retrospective) matched-pairs Y N	Docking time: 6.6 (2.0) Console time: 50.7 (17.9) Incision to close: 84.6 (20.5) EBL 8.4 (7.3) Transfusions: 0 Major complications: 0	Incision to close: 85.5 (11.8) EBL: 12.0 (7.5) Transfusions: 0 Major complications: 0						
Calatayud D 2012[116] Retrospective analysis Y N			OR time: 90.81 Conversion to open: 0	OR time: 89.45 Conversion to open: 2				
Chung PJ 2015[24] Retrospective cohort Y N	Docking time: 11.5 (5.7) Console time : 52.8 (5.7) OR time: 111.5			OR time: 106 (41) Conversion to open: 11 (15.7%)				

	(31.1) EBL: N/R Conversion to open: 1.4% (1)							
Eid JJ 2020[21] Retrospective cohort Y N			OR time: 93.4 (15.4) EBL: 10.8 (9.9) CBD Injury: 0 (0%) Conversion to open: 0 (0%)	OR time: 101.3 (49.1) EBL: 21.7 (32) CBD Injury: 1 (1.4%) Conversion to open: 3 (4.3%)				
Farnsworth J 2018[46] Observational (prospectively collected registry) Y N					OR time: 158 (38) Conversion to open: 0	OR time: 135 (62) Conversion to open: 5 (1.5%)		
Farukhi MA 2017 [52] Case control retrospective analysis Y N								
Gonzalez AM 2013[34] Retrospective cohort Y N	Surgical time (skin to close): 63 (25.2) Conversion to Open: 0% (0)	Surgical time (skin to close): 37.1 (13.3) Conversion to Open: 0% (0)						
Grochola LF 2019[13] RCT No (Switzerland) No	Console time: 35 (21-107) OR time: 85.5 (48-148) EBL: 5.0 (0-150) Conversion to Open: 0 Conversion to 4 port LC: 2 Complications: 40% (12): 8 peritoneal tears + 4 minor bleeding	OR time: 74 (31-135) EBL: 3.5 (0-300) Conversion to Open Conversion to 4 port LC: 3 Complications: 46.7% (14): 11 peritoneal tears + 3 minor bleeding						
Gustafon M 2016[36] Observational (retrospective analysis of prospective database) Y N	OR time: 98 (37) Conversion to multiport or open: 8% Major complications: 0	OR time: 68 (19) Conversion to multiport or open: 11% Major complications: 0						

Hagen ME 2018[25] Retrospective cohort, matched pair N N	OR time: 97 (39) Conversion: 4% (4) Complications: 4% (4) Bleeding: 2% (2) Organ lesion: 2% (2)			OR time: 93.5 (32.5) Conversion: 1% (1) Complications: 0				
Hagen ME 2017 [30] Retrospective, case-matched analysis Y N	OR time: 93.9			OR time: 82.5				
Hawasli A 2016[55] Observational (retrospective) Y N							Case time: 121 (15.4) OR time: 86.6 (14.3)	Case time: 98.4 (27.5) OR time: 63.9 (25.9)
Heemskerk J 2014[14] Prospective Randomized Trial N N			OR (skin to close): 86 Conversions: 0 Major complications: 0	OR (skin to close): 48 Conversions: 0 Major complications: 0				
Higgins RM 2017[61] Surgical Profitability Compass Procedure Cost Manager System Database Retrospective analysis Y N					Mean case duration: 84.3 (25.2)	Mean case duration: 75.5 (30.1)		
Jang EJ 2019[40] Retrospective analysis N N	OR time: 107.92 (24.950) Conversion (to lap or open): 2 (5.1%) Bile spillage during operation: 6 (15.4%) Use of additional robotic arm or port: 0 Complication: 0	OR time: 60.99 (17.810) Conversion (to lap or open): 2 (2.6%) Bile spillage during operation: 9 (11.5%) Use of additional robotic arm or port: 10 (12.8%) Complication: 5 (6.4%)						
Kaminski JP 2014[58] NIS dataset Retrospective analysis Y N					2010 Conversions: 0% Intraoperative complications: 4.5%	2010 Conversions: 0.32% Intraoperative complications: 1.4% 2011		

					2011 Conversions: 1.66% Intraoperative complications: 4.0%	Conversions: 0.29% Intraoperative complications: 1.3%		
Kane WJ 2020[57] Retrospective Cohort Y N					OR time: 185 (175-195)*	OR time: 160 (135-175)*		
Khorgami Z 2019[49] NIS Retrospective analysis Y N								
Kudsi OY 2017[15] Randomized controlled trial Mixed (7 institutions in US, 1 in Greece) N	OR time: 61 (27.5) EBL: 13.06mL Transfusions: 0 (0%) Coversions to open: 0 (0%) Intraoperative complications: 0 (0%)			OR time: 44 (19.9) EBL: 15.83mL Transfusions: 0 (0%) Conversions to open: 0 (0%) Intraoperative complications: 0 (0%)				
Lee JH 2019[27] Retrospective analysis Y N	OR time: 46.9 (12.1) Docking time from incision to completion fo docking procedure: 7.1 (5-20) Console time: 17.8 (5-65) Conversion to open: 0 Conversion to lap (4-port): 3 Intraoperative bile spillage: 5.4%	OR time: 53.4 (16.6) Conversion to open: 0 Conversion to 3-port lap procedure: 3 Addition of 1 additional port: 5 Intraoperative bile spillae: 7.4%						
Lescouflair T 2014[42] Retrospective review of prospectively maintained database Y N	OR time: 96. Conversion rate: 9%	OR ime: 65.2 Conversion rate: 11%						
Lee EK 2017[26] Retrospective analysis N N	OR time (total): 121.6 (22.2) Anesthesia time: 115.7 (22.3) Surgery time: 86.8 (21.7)			OR time (total): 71.9 (10.4) Anesthesia time: 65.9 (10.5) Surgery time: 34 (9.6)				

Lee SR 2018[41] Retrospective analysis N N	Docking time: 10.75 (4.33) Console time: 44.84 (13.83) Total OR time: 95.32 (20.27) Total OR time minus docking time: 82.77 (18.27 EBL: 38.20 (27.05) LOS: 2.26 (0.92) Intraoperative complications: 0 (0%)			Total OR time: 37.67 (19.73) EBL: 34.33 (32.59) LOS: 2.43 (1.73) Intraoperative complications: 0 (0%)				
Li YP 2017[28] Retrospective analysis N N	OR time: 75.7 (31.3) Conversion to open or lap: 0 (0%)			OR time: 64.37 (30.61) Conversion to open: 7 (1.9%)				
Main WPL 2017[18] Retrospective analysis Y N			OR time: 80 (29.12) Conversion to open: 0 (0%)	OR time: 60.22 (29.78) Conversion to open: 0 (0%)				
Mitko J 2016[20] Retrospective analysis Y N			OR time: 80	OR time: 62				
Moore MD 2016[43] Retrospective analysis Y N	OR time (skin to skin): 120 (32) EBL (median): 10 (0-50) Conversion to open: 0 Additionalports: 0 Intraoperative complications: 0	OR time (skin to skin): 79 (35) EBL (median): 10 (5-150) Conversion to open: 0 Additional ports: 3 (10%) Intraoperative complications: 0						
Pietrabissa A 2016[16] Prospective, randomized, double-blind trial N N	OR time (total): 98 (34) Docking time: 23 (7) Dissection time: 56 (26) Closure time: 19 (5) Bile spillage: 2 (6%) Minor bleeding: 3 (10%) Liver damage at GB fossa: 1 (3%) Conversions: 0			OR time (total): 87 (30) Dockingtime: 15 (6) Dissection time: 44 (16) Closure time: 11 (5) Bile spillage: 5 (16%) Minor bleeding: 4 (13%) Liver damage at GB fossa: 3 (10%) Conversions: 0				

Pokala B 2019[56] Retrospective analysis of Vizient database Y N								
Rosemurgy A 2015[50] Retrospective analysis Y N					OR time: 141 (25.38)	OR time: 102 (32.7)		
Ross S 2014[53] Retrospective analysis Y N					OR time: 141 (25.38)	OR time: 102 (32.7)		
Spinoglio G 2012[37] Retrospective analysis N Y	OR time: 62.7 (16.6) Intraoperative complications: 0	OR time: 83.2 (21.1) Intraoperative complications: 0						
Strosberg DS 2016[54] Retrospective analysis Y N					OR time: 80 Conversion to open: 1 (0.7%) EBL: 20.15	OR time: 68 Conversion to open: 7 (6.14%) EBL: 42.01		
Strosberg DS 2017[51] Retrospective analysis Y N					OR time: 74.5 (47-293) EBL: 10 (2-200) Transfusions: 0 (0%) Conversions to open: 1 (0.7%)	OR time: 56 (35-244) EBL: 10 (5-600) Transfusions: 1 (1%) Conversion to open: 7 (7.2%)		
Su WL 2016[38] Retrospective analysis N Y	OR time: 71.30 (48.88) Conversion rate: 0	OR time: 74.70 (30.16) Conversion rate: 2 (3.17%)						
Teoh AY 2017[31] Prospective comparative study Not reported N	OR time: 62.3 (22.6) Conversion: 0			OR time: 72.1 (19.2) Conversion: 0				
Wren SM 2011[29] Prospective analysis of SSRC with retrospective comparison to lap chole Y Y	OR time: 105.3 (82-139) Major complications: 0 Conversion: 1 (1%)			OR time: 106.1 (70-142) Major complications: 1 (10%) Conversion: 0				

Short-term Outcomes

Author **Year** **Population** **Study Design** **US (y/n)** **VA (y/n)**	**Short-Term Outcomes (<30d)** Readmissions, mean (SD) ED visits, mean (SD) LOS, mean days (SD) Mortality, N (%) Complications, N (%) Common Bile Duct Injury, N (%) Bile Leak, N (%) Retained stone, N (%) Reoperation, N (%) Pain Narcotic use Return to work							
	Single-Port Robot	**Single-Port Lap**	**Multi-Port Robot**	**Multi-Port Lap**	**Unspecified Robot**	**Unspecified Lap**	**Specified combined single and multi-port Robot**	**Specified combined single and multi-port Lap**
Abel SA 2019[32] Retrospective cohort Y N	Postoperative complications: 43 (15%)			Postoperative complication: 41 (14%)				
Aggarwal R 2020[22] Retrospective cohort N N			Postoperative events: 5 (25%) Bile Leak: 0 (0%) Wound infection :1 (5%) Bowel obstruction: 1 (5%) Constipation: 1 (5%) Gastroenteritis: 1 (5%) Pain: 1 (5%)	Postoperative events: 5 (25%) Bile Leak: 1 (5%) Wound infection :3 (15%) Bowel obstruction: 0 (0%) Constipation: 0 (0%) Gastroenteritis: 0 (0%) Pain: 1 (5%)				
Albrecht R 2017[17] Retrospective (matched-pair analysis) N N			Postoperative LOS: 3.8 (4.7) Total LOS: 3.9 (4.8) Postoperative pain: 11 (50%) Postoperative pain duration (None= 0, Less than 5d = 1, Less than 1 wk= 2, Between 7-14 days= 3, More than 2 weeks = 4): 1.55 (1.77)	Postoperative LOS: 2.8 (1.3) Total LOS: 3.5 (2.3) Postoperative pain: 8 (34.8%) Postoperative pain duration (None= 0, Less than 5d = 1, Less than 1 wk= 2, Between 7-14 days= 3, More than 2 weeks = 4): 0.74 (1.18) Reoperation: 0				

			Reoperation: 1 (4.5%)					
Altieri MS 2016[45] SPARCS database Prospective cohort Y N					LOS: 4.92 (8.95) Complications: 38 (20.43%)	LOS: 5.7 (8.71) Complications: 22,618 (20.59%)		
Aragon RJ 2014[44] Prospective observational study Y N	Requirement for hospital stay: 8.3% Hospital readmission: 6.8% Reoperation: 1	Requirement for hospital stay: 0% Hospital readmission: 11.1% Reoperation: 1	Requirement for hospital stay: 0.6% Hospital readmission: 0.6%					
Autin RL 2015[39] Retrospective analysis Y N								
Balachandran B 2017[23] Retrospective cohort Y N	Readmission: 13 (3.1%) ED Visits: 38 (9.2%) LOS: 1.9 (3.1) Bile leakage: 1 (0.2%) Wound infection: 16 (3.9%) Abdominal pain: 35 (8.4%)			Readmission: 4 (1.5%) ED visits: 14 (5.3%) LOS: 2.4 (2.3) Bile leakage: 2 (0.8%) Wound infection: 3 (1.1%) Abdominal pain: 11 (4.2%)				
Buzad FA 2013[33] Prospective cohort with historically (retrospective) matched-pairs Y N	Readmission: 1 Pain: 1	Readmission: 0 ED visit: 1 Pain: 1 Wound infection: 1						
Calatayud D 2012[116] Retrospective analysis Y N			LOS: 1.39 CV Grade 1&2: 19.3%	LOS: 1.37 CV Grade 1&2: 17.6% Bile leak: 1				
Chung PJ 2015[24] Retrospective	Readmissions: 2.8% (2) LOS: 1.5 (3.8)	Readmissions: 4.3% (3) LOS: 3.2 (3.6)						

cohort Y N	Mortality: 0 Common Bile Duct: 0 Retained stone: 1	Mortality: 0 Common Bile Duct: 0 Pain: 1 (requiring readmission)						
Eid JJ 2020[21] Retrospective cohort Y N			30d Readmission: 0 (0%) LOS: 0.8 (0.4) Bleeding: 0 (0%) UTI: 1 (5%) SSI: 1 (5%)	30d Readmission: 0 (0%) LOS: 2.7 (2.1) Bleeding: 2 (2.8%) UTI: 0 (0%) SSI: 0 (0%)				
Farnsworth J 2018[46] Observational (prospectively collected registry) Y N					LOS: 1.4 (1.4)	LOS: 2.4 (2.6)		
Farukhi MA 2017[52] Case control retrospective analysis Y N								
Gonzalez AM 2013[34] Retrospective cohort Y N	LOS: 1.2 (2.2)Complication rate: 1.8% (3) Superficial Site infection: 1 Deep surgical site infection: 2	LOS: 1.3 (5.3) Complication rate: 1.8% (3) Retained stone: 1						
Grochola LF 2019[13] RCT No (Switzerland) No	LOS: 1.9 (1-4) Complications: 13.3% (4) Grade I: 6.7% (2) Grade II: 6.7% (2) Grade III: 0 Grade IV: 0 Grade V: 0 Superficial wound infection: 3.3% (2)	LOS: 3.06 (1-26) Complications: 23.3% (7) Grade I: 13.3% (4) Grade II: 3.3% (1) Grade III: 3.3% (1) Grade IV: 3.3% (1) Grade V: 0 Superficial wound infection: 3.3% (1) Retained stone: 3.3% (1)						

Gustafon M 2016[36] Observational (retrospective analysis of prospective database) Y N	Readmissions: 0 LOS (Number of patients staying >24hrs): 1 Complications: 0 Days taking narcotics (mean): 2.3 (1.3) Days until return to normal funtion (mean): 4.0 (2.0)	Readmissions: 0 LOS (Number of patients staying >24hrs): 0 Complications: 0 Days taking narcotics (mean): 1.7 (1.2) Days until return to normal function (mean): 2.3 (1.1)						
Hagen ME 2018[25] Restrospective cohort, matched pair N N	LOS: 1.9 (1.7) Minor complication (Clavien I or II): 2% (2) Major compication (Clavien II or higher): 1% (1)			LO: 1.7 (1.6) Minor complication (Clavien I or II): 2% (2) Major complication (Clavien II or higher): 1% (1)				
Hagen ME 2017[30] Retrospective, case-matched analysis Y N	LOS: 2.4 Reoperation: 0			LOS: 2.3 Reoperation: 0				
Hawasli A 2016[55] Observational (retrospective) Y N							LOS: 1.0 (0)	LOS: 1.02 (0.15)
Heemskerk J 2014[14] Prospective Randomized Trial N N								
Higgins RM 2017[61] Surgical Profitability Compass Procedure Cost Manager System Database Retrospective analysis					Mean LOS: 1.0 (0)	Mean LOS: 1.1 (0.3)		

Y N								
Jang EJ 2019[40] Retrospective analysis N N	LOS: 1.79 (1.031) Pain score after immediate surgery: 4.95 (1.905) Pain score at discharge: 1.92 (0.900)	LOS: 2.38 (1.209) Pain score after immediate surgery: 5.00 (1.405) Pain score at discharge: 2.35 (1.209)						
Kaminski JP 2014[58] NIS dataset Retrospective analysis Y N					2010 LOS: 3.63 2011 LOS: 4.59	2010 LOS: 4.14 2011 LOS: 4.1		
Kane WJ 2020[57] Retrospective Cohort Y N					30d readmission: 0 (0%) LOS: 0.1 (0.7)	30d readmission: 27 (2.6%) LOS: 0.8 (1.9)		
Khorgami Z 2019[49] NIS Retrospective analysis Y N					LOS: 2.9 (2)	LOS: 2.8 (2.1)		
Kudsi OY 2017[15] Randomized controlled trial Mixed (7 institutions in US, 1 in Greece) N	LOS: 16.67 hours Postoperative complications: 4 (5%) Bile leak: 0 (0%) Wound infection: 2 (%) DVT/PE: 1 (1%)			LOS: 13.93 hours Postoperative complications: 2 (4%) Bile leak: 1 (2%) Wound infection: 1 (2%)				
Lee EK 2017[26] Retrospective analysis N N	LOS: 4.3 (0.5) No of analgesics given (preop): 0 (0-0) No of analgesics given during surgery: 1 (0-3) No of analgesics given (recovery room): 0 (0-1) No. of analgesics given (postop): 1 (0-9)			LOS: 4.7 (0.8) No of analgesics given (preop): 0 (0-4) No of analgesics given during surgery: 1 (0-3) No of analgesics given (recovery room): 0 (0-0) No. of analgesics given (postop): 1 (0-6)				

	Pain level (preop): 4 (0-8) 6hrs postop: 2 (0-5) First day postop: 2 (0-4) Second day postop: 0 (0-4) One week postop: 0 (0-2)			Pain level (preop): 0 (0-8) 6hrs postop: 2 (0-5) First day postop: 2 (0-6) Second day postop: 2 (0-5) One week postop: 2 (0-3)				
Lee SR 2019[27] Retrospective analysis N N	Postoperative complications: 0 (0%) Wound infection: 0 Bile leak: 0 Pain rating score (1h): 4.75 (1.24) Pain rating score (6h): 2.54 (0.59) Pain rating score (1d): 2.25 (1.02)			Postoperative complications: 0 (0%) Wound infection: 0 Bile leak: 0 Pain rating score (1h): 4.70 (1.22) Pain rating score (6h): 2.85 (1.24) Pain rating score (1d): 2.55 (1.12)				
Lee JH 2018[41] Retrospective analysis Y N	LOS: 3.3 (1.7) Bile duct injury: 0	LOS: 4.0 (1.8) Bile duct injury: 0						
Lescouflair T 2014[42] Retrospective review of prospectively maintained database Y N	Narcotic use duration: 2.4 Time to independent performance of daily activities: 4	Narcotic use duration: 1.6 Time to independent performance of daily activities: 4						
Li YP 2017[28] Retrospective analysis N N	LOS: 3.73 (1.77) Mortality: 0 (0%) Complications: 3 (3.8%) CG grade I: 2 (2.5%) CV Grade II: 0 (0%) CV Grade III-a: 0 (0%) CV Grade III-b: 1 (1.28%) CV Grade IV: 0 (0%) Residual CBD Stone: 0 (0%) Bile leak: 0 (0%)			LOS: 4.35 (0.75) Mortality: 0 (0%) Complications: 75 (20.4%) CV Grade I: 50 (13.6%) CV Grade II: 14 (3.81%) CV Grade III-a: 9 (2.45%0) CV Grade III-b: 2 (0.55%) CV Grade IV: 0 (0%) Residual CBD Stone: 2 Bile leak: 2 Biliary stricture: 2				

	Biliary stricture: 0 (0%) Subhepatic fluid collection: 0 (0%) Wound infection: 0 (0%) Analgesic requirement (days): 0.64 (2.11)			Subhepatic fluid collection: 3 Analgesic requirement (days): 1.13 (3.30) Wound infection: 10 (2.7%)				
Main WPL 2017[18] Retrospective analysis Y N			ED visits: 13 (7.2%) Bile lek: 2 (1.1%) Retained CBD Stone: 3 (1.67%) Mortality: 0 (0%) SSI: 2 (1.1%) Present to ER w/ abd pain: 1 (0.55%)	ED visits: 69 (7.2%) Bile leak: 8 (0.83%) Retained CBD Stone: 2 (0.2%) Mortality: 3 (0.3%) SSI: 4 (0.41%) Present to ER w/ abd pain: 31 (3.2%)				
Mitko J 2016[20] Retrospective analysis Y N			LOS: 0.23 Readmission (for abdominal pain): 0.55% Retained stone: 1.7%	LOS: 0.58 Readmission (for abdominal pain): 3.2% Retained stones: 0.21%				
Moore MD 2016[43] Retrospective analysis Y N	LOS (hours): 9.9 (6.7) Postoperative complications: 1 (4.8%) Choledocholithias is: 1	LOS (hours): 13.1 (13.9) Postoperative complications: 2 (6.9%) Choledocholithi asis: 1 Wound infection: 1						
Pietrabissa A 2016[16] Prospective, randomized, double-blind trial N N	LOS: 1.2 (1-3) Wound infection: 2 Patients with pain score greater than or equal to 16: 3 (10%) Median pain sum: 3 (1-8)			LOS: 1.2 (1-3) Wound infection: 0 Patients with pain score greater than or equal to 16: 2 (7%) Median pain sum: 4 (1-9)				
Pokala B 2019[56] Retrospective analysis of Vizient database Y N					Overall complications: 34 (1.7%) Post-op infection: 7 (0.4%) Post-op sepsis: 3 (0.2%) 7d readmission: 16	Overall complications: 851 (0.9%) Post-op infection: 133 (0.2%) Post-op sepsis: 53 (0.1%) 7d readmission: 998		

					(0.8%) 14d readmission: 26 (1.3%) 30d readmission: 37 (1.9%) Mortality: 1 (0.1%) LOS: 3.27 (2.72) Percentage of patients prescribed opiates: 97.2%	(1.0%) 14d readmission: 1415 (1.6%) 30d readmission: 1749 (2.0%) Mortality: 40 (<0.001%) LOS: 3.10 (2.22) Percentage of patients presribed opiates: 98.3%		
Rosemurgy A 2015[50] Retrospective analysis Y N								
Ross S 2014[53] Retrospective analysis Y N								
Spinoglio G 2011[37] Retrospective analysis N Y	LOS: 1.1 (0.3) Readmissions: 0 Major complications: 0 Wound infection: 0	LOS: 1.2 (0.7) Readmissions: 0 Major complications: 0						
Strosberg DS 2017[51] Retrospective analysis Y N					Readmissions: 5 (3.6%) LOS: 0 (0-4) Bile duct injury: 0 (0%) Bile leak: 3 (2.1%) Wound infection: 1 (0.7%) Reoperation: 2 (1.4%)	Readmissions: 4 (4.1%) LOS: 0 (0-8) Bile duct injury: 0 (0%) Bile leak: 1 (1%) Wound infection: 1 (1%) Reoperation: 1 (1%)		
Strosberg DS 2016[54] Retrospective analysis Y N					LOS: 0.55 60d readmission: 6 (4.23%) Bile duct injury: 0 Bile leak: 3 (2.11%) Reoperation: 2 (1.41%)	LOS: 1.35 60d readmission: 13 (11.4%) Bile duct injury: 0 Bile leak: 1 (0.88%) Reoperation: 2 (1.75%)		
Su WL 2016[38] Retrospective analysis N Y	LOS: 4.21 (0.72) Bile leakage: 0 (0%) Pain scale: 2.11 (0.76)	LOS: 4.13 (0.93) Bile leakage: 2 (3.17%) Pain scale: 3.98 (0.84)						

Wren SM 2011[29] Prospective analysis of SSRC with retrospective comparison to lap chole Y Y	Pain (at discharge): 2.5 (1.4) Pain (2-3 wks later): 0.67 (0.87)							
Teoh AY 2017[31] Prospective comparative study Not reported N	LOS: 1.4 (0.7) Morbidity rate: 14.3%			LOS: 1 (0) Morbidity rate: 0%				

Long-term Outcomes

Author **Year** **Population** **Study Design** **US (y/n)** **VA (y/n)**	**Long-Term Outcomes (>30d)** Readmissions Hernias GI-related complications Pain Quality of life % of patients that followed up at 6mo							
	Single-port Robot	**Single-port Lap**	**Multi-port Robot**	**Multi-port Lap**	**Unspecified Robot**	**Unspecified Lap**	**Specified combined single and multi-port Robot**	**Specified combined single multi-port Lap**
Abel SA 2019[32] Retrospective cohort Y N	Port-site hernia: 23 (8%)		Port-site hernia: 28 (10%)					
Aggarwal R 2020[22] Retrospective cohort N N								
Albrecht R 2017[17] Retrospective (matched-pair analysis) N N								
Altieri MS 2016[45] SPARCS database Prospective cohort								

Y N								
Aragon RJ 2014[44] Prospective observational study Y N								
Autin RL 2015[39] Retrospective analysis Y N	Port site hernias: 3 (11.1%)	Port site hernias: 6 (22.2%)						
Balachandran B 2017[23] Retrospective cohort Y N	Umbilical incisional hernia: 27 (6.5%)			Umbilical incisional hernia: 5 (1.9%)				
Buzad FA 2013[33] Prospective cohort with historically (retrospective) matched-pairs Y N								
Calatayud D 2012[116] Retrospective analysis Y N								
Chung PJ 2015[24] Retrospective cohort Y N								
Eid JJ 2020[21] Retrospective cohort Y N								
Farnsworth J 2018[46] Observational (prospectively collected registry) Y N								
Farukhi MA 2017[52] Case control retrospective analysis Y N								

Gonzalez AM 2013[34] Retrospective cohort Y N								
Grochola LF 2018[13] RCT No (Switzerland) No	Incisional hernia: 6.7% (2) HRQoL (Preop, median): 107(62-135) HRQoL (1mo postop, median): 123 (83-140) HRQoL (12mo postop, median): 123 (105-141) Body image (1mo postop, median): 37 (24-40) Body image (12mo postop, median): 35.5 (20-40)	Incisional hernia: 6.7% (2) HRQoL (Preop, median): 109.5 (39-131) HRQoL (1mo postop, median): 120 (55-142) HRQoL (12mo postop, median): 128 (94-143) Body image (1mo postop, median): 38 (19-40) Body image (12mo postop, median): 39 (22-40)						
Gustafon M 2016[36] Observational (retrospective analysis of prospective database) Y N	Incisional hernia: 1 (2.6%)	Incisional hernia: 2 (4.5%)						
Hagen ME 2018[25] Restrospective cohort, matched pair N N	Operation for incisional hernia: 7 (7.1%)			Operation for incisional hernia: 0				
Hagen ME 2017[30] Retrospective, case-matched analysis Y N	Incisional hernia: 6			Incisional hernia: 0				
Hawasli A 2016[55] Observational (retrospective) Y N								
Heemskerk J 2014[14] Prospective Randomized Trial								

N N								
Higgins RM 2017[61] Surgical Profitability Compass Procedure Cost Manager System Database Retrospective analysis Y N								
Jang EJ 2019[40] Retrospective analysis N N								
Kaminski JP 2014[58] NIS dataset Retrospective analysis Y N								
Kane WJ 2020[57] Retrospective Cohort Y N					90d readmission: 0 (0%)	90d readmission: 43 (4.1%)		
Khorgami Z 2019[49] NIS Retrospective analysis Y N								
Kudsi OY 2017[15] Randomized controlled trial Mixed (7 institutions in US, 1 in Greece) N								
Lee EK 2017[26] Retrospective analysis N N								
Lee SR 2019[27] Retrospective analysis N N								

Lee JH 2018[41] Retrospective analysis Y N	Incisional hernia: 1	Incisional hernia: 1						
Lescouflair T 2014[42] Retrospective review of prospectively maintained database Y N								
Li YP 2017[28] Retrospective analysis N N	Incisional hernia: 1			Incisional hernia: 2				
Main WPL 2017[18] Retrospective analysis Y N								
Mitko J 2016[20] Retrospective analysis Y N								
Moore MD 2016[43] Retrospective analysis Y N								
Pietrabissa A 2016[16] Prospective, randomized, double-blind trial N N	Incisional hernia: 1		Incisional hernia: 0					
Pokala B 2019[56] Retrospective analysis of Vizient database Y N								
Rosemurgy A 2015[50] Retrospective analysis Y N								
Ross S 2014[53] Retrospective analysis Y N								

Spinoglio G 2011[37] Retrospective analysis N Y								
Strosberg DS 2017[51] Retrospective analysis Y N					Port site hernia: 0	Port site hernia: 0		
Strosberg DS 2016[54] Retrospective analysis Y N								
Su WL 2016[38] Retrospective analysis N Y								
Teoh AY 2017[31] Prospective comparative study Not reported N	Quality of life assessment score: 22.9 (2.7)			Quality of life assessment score: 24.4 (3.1)				
Wren SM 2011[29] Prospective analysis of SSRC with retrospective comparison to lap cholecystectomy Y Y								

INGUINAL HERNIA REPAIR

Author **Year** **Population** **Study Design** **US** **VA** **# Institutions/ Surgeons** **Propensity Matching (y/n)** **Total N**	**Patient Characteristics Preop** Total patients (N) Age, mean yr (SD) Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % NH-Other/Unknown, % Hispanic, % Male, % BMI, mean (SD) ASA ≥ 3, % Diabetes, % Smokers, % Hernia characteristics Elective surgery, % Primary hernia, % Unilateral, % Pain, %			**Intraoperative Outcomes** OR time, min (SD) EBL, mL (SD) Transfusions, % Complications, % Conversion To Open, % To Lap, % Mesh repair, % Surgical approach TEP, % TAPP, % Concurrent procedures, type, % *Italicized text indicates that an outcome has been separately reported by laterality*			**Short-Term Outcomes (≤30d)** LOS, mean (SD) Readmissions, % Reoperations, % ED visits, mean (SD) Complications, % SSO, % Seroma/Hematoma, % Enterotomy, % Pain, % Narcotic use, % Return to work, % Retention, % Other, % Mortality, % *Italicized text indicates that an outcome has been separately reported by laterality*			**Long-Term Outcomes (>30d)** Follow-up at 1 year, % Length of follow-up, mean (SD) Readmissions, % Mesh infection, % Pain, % Recurrence, % QOL			**Primary Multi-Variate Findings**	**Comments**
	Robot	**Lap**	**Open**	**Robot**	**Lap**	**Open**	**Robot**	**Lap**	**Open**	**Robot**	**Lap**	**Open**		
Abdelmoaty, 2018[75] Robot vs lap Retrospective US 32/164 (115 lap; 49 robot) n N=2405	N=734 Elective 100% Primary 86.2% Unilateral 100%	N=1671 Elective 100% Primary 88% Unilateral 100%		OR Skin-skin 87 Room time 125 Conversion 5.4% (open) Concurrent 0%	OR Skin-skin 56 Room time 90 Conversion 5.3% (open) Concurrent 0%		LOS (d) 0.26	LOS (d) 0.25					Robotic significantly longer OR time (p<0.001 for both in-room and cut-to close)	
AlMarzooqi, 2019[71] Robot vs lap vs open Prospective (AHSQC) US n N=4613	N=847 Age 59.0 Male 91.0% BMI 27.0 Elective 100% Primary 100% Unilateral 100%	N=1841 Age 60.0 Male 93.0% BMI 26.0 Elective 100% Primary 100% Unilateral 100%	N=1925 Age 64.4 Male 90.9% BMI 25.9 Elective 100% Primary 100% Unilateral 100%	Mesh 100% TEP 1% TAPP 99%	Mesh 100% TEP 67% TAPP 33%	Mesh 92%	SSO 1.4% Seroma/ hematoma 2.7%	SSO 3.4% Seroma/ hematoma 5.8%	SSO 4.1% Seroma/ hematoma 13.9%	1-yr F/U 6.0% F/U 1y Recur 2.0% QOL* 12.9	1-yr F/U 9.4% F/U 1y Recur 4.0% QOL* 10.3	1-yr F/U 7.2% F/U 1y Recur 8.7% QOL* 12.1		*Calculated based on a median; 30-day EuraHS QOL score Data pooled from subgroup analyses (by procedure type)
Bittner, 2018[12] Robot vs lap vs open	N=83 Age	N=83 Age					Pain (scale) 4.0 (0.3)	Pain (scale) 4.4 (0.3) Narc*		1-yr F/U n=83 F/U (mo)	1-yr F/U N=83			*Days to no Rx

Random sample from web-based research panel US na/na y N=166 (526 unmatched)	54.4 (11.0) Male 97.6% Pain (Rx) 30.1% Pain (scale) 5.4 (0.4)	57.5 (12.3) Male 100% Pain (Rx) 25.3% Pain (scale) 5.8 (0.3)					Narc* 9.4 (1.5) RTW (d) 17.8 (2.1)	11.6 (1.7) RTW (d) 17.9 (2.8)		5.7 (0.3) Pain (scale) 1.5 (0.3)	F/U (mo) 6.0 (0.3) Pain (scale) 1.1 (0.2)			
Bittner, 2018[12] **Robot vs** lap vs **open** Random sample from web-based research panel US na/na y N= 170 (526 unmatched)	N=85 Age 53.2 (11.9) Male 97.6% Pain (Rx) 31.8% Pain (scale) 5.6 (0.3)		N=85 Age 56.2 (12.0) Male 98.8% Pain (Rx) 29.4% Pain (scale) 5.8 (0.4)				Pain (scale) 4.1 (0.3) Narc* 9.4 (1.4) RTW (d) 17.0 (2.0)		Pain (scale) 5.6 (0.3) Narc* 10.6 (1.2) RTW (d) 21.7 (2.4)	1-yr F/U n=85 F/U (mo) 5.7 (0.3) Pain (scale) 1.6 (0.3)		1-yr F/U n=85 F/U (mo) 6.7 (0.3) Pain (scale) 2.2 (0.3)	Postop pain (1 wk) significantly higher on open vs robot (p<0.01)	*Days to no Rx Pain rating = APGP score
Charles, 2018[68] Robot vs lap vs open Prospective (NSQIP) US VA 1/10 (2 robotic, 8 lap, 4 open) n N=510	N=69 Age* 52 [39-62] White 87% Male 85.5% BMI* 24.9 [22.9-28.7] ASA 14.5% Diabetes 1.5% Smokers 23.2% Primary 100% Unilateral 100%	N=241 Age* 57 [45-67] White 88.4% Male 88.8% BMI* 25.8 [23.1-28.4] ASA 15.4% Diabetes 0.4% Smokers 18.3% Primary 100% Unilateral 100%	N=191 Age* 56 [48-67] White 85.9% Male 91.6% BMI* 25.1 [23.2-27.8] ASA 28.8% Diabetes 1.6% Smokers 28.3% Primary 100% Unilateral 100%	OR Room time* 105 [76-146] Txf 0% Mesh 100% TAPP 100% Concurrent 1.5%	OR Room time* 81 [61-13] Txf 0.4% Mesh 100% TAPP 100% Concurrent 0.8%	OR Room time* 71 [56-88] Txf 0% Concurrent 1.6%	Readmit 0% Comp 2.9% SSO 2.9% Other 0% Mortality 0%	Readmit 2.1% Comp 3.3% SSO 0% Other 1.7% Mortality 0%	Readmit 3.7% Comp 5.2% SSO 0.5% Other 2.6% Mortality 0%	Recur** 0%	Recur** 0%	Recur** 0%	Total operating time greater for robot (p<0.001)	*Median [IQR] **30-day
Gamagami, 2018[69]	N=444 (652		N=444 (602	OR Skin-skin		OR Skin-skin	LOS (d) 3.0 (2.6)		LOS (d) 5.7 (6.8)				30-day postoperative	*Postop transfusion

Robot vs open Retrospective US 6/7 y N=888 (1,254 unmatched)	unmatched) Age 55.8 (15.9) Male 89.4% BMI 26.8 (4.7) ASA□3 25.2% Primary 87.4% Unilateral 84.5%		unmatched) Age 56.4 (16.0) Male 90.3% BMI 27.0 (5.0) ASA□3 27.3% Primary 87.4% Unilateral 84.0%	74.0 (30.1) Txf* 0.5% Comp 0.5% Conversion 1.4% (open) Mesh 100% TAPP 100% Concurrent 14.6%		46.6 (23.0) Txf* 0.2% Comp 0% Mesh 100% Concurrent 13.7%	Readmit 2.5% Reop 0.5% Comp** 7.2% SSO 0.2% Seroma/hematoma 1.1% Retention 2.3% Pain 0.7% Other 3.4% Mortality 0%		Readmit 2.3% Reop 1.6% Comp** 9.5% SSO 1.6% Seroma/hematoma 2.3% Retention 0.5% Pain 2.5% Other 3.2% Mortality 0.2%				complications higher in open (p=0.047) Shorter OR time (skin to skin) in open (p<0.0001) Lower inpatient LOS in robot (p=0.043)	**Post-op complications stratified between "prior to d/c" and "post-d/c, prior to 30 days". Pooled in this table.
Holcomb, 2019[84] Robot vs open Prospective (AHSQC) US na/na n N=1170	N=540 Age 60 [48-70] DM 8% Elective 100% Primary 100%		N=630 Age 65 [55-73] DM 11% Elective 100% Primary 100%	TAPP 100%			Readmit 1% Comp 5% SSO 0.4% Seroma/hematoma 1.6%		Readmit 1% Comp 5% SSO 1.6% Seroma/hematoma 1.4%	Recur* 0.2%		Recur* 0.0%		*30-day recurrence
Huerta, 2019[70] Robot vs lap vs open Retrospective US VA 1/3 (1 surgeon per approach) n N=1299	N=71 Age 59.9 (12.5) White 69.0% Black 22.5% Hispanic 7.0% Male 100% BMI 27.5 (5.2) ASA 2.4 (0.5) DM 15.5% Smoking 33.8%	N=128 Age 58.3 (12.4) White 73.4% Black 19.5% Hispanic 3.1% Male 100% BMI 26.3 (4.1) ASA 2.6 (0.6) DM 10.9% Smoking 40.6% Primary 49.9%	N=1100 Age 61.3 (12.8) White 73.7% Black 20.5% Hispanic 5.2% Male 99.9% BMI 26.6 (4.3) ASA 2.6 (0.6) DM 12.7% Smoking 32.6% Primary	OR 117.5 (61.8) Mesh 100% TAPP 100% Concurrent 11.3%	OR 78.4 (27.1) Mesh 100% TEP 100% Concurrent 11.7%	OR 65.5 (26.1) Mesh 100% Concurrent 0.4%	LOS 0.3 (0.8) Comp 18.2% SSO 0% Seroma/hematoma 2.8% Retention 5.6% Pain 2.8% Ileus 0% Other 7.0%	LOS 0.11 (0.5) Comp 21.2% SSO 0.8% Seroma/hematoma 1.6% Retention 5.5% Pain 7.0% Ileus 0% Other 6.3%	LOS 0.24 (1.1) Comp 7.9% SSO 0.8% Seroma/hematoma 2.6% Retention 1.8% Pain 0.8% Ileus 0.7% Other 1.2%	F/U (y) 2.4 (0.8) Pain 14.1% Recur 5.6%	F/U (y) 3.9 (1.8) Pain* 9.4% Recur 3.9%	F/U (y) 5.6 (3.6) Pain* 1.5% Recur 1.7%	OR time for robot sig longer than both open and lap (p<0.001 for both) Robot significantly more inguinodynia than open (p<0.001) Robot significantly more urinary retention than open (p=0.03)	*Inguinodynia

	Primary 74.6% Unilateral 40.8%	Unilateral 19.0%	99.2% Unilateral 92.7%										Robot had significantly more overall complications than open (p<0.001) Recurrence higher in robot vs open (p<0.02) Open had a longer f/u time than both lap and robot (p<0.001)	
Janjua, 2020[77] Robot vs lap vs open Prospective database (AHA-HCUP) US na/na y N=35916 **Pooled**	N=1480 Age >70: 19% Race: 79% white 8% AA 7% Hispanic 1% Asian 5% other Male: 95% CCS ≥1: 91% Elective: 75% Unilateral: 75%	N=7011 Age >70: 42% Race: 76% white 8% AA 10% Hispanic 2% Asian 4% other Male: 81% CCS ≥1: 42% Elective: 35% Unilateral: 68%	N=27425 Age >70: 46% Race: 70% white 12% AA 12% Hispanic 2% Asian 4% other Male: 85% CCS ≥1: 49% Elective: 22% Unilateral: 92%				LOS: 2.22 (2.85) *U/L: 2.2 (2.8)* *B/L: 2.3 (3.1)*	LOS: 3.27 (4.74) *U/L: 3.5 (5.2)* *B/L: 2.8 (3.6)*	LOS: 4.22 (6.22) *U/L: 4.3 (6.3)* *B/L: 4 (5.3)*				LOS for robot significantly decreased vs lap vs open (p<0.0001)	
Janjua, 2020[77] **Matched**	N=1480	N=2960	N=2960				LOS: 2.22 (2.85)	LOS: 3.6 (5.5)	LOS: 5.0 (8.2)				LOS for robot significantly decreased vs lap vs open (p<0.0001)	
Kakaishvili, 2018[72] Robot vs lap vs open Retrospective Israel 1/na	N=24 Unilateral 29.2%	N=16 Unilateral 50%	N=97 Unilateral 87.6%	OR 92.5	OR 79.0	OR 44.0	LOS 1.0 Pain* 0 Narc** 1.0	LOS 1.0 Pain* 2.0 Narc** 1.5	LOS 1.0 Pain* 5.0 Narc** 3.0				*Median VAS score **Analgesia (per day) Postoperative VAS level significantly	

n N=137													higher in open (p<0.001) Robot had a longer OR time than lap or open (p<0.001)	
Khoraki 2019[78] Robot vs lap Retrospective cohort US 1/4 n N=183	N=45 Age: 49.6 (13.7) Male: 93.3% BMI: 27.5 (5.8) ASA ≥ 3: 20% DM: 4.4% Primary: 88.9% Unilateral: 82.2%	N=138 Age: 50 (13.3) Male: 96.4% BMI: 26.2 (3.6) ASA ≥ 3: 8.7% DM: 10.1% Primary: 95.7% Unilateral: 70.3%		OR time: 116 (36) U/L: 110 (35) B/L: 143 (33) Conversion to open: 0% Mesh: 100% TAPP: 100% TEP: 0%	OR time: 95 (44) U/L: 88 (37) B/L: 114 (54) Conversion to open: 0.7% Mesh: 100% TAPP: 0% TEP: 100%		LOS: 0.13 [0-2] Readmit: 3 (6.7%) Reop: 3 (6.7%) Comp: 13 (28.9%) SSI: 1 (2.2%) Seroma: 5 (11.1%) Hematoma: 1 (2.2%) Retention: 2 (4.4%) SBO: 2 (4.4%) Ileus: 1 (2.2%)	LOS: 0.04 [0-1] Readmit: 1 (0.7%) Reop: 0 (0%) Comp: 25 (18.1%) SSI: 0 (0%) Seroma: 16 (11.6%) Hematoma: 1 (0.7%) Retention: 7 (5.1%) SBO: 0 (0%) Ileus: 0 (0%)		F/U: 30 d	F/U: 30 d		Overall OR time longer for robot (p<0.01) and unilateral repairs (p<0.01); bilateral repairs not significant (p=0.06) No difference in conversion to open (p=0.57) Similar LOS (p=0.16), complications (p=0.14); increased reoperations with robot (p=0.01) and 30-day readmission with robot (p=0.04)	
Knott, 2017[80] Robot vs lap vs open Prospective (Truven MarketScan) na/na n N=75,981	N=262 Primary 100%	N=25,433 Primary 100%	N=50,286 Primary 100%							F/U 1 y Recur 2.7%	F/U 1 y Recur 3.5%	F/U 1 y Recur 3.9%	Rate of repeat IHR was significantly lower in lap vs open [HR 0.90 (CI 0.83-0.98), p=0.019] and trended lower in RAS vs open [HR 0.69 (CI 0.33-1.44), p=0.32]	

Kolachalam, 2017[66] Robot vs open Retrospective US 6/7 y N=188	N=95 Age 53.5 (11.9) Male 91.6% BMI 33.6 (3.8) ASA 35.8% Unilateral 87.4%		N=93 Age 54.0 (14.5) Male 88.2% BMI 34.2 (5.2) ASA 33.3% Unilateral 86.0%	OR Skin-skin 82.9 (35.7) Txf 0% Conversion 3.2% (open) Comp 1.1% Mesh 100% TAPP 100% Concurrent 17.9%		OR Skin-skin 51.5 (20.9) Txf 0% Comp 0% Mesh 100% Concurrent 19.4%	LOS (d) 1.9 (0.9) Readmit 1.0% Reop 0.0% Comp 3.2% SSO 0% Seroma/ Hematoma 1.1% Retention 2.1% Other 0%		LOS (d) 4.4 (3.6) Readmit 2.2% Reop 2.2% Comp 10.8% SSO 3.2% Seroma/ Hematoma 2.2% Retention 1.1% Other 4.3%				Open had more postop complications (p=0.047) Robot had longer OR time (p<0.001)	Propensity matched for BMI >= 30 group
Kosturakis, 2018[67] Robot vs open Retrospective US VA 1/na n N=200	N=100 Age 57.2 (1.3) Male 100% BMI 27.8 (0.5) ASA 35% Primary 78% Unilateral 41% Pain (scale) 0		N=100 Age 63.5 (1.1) Male 99% BMI 26.2 (0.5) ASA 62% Primary 87% Unilateral 93% Pain (scale) 0	OR 109.7 (3.6) *Unilateral* *90.5 (5.0)* *Bilateral* *121.9 (4.9)* Comp 0% Mesh 100% TAPP 100% Concurrent 9%		OR 83.7 (2.6) *Unilateral* *80.2* *(2.2)* *Bilateral* *121.5* *(18.3)* Comp 0% Concurrent 5%	ED 6% Comp 21% SSO 3% Pain (scale) 0 Pain (visits) 0% Narcotic 5% Retention 18% Other 0%		ED 11% Comp 22% SSO 7% Pain (scale) 0 Pain (visits) 9% Narcotic 12% Retention 13% Other 2%	Pain (referral) 0% Recur 4%		Pain (referral) 1% Recur 4%	OR times longer for robot (p<0.0001) More post-op visits for pain in open group (p=0.003)	
Kudsi, 2017[74] Robot vs lap Retrospective US 1/1 n N=275	N=118 Age 58.8 (15.4) Male 85.6% BMI 28.4 (5.0) ASA□3 28.0% Elective 97.5% Primary 93.2% Unilateral	N=157 Age 55.1 (14.8) Male 94.9% BMI 27.1 (4.9) ASA□3 19.9% Elective 99.4% Primary 91.1% Unilateral 76.4%		OR Skin-skin 69.1 (35.1) *Unilateral* *64.5 (35.6)* *Bilateral* *80.2 (31.7)* Comp 0 Conversion 0% Mesh 100% TAPP 100%	OR Skin-Skin 69.1 (26.3) *Unilateral* *63.3 (23.6)* *Bilateral* *88.3 (26.1)* Comp 0.6% Conversion 0.6% Mesh 100% TEP 100%		Readmit 3.4% Comp[*] 6.8% SSO 0% Seroma/ hematoma 1.7% Retention 1.7% Other 3.4%	Readmit 1.9% Comp[*] 5.1% SSO 0% Seroma/ hematoma 1.9% Retention 1.3% Other 1.3%		1-yr F/U 85.6% F/U 1 y Pain[**] 0.8% Recur 0%	1-yr F/U 100% F/U 1 y Pain[**] 0.6% Recur 0.6%			[*]3-month complications [**]Inguinodynia

	70.3%													
Lammers, 2019[83] Robot vs lap vs open Retrospective US 1/na y N=277	BMI 31	BMI 26	BMI 27	OR 146	OR 86	OR 75	Readmit 0%	Readmit 1.2%	Readmit 2.4%	F/U 30 d	F/U 30 d	F/U 30 d	Robot had significantly longer OR times (p<0.001) Higher readmission in open group (p=0.03)	
Macias, 2017[81] Robot vs lap Retrospective US 2/1 n N=55	N=21	N=34		OR 71.2	OR 54.2		LOS (min)* 113.4	LOS (min)* 144.4		Pain** 24%	Pain** 3%		Mean OR time longer for robot (p=0.001) Higher prevalence of inguinodynia in robot group	*Recovery room time **Inguinodynia
Muysoms, 2018[73] Robot vs lap Prospective (lap data from previous published studies) Belgium 1/1 n N=112 **Pooled**	N=49 Age 58.8 Male 98.0% BMI 25.0 Unilateral 69.4% QOL* 24 [14-37] Pain 7 [4-13]	N=63 Age 57.7 Male 96.8% BMI 24.4 Unilateral 59.5% QOL* 17 [11-28] Pain 4 [2-9]		OR Skin-skin 61.3 Room time 101.7 Comp 0% Conversion 0% Mesh 100% TAPP 100%	OR Skin-skin 59.3 Room time 95.1 Comp 0% Conversion 0% Mesh 100% TAPP 100%		Comp 24.5% Seroma/ hematoma 14.3% Retention 10.2%	Comp 15.9% Seroma/ hematoma 11.1% Retention 4.8%		F/U (wk) 4 (100%) QOL** 4 [1-12] Pain: 1 [0-3]	F/U (wk) 4 (100%) QOL** 6 [3-14], Pain: 2 [0-5]			*EuraHS **EuraHS 1 mo postop Median [IQR] Examined learning curve (single surgeon without clinical experience with robot)
Muysoms, 2018[73] Robot vs lap **Unilateral**	N=34 Age 60.4 (16.5) Male 97.1% BMI 25 (3.4)	N=22 Age 59.0 (11.8) Male 90.9% BMI 24 (3.0)		OR Skin-skin 54 (16) Room time 94 (17) Concurrent 3%	OR Skin-skin 45 (11) Room time 79 (10) Concurrent 5%		Comp 23.5% Seroma/ hematoma 15% Retention 9%	Comp 9% Seroma/ hematoma 9% Retention 0%						
Muysoms, 2018[73] Robot vs lap **Bilateral**	N=15 Age 55.3 (12.5)	N=41 Age 57.0 Male		OR Skin-skin 78 (16) Room time	OR Skin-skin 67.0 Room time		Comp 26.6% Seroma/ hematoma	Comp 19.5% Seroma/ hematoma						

	Male 100% BMI 25 (2.1) Primary 86.7%	100% BMI 24.6 Primary 100%		119 (15)	101.8		13.3% Retention 13.3%	12.2% Retention 7.3%						
Pokala, 2019[82] Robot vs lap vs open Prospective (Vizient) US na/na n N=3,547	N=594 White 81.5% Black 9.4% Other 9.1% Male 95.3% Elective 100%	N=540 White 77.0% Black 11.9% Other 11.1% Male 80.4% Elective 100%	N=2413 White 75.8% Black 12.1% Other 12.2% Male 84.1% Elective 100%				LOS (d)* 1.8 [1.6] Readmit 0.8% Comp 0.7% SSI 0.0% Narcotic** 93.8% (7.6, 1.5) Mortality 0.2%	LOS (d)* 2.2 [2.1] Readmit 2.2% Comp 4.4% SSI 0.6% Narcotic** 93.1% (9.7, 1.7) Mortality 0.2%	LOS* 3.6 d [4.1] Readmit 3.6% Comp 3.9% SSI 8.3% Narcotic** 96.0% (24.8, 2.3) Mortality 0.2%	F/U 30 d	F/U 30 d	F/U 30 d	Overall complications lower for robot (p<0.05 vs open and lap) Postop infection + LOS significantly higher in open (p<0.05 for lap and robot)	*Median [IQR] **Pain quantified by: % patients prescribed opiates (mean units used, mean days used) Direct cost 9431 (5490) vs 6502 (4005) vs 8837 (14353) Open more expensive than lap (p<0.05) Robot more expensive than lap (p<0.05)
Prabhu 2020[63] Robot vs lap RCT US 6/na n/a N=102	N=48 Age: 56.1 (14.1) Race: 83.3% white, 4.2% Hispanic, 10.4% AA, 0% Asian, 2.1% other Male: 91.6% BMI: 24.9 (3.24) DM: 7.4% Tob: 11.3%	N=54 Age: 57.2 (13.3) Race: 83.3% white, 1.8% Hispanic, 11.1% AA, 1.8% Asian, 0% other Male: 88.9% BMI: 26.9 (4.42) DM: 4.2% Tob: 6.2% Primary: 94.4% Unilateral: 100% Pain*: 18.8		Skin-skin time: 75.5 {59.0-93.8} Conversion to lap: 2.1% TAPP: 100%	Skin-skin time: 40.5 {29.2-63.8} TAPP: 100%		LOS (hrs): 5.75 {5-7} Readmit: 4 (8.3%) Comp: 8 (16.7%) SSI: 0% Seroma: 6 (12.5%) Hematoma: 1 (2.1%) Retention: 1 (2.1%) 1-w pain*: +5.53 1-m pain*: -7.00	LOS (hrs): 5.11 {4-7} Readmit: 2 (3.8%) Comp: 5 (9.3%) SSI: 2 (3.7%) Seroma: 3 (5.6%) Hematoma: 0 (0%) Retention: 1 (1.8%) 1-w pain*: +4.60 1-m pain*: -7.92		F/U: 30 d % F/U: 93.8%	F/U: 30 d % F/U: 98.1%		Greater skin-skin time in robot group (p<0.001) Similar LOS (p=0.424) readmission rate (p=0.420), and overall complication rate (p=0.374) No differences in change in VAS score from baseline at 1-week (p=0.86) and 30-d (p-0.85)	{} = IQR * Visual Analog Scale (VAS); follow-up pain assessments reflect score change from baseline

	Primary: 89.4% Unilateral: 100% Pain*: 15.2													
Sheldon 2019[79] Robot vs lap vs open Retrospective cohort US 1/na n N=173	N=49 Age: 38.2 (11) Male: 87.8% Primary: 100% Unilateral: 61.2%	N=34 Age: 40.8 (12) Male: 91.2% Primary: 100% Unilateral: 58.9%	N=90 Age: 39.7 (14) Male: 97.8% Primary: 100% Unilateral: 98.9%	TAPP: 100% TEP: 0%	TAPP: 0% TEP: 100%	Mesh: 100%	Pain (MME): 208.4 (123.6) *U/L: 205.4 (139.5)* Narc: 98.2% *U/L: 96.7%*	Pain (MME): 229.4 (126.2) *U/L: 198.7 (116.1)* Narc: 97.2% *U/L: 95.0%*	Pain (MME): 230.4 (122.3) *U/L: 230.5 (123.2)* Narc: 98.5% *U/L: 97.8%*	F/U: 3 mo Repeat Rx: 8.2% *U/L: 6.7%*	F/U: 3 mo Repeat Rx: 8.8% *U/L: 5.0%*	F/U: 3 mo Repeat Rx: 10.0% *U/L: 9.0%*	Equal opioid use in all groups at discharge (p=0.962) and at follow-up requiring repeat Rx (p=0.935); same for laterality-controlled subanalysis (p=0.803 and p=0.807)	MME = morphine milligram equivalents
Switzer, 2019[64] Robot vs lap Prospective (AHSQC) US na/na n N=148	N=33 Elective 100% Unilateral 100% Pain 10 QOL* 33 (pain 10, restriction 17, cosmetic 6)	N=115 Elective 100% Unilateral 100% Pain 6 QOL* 20 (pain 6, restriction 9, cosmetic 5)					Comp 15%	Comp 9%		F/U 6 mo Readmit 3% Mesh inf 0% Pain 0 Recur 0% QOL* 0	F/U 6 mo Readmit 0% Mesh inf 0% Pain 0 Recur 0% QOL* 0		No significant outcome differences	*EuraHS score
Waite, 2016[65] Robot vs lap Retrospective US 1/1 n N=63	N=39 Age* 58.1 {21-80} Male 97.4% BMI* 27.5 {23.0-35.9} Unilateral 74.4%	N=24 Age* 57.5 {43-72} Male 100% BMI* 27.6 {21.0-33.3} Unilateral 75.0%		OR Skin-skin* 77.5 {n/a} *Unilateral 67.6* *Bilateral 106.2* Room time 109.3 *Unilateral 100.0* *Bilateral 135.4* Mesh 100% TAPP 100%	OR Skin-skin* 60.7 {45-102} *Unilateral 55.0* *Bilateral 77.8* Room time 93.0 *Unilateral 87.7* *Bilateral 108.7* Mesh 100% TAPP		LOS (min) 218.4 *Unilateral 209.4* *Bilateral 244.4* Pain** 2.5 *Unilateral 2.2* *Bilateral 3.5*	LOS (min) 226.5 *Unilateral 216.3* *Bilateral 256.8* Pain** 3.8 *Unilateral 3.4* *Bilateral 5.1*					Significantly longer OR time for robotic (p=0.001) Robotic surgery patients spent less time in recovery (p=0.033 for bilateral surgery, p=0.149 for unilateral	*Mean {Range} **Median of scale (1-10) Cost data (no sig diff) Ave direct cost: 3216 vs 3479 (lap vs robot)

				Concurrent 12.8%	100% Concurrent 0%								surgery) with less reported pain (p=0.062 for unilateral, p=0.090 for bilateral)	
Zayan, 2019[76] Robot vs lap Retrospective US 1/3 n N=105	N=37 Age 53.9 (49.1–58.6) Male 100% BMI 27.4 (25.3–29.4) DM 5.4% Smoker 27.0% Elective 100% Primary 81.1% Unilateral 48.6% QOL* 29.7 (19.3–39.1)	N=68 Age 52.7 (49.2–56.1) Male 86.8% BMI 26.1 (25.1–27.1) DM 7.4% Smoker 11.8% Elective 100% Primary 91.2% Unilateral 76.5% QOL* 19.4 (11.4–26.9)		OR 120 (105-135) Mesh 100% TEP 0% TAPP 100% Concurrent 5.4%	OR 58 (54-63) Mesh 100% TEP 52.9% TAPP 47.1% Concurrent 0%		LOS (h) 15.5 (10.0–20.8) QOL* 10.7 (2.1–18.3)	LOS (h) 9.6 (8.3–11.0) QOL* 10.2 (5.5–14.3)		F/U (mo) 14.1 (13.1–15.0) Recur 0.0% QOL* 8.4 (2.6–14.0)	F/U (mo) 15.5 (14.7–16.3) Recur 5.9% QOL* 5.1 (2.0–7.4)		Significantly longer OR time for robotic (p<0.001)	*Carolinas Comfort Scale (CCS)

VENTRAL HERNIA REPAIR

Author, Year Population Study Design US (y/n) VA (y/n) #Institutions/ Surgeons Propensity Matching (y/n) Total N	**Patient Characteristics Preop** Total N Age, mean yr (SD) Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % NH-Other/Unknown, % Hispanic, % Male, % BMI, mean (SD) ASA class, mean (SD) Diabetes, % Smokers, % Hernia characteristics Elective surgery, N (%) Hernia area, cm^2 (SD) Midline hernia, N (%) Recurrent hernia, N (%)			**Intraoperative Outcomes** OR time, min (SD) EBL, mL (SD) Transfusions, % Complications, % Conversion To Open, % To Lap, % Mesh repair, % Fascial closure, % Concurrent procedure, %			**Short-Term Outcomes (<=30d)** Readmissions, N (%) Reoperations, N (%) ED visits, mean (SD) LOS, mean days (SD) Complications, N (%) SSI, N (%) SSO, N (%) Seroma, N (%) Hematoma, N (%) Enterotomy, N (%) Pain, N (%) Narcotic use, N (%) Return to work, N (%) Mortality, N (%) Urinary retention, N (%) Other, N (%) Ileus, N (%)			**Long-Term Outcomes (>30d)** Follow-up at 1 year, % Length of follow-up, mean (SD) Readmissions, N (%) Mesh infection, N (%) Pain, N (%) Recurrence, N (%) QOL			**Primary Multi-Variate Findings**	**Comments**
	Robot	Lap	Open	Robot	Lap	Open	Robot	Lap	Open	Robot	Lap	Open		
Abdalla, 2017[85] Robot vs lap VHR RCT N (Brazil) N 1/NR N N=38 Abstract only	N=19	N=19					Mortality: 0	Mortality: 1 (5.26%)		F/U length: >1 yr Recur: 2 (10.53%)	F/U length: >1 yr Recur: 4 (21.05%)		Trend toward better QOL improvement and improved abdominal wall function in robot group Similar outcomes and morbidities	Cost
Altieri, 2018[99] Robot vs lap VHR Prospective cohort (NY Statewide Planning and Research Cooperative System) Y N NR/NR	N=679 Race: 75.11% white, 12.37% AA, 0.44% Asian, 4.57% Hispanic, 7.51% other	N=20896 Race: 65.12% white, 12.79% AA, 1.02% Asian, 11.79% Hispanic, 9.28% other					Readmit: 63 (9.28%) Reop: ED: 98 (14.43%) LOS: 2.19 (6.31) Complication: 137 (20.18%)	Readmit: 1058 (5.06%) Reop: ED: 2185 (10.46%) LOS: 4.32 (18.04) Complication: 2206 (10.56%)		F/U length: 30 d	F/U length: 30 d		Higher readmission (p<0.0001), ED revisit (p<0.0001), complication rate (p<0.0001), and longer LOS (p=0.0023) in robot group	

Y (see row below) N=21575	Male: 86.89 % BMI>30: 25.77 % DM: 19.00 %	Male: 44.55% BMI>30: 11.27% DM: 11.23%												
Altieri, 2018[99] N=1356 Propensity score matched	N=678	N=678					Readmit: ED: LOS: Complication:	Readmit: ED: LOS: Complication:					Propensity score matched, no difference in 30-day readmission (p=0.2760), ED revisit (p=0.2043); shorter LOS (-1 day, p<0.0001) and decreased complication rate (-0.0575 risk difference, CI -0.1023- -0.0128, p=0.0134)	
Armijo, 2018[104] Robot vs lap vs open VHR Prospective cohort (Vizient) Y N NR/NR N N=46799	N=465 Age: 59 (13.1) Male: 40.2% ASA: NR (“major” illness: 15.3%)	N=6829 Age: 57 (13.2) Male: 60.8% ASA: NR (“major” illness: 6.9%)	N=39505 Age: 57 (13.3) Male: 58.3% ASA: NR (“major” illness: 18.8%)				Readmit: 3.87%, CI 2.31-6.05 LOS: 2 (IQR 1-4) Complication: 7.3%, CI 5.1-10.0 SSI*: 1.72%, CI 0.75-3.36 Narc**: 95.8%, 19.5, 2.8 Mortality: 0.43%, CI 0.05-1.54	Readmit: 2.86%, CI 2.47-3.28 LOS: 3 (IQR 2-4) Complication: 3.5%, CI 3.1-4.0 SSI*: 0.67%, CI 0.49-0.90 Narc**: 96.3%, 20.8, 2.6 Mortality: 0.16%, CI 0.08-0.29	Readmit: 7.55%, CI 7.29-7.81 LOS: 5 (IQR 3-8) Complication: 11.4%, CI 11.1-11.75 SSI*: 2.83%, CI 2.67-3.00 Narc**: 95.7%, 52.7, 4.8 Mortality: 0.99%, CI 0.90-1.1	F/U length: 30 d	F/U length: 30 d	F/U length: 30 d	Open group highest rate of complications, then robot, then lap (p<0.01) Highest mortality in open group vs lap (p<0.05) Lowest post-op infection rate in lap vs open and robot (p<0.05) Longer LOS for open patients (p<0.05), no difference lap vs robot No difference in opiate Rx, however higher units used and longer duration in open group	Cost *”postoperative infection” interpreted as SSI **narcotic use assessed by % patients prescribed opiates, mean resource units used/case (units), and mean days of resource units used/case (days)
Bittner, 2018[86]	N=26		N=76	OR time: 365 (78)		OR time: 287 (121)	Readmit: 7.7%		Readmit: 6.6%	F/U length: 90 days		F/U length: 90 days	r-TAR decreased mean hospital LOS by 3 days (p<0.01)	*Post-op complications up to 90 days post-op

Robot vs open TAR + VHR Retrospective cohort (prospective data) Y N 1/1 N N=102	Age: 52.4 (12.9) Male: 33.3% BMI: 33.4 (9) ASA: 3 DM: 0% Tob: 0% Elective: 100% Size (area): 235 (107) [length: 18.5 (5.1), width: 12.3 (3)] Midline: 83% Recurrent: 58.3%		Age: 54.6 (14) Male: 46% BMI: 32.1 (7) ASA: 3 DM: 22.3% Tob: 13% Elective: 100% Size (area): 260 (209) [length: 17.1 (7.1), width: 13.7 (5.9)] Midline: 89.5% Recurrent: 52.6%	Complication: 0% Conversion: 0% Mesh: 100% Closure: 100% Concurrent: 0%		Complication: 5.3% Mesh: 100% Closure: 100% Concurrent: 16%	LOS: 3.8 (1.5) Complication: 19.2%* SSI: 0% Seroma/ hematoma: 1 (3.8%) Mortality: 0% Retention: 2 (7.69%) Other: 1 (3.85%) Ileus: 1 (3.85%)		LOS: 7.1 (5.4) Complication: 30.2%* SSI: 2 (2.6%) Seroma/ hematoma: 0 Mortality: 0% Retention: 6 (7.89%) Other: 25 (32.89%) Ileus: 1 (1.32%)				Longer OR times in r-TAR group (p<0.01) Similar complication rates (p=0.09)	
Carbonell, 2018[90] Robot vs open VHR (TAR permitted) Prospective cohort (AHSQC) Y N 219/181 (14 robot, 39 open after matching) Y N=1205 (333 matched)	N=111 Age: 55.59 (12.36) Race: 86% white Male: 39% BMI: 33.88 (7.30) ASA: 2.60 DM: 25% Tob: 22% Elective: 100% Size: 87.96		N=222 Age: 55.08 (13.76) Race: 82% white Male: 43% BMI: 33.23 (7.39) ASA: 2.62 DM: 25% Tob: 20% Elective: 100% Size: 80.13 cm^2	OR time >2h: 45.05% Complication: 2 (1.80%) Conversion: 3.60% to open Mesh: 100% Closure: 100% Concurrent: 0% TAR: 85%		OR time >2h: 12.61% Complication: 3 (1.35%) Mesh: 100% Closure: 99% Concurrent: 0% TAR: 83%	Readmit: 6% Reop: 2% LOS: 2 (IQR 2) Complication: 66 (29.71%) SSI: 2% SSO: 32% Seroma/ hematoma: 31 (27.93%) Enterotomy: 2 (1.80%) [+1 (0.90%) gastric injury] Pain: 1 (0.90%,		Readmit: 5% Reop: 3% LOS: 3 (IQR 3) Complication: 48 (43.24%) SSI: 4% SSO: 14% Seroma/ hematoma: 11 (4.95%) Enterotomy: 3 (1.35%) Pain: 1 (0.45%, readmission) Mortality: 2 (0.90%)	F/U length: 30 d		F/U length: 30 d	Shorter OR times with open repair (p<0.001) Decreased LOS with robot VHR (p<0.001) No difference in intraop complications (p=1), reoperations, readmissions, or SSIs, but higher proportion of robot patients experienced SSOs (p<0.001), mostly seromas (p<0.001)	First author and several others received honoraria or grants from Intuitive Robotic data overlaps with Warren, 2016

	cm^2 (67.57), width 7.51 (3.34), length 13.17 (6.58) Recurrent: 38%		(74.02), width 7.17 (3.68), length 12.00 (6.89) Recurrent: 37%				readmission) Mortality: 0							
Chen, 2016[100] Robot vs lap VHR Retrospective cohort Y N 1/3 N N=72	N=39 Age: 47.2 {24-69} Male: 43.6% BMI: 33 {23-53} ASA: 2.15 DM: 12.82 % Size: 3.07 cm {1-9} Recurrent: 10.26 %	N=33 Age: 46.6 {27-68} Male: 72.7% BMI: 32 {25-45} ASA: 1.97 DM: 15.15% Size: 2.02 cm {0.5-5} Recurrent: 9.09%		OR time: 156.6 {77-261} Mesh: 100% Closure: 7.69%	OR time: 65.9 {25-128} Mesh: 100% Closure: 0		LOS: 0.49 {0-3} (for N=14) Complication: 3 (7.7%) SSI: 0 Seroma/ hematoma: 1 (2.56%) Retention: 2 (5.13%)	LOS: 0.21 {0-1} (for N=7) Complication: 3 (9.1%) SSI: 1 (3.03%) Seroma/ hematoma: 1 (3.03%) Retention: 1 (3.03%)		F/U length: 47 d Recur*: 0	F/U length: 47 d Recur*: 0		Longer operative time in robot group (p<0.0001) Larger hernia sizes in robot group (p<0.0001) No difference in LOS for those who stayed (p=0.09) No difference in complications (p=1)	{}=range *30-d recurrence
Coakley, 2017[98] Robot vs lap VHR Prospective cohort (HCUP-NIS) Y N NR/NR N N=32594	N=351 Age: 59.4 (14.6) Race: 73% white, 11.3 AA, 9.5% Hispanic, 6.2% other Male: 48% BMI>30: 20.5%	N=32243 Age: 57.4 (14.9) Race: 75.3% white, 10.5% AA, 10.1% Hispanic, 4.1% other Male: 43% BMI>30: 25.3% ASA: NR [CCI		Concurrent: 0%	Concurrent: 0%		LOS: 3.5 (3.6) Complication: 20.24% SSI: 0.85% SSO: 0.28% Mortality: 0% Other: 13.7% Ileus: 5.41%	LOS: 3.4 (2.6) Complication: 18.73% SSI: 0.47% SSO: 0.07% Mortality: 0.1% Other: 9.75% Ileus: 8.34%					No difference between LOS (p=0.2), minor or major complication rates (p=0.858, p=0.226), mortality (p=0.478)	Cost/utilization CCI = Charlson comorbidity index

	ASA: NR [CCI 1.1 (1.7)] DM: 18.0% Elective: 100%	0.83 (1.3)] DM: 22.2% Elective: 100%												
Gonzalez, 2015[95] Robot vs lap VHR Retrospective cohort Y N 1/2 N N=134	N=67 Age: 56.6 (14.5) Male: 38.8% BMI: 34.7 (9.0) ASA: 2.2 (0.7) Midline: 65.6%	N=67 Age: 55.0 (13.2) Male: 31.4% BMI: 33.5 (9.5) ASA: 2.0 (0.8) Midline: 74.6%		Skin-skin time: 107.6 (33.9) Conversion: 1 (1.5%) to open Mesh: 100% Closure: 100% Concurrent: 3.0%	Skin-skin time: 87.9 (53.1) Conversion: 3 (4.5%) to open Mesh: 100% Closure: 0% Concurrent: 4.5%		Reop: 1 (1.5%)* LOS: 2.5 (4.1) Complication: 2 (3.0%) SSO: NR Seroma/ hematoma: NR Enterotomy: NR Mortality: 0% Other: 1 (1.5%)	Reop: 2 (3.0%) LOS: 3.7 (6.6) Complication: 7 (10.4%) SSI: 2 (3.0%) Seroma/ hematoma: 2 (3.0%) Enterotomy: 1 (1.5%) Mortality: 0% Other: 2 (3.0%)		1-yr F/U: NR F/U length: 17.1 mo (9.5) Mesh infxn: 1 (1.5%) Recur: 1 (1.5%)	1-yr F/U: NR F/U length: 21.7 mo (12.1) Mesh infxn: NR Recur: 5 (7.5%)		Longer surgical time for PCD (robot) by 19.7 (p=0.012) Longer follow-up for NPCD (lap) by 4.6 mo (p=0.016) Trend toward increased complications (p=0.084) and recurrences (p=0.095) in NPCD (lap) No difference in LOS (p=0.461) or rate of conversion (p=0.310)	*SBO requiring reoperation 4 mo post-op PCD vs non-PCD associated with robot vs lap
Guzman-Pruneda, 2020 (#1457) Robot vs open VHR + CS Prospective database (AHSQC) Y N NR/303 N N=236	N=42 Age: 59 {54-65} Male: 36% BMI: 32 {28-39} ASA: 2.60 DM: 19% Tob: 14% Elective: 100% Area: 61 {40-120}; length		N=194 Age: 62 {53-68} Male: 57% BMI: 31 {28-35} ASA: 2.73 DM: 22% Tob: 3% Elective: 100% Area: 193 {106-300}; length 19 {15-25};	OR time >240: 33% Comp: 0% Conversion to open: 7.1% Mesh: 100%		OR time >240: 18% Comp: 0% Mesh: 100%	Readmit: 1 (2%) Reop: 1 (2%) LOS: 1.5 {1-2.8} Comp: 4 (9.5%) SSI: 0 (0%) SSO: 3 (7.1%) Seroma: 2 (4.8%) Hematoma: 1 (2.4%) Other: 1 (2.4%) QOL: 50 {35-59}		Readmit: 13 (7%) Reop: 3 (2%) LOS: 5 {4-6} Comp: 30 (15.5%) SSI: 3 (1.5%) SSO: 17 (8.8%) Seroma: 5 (2.6%) Hematoma: 2 (1.5%) Other: 10 (5.2%) QOL: 46 {28-72}	1-yr F/U: 100% Recur: 10 (24%) QOL: 90 {58-94}		1-yr F/U: 100% Recur: 38 (20%) QOL: 88 {67-93}	Significantly shorter LOS with robot (p<0.01) Otherwise no significant differences between robot and open approaches for QOL (p=0.66), wound morbidity (p=0.53), readmission (p=0.36), or recurrence (p=0.28)	{}=IQR *Only patients with 1 or fewer hernia recurrences included QOL described by HerQLes score

	13 {8-19}; width 7 {5.2-8.8} Recur*: 33% QOL: 38 {20-67}		width 13 {9-16} Recur*: 31% QOL: 43 {20-67}											
Khorgami, 2018[94] Robot vs lap VHR Prospective cohort (HCUP-NIS, AHRQ) Y N NR/NR N N=3699	N=99	N=3600		Concurrent: 0%	Concurrent: 0%		LOS: 2.9 (3.1)	LOS: 2.7 (1.9)						Cost Data pooled into robot vs lap for multiple procedures (chole, VHR, colectomies, sigmoidectomy, APR, TAH) – no subgroup analyses for outcomes
Lu, 2019 (#1479) Robot vs lap VHR Retrospective cohort Y N 1/NR N N=206	N=86 Age: 50.8 (12.8) Male: 47.6% BMI: 34.4 (7.4) ASA: 2.4 (0.52) DM: 19.8% Size: 7.1 (2.6) Recur: 18.6%	N=120 Age: 53.2 (14.6) Male: 61.7% BMI: 31.3 (6.1) ASA: 2.1 (0.52) DM: 8.3% Size: 5.5 (1.8) Recur: 18.3%		OR time: 174.7 (44.9) Mesh: 100%	OR time: 120.4 (35.0) Mesh: 100%		Readmit: 2 (2.3%) Reop: 2 (2.3%) LOS: 0.1 (0.5) Comp: 2 (2.3%) SSO: 2 (2.3%) Seroma: 0 (0%) Hematoma: 1 (1.2%) Other: 0 (0%)	Readmit: 3 (2.5%) Reop: 3 (2.5%) LOS: 0.2 (0.9) Comp: 11 (9.2%) SSO: 6 (6.7%) Seroma: 4 (3.3%) Hematoma: 2 (1.7%) Other: 3 (2.5%)		1-yr F/U: 73.8% F/U: 5.5 mo (5.9) Recur: 1 (1.2%)	1-yr F/U: 33.3% F/U: 5.7 mo (4.9) Recur: 2 (1.7%)		Longer OR times in robot group (p<0.001) Higher rate of complications with lap (p=0.046) No significant differences for LOS (p=0.294), reoperation (p=0.938), readmission (p=0.938), and recurrence (p=0.771) In a subgroup analysis of patients (n=71) with at least 12-mo follow-up, there was no difference in complications or recurrence	QOL described by Carolina Comfort Scale (CCS)

Martin-del-Campo, 2018[87] Robot vs open TAR + VHR Retrospective cohort Y N 2/NR Y (defect size) N=114	N=38 Age: 58.9 (12.7) Male: 39.5% BMI: 33.1 (8.8) ASA□3: 50% DM: 18.4% Tob: 15.8% Elective: 100% Size (width): 13.5 (4.5) Recurrent: 28.9%		N=76 Age: 58.8 (11.8) Male: 32.9% BMI: 33.51 (5.7) ASA□3: 75% DM: 22.3% Tob: 9.2% Elective: 100% Size (width): 13.5 (4.5) Recurrent: 64.5%	OR time: 299 (95) EBL: 49 (60) Transfxn: 0% Complication: 0% Conversion: NR Mesh: 100%		OR time: 211 (63) EBL: 139 (149) Transfxn: 6.57%* Complication: 0% Mesh: 100%	Readmit: 0% LOS: 1.3 (1.3) Complication: 0% SSO: 1 (2.6%) Mortality: 0% Other: 0% Ileus: 0%		Readmit: 2 (2.64%) LOS: 6 (3.4) Complication: 13 (17.1%) SSO: 9 (11.8%) Mortality: 0% Other: 10 (13.15%) Ileus: 3 (3.95%)				Longer OR times for r-TAR (p<0.001) Lower EBL for r-TAR (p<0.001) No difference between in-hospital transfusions (p=0.106) Higher rate of systemic complications with o-TAR (p=0.007) No difference in wound morbidity (p=0.101) Shorter hospital stay in r-TAR (p<0.001)	*Post-op transfusion
Mudyanadzo, 2020 (#1503) Robot vs lap VHR Retrospective cohort Y N 1/NR N N=35	N=16 Elective: 100% Recur: 0%	N=19 Elective: 100% Recur: 0%					LOS: 1.3 (0.1) Pain*: 1 (6.2%) Narc**: 4.2 (4.25)	LOS: 1.7 (0.2) Pain*: 6 (31.6%) Narc**: 14.5 (5.218)		F/U: 8 w	F/U: 8 w		Similar LOS between groups (p n.s.) Decreased pain in robot group (p<0.05) Increased narcotic use in lap group (p<0.05)	*Pain measured as requiring additional narcotics within follow-up period **Narcotic use defined as daily opioid use (morphine equivalents)
Nguyen, 2017[88] Robot vs open TAR + VHR Retrospective cohort Y N 1/1 N	N=27 Age: 55.4 (12.4) BMI: 32.2 (6.4) Size (area): 216		N=16 Age: 58.6 (10.4) BMI: 33.3 (5.5) Size (area): 242	OR time: 272.1 EBL: 43 Mesh: 100%		OR time: 206.5 EBL: 146.9 Mesh: NR	Readmit: 0% Reop: 0% ED: 4 (14.81%) LOS: 3.0 SSO: 1 (3.70%) Seroma/ hematoma: NR Other: NR		Readmit: 2 (12.5%) Reop: 2 (12.5%) ED: 4 (25%) LOS: 9.6 SSO: 3 (18.75%) Seroma/ hematoma: 1 (6.25%) Other: 4 (25%)				Decreased LOS (p<0.001) and EBL (p<0.001) for RAR Longer OR times for RAR (p<0.001) OAR patients more likely to be admitted (p=0.132) and undergo reoperation	

N=43 Abstract only														
Prabhu, 2017[96] Robot vs lap VHR Prospective cohort (AHSQC) Y N 181/100 (40 robot, 79 lap) Y N=1103 (638 matched for fascial closure)	N=200 (186 matched) Age: 59 {48-68} Race: 85% white Male: 41% BMI: 32 {28-36} ASA (2): 47% DM: 19% Tob: 17% Elective: 100% Size: 19 cm² {7-47} (width 4 cm {3-6}, length 6 cm {3-11}) Recurrent: 33%	N=903 (452 matched) Age: 59 {48-68} Race: 84% white Male: 41% BMI: 32 {28-37} ASA (2): 47% DM: 19% Tob: 15% Elective: 100% Size: 16 cm² {7-38} (width 4 cm {3-6}, length 5 cm {3-8}) Recurrent: 31%		OR time >2h: 46% Transfxn: 1 (0.54%) Complication: 4 (2.15%) Mesh: 100% Closure: 91%	OR time >2h: 30% Transfxn: 0 Complication: 4 (0.88%) Mesh: 100% Closure: 90%		Readmit: 5 (2.69%) Reop: 0 LOS: 0 (IQR 2.00) Complication: 14 (8%) SSI: 1% SSO: 5% Seroma/ hematoma: 4% Enterotomy: 0 Pain: 1 (0.54%) Mortality: 1 (0.54%) Other: 2 (1.08%) Ileus: 1 (0.54%)	Readmit: 19 (4.20%) Reop: 8 (1.77%) LOS: 1 (IQR 2.00) Complication: 84 (19%) SSI: 1% SSO: 12% Seroma/ hematoma: 10% Enterotomy: 4 (0.88%) Pain: 2 (0.44%) Mortality: 0 Other: 19 (4.20%) Ileus: 8 (1.77%)		F/U length: 30 d	F/U length:30 d		Higher rate of fascial closure in robot group (93% vs 56%, p<0.05) Post-hoc analysis (N=638, matched for fascial closure), hernia length was longer (p=0.01) and OR time was longer (p<0.001) in robot group; increased SSO (p=0.006) or any complication (p<0.001) in lap group Increased LOS in lap group (p<0.001) without difference in readmission (p=0.4) or reoperation (p=0.1128)	First author received grant money from Intuitive {}=range
Roberts, 2019 (#1585) Robot vs open VHR + TAR Prospective database (AHSQC) Y N 1/NR	N=13 Area: 87.4		N=12 Area: 175.9	OR time: 297.9 Conversion to open: 7.7%		OR time: 267.8	LOS: 1.67 Seroma: 1 (7.7%) Hematoma: 1 (7.7%) Pain*: 0 (0%)		LOS: 6.5 Seroma: 10 (8.3%) Hematoma: 10 (8.3%) Pain*: 3 (25%)				No difference in OR time (p=0.47) or hematoma/seroma (p=0.95) Decreased LOS for robot (p<0.0001) Trend toward decreased readmission for pain in robot group (p=0.0546)	*Pain defined as 30-day readmission due to pain

N N=25 Abstract only														
Song, 2017[103] Robot vs lap vs open VHR Retrospective cohort Y N NR/NR (Premier Perspective Database) Y N=6642 (N=286 matched) Abstract only	N=96 matched vs open (N=94 matched vs lap) Elective: 100%	N=1992 (N=94 matched) Elective: 100%	N=4354 (N=96 matched) Elective: 100%	OR time: 231 (101) Transfxn: 0% Complication: 1 (1.0%) Conversion: 2 (2.1%)	OR time: 169 (108) Transfxn: 5 (5.3%) Complication: 4 (4.3%) Conversion: 13 (13.9%)	OR time: 163 (101) Transfxn: 5 (5.2%) Complication: 1 (1.0%)	LOS: 3.0 (2.4) Complication: 17 (17.7%) SSO: 0% Seroma/ hematoma: 0% Narc*: 48 (30, 96)	LOS: 3.2 (3.0) Complication: 23 (24.5%) SSO: 0% Seroma/ hematoma: 3 (3.2%) Narc*: 60 (30, 60)	LOS: 5.3 (5.2) Complication: 38 (39.6%) SSO: 3 (3.1%) Seroma/ hematoma: 4 (4.2%) Narc*: 93 (48, 159)	Mesh infxn: 0%	Mesh infxn: 0%	Mesh infxn: 0%	Lower complications RVHR compared to OVHR (p=0.001), Fewer blood transfusions in RVHR compared to LVHR and OVHR (p=0.02) Fewer conver. compared to LVHR (p=0.003) Less in-hospital PCA compared to OVHR (p=0.02) Shorter LOS compared to OVHR (p=0.003) Longer OR time compared to LVHR and OVHR (p<0.0001)	Obese patients only (BMI>30) Cost analysis *In-hospital PCA morphine equivalent dosage (Q1, Q3)
Switzer, 2017[89] Robot vs open VHR Prospective cohort (AHSQC) Y N NR/NR Y N=120 Abstract only	N=30 Age: 58 (IQR 51-63) Male: 27% Size (width): 7 cm		N=90 Age: 61 (IQR 52-68) Male: 31% Size (width): 6 cm				Readmit: 3% Complications: NR HerQLes: 48		Readmit: 3% Complications: NR HerQLes: 48	F/U: 1 yr Recur: 23% QOL (HerQLes): 82		F/U: 1 yr Recur: 19% QOL (HerQLes): 81	Similar complication rates (p=0.29) No significant difference in 1-year recurrence (p=0.6) Improved QOL outcomes in both robotic and open repairs without major differences at 30 days (p=0.54) or 1 year (p=0.86)	
Walker, 2018[97] Robot vs lap VHR Retrospective cohort Y N	N=142 Age: 53.2 (13.2) Male: 50.0% BMI: 31.6 (5.1)	N=73 Age: 49.5 (13.3) Male: 32.8% BMI: 35.7 (7.9)		Skin-skin time: 116.9 (47.9) Conversion: Mesh: 100%	Skin-skin time: 98.7 (56.6) Conversion: Mesh: 100%		LOS: 1.4 (0.4) SSI: 0 SSO: 24 (16.9%) Seroma/ hematoma: 13 (9.1%)	LOS: 0.7 (0.3) SSI: 5 (6.8%) SSO: 24 (32.8%) Seroma/		F/U length: 12.3 w (2.6) Recur: 11 (7.7%)	F/U length: 23.6 w (8.4) Recur: 5 (6.8%)		Fascial closure more often with robot (p=0.05) Shorter OR times with lap (p=0.03) No difference in recurrence (p=1) Robot had decreased SSO	

2/10 Y (see row below) N=215	ASA: 2.5 (0.7) DM: 13.3% Tob: 31.0% Elective: 100% Size: horizontal 4.3 cm (3.2) Recurrent: 35.2%	ASA: 2.6 (0.7) DM: 19.2% Tob: 38.4% Elective: 100% Size: horizontal 4.1 cm (2.1) Recurrent: 34.2%		Closure: 71.1% Concurrent: 0%	Closure: 54.8% Concurrent: 0%			hematoma: 14 (19.2%)					(p=0.01), seromas (p=0.02), and SSI (p<0.01) Robot had decreased SO on multivariable analysis (OR 0.23, CI 0.08-0.67)	
Walker, 2018[97] Propensity score matched N=96	N=48	N=48		Closure: 77%	Closure: 67%		SSO: 4.2%	SSO: 18.8%		F/U: 4.9 w (IQR 2.0-11.5) Recur: 2.1%	F/U: 6.0 w (IQR 3.9-9.4) Recur: 4.2%		Propensity score matched analysis: robot had increased rates of fascial closure (p<0.01), decreased SSO (p<0.001), decreased recurrence (p<0.01)	
Warren, 2016[101] Robot vs lap VHR (TAR permitted) Prospective cohort (AHSQC) Y N 1/NR N N=156	N=53 Age: 52.9 (12.3) Race: 84.91% white, 7.55% black, 7.55% other Male: 41.51% BMI: 34.7 (7.4) ASA: 2.64 DM: 28.3% Tob: 24.53%	N=103 Age: 60.2 (13.4) Race: 85.44% white, 11.65% black, 2.91% other Male: 26.21% BMI: 35.7 (9.5) ASA: 2.61 DM: 33.01% Tob: 16.5% Size: 88.0 cm^2 (94.0),		OR time: 245.6 (98.5) Complication: 1 (1.89%) Conversion: 0 Mesh: Closure: 96.23% Concurrent: TAR: 43.4%	OR time: 121.5 (57.2) Complication: 9 (8.74%) Conversion: 3.88% to open Mesh: 97.09% Closure: 50.49% Concurrent: TAR: 0%		Readmit: 4 (7.5%) Reop: 2 (3.77%) LOS: 1 {1-3} Complication: 6 (11.32%) SSI: 2 (3.77%) SSO: 28 (52.83%) Seroma/hematoma: 25 (47.17%) Enterotomy: 1 (1.89%) Narc (mg/hr): POD0: 1.9 {1.0-3.7}; POD1: 1.4 {0.4-2.1}	Readmit: 5 (4.8%) Reop: 2 (1.94%) LOS: 2 {2-4} Complication: 7 (6.80%) SSI: 1 (0.97%) SSO: 19 (18.45%) Seroma/hematoma: 17 (16.5%) Enterotomy: 9 (8.74%) Narc (mg/hr): POD0: 2.1 {1.2-3.1}; POD1: 1.8 {0.7-2.7}		F/U length: "short term"	F/U length: "short term"		Fascial defect more likely to be closed with robot (p<0.001) Longer operative time longer for robot (p<0.001) Shorter LOS with robot by 1 day (p=0.004) No difference in narcotic requirement through POD1 (p=0.176) No difference in SSI (p=0.592), but increased SSO with robot (p<0.001), particularly seromas Similar periop complications	Cost {}=IQR

	Size: 82.5 cm^2 (69.8), width 6.5 (2.9) Recurrent: 7.55%	width 6.9 (4.1) Recurrent: 1.94%					Mortality: 0 Other: 3 (5.66%) Ileus: 2 (3.77%)	Mortality: 1 (0.97%) Other: 5 (4.85%) Ileus: 1 (0.97%)					Increased bowel injuries in lap group (p=0.011)	
Zayan, 2019[76] Robot vs lap VHR Retrospective cohort Y N 1/3 N N=49	N=16 Age: 49.0 (IQR 42.2-55.2) Male: 62.5% BMI: 48.97 (IQR 42.15-55.23) ASA: NR DM: 6.25% Tob: 25.0% Elective: 100% Recurrent: 12.5% CCS: 8.8 (IQR -2.5-15.7)	N=33 Age: 51.5 (IQR 46.5-56.2) Male: 42.4% BMI: 33.71 (IQR 30.84-42.88) ASA: NR DM: 15.2% Tob: 9.1% Elective: 100% Recurrent: 12.1% CCS: 23.9 (IQR 12.1-34.1)		OR time: 139 (IQR 108-186) Mesh: 100% Closure: 100% Concurrent: 6.06% BIHR	OR time: 86 (IQR 67-104) Mesh: 100% Closure: 87.9% Concurrent: 0%		LOS (hrs): 22.1 (IQR 9.4-33.7) CCS: 19.0 (IQR -8.3-34.2)	LOS (hrs): 46.3 (IQR 26.3-65.6) CCS: 24.3 (IQR 3.8-33.7)		F/U length: 14.4 mo (IQR 12.9-15.8) Recur: 0% QOL (CCS): 17.2 (IQR 1.7-31.5)	F/U length: 15.1 mo (IQR 13.9-16.2) Recur: 1 (3.0%) QOL (CCS): 6.8 (IQR 2.1-11.4)		No difference in rate of fascial closure (p=0.289) Shorter LOS in robotic VHR (p=0.044) Shorter OR time for lap (p=0.009), although robot operative times decrease with number of cases and are comparable to lap No significant difference in QOL (CCS) outcomes between robot vs lap	Cost

APPENDIX H. CITATIONS FOR EXCLUDED PUBLICATIONS

Cholecystectomy

Comparison (n=4)

1. Ayloo, S., Y. Roh and N. Choudhury (2014). "Laparoscopic versus robot-assisted cholecystectomy: a retrospective cohort study." Int J Surg **12**(10): 1077-1081.
2. Jeong, S. Y., J. W. Lee, S. H. Choi and S. W. Kwon (2018). "Single-incision laparoscopic cholecystectomy using instrumental alignment in robotic single-site cholecystectomy." Ann Surg Treat Res **94**(6): 291-297.
3. Lim, C., G. Bou Nassif, E. Lahat, M. Hayek, M. Osseis, C. Gomez-Gavara, T. Moussalem, D. Azoulay and C. Salloum (2017). "Single-incision robotic cholecystectomy is associated with a high rate of trocar-site infection." Int J Med Robot **13**(4).
4. Morel, P., F. Pugin, P. Bucher, N. C. Buchs and M. E. Hagen (2012). "Robotic single-incision laparoscopic cholecystectomy." J Robot Surg **6**(3): 273-274.

No Outcome of Interest (n=4)

1. Aslam U, Amadi C, Goparaju A, Brathwaite CE, Adrales GL. Trends in Use of Robotic-Assisted Surgery for Inpatient Elective General Surgery in the United States, 2010–2015. *Journal of the American College of Surgeons.* 2019;229(4):S116.
2. Aslam U, Howell RS, Brathwaite CEM, Adrales G. Analysis of Outcomes for Elective Inpatient Robotic-Assisted, Laparoscopic, and Open General Surgery in the United States, 2010–2015. *Journal of the American College of Surgeons.* 2019;229(4):S88.
3. Norwick, P. M., S. Shaheen, J. Blebea, N. Conti, R. Heckburn, M. Zayout, J. Clements and M. Ghanem (2019). "Robotic vs standard laparoscopic cholecystectomy: Clinical outcomes." Surgical Endoscopy **33**: S397.
4. Sheetz KH, Claflin J, Dimick JB. Trends in the Adoption of Robotic Surgery for Common Surgical Procedures. *JAMA Network Open.* 2020;3(1).

No Clinical Data (n=3)

1. Armijo, P. R., S. Pagkratis, E. Boilesen, T. Tanner and D. Oleynikov (2018). "Growth in robotic-assisted procedures is from conversion of laparoscopic procedures and not from open surgeons' conversion: a study of trends and costs." Surg Endosc **32**(4): 2106-2113.
2. Coca-Soliz, VS, R. C. Gooding, J. Hubbard and P. R. Corvo (2017). "Comparison of laparoscope versus da vinci robot on surgical site infections based on operation time and operator volume." Surgical Endoscopy and Other Interventional Techniques **31**: S314.
3. Hirides, S. (2017). "Cholecystectomy using conventional lap, minilap needlescopic or robotic single-site approaches. A technical comparison." Surgical Endoscopy and Other Interventional Techniques **31**(2): S235.

Other (n=2)

1. Aziz, H., M. Zeeshan, R. R. Selby and M. R. Sheikh (2019). "Looking beyond laparoscopic cholecystectomy – Will robotic cholecystectomy be the new the gold standard in patients with advanced liver disease?" HPB **21**: S31.
2. Lee, M. M., K. K. Seeras and J. J. Lim (2019). "Cost comparison of single site robotic and conventional laparoscopic cholecystectomy at a single institution." Surgical Endoscopy **33**: S395.

Review/Editorial (n=8)

1. Awad, M. M. and J. W. Fleshman (2010). "Robot-assisted surgery and health care costs [10]." New England Journal of Medicine **363**(22): 2174-2175.
2. Barbash, G. I. and S. A. Glied (2010). "New technology and health care costs - The case of robot-assisted surgery." New England Journal of Medicine **363**(8): 701-704.
3. Biglarian, S. and N. Katkhouda (2017). "Requesting Patient Characteristics for Readmissions Noted in "Single-site Robotic Cholecystectomy in a Broadly Inclusive Patient Population: A Prospective Study"." Ann Surg **265**(4): e34-e35.
4. Brody, F. and N. G. Richards (2014). "Review of robotic versus conventional laparoscopic surgery." Surgical Endoscopy **28**(5): 1413-1424.
5. Castellanos, A., J. Fazendin and L. Panait (2015). "Single-incision laparoscopic cholecystectomy." Clinical Liver Disease **5**(1): 5-7.
6. Giulianotti, P. C. (2017). "Why I think the robot will be the future for laparoscopic cholecystectomies." Surgery **161**(3): 637-638.
7. Lee, E. K., E. Park, W. O. Oh and N. M. Shin (2017). "CORRIGENDUM: Correction of the affiliation name. Comparison of the outcomes of robotic cholecystectomy and laparoscopic cholecystectomy." Ann Surg Treat Res **93**(4): 229.
8. Newman, R. M., A. Umer and S. Ellner (2016). "Traditional Four-Port vs Single-Incision and Robotically Assisted Cholecystectomy: In reply to Bloomstone and colleagues." J Am Coll Surg **223**(1): 208.

Duplicate (n=11)

1. Armijo, P. R., S. Pagkratis, E. Boilesen, T. N. Tanner and D. Oleynikov (2017). "Growth in robotic-assisted procedures is from conversion of laparoscopic procedures and not from open surgeons conversion: a study of trends and costs." Surgical endoscopy and other interventional techniques. Conference: 2017 scientific session of the society of american gastrointestinal and endoscopic surgeons, SAGES 2017. United States **31**: S31.
2. Balachandran, B., T. Mustafa, T. A. Hufford, K. Kochar, L. M. Prasad, S. Sulo and J. Khorsand (2016). "A comparative study of outcomes between single-site robotic and multi-port laparoscopic cholecystectomy: An experience from a tertiary care center." Surgical Endoscopy and Other Interventional Techniques **30**: S258.
3. Charles EJ, Hunter Mehaffey J, Kane WJ, Hawkins RB, Tache-Leon CA, Yang Z. Robotic compared to laparoscopic cholecystectomy: A propensity matched analysis. *Surgical Endoscopy and Other Interventional Techniques.* 2018;32(1):S34.
4. Gonzalez AM, Verdeja JC, Rabaza JR, et al. Single incision cholecystectomy: Comparative study between laparoscopic, robotic and spider platforms. *Surgical*

Endoscopy and Other Interventional Techniques. 2013;27:S274.

5. Grochola, L. F., C. Soll and S. Breitenstein (2018). "Robot-assisted single-site compared with laparoscopic single-incision cholecystectomy for benign gallbladder disease: results of a single-blinded randomized controlled trial." European surgical research. Europaische chirurgische forschung. Recherches chirurgicales europeennes **59**: 4-.
6. Grochola, L. F., C. Soll, A. Zehnder, R. Wyss, P. Herzog and S. Breitenstein (2018). "Robot-assisted versus laparoscopic single-incision cholecystectomy: results of a randomized controlled trial." Surgical endoscopy.
7. Grochola, L. F., C. Soll, A. Zehnder, R. Wyss, P. Herzog and S. Breitenstein (2018). "Robot-assisted single-site compared with laparoscopic single-incision cholecystectomy for benign gallbladder disease: results of a single-blinded randomized controlled trial." HPB **20**: S726.
8. Grochola, L. F., C. Soll, A. Zehnder, R. Wyss, P. Herzog and S. Breitenstein (2018). "Robot-Assisted Single-Site compared with laparoscopic single-incision cholecystectomy for benign gallbladder disease: Results of a single-blinded randomized controlled trial." Swiss Medical Weekly **148**: 4S.
9. Higgins, R. M., M. J. Frelich, M. E. Bosler and J. C. Gould (2016). "Cost analysis of robotic versus laparoscopic general surgery procedures." Surgical Endoscopy and Other Interventional Techniques **30**: S243.
10. Kaminski, J. P., K. W. Bueltmann and M. Rudnicki (2014). "Robotic versus laparoscopic cholecystectomy: Does the end justify the means?" Surgical Endoscopy and Other Interventional Techniques **28**: 262.
11. Newman, R. M., B. J. Bozzuto, J. L. Dilungo and S. J. Ellner (2014). "The surgical value of nontraditional, minimally invasive gallbladder removal: Traditional 4 port vs single incision and robotically-assisted cholecystectomy." Journal of the American College of Surgeons **219**(4): e34.

Inguinal Hernia Repair

Comparison (n=2)

1. Edelman, D. (2018). "Is robotic inguinal hernia repair safe?" Hernia **22**(1): S103.
2. Edelman, D. S. (2017). "Robotic inguinal hernia repair." Surgical Endoscopy and Other Interventional Techniques **31**: S330.

No Clinical Data (n=3)

1. Delgado, M., J. C. Quispe, K. Medani, C. Wang and E. Yung (2019). "A 5 year retrospective study comparing results of laparoscopic versus robotic inguinal hernia repair." Journal of Investigative Medicine **67**(1): 221.
2. McCoy, K., W. Symons, J. Clarke, M. Novack and M. Broderick (2018). "Open versus robotic inguinal hernia repair: Is there a superior approach?" Surgical Endoscopy and Other Interventional Techniques **32**(1): S346.
3. Verduzco-Gomez, E., A. Badami and F. Sabido (2018). "Robotic inguinal hernia repair eliminates the need for post-operative narcotics and demonstrates lower post-operative pain scores." Hernia **22**(1): S183.

No Outcome of Interest (n=6)

1. Armijo, P. R., S. Pagkratis, E. Boilesen, T. N. Tanner and D. Oleynikov (2017). "Growth in robotic-assisted procedures is from conversion of laparoscopic procedures and not from open surgeons conversion: a study of trends and costs." Surgical endoscopy and other interventional techniques. Conference: 2017 scientific session of the society of american gastrointestinal and endoscopic surgeons, SAGES 2017. United States **31**: S31.
2. Aslam U, Amadi C, Goparaju A, Brathwaite CE, Adrales GL. Trends in Use of Robotic-Assisted Surgery for Inpatient Elective General Surgery in the United States, 2010–2015. *Journal of the American College of Surgeons.* 2019;229(4):S116.
3. Aslam U, Howell RS, Brathwaite CEM, Adrales G. Analysis of Outcomes for Elective Inpatient Robotic-Assisted, Laparoscopic, and Open General Surgery in the United States, 2010–2015. *Journal of the American College of Surgeons.* 2019;229(4):S88.
4. Muysoms, F., C. Ballecer and A. Ramaswamy (2018). "Evaluation of the operative time for robotic assisted laparoscopic groin hernia repair during the learning curve of 125 cases." Surgical Endoscopy and Other Interventional Techniques **32**(1): S144.
5. Sheetz KH, Claflin J, Dimick JB. Trends in the Adoption of Robotic Surgery for Common Surgical Procedures. *JAMA Network Open.* 2020;3(1).
6. Zayadin Y, D'John J, Yaldo B, McKany M. Urinary Retention Post Open vs Laparoscopic vs Robotic Inguinal Hernia Repair: A Comparative Retrospective Review. *Journal of the American College of Surgeons.* 2019;229(4):e129.

Procedure (n=1)

1. Tran, H. (2011). "Robotic single-port hernia surgery." Jsls **15**(3): 309-314.

Systematic Review (n=1)

1. Jacks BE, Agor UJ, Sanni AO. Clinical Outcomes after Robotic Assisted Transabdominal Preperitoneal (R-TAPP) vs Laparoscopic Totally Extraperitoneal (L-TEP) Inguinal Hernia Repair. *Journal of the American College of Surgeons.* 2019;229(4):e109.

Review/Editorial (n=2)

1. Bernhardt, G. A., K. Gruber and G. Gruber (2010). "TAPP repair in a giant bilateral scrotal hernia - limits of a method." ANZ J Surg **80**(12): 947-948.
2. Godshall, E., S. Eckhouse, C. Johnson, A. Patterson and R. Pullatt (2015). "Transabdominal Preperitoneal Inguinal Hernia Repair as a Salvage Operation after Failure of Prior Total Extraperitoneal Repair." Am Surg **81**(8): 312-313.

Duplicate (n=3)

1. Hennings, D. L., P. R. Armijo and D. Oleynikov (2018). "Robotic inguinal hernia repair is superior to open or laparoscopic inguinal hernia repair: A national data base review." Surgical Endoscopy and Other Interventional Techniques **32**(1): S344.
2. Muysoms, F., C. Ballacer, A. Ramaswamy, S. Van Cleven and I. Kyle-Leinhase (2017). "Evaluation of the operative time for robotic assisted laparoscopic groin hernia repair

during the learning curve." Hernia **21**(2): S159.
3. Zayan NE, Meara MP, Schwartz JS, Narula VK. A direct comparison of robotic and laparoscopic hernia repair: patient-reported outcomes and cost analysis. *Hernia.* 2019;23(6):1115-1121.

Unavailable (n=1)

1. Edelman, D. S. (2017). "Robotic Inguinal Hernia Repair." Am Surg **83**(12): 1418-1421.

Ventral Hernia Repair

Comparison (n=6)

1. Halka, J., A. Vasyluk, A. DeMare, A. Iacco and R. Janczyk (2018). "Hybrid robotic assisted transversus abdominis release is associated with a significantly decreased length of stay without increased complications compared to open transversus abdominis release in patients with large ventral hernias." Hernia **22**(1): S27.
2. Halka, J. T., A. Vasyluk, A. Demare, A. Iacco and R. Janczyk (2019). "Hybrid robotic-assisted transversus abdominis release versus open transversus abdominis release: a comparison of short-term outcomes." Hernia **23**(1): 37-42.
3. Muse, T. O., B. A. Zwischenberger, M. T. Miller, D. A. Borman, D. L. Davenport and J. S. Roth (2018). "Outcomes after Ventral Hernia Repair Using the Rives-Stoppa, Endoscopic, and Open Component Separation Techniques." Am Surg **84**(3): 433-437.
4. Oviedo, R. J., J. C. Robertson and A. S. Desai (2017). "Robotic Ventral Hernia Repair and Endoscopic Component Separation: Outcomes." Jsls **21**(3).
5. Sailes, F. C., J. Walls, D. Guelig, M. Mirzabeigi, W. D. Long, A. Crawford, J. H. Moore, Jr., S. E. Copit, G. A. Tuma and J. Fox (2011). "Ventral hernia repairs: 10-year single-institution review at Thomas Jefferson University Hospital." J Am Coll Surg **212**(1): 119-123.
6. Ioannidis A, Machairas N, Koutserimpas C, Spartalis E, Konstantinidis M, Konstantinidis K. Evolution of robot-assisted general surgery in Greece and Cyprus. *Journal of Robotic Surgery.* 2019;13(2):315-317.

No Outcome of Interest (n=7)

1. Addo AJ, Zahiri HR, Broda A, et al. Early Perioperative Outcomes in Obese Patients Undergoing Minimally Invasive Abdominal Wall Reconstruction. *Journal of the American College of Surgeons.* 2019;229(4):e112.
2. Armijo PR, Pagkratis S, Boilesen E, Tanner T, Oleynikov D. Growth in robotic-assisted procedures is from conversion of laparoscopic procedures and not from open surgeons' conversion: a study of trends and costs. *Surgical Endoscopy.* 2018;32(4):2106-2113.
3. Aslam U, Amadi C, Goparaju A, Brathwaite CE, Adrales GL. Trends in Use of Robotic-Assisted Surgery for Inpatient Elective General Surgery in the United States, 2010–2015. *Journal of the American College of Surgeons.* 2019;229(4):S116.
4. Aslam U, Howell RS, Brathwaite CEM, Adrales G. Analysis of Outcomes for Elective Inpatient Robotic-Assisted, Laparoscopic, and Open General Surgery in the United

States, 2010–2015. *Journal of the American College of Surgeons.* 2019;229(4):S88.
5. Forester B, Donovan K, Kuchta K, et al. Short-Term Quality of Life Comparison of Laparoscopic, Open, and Robotic Incisional Hernia Repairs. *Journal of the American College of Surgeons.* 2019;229(4):e127.
6. Sheetz KH, Claflin J, Dimick JB. Trends in the Adoption of Robotic Surgery for Common Surgical Procedures. *JAMA Network Open.* 2020;3(1).
7. Zayan NE, Meara MP, Schwartz JS, Narula VK. A direct comparison of robotic and laparoscopic hernia repair: patient-reported outcomes and cost analysis. *Hernia.* 2019;23(6):1115-1121.

Sample Size (n<10) (n=2)

1. Belyansky, I., A. S. Weltz, U. S. Sibia, J. J. Turcotte, H. Taylor, H. R. Zahiri, T. R. Turner and A. Park (2018). "The trend toward minimally invasive complex abdominal wall reconstruction: is it worth it?" Surgical Endoscopy **32**(4): 1701-1707.
2. Mejia, A., C. G. Fasola and A. Stegall (2019). "Incisional ventral hernia repair (IVHR) in post liver transplant recipients (OLT) through a robotic-assisted intervention (RAI): Initial single-center experience." American Journal of Transplantation **19**: 863-864.

Case series n<10 (n=2)

1. Daes, J. (2014). "Endoscopic subcutaneous approach to component separation." J Am Coll Surg **218**(1): e1-4.
2. Gillespie, J. W., 3rd, D. D. Zabel, M. K. Conway, E. D. Kalish and D. E. Sarmiento Garzon (2015). "Abdominal Wall Reconstruction for Large Ventral Hernias in the Octogenarian." Am Surg **81**(11): E373-375.

Systematic Review (n=1)

1. Souza, J. M. and G. A. Dumanian (2012). "An evidence-based approach to abdominal wall reconstruction." Plast Reconstr Surg **130**(1): 116-124.

Review (n=1)

1. (2012). "Hernia repair: which surgical approach is best?" Johns Hopkins Med Lett Health After 50 **24**(8): 4-5.

Duplicate (n=6)

1. Addo A, Parlacoski S, Ewart Z, Broda A, Zahiri R, Belyansky I. Comparative review of outcomes: Laparoscopic and robotic enhanced-view totally extraperitoneal rives-stoppa abdominal wall reconstruction. *Surgical Endoscopy.* 2019;33:S15.Alrefai, S., M. Mabe, M. Vy, P. Del Prado, N. L. Clingempeel and J. G. Bittner (2017). "Comparative analysis of robot-assisted minimally invasive vs open transvs abdomens release outcomes in abdominal wall reconstruction." Journal of the American College of Surgeons **225**(4): e83-e84.
2. Alrefai S, Mabe M, Vy M, Del Prado P, Clingempeel NL, Bittner JG. Comparative

analysis of robot-assisted minimally invasive vs open transvs abdomens release outcomes in abdominal wall reconstruction. *Journal of the American College of Surgeons.* 2017;225(4):e83-e84.

3. Costa, T. N., R. Z. Abdalla, I. Cecconello and U. Ribeiro (2017). "Randomized clinical trial: Comparison between robotic assisted and laparoscopic incisional hernia repair." Hernia **21**(2): S158.
4. Khorgami, Z., T. Jackson, W. T. Li, C. A. Howard and G. M. Sclabas (2017). "Extra costs of robotic surgery in minor and major surgeries: An analysis of national inpatient sample." Journal of the American College of Surgeons **225**(4): e86.
5. Walker, P., A. May, M. R. Santillan, S. Kim, S. Shah, E. Wilson, M. Liang and S. Tsuda (2017). "Multicenter review of robotic versus laparoscopic ventral hernia repair: is there a role for robotics?" Surgical endoscopy and other interventional techniques. Conference: 2017 scientific session of the society of american gastrointestinal and endoscopic surgeons, SAGES 2017. United states **31**: S29.
6. Weltz, A. S., J. Turcotte, U. S. Sibia, E. Zakharov, N. Wu, T. R. Turner, A. Park, H. R. Zahiri and I. Belyansky (2017). "The trend toward minimally invasive complex abdominal wall reconstruction: Is it worth it?" Surgical Endoscopy and Other Interventional Techniques **31**: S22.

Unavailable (n=1)

1. Espinosa-de-los-Monteros, A. (2012). "[Abdominal wall reconstruction for complex incisional hernias]." Rev Invest Clin **64**(6 Pt 2): 634-640.