APPENDIX A. SEARCH STRATEGIES

DATABASE SEARCHED & TIME PERIOD COVERED:
PUBMED – 2013-2020
362 results

(Randomized) OR ("control")) OR (randomly)) OR (trial)) OR (comparative)) OR (prospective))

AND

(Esophageal neoplasms[MESH terms]) OR ("Esophageal neoplasm")) OR ("Esophageal cancer")) OR ("Esophagus neoplasm")) OR ("Oesophageal neoplasm")) OR ("Oesophageal cancer")) OR ("Esophageal squamous cell carcinoma")) OR (Esophageal squamous cell carcinoma[MESH terms])) OR (Esophageal adenocarcinoma)) OR ("Esophagus cancer")))

AND

("minimally invasive") OR (Minimally invasive)) OR (Laparoscopic)) OR (Thoracoscopic)) OR (Thoracolaparoscop*)) OR (Laparothoracoscop*)) OR (Video-assisted)) OR (video assisted)) OR (Video-assisted thoracic surgery)) OR (VATS)) OR (Open)) OR (Thoracotomy)) OR (Laparotomy)) OR (Transhiatal)) OR (McKeown)) OR ("Three-hole")) OR (3-hole)) OR (Ivor-Lewis)) OR (Esophagectomy)) OR (Oesophagectomy)) OR (Esophagectomies)) OR (Oesophagectomies)) OR (Esophageal resection)) OR (Oesophageal resection)) OR (Trans-hiatal)))

AND

"thoracic surgical procedures"[MESH Terms]) OR (Robotic Surgical Procedures [MeSH terms])) OR (Robotics)) OR (Robot-assisted)) OR (Robot))

Filters: from 2013 – 2020

DATABASE SEARCHED & TIME PERIOD COVERED:
OVID MEDLINE & Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily – 2013-2020
1 result

(randomized or "control" or randomly or trial or comparative or prospective).af.

AND

exp Esophageal Neoplasms/ OR exp esophageal Squamous Cell Carcinoma/ OR ("esophageal neoplasm" or "esophageal cancer" or "esophagus neoplasm" or "oesophageal neoplasm" or "oesophageal cancer" or "esophageal squamous cell carcinoma" or "esophageal adenocarcinoma" or "esophagus cancer").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]

AND

("minimally invasive" or "minimally invasive" or laparoscopic or thoracoscopic or thoracolaparoscop* or laparothoracoscop* or "video-assisted" or "video assisted" or "video-assisted thoracic surgery" or "VATS" or open or thoracotomy or laparotomy or transhiatal or McKeown or "three-hole" or "3-hole" or "Ivor-Lewis" or esphagectomy or oesophagectomy or esophagectomies or oesophagectomies or "esophageal resection" or "oesophageal resection" or "trans-hiatal").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]

AND

exp Thoracic Surgical Procedures/ OR exp/Robotic Surgical Procedures/ OR (robotics or "robot-assisted" or robot).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]

AND

Publication years 2013-2020

DATABASE SEARCHED & TIME PERIOD COVERED:
EMBASE – 2013-2020
15 results

randomized:ti,ab,kw OR control:ti,ab,kw OR randomly:ti,ab,kw OR trial:ti,ab,kw OR comparative:ti,ab,kw OR prospective:ti,ab,kw

AND

'esophageal neoplasms'/exp OR 'esophageal neoplasm':ti,ab,kw OR 'esophageal cancer':ti,ab,kw OR 'esophagus neoplasm':ti,ab,kw OR 'oesophageal neoplasm':ti,ab,kw OR 'oesophageal cancer':ti,ab,kw OR 'esophageal squamous cell carcinoma':ti,ab,kw OR 'esophageal squamous cell carcinoma'/exp OR 'esophageal adenocarcinoma':ti,ab,kw OR 'esophagus cancer':ti,ab,kw

AND

'minimally invasive':ti,ab,kw OR 'minimally invasive':ti,ab,kw OR laparoscopic:ti,ab,kw OR thoracoscopic:ti,ab,kw OR thoracolaparoscop*:ti,ab,kw OR laparothoracoscop*:ti,ab,kw OR 'video-assisted':ti,ab,kw OR 'video assisted':ti,ab,kw OR 'video-assisted thoracic surgery':ti,ab,kw OR vats:ti,ab,kw OR open:ti,ab,kw OR thoracotomy:ti,ab,kw OR laparotomy:ti,ab,kw OR transhiatal:ti,ab,kw OR mckeown:ti,ab,kw OR 'three hole':ti,ab,kw OR '3-hole':ti,ab,kw OR 'ivor-lewis':ti,ab,kw OR esophagectomy:ti,ab,kw OR oesophagectomy:ti,ab,kw OR esophagectomies:ti,ab,kw OR oesophagectomies:ti,ab,kw OR 'esophageal resection':ti,ab,kw OR 'oesophageal resection':ti,ab,kw OR 'trans-hiatal':ti,ab,kw

AND

'thoracic surgicial procedures' OR 'robotic surgerical procedures' OR robotics:ti,ab,kw OR 'robot-assisted':ti,ab,kw OR robot:ti,ab,kw

AND

Publication years 2013-2020

DATABASE SEARCHED & TIME PERIOD COVERED:
COCHRANE Reviews – 2013- 2020
12 results

ID Search Hits
#1 MeSH descriptor: [Esophageal Neoplasms] explode all trees
#2 MeSH descriptor: [Esophageal Squamous Cell Carcinoma] explode all trees
#3 (Randomized OR control OR randomly OR trial OR comparative OR prospective):ti,ab,kw
#4 ("Esophageal neoplasm" OR "Esophageal cancer" OR "Esophagus neoplasm" OR "Oesophageal neoplasm" OR "Oesophageal cancer" OR "Esophageal squamous cell carcinoma" OR "Esophageal adenocarcinoma" OR "Esophagus cancer"):ti,ab,kw
#5 #1 OR #2 OR #4
#6 ("minimally invasive" OR "Minimally invasive" OR Laparoscopic OR Thoracoscopic OR Thoracolaparoscop* OR Laparothoracoscop* OR "Video-assisted" OR "video assisted" OR "Video-assisted thoracic surgery" OR VATS OR Open OR Thoracotomy OR Laparotomy OR Transhiatal OR McKeown OR "Three-hole" OR "3-hole" OR "Ivor-Lewis" OR Esophagectomy OR Oesophagectomy OR Esophagectomies OR Oesophagectomies OR "Esophageal resection" OR "Oesophageal resection" OR "Trans-hiatal"):ti,ab,kw
#7 MeSH descriptor: [Thoracic Surgical Procedures] explode all trees
#8 MeSH descriptor: [Robotic Surgical Procedures] explode all trees
#9 (robotics OR "robot-assisted" OR robot):ti,ab,kw (Word variations have been searched)
#10 #7 OR #8 OR #9
#11 #3 AND #5 AND #6 AND #10

AND

Publication years Jan 2013- Dec2020

APPRENDIX B. PEER REVIEWER COMMENTS AND AUTHOR RESPONSES

Reviewer comments	Authors Responses
Yes - Yang L, Wang T, Weidner TK, Madura JA 2nd, Morrow MM, Hallbeck MS. Intraoperative musculoskeletal discomfort and risk for surgeons during open and laparoscopic surgery. Surg Endosc. 2020 Oct 20. doi: 10.1007/s00464-020-08085-3. Epub ahead of print. PMID: 33083930.	Thank you for this reference. We have included it in our discussion. This study highlights the physical burdens of open surgery and the potential benefit of laparoscopic and robotic surgery.
Outcomes of esophagectomy are known to correlate with certain preoperative variables including tumor location, stage, neoadjuvant therapy and with intraoperative technique such as MIS and/or robot used for thoracic, abdominal, both, and anastomotic location/technique. Appendix G provides insightful summaries of matching strategies used in included studies. Would clearer reference to matching of critical factors and citation of Appendix G in the Discussion (or Methods) section be advisable?	Thank you for your suggestion. We included a reference to Appendix G in the discussion. We agree that these are important variables to consider. Many of the studies corrected for these factors with propensity matching. Also, the majority of studies included in this review utilized the same approach (McKeown or Ivor-Lewis) in the study arms but utilized a different technique (robot vs open or MIE). Of note, we used inclusion criteria to identify studies where the robotic approach was the within study comparison.
This paper appears to be well written and researched. It has included the review of major literature in the adaption of the robotic platform to the esophagectomy. Especially for use in the VA, many centers already have the Da Vinci Robot, so it makes sense to try to utilize it for Esophagectomy without a huge cost burden. However, there are some issues that may arise especially with esophageal cancer volume and robotics in various centers. I Regarding study selection, only studies with greater than 10 patients per arm were included when it comes to observational studies. Why not include studies with less than 10?	Case series with less than 10 subjects in each study arm were deemed too high risk for potential biases because of the differences in patient level factors and tumor factors. Differences (or the lack of) between study groups in these smaller studies would be more potentially underpowered and may lead to incorrect conclusions. Also, only one study (including at the abstract and full text review) was identified with a study arm with less than 10 patients (N=4) in the abstract and full text screening phases.
Next, I had a question regarding anastomotic leak when comparing RAMIE with VAMIE or open. It states here at there were three studies with anastomotic leak difference between Open and RAMIE. Did this make a difference in outcomes? Were the leaks managed differently? And were the leaks with RAMIE less morbid and managed differently than the Open patients? Also, did this change adjuvant systemic therapy at all?	The draft had a typo regarding this. No studies comparing OE with RAMIE found a difference in anastomotic leak rate. This has been corrected. These are great questions, but unfortunately the published studies do not go into that level of detail. This was added to our limitations paragraph.
Page 8/line 11: why is the US specifically referenced for LOS in RAMIE vs VAMIE? is there an LOS difference outside of the US?	There are international variations in length of stay with many non-US studies allowing very prolonged hospital stays based on a variety of factors (cultural, health care system, *etc*). As such, the association of the procedure approach (robot) would differ based on the origin of the study. Thus, for this one outcome we elected to restrict the analysis to USA-only

	studies, as we judged these would be more relevant to the VA population and system.
9/15: "there are no differences LOS...", consider inserting the word WITH before LOS.	Thank you noticing this error. It has been corrected.
13/21: abbreviation for open esophagectomy needed (OE)	The requested edit was made.
13/25: i feel this paragraph implies that minimally invasive approaches may be less technically demanding than OE, which is untrue. minimally invasive approaches are much more technically demanding but have fewer postoperative complications. Possibly removing the wording that "OE is a technically difficult operation", or just that esophagectomy is a technically difficult operation whether done open or by minimally invasive approaches.	We agree. Thank you for making this important point. Esophagectomy is a technically challenging operation and minimally invasive techniques require additional expertise to be proficient. We have corrected this to convey that esophagectomy, regardless of approach or technique, is technically difficult.
23/18: when it is described that the studies reported a difference in leak rate, it is not obvious which had lower leak rates (RAMIE or OE). Because in the summary it is stated that there is no difference, possibly it is meant to state "...observational studies reported NO difference in leak rate."?	Thank you noticing this discrepancy. We have corrected it in the manuscript.
36/5: "...which was not an include in our review...", possibly change to "which was not INCLUDED in our review".	Thank you for careful review. We have made the requested change.
36/33: I find it odd that there is a reference that shows increased physical discomfort and symptoms or poor posture with laparoscopy when compared with open surgery, my understanding is the opposite. Possibly more references need to be included or the statement can be deemed as an ongoing controversy with unclear understanding. One such is below. Yang L, Wang T, Weidner TK, Madura JA 2nd, Morrow MM, Hallbeck MS. Intraoperative musculoskeletal discomfort and risk for surgeons during open and laparoscopic surgery. Surg Endosc. 2020 Oct 20. doi: 10.1007/s00464-020-08085-3. Epub ahead of print. PMID: 33083930.	Thank you for your comments and your understanding of the existing controversy. We agree with you that typically laparoscopy should help to prevent musculoskeletal problems for surgeons. However, several questionnaire studies (which we referenced in our report) consistently found higher rates of physical discomfort with minimally invasive surgery compared to open. In contrast, the study you shared has objective data regarding surgeon posture and is an important aspect for this ongoing debate. We appreciate your insight in this matter and certainly it is unclear what role laparoscopy plays in minimizing surgeon discomfort.
This is an incredibly detailed and thoughtful review of the many potential clinical and economic benefits and risks of robotic esophagectomy compared to non-robotic approaches. There is clearly limited data from which the authors had to draw conclusions with only 2 RCTs and a total of 20 publications out of 390 potential papers that met inclusion criteria. Unfortunately, there is also tremendous diversity in terms of cancer epidemiology and with regards to surgical approach and technique. This heterogeneity is dizzying and makes it near impossible to draw conclusions from any comparisons across studies. This is well stated by the authors who comment that it is “difficult to disentangle” the impact of the robot from the various other techniques. That said, the authors	Thank you for those encouraging comments. We agree that the heterogeneity among the studies and paucity of RCTs were limitations and are hopeful that more data will soon emerge so that we can make definitive conclusions with a high level of certainty

<table>
<tr><td>should be commended for the rigorousness of their methodology. Frustratingly, their ability to draw meaningful conclusions is quite limited by the quality of publications, inconsistency, imprecision, bias, and heterogeneity. The section on research gaps and future research is the highlight of the paper.</td><td></td></tr>
<tr><td>While reading the text, I found myself asking, “Was the robot being used for the abdominal portion instead of laparoscopy or laparotomy? Was the robot used for the thoracic portion instead of thoracotomy or VATS? Was the anastomosis being done in the neck or in the chest? How was the anastomosis performed, hand sewn or stapled? Did the surgical approach include a pyloric relaxing procedure? Was a feeding tube placed at the time of esophagectomy?” Many of these technical differences have implications for OR time, pulmonary complications, etc. These variables may have an impact on measured outcomes that are independent of whether the robot was used. The answers to these questions can be found in Appendix G. I hesitate to make this suggestion given the herculean efforts involved in putting together this table, but it might be worth considering adding a few additional columns to simplify for the readers. Eg:

<table>
<tr><td></td><td></td><td>Abdomen</td><td>Chest</td><td>Neck</td><td>Anastomosis</td><td></td></tr>
<tr><td>Study A</td><td>VAMIE</td><td>Laparoscopy</td><td>VATS</td><td>NA</td><td>EEA</td><td></td></tr>
<tr><td></td><td>RAMIE</td><td>Laparoscopy</td><td>robotic</td><td>NA</td><td>EEA</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td><td>Thank you for this suggestion. We created an additional table to highlight the technical differences/surgical approaches between arms for each study. Specifically, we indicate the following when provided: the approach (McKeown, Ivor-Lewis, transhiatal), tool or technique used for the 2- or 3-stage operations (ie, robotic, thoracolaparoscopic, or open techniques for the abdomen and chest), and the anastomotic technique. Again, the main difference we were assessing was the within study comparison of the robotic portion of the operation.</td></tr>
<tr><td>I confess that I am often frustrated by the amount of effort that goes into general comparisons between robotic surgery and open surgery or robotic surgery and VATS/laparoscopy. The robot is a tool that is likely here to stay. With favorable ergonomics, excellent visualization, and an ever expanding pallet of graspers and energy at the surgeons disposal, adoption seems inevitable. New robotic platforms are coming to the market in the near future which are anticipated to decrease costs with new competition in the marketplace. I have argued with colleagues that a researchers time could be better spent contemplating more profound, substantive questions about the extent of resection, for example, or the intricacies of multimodal therapy, patient selection, etc. That said, I do find the authors reference to and the results of the Laparoscopic Approach to Cervical Cancer (LACC) trial intriguing. In the context of esophageal cancer, I would be surprised if we could ever detect a clear oncologic signal amidst the cacophonous noise of surgical esophagectomy research but this review, if nothing else, has prompted me to reconsider my indifference. I encourage the</td><td>Thank you for your comments. We feel that an updated systematic review will be warranted when robot-assisted esophagectomy becomes widely adopted, more long term outcomes are published, and additional robotic platforms on the market.</td></tr>
</table>

authors to continue with their future endeavors and would be glad to continue to participate in trial design and enrollment.	
I think that this is a very well designed and executed study of techniques for esophagectomy. The conclusions are limited due to the limitations in RCTs or other large patient population studies. The results are not surprising. Utilizing minimally invasive techniques in esophageal resection improves patent outcomes. Even when the surgical procedure is a hybrid of minimally invasive and open techniques patients do better as described in NEJM. The technique, MIS/open, versus the tool, RAMIE/VAMIE determines patient benefit. The tool (robot, LAPVATS) should be chosen based on Surgeon comfort and availability. Future studies will be impacted greatly by STS database including 5 year survival for cancer surgeries. This database is more clear in the definitions of open and MIS. Hybrid techniques will be identifiable. Hopefully this can help answer questions related to long term survival implications of open vs MIS abdominal approaches, open vs MIS chest approaches and cervical/chest anastomoses.	Thank you for your comments. Indeed the STS database may have additional granularity and better long-term data such that we can hopefully understand if the platform affects these outcomes. We added some of your points to our discussion.
Yes, the findings are presented in a way that is helpful for decision-making.	Thank you for the comment.
No recommendations; presentation format supports utilization decisions.	We appreciate your comments.
The report will be utilized in conjunction with the other ESP robotic-assisted surgery reports. The findings will inform policy and decisions by facilities/VISNs to purchase robotic technology.	Thank you for the comment.
Esophagectomy-specific outcome tracking	Thank you for the comment.
Recommend VA webinar/cyberseminar and presentation to the surgical community of practice to be coordinated by the National Surgery Office.	We are happy to participate.
I support plans for a national VHA webinar and will also assess for VISN Surgery Integrated Clinical Community presentation by ESP Center.	We are happy to participate.
Thoracic Surgeons, Oncologists, and GI providers	Anesthesiologists and surgical oncologists may be interested as well.
Very, excellent report.	Thank you for your comment.
Very satisfied. Report clearly assessed available literature and identified limitations/gaps and potential areas for future research. Conclusions were appropriate based upon available information and completed narrative analysis.	We appreciate your comments.

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,	Bias due to problems not covered elsewhere in the table.

	responses should be provided for each question/entry.	

* 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[12]

Pre-intervention	Risk of bias assessment is mainly distinct from assessments of randomised trials
Bias due to confounding	Baseline confounding occurs when one 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

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
He, 2020[15]	○	◒	◒	◒	Short-term: ○ Long-term: ○	○	○
van der Sluis, 2019[14]	○	○	○ *Patients blinded to intervention	● Trial coordinators recorded daily outcomes	Short-term: ○ Long-term: ○	○	○

○ = low risk of bias ● = risk of bias ◒ = unknown
* low risk of bias for primary outcomes (all-cause mortality and amputation-free survival, but high risk of bias for secondary outcome

APPENDIX F. QUALITY ASSESSMENT FOR INCLUDED OBSERVATIONAL STUDIES

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
Chao 2018[16]	**Low**	**Moderate** RAMIE offered to all patients after 2014, but it was only partially insured while MIE was fully covered	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
Chen 2019[17]	**Low**	**Moderate** Unknown how intervention offered; propensity matched for pre-op factors	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
Deng 2019[18]	**Low**	**Low** Offered RAMIE & VAMIE, patients chose on their own will	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
Espinoza-Mercado 2019[19] NCDB	**Low**	**Moderate** Unknown how intervention offered; propensity matched for pre-op factors	**Moderate** Unable to differentiate the surgical approach – transhiatal, IL, McKeown	**Low**	**Low**	**Low**	**Low**	**n/a**
Gong 2020[34]	**Serious** Clinical stage and neoadjuvant treatment were different between treatment arms	**Serious** Unknown who was offered which technique	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
He 2018[20]	**Low**	**Moderate** Unknown how intervention offered; propensity matched for pre-op factors	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
Jeong 2016[47]	**Low**	**Moderate**	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**

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
		RAMIE recommended for specific indications (*eg*, low clinical stage); however, the propensity matched for most of these factors				Standardized tools were used to assess pain and delirium		
Meredith 2019[27]	**Serious** No p-values provided	**Serious** Unknown how intervention offered	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
Motoyama 2019[30]	**Low**	**Serious** Unknown how intervention offered; between 2014 and 2018. RAMIE was not covered by insurance; so only those who could pay underwent robot during that time period	**Low**	**Low**	**Low**	**Low**	**Moderate** Do not report several outcomes	**n/a**
Naffouje 2019[22] NSQIP	**Low**	**Moderate** Unknown how intervention offered; propensity matched for pre-op factors	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
Osaka 2018[32]	**Moderate** List very few patient characteristics	**Serious** Unknown who was offered RAMIE. Do not explicitly state what the "criteria for robot" are that they used to match open surgery	**Low**	**Low**	**Low**	**Low**	**Moderate** Do not report several outcomes that are given in similar studies	**n/a**
Park 2016[48]	**Low**	**Serious** Unknown who RAMIE was offered to	**Low**	**Low**	**Short-term outcomes: Low** **Long-term outcomes: Serious** (>50%	**Low**	**Serious** Several outcomes of high importance	**n/a**

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
					lost to follow up at 5-year outcomes)		not included (*ie*, LOS).	
Rolff 2017[33]	**Serious** Very few patient characteristics, no clinical oncologic data, *etc*	**Moderate** Intervention depended on date of operation and robot availability. However, large tumors and BMI >35 were initially precluded from robot. This changed early in the study and the restriction on BMI was relaxed	**Low**	**Low**	**Low**	**Low**	**Moderate** Few outcomes given	**n/a**
Sarkaria 2019[28]	**Low**	**Moderate** Receipt of RAMIE depended on which surgeon the patient was referred to	**Low**	**Low**	**Low**	**Moderate** Subjective data collected by research staff. Used validated tools/ questionnaires	**Low**	**n/a**
Tagkalos 2019[23]	**Low**	**Moderate** Unknown how intervention offered; propensity matched for pre-op factors	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**
Washington 2019[29]	**Serious** Very few patient characteristics listed	**Moderate** Receipt of RAMIE was dependent on robot availability and other factors. Transition was made to all robot, so it hints that most patients toward the end of the study were all offered RAMIE. No propensity matching.	**Low**	**Low**	**Low**	**Low**	**Serious** Missing some outcomes compared to similar studies	**n/a**

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
Yang 2019[24]	**Low**	**Low** Some patients were randomized as part of an ongoing trial, and others were given the choice and selected on their own will. Authors state there was no intended selection bias toward one option versus the other. Patients were also propensity matched.	**Low**	**Low**	**Short-term outcomes: Low** **Long-term outcomes: Serious** Relatively short follow-up time; authors point out that their follow up time was adequate for time to recurrence as opposed to overall survival analysis	**Low**	**Low**	**n/a**
Yun 2019[25]	**Low**	**Moderate** Patients were able to decide between open or robot, but bulky tumors or large metastatic lymph nodes were contraindications to RAMIE; cohorts were adjusted with propensity score inverse probabilities	**Low**	**Low**	**Short-term outcomes: Low** **Long-term outcomes: Serious** Large loss to follow up, particularly in the robot arm	**Low**	**Low**	**n/a**
Zhang 2019[26]	**Moderate** Even after PSM, TNM stage is worse for Robot cohort, but not significant	**Moderate** Patients were able to decide between open or robot, but between 2014 and 2015 – part of the enrollment period – RAMIE was not performed; propensity matching performed	**Low**	**Low**	**Low**	**Low**	**Low**	**n/a**

APPENDIX G. EVIDENCE TABLES

Patient Characteristics and Intra-operative Outcomes

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
Chao 2018[16] N Retrospective Y Single institution N N	McKeown (transthoracic robot + laparoscopic) vs McKeown (VATS + laparoscopic). Stapled cervical anastomosis for both.		Matched N=34 Age: 56.76 (8.39) Male: 32 (94.1) BMI: NR ASA: NR Comorbidity index: 2.88 (1.27) Smoking: NR DM: NR Albumin: NR Tumor location: Upper: 10 (29.4) Mid: 15 (44.1) Lower: 9 (26.5) Stage: I/II: 16 (47.1) III: 18 (52.9) Neoadjuvant treatment: 17 (50) Squamous: 34 (100)	Matched N=34 Age: 53.47 (8.69) Male: 33 (97.1) BMI: NR ASA: NR Comorbidity index: 2.88 (1.27) Smoking: NR DM: NR Albumin: NR Tumor location: Upper: 10 (29.4 Mid: 19 (55.9) Lower: 5 (14.7) Stage: I/II: 16 (47.1) III: 18 (52.9) Neoadjuvant treatment: 17 (50) Squamous: 34 (100)		Matched Thoracic OR time: 231.15 (42.84) EBL: 92.06 (99) Transfusions: 3 (8.8) Conversions: 0 (0) LN harvest: 37.18 (18.25) Margins: R0: 34 (100)	Matched Thoracic OR time: 200.15 (103.48) EBL: 102.65 (96.67) Transfusions: 2 (5.9) Conversions: 0 (0) LN harvest: 36.24 (12.95) Margins: R): 33 (97.1)

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		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
Chen 2019[17] N Retrospective Y Single institution/ 1 surgical team N N **COST**	Robotic McKeown vs MIE (laparoscopy & VATS) McKeown		Matched N: 54 Age: 61.8 (9.4) Male: 41 (75.9) BMI: 22.7 (2.9) ASA: NR Comorbidity index: NR Smoking: 25 (46.3) DM: 1 (1.9) Albumin: NR cT stage: 1: 14 (25.9) 2: 7 (13) 3: 33 (61.1) 4a: 0 cN stage: 0: 30 (55.6) 1: 11 (20.4) 2: 11 (20.4) 3: 2 (3.7) Neoadjuvant chemoradiation: 14 (25.9) Squamous cell carcinoma: 54 (100)	Matched N: 54 Age: 61.8 (8.3) Male: 43 (79.6) BMI: 23 (2.7) ASA: NR Comorbidity index: NR Smoking: 27 (50) DM: 1 (1.9) Albumin: NR cT stage: 1: 15 (27.8) 2: 7 (13) 3: 31 (57.4) 4a: 1 (1.9) cN stage: 0: 22 (40.7) 1: 14 (25.9) 2: 16 (29.6) 3: 2 (3.7) Neoadjuvant chemoradiation: 17 (31.5) Squamous cell carcinoma: 54 (100)		Matched OR time: 187.2 (34) EBL: 118.9 (77.4) Conversion: NR LN harvest: 25.4 (7.5) Negative margins: 54 (100)	Matched OR time: 193.4 (27.1) EBL: 116.5 (85.9) Conversion: NR LN harvest: 24.7 (11.2) Negative margins: 54 (100)

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		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
Deng 2018[18] N Retrospective (prospective inclusion) Y Single institution/2 surgeons N N	Robot McKeown (abd and thoracic portions) vs thoraco-laparoscopic McKeown		Matched N: 52 Age: 61 (7.2) Male: 40 (76.9) Height: 163.4 (6.8) Weight: 58.7 (8) ASA: NR Major comorbidity: 12 (23.1) Smoking: NR DM: 3 (5.8) Albumin: NR Tumor location: Upper: 10 (19.2) Mid: 33 (63.5) Lower: 9 (17.3) Esophagogastric: 0 Clinical Stage: I: 12 (23.1) II: 36 (69.2) III: 4 (7.7) Squamous: 52 (100)	Matched N: 52 Age: 60.9 (9.2) Male: 39 (75) Height: 163.5 (5.5) Weight: 59.9 (8.5) ASA: NR Major comorbidity: 14 (26.9) Smoking: NR DM: 2 (3.8) Albumin: NR Tumor location: Upper: 7 (13.5) Mid: 30 (57.7) Lower: 14 (26.9) Esophagogastric: 1 (1.9) Clinical Stage: I: 9 (17.3) II: 35 (67.3) III: 8 (15.4) Squamous: 52 (100)		Matched OR time: 353 (71.8) Thoracic time: 130.6 (28.7) Abdominal time: 94.5 (21.6) EBL: 96.3 (53.4) LN harvest: 21.5 (8.4) Mediastinal LN harvest: 11.8 (5.1) Abdominal LN harvest: 9.7 (6.4) R RLN LN harvest: 2.4 (1.9) L RLN LN harvest: 1 (1.8)	Matched OR time: 274.2 (51.7) Thoracic time: 121.7 (24.6) Abdominal time: 87.5 (20.9) EBL: 127.5 (127.8) LN harvest: 17.3 (6.5) Mediastinal LN harvest: 10.1 (4.3) Abdominal LN harvest: 7.3 (5.1) R RLN LN harvest: 1.9 (2.2) L RLN LN harvest: 0.4 (0.8)
Espinoza-Mercado 2019[19] Y (NCDB 2010-2015)	Robot-assisted vs minimally invasive vs open	Unmatched N: 3,542 Age (med, IQR): 63 (56-69)	Unmatched N: 433 Age (med, IQR): 64 (57-70)	Unmatched N: 1,578 Age (med, IQR): 63 (57-69)	Margin: R0: 3,318 (94) LN harvest	Margin: R0: 408 (94.9) LN harvest	Margin: R0: 1,474 (94.1) LN harvest

Author **Year** **Large Database (y/n)** **Study Design** **Propensity matching (y/n)** **#Institutions/ Surgeons** **US (y/n)** **VA (y/n)**	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Patient & Tumor Characteristics Preop** N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			**Intra-operative Outcomes** OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
Retrospective Y 1,500+ Y N		Male: 2,995 (84.6) White: 3,308 (93.4) CCI zero: 2,434 (68.7) CCI 1: 892 (25.2) CCI >2: 216 (6.1) Tumor location: Mid: 422 (11.9) Lower: 3,120 (88.1) cT Stage: T1: 719 (20.5) T2: 761 (21.7) T3: 1,895 (54.1) cN stage: N0: 1,785 (50.8) N1: 1,329 (37.8) N2: 33 (9.5) Grade: Well-differentiated: 222 (7.1) Moderately-differentiated:	Male: 371 (85.7) White: 398 (91.9) CCI zero: 311 (71.8) CCI 1: 95 (21.9) CCI >2: 24 (5.9) Tumor location: Mid: 53 (12.2) Lower: 380 (87.8) cT Stage: T1: 72 (16.7) T2: 79 (18.4) T3: 263 (61.2) cN stage: N0: 214 (49.4) N1: 171 (39.5) N2: 40 (9.2) Grade: Well-differentiated: 38 (9.7) Moderately-differentiated: 175 (44.6) Poorly-differentiated: 179 (45.7) pT stage: T1: 156 (37.9)	Male: 1,348 (85.4) White: 1,490 (94.4) CCI zero: 1,088 (68.9) CCI 1: 384 (24.3) CCI >2: 106 (6.8) Tumor location: Mid: 184 (11.7) Lower: 1,394 (88.3) cT Stage: T1: 346 (22.1) T2: 341 (21.8) T3: 826 (52.8) cN stage: N0: 821 (52.3) N1: 591 (37.6) N2: 133 (8.5) Grade: Well-differentiated: 145 (10.3) Moderately-differentiated: 593 (41.9) Poorly-differentiated: 676 (47.8) pT stage: T1: 569 (38.7) T2: 279 (19)	(med, IQR): 13 (8-20)	(med, IQR): 17 (11-24)	(med, IQR): 15 (9-22)

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		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
		1,374 (43.9) Poorly-differentiated: 1,532 (49) pT stage: T1: 1,113 (35.8) T2: 633 (19.2) T3: 1,264 (40.6) pN stage: N0: 2,186 (64.4) N1: 734 (21.6) N2: 326 (9.6) p Stage: 0: 252 (7.1) 1: 1,140 (32.2) 2: 1,153 (32.6) 3: 997 (28.1) Neoadjuvant chemoradiation: 2,230 (63.6) Neoadjuvant chemotherapy: 215 (6.1) Adenocarcinoma: 3,022 (85.3) SCC: 520 (14.7)	T2: 83 (20.1) T3: 136 (33) pN stage: N0: 275 (64.9) N1: 99 (23.3) N2: 33 (7.8) p Stage: 0: 40 (10.1) 1: 143 (35.9) 2: 137 (34.4) 3: 78 (19.6) Neoadjuvant chemoradiation: 290 (67.1) Neoadjuvant chemotherapy: 21 (4.9) Adenocarcinoma: 363 (83.8) SCC: 70 (16.2)	T3: 511 (34.8) pN stage: N0: 987 (65.1) N1: 307 (20.3) N2: 163 (10.9) p Stage: 0: 123 (8.6) 1: 514 (36.1) 2: 475 (33.4) 3: 310 (21.8) Neoadjuvant chemoradiation: 981 (62.6) Neoadjuvant chemotherapy: 89 (5.7) Adenocarcinoma: 3,022 (85.3) SCC: 520 (14.7)			

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		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
Matched data for Espinoza-Mercado 2019[19]		Matched N: 406 Age (med, IQR): 64 (56-68) Male: 354 (87.2) White: 382 (94.1) CCI zero: 280 (69) Tumor location: Lower: 346 (85.2) Clinical Stage: 0: 4 (1) I: 113 (27.8) II: 120 (29.6) III: 169 (41.6) cT Stage: Tis: 4 (1) T1: 93 (22.9) T2: 87 (21.4) T3: 211 (52) T4: 8 (2) cN stage: N0: 201 (51) N1: 143 (35.2) N2: 47 (11.6)	Matched N: 406 Age: 64 (57-70) White: 374 (92.1) Male: 349 (86) CCI zero: 296 (72.9) Tumor location: Lower: 357 (87.9) Clinical Stage: 0: 6 (1.5) I: 89 (21.9) II: 138 (34) III: 173 (42.6) cT Stage: Tis: 5 (1.2) T1: 66 (16.3) T2: 74 (18.2) T3: 248 (61.1) T4: 10 (2.5) cN stage: N0: 207 (49.5) N1: 160 (39.4) N2: 38 (9.4) N3: 7 (1.7) Grade: Poorly-differentiated:	MIE vs RAMIE matched patient/pre-op characteristics not reported. The outcomes for matched are shown, however.	OR time: NR EBL: NR Conversion: NR Margin: R0: 374 (92.1) LN harvest(med, IQR): 13 (7-21)	OR time: NR EBL: NR Conversion: NR Margin: R0: 383 (95) LN harvest(med, IQR): 17 (11-24)	OR time: NR EBL: NR Conversion: NR Margin: R0: 388 (96.3) LN harvest(med, IQR): 16 (10-22)

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		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
		N3: 6 (1.5) Grade: Poorly-differentiated: 173 (42.6) Neoadjuvant chemoradiation: 252 (62.1) Neoadjuvant chemotherapy: 18 (4.4) Adenocarcinoma: 341 (84)	172 (42.4) Neoadjuvant chemoradiation: 276 (68) Neoadjuvant chemotherapy: 17 (4.2) Adenocarcinoma: 344 (84.7)				
Gong 2020[34] N Retrospective N Single institution/ 4 surgeons (only 2 surgeons performed robot) N N	Open vs total robotic vs thoraco-laparoscopic McKeown	N: 77 Age: 59.77 Race: NR Male: 74 (96.1) BMI: NR CCI: 0: 5 (6.5) 1: 28 (36.4) 2: 33 (42.9) 3: 11 (14.3) 4: 0 Smoking: NR DM: NR	N: 91 Age: 60.04 Race: NR Male: 78 (85.71) BMI: NR CCI: 0: 8 (8.79) 1: 25 (27.47) 2: 40 (44) 3: 14 (15.38) 4: 4 (4.4) Smoking: NR DM: NR	N: 144 Age: 60.22 Race: NR Male: 130 (90.28) BMI: NR CCI: 0: 10 (6.94) 1: 44 (30.56) 2: 64 (4.44) 3: 22 (15.28) 4: 4 (2.78) Smoking: NR DM: NR	OR time: 299.38 (57.98) EBL: 289.61 (355) Total LN harvest: 24.09 (10.77) Cervical LN: 1.25 (4.3) Upper mediastinum LN: 4.33 (3.61) Middle	OR time: 318.02 (53.9) EBL: 215.49 (125.4) Total LN harvest: 22.84 (8.37) Cervical LN: 0.29 (1.99) Upper mediastinum LN: 6.22 (4.1) Middle	OR time: 321.13 (57.21) EBL: 200.49 (59.54) Total LN harvest: 23.07 (10.18) Cervical LN: 0.42 (1.7) Upper mediastinum LN: 5.63 (3.88) Middle mediastinum LN:

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		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
		Albumin: NR Tumor location: Upper: 8 (10.39) Mid: 37 (48.05) Lower: 32 (41.56) Clinical Stage: I: 2 (2.6) II: 21 (27.27) III: 47 (61.04) IVA: 7 (9.09) Neoadjuvant therapy: 40 (51.95) Squamous cell carcinoma: 74 (96.1) Adenocarcinoma: NR	Albumin: NR Tumor location: Upper: 7 (7.69) Mid: 31 (34.07) Lower: 53 (58.24) Clinical Stage: I: 15 (16.48) II: 38 (41.76) III: 34 (37.36) IVA: 4 (4.4) Neoadjuvant therapy: 20 (21.98) Squamous cell carcinoma: 86 (94.51) Adenocarcinoma: NR	Albumin: NR Tumor location: Upper: 4 (2.78) Mid: 72 (50) Lower: 68 (47.22) Clinical Stage: I: 20 (13.89) II: 59 (40.97) III: 47 (32.64) IVA: 18 (12.5) Neoadjuvant therapy: 28 (19.44) Squamous cell carcinoma: 134 (93.06) Adenocarcinoma: NR	mediastinum LN: 7.81 (4.89) Lower mediastinum: 1.77 (2.32) Abdominal LN: 8.94 (5.55) Right RLN LN: 2.14 (1.95) Left RLN LN: 29 (37.66) Margins positive: R0 resection: 75 (97.4)	mediastinum LN: 6.34 (3.74) Lower mediastinum: 1.9 (1.87) Abdominal LN: 8.13 (5.53) Right RLN LN: 2.74 (2.03) Left RLN LN: 2.35 (3.0) Margins positive: R0 resection: 91 (100)	7.2 (4.69) Lower mediastinum: 1.74 (2.18) Abdominal LN: 8.1 (4.77) Right RLN LN: 2.57 (2.08) Left RLN LN: 1.95 (2.67) Margins positive: R0 resection: 144 (100)
He 2018[20] N Retrospective Y Single institution	McKeown RAMIE (abdominal and thoracic portions) vs VAMIE (MIE for thoracic and		N: 27 Age: 61 (8) Male: 20 (74.1) BMI: 21.5 (2.7) FEVI%: 94.6 (13.8) CCI: 1: 1 (3.7)	N: 27 Age: 61.6 (9.8) Male: 20 (74.1) BMI: 21.9 (2.8) FEVI%: 92.9 (23) CCI: 1: 4 (14.8)		OR time: 349 (45) EBL: 119 (72) Lymph node harvest: 20 (7)	OR time: 285 (66) EBL: 158 (82) Lymph node harvest: 19 (5)

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		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
N N	abdominal portions)		2: 10 (37) 3: 13 (48.1) 4: 3 (11.1) Tumor location: Upper: 1 (3.7) Mid: 18 (66.6) Lower: 8 (29.6) pT stage: T1: 4 (14.8) T2: 13 (48.1) T3: 10 (37) pN stage: N0: 13 (48.1) N1: 10 (37) N2: 3 (11.1) N3: 1 (3.7) Tumor grade: Well-differentiated: 2 (7.4) Moderately differentiated: 19 (70.4) Poorly differentiated: 6 (22.2) Squamous: 23 (85.2)	2: 8 (29.6) 3: 11 (40.7) 4: 4 (14.8) Tumor location: Upper: 3 (11.1) Mid: 15 (55.6) Lower: 9 (33.3) pT stage: T1: 1 (3.7) T2: 13 (48.1) T3: 13 (48.1) pN stage: N0: 18 (66.6) N1: 8 (29.6) N2: 1 (3.7) N3: 0 Tumor grade: Well-differentiated: 6 (22.2) Moderately differentiated: 17 (63) Poorly differentiated: 4 (14.8) Squamous: 25 (92.6)			
He 2020[15] N	Robot-assisted esophagectomy		N: 94 Age: 61.3 (8.2)	N: 98 Age: 62.4 (9.1)		Operating time: Thoracic	Operating time: Thoracic portion:

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		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
RCT N Single institution/ NR surgeons N N	and thoraco-laparoscopic esophagectomy		Race: NR Male: 72% BMI: 22.7 ASA: 1: 6 (6.4) 2: 82 (87.2) 3: 6 (6.4) Smoking: NR DM: 12 (12.8) Tumor location: intrathoracic Upper: 9 (9.6) Mid: 64 (68.1) Lower: 21 (22.3) Stage: 0-I: 51 (54) II: 29 (30.9) III: 14 (14.9) Neoadjuvant: NR Squamous: 94 (100) Adenocarcinoma: 0	Race: NR Male: 72% BMI: NR ASA: 22.8 1: 9 (9.2) 2: 80 (81.6) 3: 9 (9.2) Smoking: NR DM: 14 (14.3) Tumor location: intrathoracic Upper: 7 (7.1) Mid: 68 (69.4) Lower: 23 (23.5) Stage: 0-I: 49 (50.0) II: 34 (34.7) III: 15 (15.3) Neoadjuvant: NR Squamous: 98 (100) Adenocarcinoma: 0		portion: NR Abd + cervical: NR Total: 304.2 (82.5) Thoracic EBL: NS Total EBL: 202.5 (73.4) Transfusions: NR Conversions total: 1 Thoracic conversion (to lap transhiatal): NR Complications: NR LN harvest: 22.2 (12.5) Margins positive: R0: 88 (95.7)	NR Abd + cervical: NR Total: 315.5 (35.7) Thoracic EBL: NS Total EBL: 216.8 (44.6) Transfusions: NR Conversion total: 1 Thoracic conversion (to lap transhiatal): NR Complications: NR LN harvest: 20.1 (8.3) Margins positive: R0: 93 (96.9)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Patient & Tumor Characteristics Preop** N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			**Intra-operative Outcomes** OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
Jeong 2016[21] N Retrospective Y Single institution N N	Robot: 3-hole or 3-field (laparotomy; only thoracic portion is robotic) Open: Ivor-Lewis, 3-hole, or 3-field	N: 159 Age >65 years: 50 (31%) Male: 149 (94) BMI: 22.7 (2.9) ASA >2: 1 (0.6) Smoking: 138 (87) DM: 18 (11) Albumin, med/IQR: 4.3 (4.1-4.5) Tumor location: NR Clinical stage: I: 101 (64) II: 46 (29) III: 10 (6) IV: 2 (1)	N: 88 Age >65 years: 25 (28%) Male: 80 (91) BMI: 22.6 (2.5) ASA >2: 2 (2) Smoking: 76 (86) DM: 9 (10) Albumin, med/IQR: 4.3 (4.2-4.6) Tumor location: NR Clinical stage: I: 59 (67) II: 23 (26) III: 5 (6) IV: 1 (1)		OR time (hours, median/IQR): 4.4 (3.8-5.1) EBL (med/IQR): 200 (150-300) Intraop transfusion: 4 (2.5) Intraop afib: 9 (6)	OR time (hours, median/IQR): 4.8 (3.9-5.6) EBL (med/IQR): 200 (100-250) Intraop transfusion: 0 Intraop afib: 7 (8)	
Meredith 2019[27] N Retrospective (prospectively maintained database) N	Six approaches compared. The only robotic approach is Ivor-Lewis. Comparable methods using	N: 475 Age: 64 (11) Male: 412 (86.7) BMI: 28 (6) ASA: I: 2 (0.5) II: 207 (54)	N: 144 Age: 66 (10) Male: 113 (78.5) BMI: 28 (9) ASA: I: 0 II: 50 (35.2)	N: 95 Age: 62 (9) Male: 81 (85.3) BMI: 27 (5) ASA: I: 1 (1.1) II: 53 (60.9)	OR time (min; mean/SD): 286 (69) EBL: 289 (354) Complications: 7 (1.5) LN harvest: 10	OR time (min; mean/SD): 409 (104) EBL: 156 (107) Complications: 2 (1.4) LN harvest: 20	OR time (min; mean/SD): 299 (87) EBL: 189 (188) Complications: 2 (2.1) LN harvest: 14

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
Unknown Y N	other approaches in this study are open Ivor-Lewis and MIE transthoracic.	III: 172 (44.9) IV: 2 (0.5) CCI: NR Smoking: NR DM: NR Albumin: NR Tumor location: NR Clinical Stage: I: 47 (12.6) II: 142 (38.2) III: 162 (43.5) IV: 13 (3.5) Neoadjuvant therapy: 274 (57.7)	III: 90 (63.4) IV: 2 (1.4) CCI: NR Smoking: NR DM: NR Albumin: NR Tumor location: NR Clinical Stage: I: 32 (23.5) II: 46 (33.8) III: 56 (41.2) IV: 1 (0.7) Neoadjuvant therapy: 112 (77.8)	III: 33 (37.9) IV: 0 CCI: NR Smoking: NR DM: NR Albumin: NR Tumor location: NR Clinical Stage: I: 12 (14.3) II: 24 (28.6) III: 42 (50) IV: 5 (6) Neoadjuvant therapy: 73 (76.8)	(6) Margins: R1: 18 (3.8) R2: 7 (1.5)	(9) Margins: R1: 0 R2: 0	(7) Margins: R1: 6 (6.5) R2: 0
Motoyama 2019[30] N Retrospective N Single institution N N	Robot: transthoracic (unclear how abdominal portion was performed) MIE: transthoracic (unclear how		N: 21 Age (med/range): 63 (44-76) Male: 19 (90) BMI: NR ASA: NR CCI: NR Smoking: NR DM: NR Albumin: NR	N: 38 Age (med/range): 66 (49-75) Male: 32 (84) BMI: NR ASA: NR CCI: NR Smoking: NR DM: NR Albumin: NR		OR time (min; med/range): 634 (529-699) OR time thoracic: 320 (242-401) EBL (med/range): 492 (195-1591) EBL thoracic:	OR time (min; med/range): 598.5 (475-761) OR time thoracic: 312.5 (152-417) EBL (med/range): 385 (177-3184) EBL thoracic:

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Patient & Tumor Characteristics Preop** N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			**Intra-operative Outcomes** OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
	abdominal portion was performed)		Tumor location: Upper: 6 (29) Mid: 7 (33) Lower: 8 (38) Clinical T stage: T1b: 5 (24) T2: 5 (24) T3: 11 (52) Clinical N stage: N0: 8 (38) N1: 10 (48) N2: 3 (14) Clinical stage: IA: 4 (19) IB: 3 (14) IIA: 1 (5) IIB: 3 (14) IIIA: 7 (33) IIIB: 3 (14) Neoadjuvant Chemoradiation: 12 (57) Neoadjuvant chemo only: 0 Squamous cell carcinoma: 21 (100)	Tumor location: Upper: 9 (24) Mid: 16 (42) Lower: 13 (34) Clinical T stage: T1b: 16 (42) T2: 2 (5) T3: 20 (53) Clinical N stage: N0: 19 (50) N1: 13 (34) N2: 6 (15) Clinical stage: IA: 14 (37) IB: 2 (5) IIA: 3 (8) IIB: 2 (5) IIIA: 11 (29) IIIB: 6 (16) Neoadjuvant Chemoradiation: 19 (50) Neoadjuvant chemo only: 1 (3) Squamous cell carcinoma: 38 (100)		110 (15-375) LN harvest: 52 (36-104) LN harvest mediastinal: 23 (11-41)	165 (23-559) LN harvest: 59 (35-97) LN harvest mediastinal: 20 (7-68)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Patient & Tumor Characteristics Preop** N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			**Intra-operative Outcomes** OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
Naffouje 2019[22] Y (NSQIP 2016-2017) Retrospective Y Many Y N	Open vs MIE (robot and all other MIE) Ivor-Lewis Secondary analysis compared laparoscopic vs robotic (2:1 propensity match)		Matched N: 41 Age: 62.76 (9.98) White: 39 (95.1) Black: 1 (2.4) Other race: 1 (2.4) Male: 36 (87.8) BMI: 27.8 (6.19) ASA: I: 0 II: 5 (12.2) III: 35 (85.4) IV: 1 (2.4) Smoking: 12 (29.3) DM: 6 (14.6) Albumin: 3.83 (0.61) cT stage: T1: 13 (31.7) T2: 12 (29.3) T3: 16 (39) T4: 0 Tx: 0 cN stage: 0: 28 (68.3) 1: 8 (19.5) 2: 4 (9.8)	Matched N: 82 Age: 63.27 (9.28) White: 75 (91.5) Black: 3 (3.7) Other race: 4 (4.8) Male: 72 (87.8) BMI: 27.98 (5.6) ASA: I: 0 II: 11 (13.4) III: 68 (82.9) IV: 3 (3.7) Smoking: 21 (25.6)) DM: 17 (20.7) Albumin: 3.86 (0.38) cT stage: T1: 32 (39) T2: 17 (20.7) T3: 31 (37.8) T4: 0 Tx: 2 (2.4) cN stage: 0: 52 (63.4) 1: 13 (15.9) 2: 14 (17.1)		OR time: 449 (116) Conversion to open: 1 (2.4) Negative margins: 35 (85.4)	OR time: 445 (96) Conversion to open: 7 (8.5) Negative margins: 74 (90.2)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
			3: 1 (2.4) Nx: 0 Neoadjuvant chemo: 30 (73.2) Neoadjuvant radiation: 30 (73.2) Adenocarcinoma: 37 (90.2) SCC: 4 (9.8) Other malignancy: 0	3: 0 Nx: 3 (3.7) Neoadjuvant chemo: 62 (75.6) Neoadjuvant radiation: 56 (68.3) Adenocarcinoma: 76 (92.7) SCC: 5 (6.1) Other malignancy: 1 (1.2)			
Osaka 2018[32] N Retrospective N Single institution N N	Robot (thoracic) with unknown method for abdomen vs thoracotomy and unknown for abdomen	N: 30 Age (med, range): 63 (46-77) Male: 27 (90) BMI: NR ASA: NR CCI: NR Smoking: NR DM: NR Albumin: NR Tumor location: Upper: 1 (3.3) Mid: 15 (50) Lower: 14 (46.7) Clinical Stage:	N: 30 Age (med, range): 62 (49-78) Male: 27 (90) BMI: NR ASA: NR CCI: NR Smoking: NR DM: NR Albumin: NR Tumor location: Upper: 1 (3.3) Mid: 15 (50) Lower: 14 (46.7) Clinical Stage: I: 14 (46.7)		OR time, minutes (med, range): 398 (329-498) EBL total (med, range): 388 (125-990) EBL thoracic (med, range): 135 (44-325) LN harvest (med, range): 23 (12-39)	OR time, minutes (med, range): 563 (476-713) EBL total (med, range): 197 (10-640) EBL thoracic (med, range): 21 (0-97) LN harvest (med, range): 25 (8-58)	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Patient & Tumor Characteristics Preop** N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			**Intra-operative Outcomes** OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
		I: 16 (53.3) II: 13 (43.3) III: 1 (3.3) Neoadjuvant chemo: 8 (26.7) Adenocarcinoma: NR Squamous cell carcinoma: NR	II: 10 (33.3) III: 6 (20) Neoadjuvant chemo: 13 (43.3) Adenocarcinoma: NR Squamous cell carcinoma: NR				
Park 2016[48] N Retrospective N Single Institution N N	Transthoracic robot vs transthoracic VATS. In the robot cohort, 90% were McKeown and 10% were Ivor-Lewis. Abdominal portion in the robotic cohort was done robotically in 58%. In the MIE cohort, abdominal		N: 62 Age: 64.3 (8) Male: 57 (91.9) BMI: 23.5 (2.8) ASA: I: 21 (33.9) II: 37 (59.7) III: 4 (6.5) Smoking: 49 (79) Never smoker: 13 (21) DM: 9 (14.5) Albumin: NR Tumor location: Upper: 8 (12.9) Mid: 15 (24.2) Lower: 39 (62.9) FEV1; pred%, SD:	N: 43 Age: 66.2 (7.4) Male: 40 (93) BMI: 23.3 (3.1) ASA: I: 11 (25.6) II: 32 (74.4) III: 0 Smoking: 35 (81.4) DM: 11 (25.6) Albumin: NR Tumor location: Upper: 7 (16.3) Mid: 9 (20.9) Lower: 27 (62.8) FEV1; pred%, SD: 106.7 (13.8)		OR time: Total: 490.3 (84) Thoracic: 185.2 (67.4) Abdominal: 305.1 (66.6) EBL: 462.9 (493.9) LN harvest: 37.3 (17.1)	OR time: Total: 458.4 (111.9) Thoracic: 120.1 (68.5) Abdominal: 338.4 (105.4) EBL: 466.8 (333) LN harvest: 28.7 (11.8)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Patient & Tumor Characteristics Preop** N, Age, mean yr (SD), Male, %, Race/Ethnicity: NH-White, %; NH-Black, %; NH-Asian, %; Hispanic, %; BMI, mean (SD); ASA class, mean (SD); Comorbidity index (CCI):; Smoking current/former/unspecified; DM; Albumin; Tumor Location (%); Stage; Neoadjuvant therapy (%); Squamous (%); Adenocarcinoma (%)			**Intra-operative Outcomes** OR, time, min (SD); EBL, mL (SD); Transfusions (%); Conversion (%); Major Complications, N (%); Lymph node harvest, N (std dev/IQR); Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
	portion was laparoscopic in 49%, 19% were Ivor-Lewis, and 81% were McKeown.		101.6 (17.1) Clinical stage: I: 23 (37.1) II: 28 (45.2) III: 11 (17.7) Clinical T stage: T1: 31 (50) T2: 21 (33.9) T3: 10 (16.1) Clinical N stage: N0: 42 (67.7) N+: 20 (32.3) Neoadjuvant chemoradiation: 8 (12.9) Squamous cell carcinoma: 62 (100)	Clinical stage: I: 21 (48.8) II: 15 (34.9) III: 7 (16.3) Clinical T stage: T1: 25 (58.1) T2: 13 (30.2) T3: 5 (11.6) Clinical N stage: N0: 27 (64.3) N+: 15 (35.7) Neoadjuvant chemoradiation: 4 (9.3) Squamous cell carcinoma: 43 (100)			
Rolff 2017[49] N Retrospective N Single institution N N	Open Ivor-Lewis vs Hybrid minimally invasive Ivor-Lewis (Robot in abdomen + thoracotomy)	N: 160 Age (med, range): 65 (22-88) Male: 125 (78) BMI (med, range): 26.6 (15.6-43.7) ASA:	N: 56 Age (med, range): 66 (39-86) Male: 50 (88) BMI (med, range): 25.8 (18.8-31.2) ASA: 1: 17 (30) 2: 28 (50)		OR time (med, range): 248 (100-420) EBL (med, range): 600 (100-4,400) LN harvest (med, range):	OR time (med, range): 232 (174-800) EBL (med, range): 200 (50-1,970) LN harvest (med, range):	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
		1: 41 (26) 2: 80 (50) 3: 39 (24) 4: 0 CCI (med, range): 20.9 (0-100) Smoking: NR DM: NR Albumin: NR Tumor location: NR Stage: NR Neoadjuvant therapy: NR Adenocarcinoma: NR Squamous cell carcinoma: NR	3: 12 (21) 4: 1 (2) CCI (med, range): 12.2 (0-100) Smoking: NR DM: NR Albumin: NR Tumor location: NR Stage: NR Neoadjuvant therapy: NR Adenocarcinoma: NR Squamous cell carcinoma: NR		23 (11-60) Margins: NR	28 (15-61) Margins: NR	
Sarkaria 2019[28] N Non-randomized prospective trial N Single	Robotic Ivor-Lewis (62/64) and McKeown (2/64) vs open Ivor-Lewis (103/106) Thoracoabdomin	N: 106 Age (med, IQR): 63 (28-83) Male: 91 (85.8) BMI (med, IQR): 28.4 (16.9-49.5) ASA:	N: 64 Age (med, IQR): 61 (45-82) Male: 53 (82.8) BMI (med, IQR): 29.1 (15.6-47.8) ASA:		OR time (hours, median & range): 5.44 (3.5-10.3) EBL (med, range): 350 (100-2300)	OR time (hours, median & range): 6.4 (4.9-10.6) EBL (med, range): 250 (50-600)	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
institution/8 surgeons (2 performed robotic) Y N	al (3/106) "All but 1 patient who underwent MIE did so via a total RAMIE approach."	II: 15 (14.2) III: 84 (79.2) IV: 7 (6.6) # of comorbidities: 0: 31 (29.2) 1-2: 62 (58.5) >2: 13 (12.3) Smoking: NR DM: NR Albumin: NR Tumor location: GE junction: 104 (98.1) Distal: 2 (1.9) Stage: 0: 2 (1.9) I: 14 (13.2) II: 26 (24.5) III: 63 (59.4) IV: 1 (0.9) Neoadjuvant treatment: 87 (82.1) Squamous: 7 (6.6)	II: 9 (14.1) III: 51 (79.7) IV: 4 (6.3) # of comorbidities: 0: 23 (35.9) 1-2: 34 (53.1) >2: 7 (10.9) Smoking: NR DM: NR Albumin: NR Tumor location: GE junction: 60 (93.8) Distal: 4 (6.3) Stage: 0: 1 (1.6) I: 11 (17.5) II: 17 (27) III: 34 (54) IV: 0 (0) Neoadjuvant treatment: 48 (75) Squamous: 4 (6.3) Adenocarcinoma: 59 (93.7) Other pathology: 0 (0)		LN harvest (med, range): 22 (0-50) Margins positive (R1): 3 (2.8)	LN harvest (med, range): 25 (14-56) Margins positive (R1): 2 (3.1)	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
		Adenocarcinoma: 98 (92.5) Other pathology: 1 (0.9)					
Tagkalos 2019[23] N Retrospective study of prospectively collected database Y Single institution/Single surgeon N N	Robot (thoracic and abdominal) Ivor-Lewis vs minimally invasive (VATS and laparoscopy) Ivor-Lewis		Matched: N: 40 Age: 62 BMI: 26.4 ASA: 1-2: 22 (55) 3-4: 18 (45) DM: 4 (10) Pulmonary comorbidities: 8 (20) CV comorbidities: 15 (37.5) Tumor location: Upper: 0 Mid: 8 (20) Lower: 32 (80) cT stage: 1-2: 7 (17.5) 3-4: 33 (82.5) cN stage: 0: 8 (20) 1: 32 (80)	Matched: N: 40 Age: 63 BMI: 25.6 ASA: 1-2: 19 (47.5) 3-4: 21 (52.5) DM: 5 (12.5) Pulmonary comorbidities: 6 (15) CV comorbidities: 16 (40) Tumor location: Upper: 2 (5) Mid: 6 (15) Lower: 32 (80) cT stage: 1-2: 10 (25) 3-4: 30 (75) cN stage: 0: 10 (25) 1: 30 (75) Chemoradiation: 21		Matched OR time (med, range): 388 (255-475) Abd time: 151 (80-250) Thoracic time: 223 (170-320) EBL: 339 (198) LN harvest (median, range): 27 (13-84) Negative margins: 38 (95)	Matched OR time (med, range): 321 (224-519) Abd time: 125 (66-325) Thoracic time: 201 (158-295) EBL: 343 (181) LN harvest (median, range): 23 (11-48) Negative margins: 39 (97.5)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
			Chemoradiation: 22 (55) Chemo only: 11 (27.5)	(52.5) Chemo only: 9 (22.5)			
van der Sluis 2019[14] N RCT N Single institution/2 surgeons N N	Open McKeown v Robot transthoracic with laparoscopic abdominal and open cervical portions	N: 55 Age: 65 (8.2) Male: 42 (76) BMI: 25.5 (4.7) ASA: 1: 11 (20) 2: 34 (62) 3: 10 (18) Comorbidity: 41 (75) Smoking: NR DM: NR Albumin: NR Tumor location: Upper: 0 (0) Mid: 8 (15) Lower: 29 (53) Clinical stage: IA: 4 (7) IIA: 3 (6) IIB: 18 (33) IIIA: 21 (38) IIIB: 6 (11)	N: 54 Age: 64 (8.9) Male: 46 (85) BMI: 26.1 (4.4) ASA: 1: 13 (24) 2: 37 (69) 3: 6 (11) Comorbidity: 43 (80) Smoking: NR DM: NR Albumin: NR Tumor location: Upper: 1 (2) Mid: 5 (9) Lower: 26 (48) Clinical stage: IA: 4 (7) IIA: 5 (9) IIB: 11 (20) IIIA: 13 (24) IIIB: 13 (24) IIIC: 8 (15)		Operating time: Thoracic portion: 135 (23.3) Abd + cervical: 161 (30.1) Total: 296 (33.9) Thoracic EBL: 200 (195-313) Total EBL: 568 (428-800) Complications: 9 (16.4) LN harvest: 25 (17-31) Margins positive: R1: 2 (4)	Operating time: Thoracic portion: 170 (34.6) Abd + cervical: 186 (38.7) Total: 349 (56.9) Thoracic EBL: 120 (78-200) Total EBL: 400 (258-581) Conversion total: 3 (5.6) Thoracic conversion (to lap transhiatal): 1 (1.9) Complications: 7 (13) LN harvest: 27 (17-33) Margins	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
		IIIC: 3 (6) Neoadjuvant: 48 (87) Squamous: 12 (23) Adenocarcinoma: 43 (78)	Neoadjuvant: 48 (90) Squamous: 13 (24) Adenocarcinoma: 41 (76)			positive: R1: 2(4)	
Van Der Sluis 2018[35] N RCT N NR N N **Cost only**	Open transthoracic esophagectomy vs RAMIE						
Washington 2019[29] N Retrospective N Single institution/ Single surgeon	Robotic vs laparoscopic transhiatal esophagectomy		N: 18 Age: 61.9 (range 42-76) Male: 17 (94.4) BMI: 27.6 (range 20.7-38.2) ASA: NR CCI: NR Smoking: NR	N: 18 Age: 58.9 (range 40 to 70) Male: 16 (88.9) BMI: 27.5 (range 19.2-39.4) ASA: NR CCI: NR Smoking: NR		OR time: 168 (24) LN harvest: 14.28 (7.8) Margins positive (R1): 1 (5.6)	OR time: 164 (23.1) LN harvest: 13.9 (8.5) Margins positive (R1): 1 (5.6)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
Y N			DM: NR Albumin: NR Neoadjuvant treatment: 18 (100) cT stage: 1: 0 2: 4 (22.2) 3: 14 (77.8) cN stage: 0: 6 (33.3) 1: 12 (66.7) Squamous: 4 (22.2) Adenocarcinoma: 14 (77.8)	DM: NR Albumin: NR Neoadjuvant treatment: 15 (83.3) cT stage: 1: 3 (16.7) 2: 2 (11.1) 3: 12 (66.7) cN stage: 0: 6 (33.3) 1: 8 (44.4) Squamous: 3 (16.7) Adenocarcinoma: 15 (83.3)			
Yang 2019[24] N Retrospective Y Single institution/ Single surgeon N N	Robot McKeown (abd and thoracic portions) vs thoraco-laparoscopic McKeown		Matched N: 271 Age: 63.4 (7.1) Male: 222 (81.9) BMI: 23.2 (3) ASA: I: 4 (1.5) II: 243 (89.7) III: 24 (8.9) CCI: NR Smoking: NR DM: NR	Matched N: 271 Age: 63.5 (7.4) Male: 221 (81.5) BMI: 23.2 (2.9) ASA: I: 4 (1.5) II: 242 (89.3) III: 25 (9.2) CCI: NR Smoking: NR DM: NR		Matched OR time: 244.5 (60.4) Thoracic time: 85 (27.8) EBL: 210.7 (86.8) Thoracic conversion: 2 (0.7) Total LN harvest: 20.3	Matched OR time: 276 (59.4) Thoracic time: 102.9 (28.6) EBL: 209.6 (107.4) Thoracic conversion: 16 (5.9) Total LN harvest: 19.2 (9.6)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
			Albumin: NR Tumor location: Upper: 38 (14) Mid: 169 (62.4) Lower: 64 (23.6) Clinical stage: I: 70 (25.8) II: 97 (35.8) III: 79 (29.2) IV: 25 (9.2) Neoadjuvant therapy: 29 (10.7) Squamous cell: 271 (100)	Albumin: NR Tumor location: Upper: 31 (11.4) Mid: 171 (63.1) Lower: 69 (25.5) Clinical stage: I: 83 (30.6) II: 86 (31.7) III: 67 (24.7) IV: 35 (12.9) Neoadjuvant therapy: 28 (10.3) Squamous cell: 271 (100)		(9.9) Abdominal LN: 7.9 (4.8) Thoracic LN: 12.4 (7) RLN LN: 4.8 (3.3) Negative margins: 255 (94.1)	Abdominal LN: 6.8 (3.6) Thoracic LN: 12.4 (6.5) RLN LN: 4.1 (3) Negative margins: 254 (93.7)
Yun 2019[25] N Retrospective (prospective database) Y Single surgeon/Single institution N N	Open (Ivor-Lewis 54.4%; McKeown 45.6%) vs robot-assisted (Ivor-Lewis 57.1%; McKeown 42.9%) (abdominal portion was either robot-	Matched (Inverse probability of treatment weighting) N: 130* (table says 241, but it should be matched) Age: 63 (7.8) Male: 93% BMI: 23.4 (2.8)	Matched (Inverse probability of treatment weighting) N: 130 Age: 63 (8.6) Male: 92.6% BMI: 23.4 (3.3) ASA: NR CCI: NR Smoking: 81.9% DM: 14.4% Albumin: NR		Unadjusted OR time: 240 (48.9) EBL: 93.8 (140.9) LN harvest: 38.3 (12.9) Margins positive: 3.3% R0: 233 (96.7) R1: 7 (2.9) R2: 1 (0.4)	Unadjusted OR time: 275.6 (71.1) EBL: 110.8 (125.8) Conversion: 3 (2.3) LN harvest: 39.1 (13.8) Margins positive: 2.3% R0: 127 (97.7)	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)
	assisted or laparoscopic)	ASA: NR CCI: NR Smoking: 89.9% DM: 14.2% Albumin: NR Tumor location: Upper: 29.6% Mid: 48.3% Lower: 22.1% Clinical Stage: I: 60.6% II: 21.3% III: 18.1% Neoadjuvant treatment: 32.9% Squamous cell carcinoma: 100%	Tumor location: Upper: 27.5% Mid: 45.4% Lower: 27.1% Clinical Stage: I: 66.5% II: 18.1% III: 15.4% Neoadjuvant treatment: 25.5% Squamous cell carcinoma: 100%			R1: 3 (2.3) R2: 0	
Zhang 2019[26] N Retrospective Y Single institution/ Single surgeon N N	Robot-assisted Ivor-Lewis (abdomen and thorax robot) vs thoraco-laparoscopic Ivor-Lewis		Matched N: 66 Age: 62.3 (7.8) Male: 50 (75.8) BMI: 22.9 (3.1) ASA: 1: 30 (45.5) 2: 33 (50) 3: 3 (4.5)	Matched N: 66 Age: 62 (7.8) Male: 50 (75.8) BMI: 23.1 (4.5) ASA: 1: 26 (39.4) 2: 36 (54.5) 3: 4 (6.1)		Matched OR time: 302 (62.9) EBL: 200 (100-262.5) Conversion: 1 (1.5) LN harvest: 19.2 (9.2)	Matched OR time: 274.7 (38) EBL: 200 (150-245) Conversion: 0 LN harvest: 19.3 (9.5) Abd LN harvest:

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Patient & Tumor Characteristics Preop N Age, mean yr (SD) Male, % Race/Ethnicity NH-White, % NH-Black, % NH-Asian, % Hispanic, % BMI, mean (SD) ASA class, mean (SD) Comorbidity index (CCI): Smoking current/former/unspecified DM Albumin Tumor Location (%) Stage Neoadjuvant therapy (%) Squamous (%) Adenocarcinoma (%)			Intra-operative Outcomes OR, time, min (SD) EBL, mL (SD) Transfusions (%) Conversion (%) Major Complications, N (%) Lymph node harvest, N (std dev/IQR) Margins positive (%)		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**
			Comorbidity: 28 (42.2) Smoking history: 33 (50) DM: NR Albumin: NR Tumor location: Mid: 29 (43.9) Lower: 37 (56.1) Neoadjuvant therapy: 0 Adenocarcinoma: 0 Squamous cell carcinoma: 64 (97)	Comorbidity: 32 (48.5) Smoking history: 42 (63.6) DM: NR Albumin: NR Tumor location: Mid: 26 (39.4) Lower: 40 (60.6) Neoadjuvant therapy: 0 Adenocarcinoma: 0 Squamous cell carcinoma: 65 (98.5)		Abd LN harvest: 8.9 (6.7) Thoracic LN harvest: 10.3 (5.8) R RLN LN harvest: 1.4 (1.6) L RLN LN harvest: 1.3 (1.9) Margins positive: 0	7.3 (5.9) Thoracic LN harvest: 11.9 (8.3) R RLN LN harvest: 1.6 (2.8) L RLN LN harvest: 0.9 (1.9) Margins positive: 0

Short- and Long-term Outcomes

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg,* open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Short-term Outcomes LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			Long-term Outcomes Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	Robot (RAMIE)	Other minimally invasive approach (VAMIE)	Open	Robot	Other minimally invasive approach (VAMIE)
Chao 2018[16] N Retrospective Y Single institution N N	McKeown (transthoracic robot + laparoscopic) vs McKeown (VATS + laparoscopic). Stapled cervical anastomosis for both.		Matched LOS: 16.36 (5.79) Readmissions: 5 (14.7) ICU stay (hours): 31.85 (18.22) Pneumonia: 2 (5.9) Pleural effusion: 4 (11.8) 30-day mortality: 0 (0) 90-day mortality: 0 (0) Anastomotic leak: 0 (0) Reoperations: NR RLN palsy: 7 (20.6)	Matched LOS: 17.82 (5.76) Readmissions: 4 (11.8) ICU stay (hours): 35.62 (47.33) Pneumonia: 6 (17.6) Pleural effusion: 6 (17.6) 30-day mortality: 0 (0) 90-day mortality: 1 (2.9) Anastomotic leak: 2 (5.9) Reoperations: NR RLN palsy: 10 (29.4)		NR	NR
Chen 2019[17] N Retrospective Y Single institution/1 surgical team N N **COST**	Robotic McKeown vs MIE (laparoscopy & VATS) McKeown		Matched LOS: 17.1 (10.1) Readmissions: NR ICU stay: 4 (6.3) Pneumonia: 8 (14.8) Chylothorax: 1 (1.9) MACE: 2 (3.7) Anastomotic leak: 5 (9.3) Hoarseness/RLN palsy: 7 (13) Mortality: 0	Matched LOS: 15.2 (9.8) Readmissions: NR ICU stay: 2.5 (3.7) Pneumonia: 13 (24.1) Chylothorax: 2 (3.7) MACE: 0 Anastomotic leak: 2 (3.7) Hoarseness/RLN palsy: 17 (31.5) Mortality: 0		NR	NR

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
			Total expense: $25,300 (9,000) Expenses/day: $1,700 (700)	Total expense: $20,800 (9,000) Expenses/day: $1,500 (400)			
Deng 2018[18] N Retrospective (prospective inclusion) Y Single institution/2 surgeons N N	Robot McKeown (abd and thoracic portions) vs thoraco-laparoscopic McKeown		Matched LOS: 14.3 (6.9) Total major complications: 15 (28.8) Grade 1-2 complications: 9 (17.3) Grade 3+ complications: 6 (11.5) Pneumonia: 5 (9.6) Chylothorax: 0 Anastomotic leak: 3 (5.8) RLN palsy: 7 (13.5) In-hospital mortality: 1 (1.9) 90-day mortality: 2 (3.8)	Matched LOS: 12.7 (7.7) Total major complications: 12 (23.1) Grade 1-2 complications: 6 (11.5) Grade 3+ complications: 6 (11.5) Pneumonia: 4 (7.7) Chylothorax: 1 (1.9) Anastomotic leak: 2 (3.8) RLN palsy: 4 (7.7) In-hospital mortality: 2 (3.8) 90-day mortality: 2 (3.8)		NR	NR
Espinoza-Mercado 2019[19] Y (NCDB 2010-2015) Retrospective Y	Robot-assisted vs minimally invasive vs open	Readmission: 239 (6.9) LOS (med, IQR): 10 (8-15) 30-day mortality: 130 (3.7)	Readmission: 26 (6.1) LOS (med, IQR): 9 (7-14) 30-day mortality: 18 (4.2)	Readmission: 96 (6.2) LOS (med, IQR): 9 (8-14) 30-day mortality: 50 (3.2) 90-day mortality: 114 (7.3)	Overall survival (med, months; 95% CI): 43.6 (40-46)	Overall survival (med, months; 95% CI): 58.8 (47-69)	Overall survival (med, months; 95% CI): 47.5 (42-52)

Author **Year** **Large Database (y/n)** **Study Design** **Propensity matching (y/n)** **#Institutions/ Surgeons** **US (y/n)** **VA (y/n)**	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
1,500+ Y N		90-day mortality: 259 (7.4)	90-day mortality: 35 (8.2)				
Matched data for Espinoza-Mercado 2019[19]		LOS (med, IQR): 10 (8-16) Readmission: 25 (6.2) ICU stay: NR Complications: NR 30-day mortality: 20 (4.9) 90-day mortality: 32 (7.9)	LOS (med, IQR): 9 (7-14) Readmission: 24 (6.1) ICU stay: NR Complications: NR 30-day mortality: 16 (3.9) 90-day mortality: 31 (7.6)	LOS (med, IQR): 9 (8-15) Readmission: 20 (4.9) ICU stay: NR Complications: NR 30-day mortality: 13 (3.2) 90-day mortality: 25 (6.2)	Overall survival (med, months; 95% CI): 53.9 (42-85)	Overall survival (med, months; 95% CI): 58.8 (48-69)	Overall survival (med, months; 95% CI): 45.9 (33-58)
Gong 2020[34] N Retrospective N Single institution/4 surgeons (only 2 performed robot) N N	Open vs total robotic vs thoraco-laparoscopic McKeown	LOS: 16.66 (9.3) Reoperations: NR ICU stay: NR Total complications: 26 (33.77) Pneumonia: 10 (12.99) Atrial fibrillation: 10 (12.99) Anastomotic leak: 2 (2.6) Chylothorax: 3 (3.9) Bleeding: 0 RLN palsy: 12 (15.58) Wound infection: 2	LOS: 16.57 (8.0) Reoperations: NR ICU stay: NR Total complications: 33 (36.26) Pneumonia: 9 (9.89) Atrial fibrillation: 13 (14.29) Anastomotic leak: 4 (4.4) Chylothorax: 1 (1.1) Bleeding: 0 RLN palsy: 20 (21.98) Wound infection: 1 (1.67) ICU readmission: 6 (6.59)	LOS: 18.73 (13.29) Reoperations: NR ICU stay: NR Total complications: 49 (34.03) Pneumonia: 15 (10.42) Atrial fibrillation: 21 (14.58) Anastomotic leak: 10 (6.94) Chylothorax: 1 (0.7) Bleeding: 1 (0.7) RLN palsy: 34 (23.61) Wound infection: 0 ICU readmission: 12 (8.33)	NR	NR	NR

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Short-term Outcomes LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			Long-term Outcomes Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
		(2.6) ICU readmission: 7 (9.09) Reoperations: NR Mortality (90-day): 2 (2.6)	Reoperations: NR Mortality (90-day): 0	Reoperations: NR Mortality (90-day): 0			
He 2018[20] N Retrospective Y Single institution N N	McKeown RAMIE (abdominal and thoracic portions) vs VAMIE (MIE for thoracic and abdominal portions)		LOS: 13.8 (2) Overall complication rate: 10 (37) Pulmonary complications: 5 (18.5) Chylothorax: 0 Arrhythmia: 1 (3.7) Anastomotic leak: 3 (11.1) Bleeding: 1 (3.7) RLN palsy: 4 (14.8) 90-day mortality: 0	LOS: 12.8 (2.7) Overall complication rate: 9 (33.3) Pulmonary complications: 2 (7.4) Chylothorax: 1 (3.7) Arrhythmia: 0 Anastomotic leak: 1 (3.7) Bleeding: 1 (3.7) RLN palsy: 3 (11.1) 90-day mortality: 1 (3.7)		NR	NR
He 2020[15] N RCT N Single institution/ NR surgeons N N	Robot-assisted esophagectomy and thoraco-laparoscopic esophagectomy		LOS (median): 12 (5-78 range) Readmissions: NR ICU stay: 1.5 (1-24) Pulmonary complications: 18 Chylothorax: 2 MACE: NR Mortality: 2 Anastomotic leak: 7 All complications: 30 (32.6)	LOS (median): 13 (8-125) range Readmissions: NR ICU stay: 1.5 (1-20) Pulmonary complications: 24 Chylothorax: 2 MACE: NR Mortality: 1 Anastomotic leak: 9 All complications: 38 (39.6)		Overall survival: NR Recurrence: 14 Recurrence free: 1-yr: 92.4 3-yr: 87.3 followup time: 15 (9-42)	Overall survival: NR Recurrence: 25 Recurrence free: 1-yr: 81.7 3 -r: 67.9 followup time: 9 (3-42)

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
			Complications: Grade >2 directly related to surgery: NR Grade >2 overall: NR Reoperations: NR RLN palsy: 6	Complications: Grade >2 directly related to surgery: NR Grade >2 overall: NR Reoperations: NR RLN palsy: 9			
Jeong 2016[21] N Retrospective Y Single institution N N	Robot: 3-hole or 3-field (laparotomy; only thoracic portion is robotic) Open: Ivor-Lewis, 3-hole, or 3-field	LOS (med/IQR): 13 (12-16) ICU stay (hours; med/IQR): 1.9 (1.8-2) Complications (at least 1): 56 (35) Pneumonia: 11 (7) Anastomotic leak: 3 (2) Afib: 9 (6) Vocal cord palsy: 1 (0.6) Death: 1 (0.6)	LOS (med/IQR): 12 (10-15) ICU stay (hours; med/IQR): 1.8 (1.8-1.9) Complications (at least 1): 14 (16) Pneumonia: 3 (3.4) Anastomotic leak: 1 (1.1) Afib: 2 (2.3) Vocal cord palsy: 1 (1.1) Death: 1 (1.1)		NR	NR	
Meredith 2019[27] N Retrospective (prospectively maintained database) N Unknown Y N	Six approaches compared. The only robotic approach is Ivor-Lewis. Comparable methods using other approaches in this study are open Ivor-Lewis	LOS (med/range): 10 (1-115) Complication rate: 145 (30.5) Pulmonary complication: 81 (17.1) Pneumonia: 72 (15.2) PE: 9 (1.9)	LOS (med/range): 10 (4-66) Complication rate: 34 (23.6) Pulmonary complication: 14 (9.7) Pneumonia: 10 (6.9) PE: 3 (3.2) Chylothorax: 1 (0.7)	LOS (med/range): 9 (6-60) Complication rate: 28 (29.5) Pulmonary complication: 18 (18.9) Pneumonia: 8 (8.4) Chylothorax: 1 (1.1) MI: 3 (3.2)		NR	NR

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
	and MIE transthoracic.	Chylothorax: 5 (1.1) MI: 6 (1.3) Arrhythmia: 55 (11.6) Anastomotic leak: 23 (4.8) Reoperation: 12 (2.5) 90-day mortality: 7 (1.5)	MI: 1 (0.7) Arrhythmia: 25 (17.4) Anastomotic leak: 4 (2.8) Reoperation: 0 90-day mortality: 2 (1.4)	Arrhythmia: 17 (17.9) Anastomotic leak: 4 (4.2) Reoperation: 2 (2.1) 90-day mortality: 2 (2.1)			
Motoyama 2019[30] N Retrospective N Single institution N N	Robot: transthoracic (unclear how abdominal portion was performed) MIE: transthoracic (unclear how abdominal portion was performed)		Chylothorax: 1 (5) Pneumonia: 0 Anastomotic leak: 1 (5) Right RLN palsy: 2 (10) Left RLN palsy: 5 (24)	Chylothorax: 1 (3) Pneumonia: 0 Anastomotic leak: 3 (8) Right RLN palsy: 12 (32) Left RLN palsy: 18 (47)		NR	NR
Naffouje 2019[22] Y (NSQIP 2016-2017) Retrospective Y Many Y N	Open vs MIE (robot and all other MIE) Ivor-Lewis Secondary analysis compared laparoscopic vs robotic (2:1 propensity match)		LOS (median, IQR): 7 (7-9.5) Readmissions: 6 (14.6) Pneumonia: 3 (7.3) PE: 1 (2.4) Transfusion: 1 (2.4) Reintubation: 4 (9.8) Superficial SSI: 0 Deep SSI: 0	LOS (median, IQR): 8 (7-12.25) Readmissions: 12 (14.6) Pneumonia: 16 (19.5) PE: 2 (2.4) Transfusion: 2 (2.4) Reintubation: 9 (11) Superficial SSI: 2 (2.4)			

Author **Year** **Large Database (y/n)** **Study Design** **Propensity matching (y/n)** **#Institutions/ Surgeons** **US (y/n)** **VA (y/n)**	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
			Organ space SSI: 3 (7.3) Overall complications (patients with at least one complication): 12 (29.3) Mortality: 0 Anastomotic leak: 6 (14.6) Reoperation: 5 (12.2)	Deep SSI: 1 (1.2) Organ space SSI: 14 (17.1) Overall complications (patients with at least one complication): 28 (34.6) Mortality: 2 (2.4) Anastomotic leak: 17 (20.7) Reoperation: 15 (18.3)			
Osaka 2018[32] N Retrospective N Single institution N N	Robot (thoracic) with unknown method for abdomen vs thoracotomy and unknown for abdomen	LOS (med, range): 30 (22-35) Pulmonary complications: 3 (10) Anastomotic leak: 6 (20) SSI: 3 (10) Vocal cord palsy: 5 (16.7)	LOS (med, range): 17 (10-38) Pulmonary complications: 2 (6.7) Anastomotic leak: 3 (10) SSI: 0 Vocal cord palsy: 5 (16.7)		NR	NR	
Park 2016[31] N Retrospective N Single Institution N N	Transthoracic robot vs transthoracic VATS. In the robot cohort, 90% were McKeown and 10% were Ivor-Lewis. Abdominal portion in the robotic cohort was done		LOS: NR Readmissions: NR ICU stay: NR Respiratory complication: 9 (14.5) Anastomotic leak: 5 (8.1) RLN palsy: 8 (12.9)	LOS: NR Readmissions: NR ICU stay: NR Respiratory complication: 6 (14) Anastomotic leak: 1 (2.3) RLN palsy: 10 (23.8) Complication ≥		Median follow-up: 17 months 5-year survival: 69% 5-year freedom of locoregional recurrence: 88% 5-year freedom	Median follow-up: 26 months 5-year survival: 59% 5-year freedom of locoregional recurrence: 74% 5-year freedom of

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Short-term Outcomes LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			Long-term Outcomes Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
	robotically in 58%. In the MIE cohort, abdominal portion was laparoscopic in 49%, 19% were Ivor-Lewis, and 81% were McKeown.		Complication ≥ Clavien Dindo IIIa: 10 (16.1) 30-day mortality: 1 (1.6)	Clavien Dindo IIIa: 9 (20.9) 30-day mortality: 0		of distal recurrence: 72%	distal recurrence: 71%
Rolff 2017[33] N Retrospective N Single Institution N N	Open Ivor-Lewis vs Hybrid minimally invasive Ivor-Lewis (Robot in abdomen + thoracotomy)	LOS (med, range): 11.5 (8-101) Complications (Clavien-Dindo): ≥1: 122 (76) ≥2: 91 (57) ≥3: 51 (32) Pulmonary complications: 81 (51) Anastomotic leak: 11 (7) 30-day mortality: 3 (2) 90-day mortality: 5 (3)	LOS (med, range): 10 (8-69) Complications (Clavien-Dindo): ≥1: 37 (65) ≥2: 22 (39) ≥3: 14 (25) Pulmonary complications: 24 (43) Anastomotic leak: 4 (7) 30-day mortality: 0 90-day mortality: 3 (5)		NR	NR	
Sarkaria 2019[28] N Non-randomized prospective trial N Single	Robotic Ivor-Lewis (62/64) and McKeown (2/64) vs open Ivor-Lewis (103/106) Thoracoabdominal (3/106)	Readmissions: 17 (16) LOS (med, range): 11 (6-131) ICU admission: 19 (19.8) Complication (≥	Readmissions: 13 (20.4) LOS (med, range): 9 (5-17) ICU admission: 5 (7.8) Complication (≥		Functional Assessment of Cancer Therapy–Esophageal (FACT-E): no difference	Functional Assessment of Cancer Therapy–Esophageal (FACT-E): no difference	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
institution/8 surgeons (2 performed robotic) Y N	"All but 1 patient who underwent MIE did so via a total RAMIE approach."	grade 3): 55 (51.9) Pulmonary complication: 36 (34) Chylothorax: 1 (0.9) MACE (afib): 2 (1.9) Infection (any): 38 (35.8) Anastomotic leak: 10 (9.4) RLN palsy: 0 (0) 30-day mortality: 2 (1.9) 90-day mortality: 4 (3.8)	grade 3): 25 (39.1) Pulmonary complication: 9 (14.1) Chylothorax: 0 (0) MACE (afib): 1 (1.6) Infection (any): 11 (17.2) Anastomotic leak: 2 (3.1) RLN palsy: 2 (3.1) 30-day mortality: 1 (1.6) 90-day mortality: 1 (1.6)		between surgical approach	between surgical approach	
Tagkalos 2019[23] N Retrospective study of prospectively collected database Y Single institution/Single surgeon N N	Robot (thoracic and abdominal) Ivor-Lewis vs minimally invasive (VATS and laparoscopy) Ivor-Lewis		Matched LOS (med, range): 12 (7-59) ICU stay (med, range): 1 (1-43) Pneumonia: 6 (15) Anastomotic leak: 5 (12.5) Wound infection: 0 30-day mortality: 0 90-day mortality: 2 (5)	Matched LOS (med, range): 12.5 (9-54) ICU stay (med, range): 2 (1-17) Pneumonia: 7 (17.5) Anastomotic leak: 5 (12.5) Wound infection: 1 (2.5) 30-day mortality: 1 (2.5) 90-day mortality: 1 (2.5)		NR	NR

Author **Year** **Large Database (y/n)** **Study Design** **Propensity matching (y/n)** **#Institutions/ Surgeons** **US (y/n)** **VA (y/n)**	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
van der Sluis 2019[14] N RCT N Single institutions/2 surgeons N N	Open McKeown v Robot transthoracic with laparoscopic abdominal and open cervical portions	Readmissions: 4 (7.3) LOS (median): 16 ICU stay: 1 (median) Grade >2 complications overall: 44 (80) Grade >2 complications directly related to surgery: 44 (80) Pulmonary complications: 32 (58) Chylothorax: 12 (22) MACE: 26 (47) 30-day mortality: 0 (0) 60-day mortality: 1 (2) 90-day mortality: 1 (2) Anastomotic leak: 11 (20) Reoperations: 18 (32.7) Health-related QOL (6wk): 57.6 (50.6-64.6)	Readmissions: 6 (11.1) LOS (median): 14 ICU stay: 1 (median) Grade >2 complications overall: 34 (63) Grade >2 complications directly related to surgery: 32 (59) Pulmonary complications: 17 (32) Chylothorax: 17 (31.5) MACE: 17 (22) 30-day mortality: 1 (2) 60-day mortality: 3 (6) 90-day mortality: 5 (9) Anastomotic leak: 13 (24.1) Reoperations: 13 (24.1) Health-related QOL (6wk): 68.7 (61.5-75.9) Physical functioning		Median follow-up: 40 months for all both arms Median OS not reached in either arm (no differences between arms). Median DFS: 28 months	Median follow-up: 40 months for all both arms Median OS not reached in either arm (no differences between arms). Median DFS: 26 months	

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	Short-term Outcomes LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			Long-term Outcomes Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
		Physical functioning (6wk): 58.6 (51.1-66)	(6wk): 69.3 (61.6-76.9)				
Van Der Sluis 2018[35] N RCT N NR N N **Cost only**	Open transthoracic esophagectomy vs RAMIE	Cost: Euros: 39,463	Cost: Euros: 34,892				
Washington 2019[29] N Retrospective N Single institution/Single surgeon Y N	Robotic vs laparoscopic transhiatal esophagectomy		LOS: 9.9 (4) ICU stay: 1.7 (2.4) Anastomotic leak: 1 (5.6) Clavien Dindo ≥3: 2 (11.1) Mortality: 0 (0)	LOS: 9.8 (4.7) ICU stay: 2.7 (6.1) Anastomotic leak: 1 (5.6) Clavien Dindo >3: 1 (5.6) Morality: 1 (5.6)		Median OS not reached in either arm.	
Yang 2019[24] N Retrospective Y Single institution/Single surgeon	Robot McKeown (abd and thoracic portions) vs thoraco-laparoscopic McKeown		Matched LOS (med, range): 11 (6-54) ICU stay: 2 (0-15) Reoperation: 4 (1.5) Total complication: 122 (45) Pneumonia: 24 (8.9)	Matched LOS (med, range): 11 (4-94) ICU stay: 1 (0-61) Reoperation: 9 (3.3) Total complication: 101 (37.3) Pneumonia: 34 (12.5)		Matched N: 255 Total recurrence: 30 (11.8) Locoregional recurrence only: 9 (3.5)	Matched N: 254 Total recurrence: 26 (10.2) Locoregional recurrence only: 10 (3.9) Distal recurrence:

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
N N			Pleural effusion: 19 (7) Pneumothorax: 7 (2.6) Re-intubation/trach: 12 (4.4) Empyema: 9 (3.3) Arrhythmia: 9 (3.3) Cardiac arrest: 0 GI bleeding: 0 Anastomotic leak: 32 (11.8) RLN palsy: 79 (29.2) Wound infection: 2 (0.7) Chyle leak: 4 (1.5) 90-day mortality: 0	Pleural effusion: 31 (11.4) Pneumothorax: 11 (4.1) Re-intubation/trach: 12 (4.4) Empyema: 11 (4.1) Arrhythmia: 8 (3) Cardiac arrest: 2 (0.7) GI bleeding: 1 (0.4) Anastomotic leak: 39 (14.4) RLN palsy: 41 (15.1) Wound infection: 2 (0.7) Chyle leak: 2 (0.7) 90-day mortality: 2 (0.7)		Distal recurrence: 17 (6.7) Locoregional and distal: 4 (1.6) Mediastinal LN recurrence: 5 (2) Median follow up (med, IQR): 17.2 (1-33)	7 (2.8) Locoregional and distal: 9 (3.6) Mediastinal LN recurrence: 13 (5.3) Median follow up (med, IQR): 9.3 (1-33)
Yun 2019[25] N Retrospective (prospective database) Y Single institution/Single surgeon N N	Open (Ivor-Lewis 54.4%; McKeown 45.6%) vs robot-assisted (Ivor-Lewis 57.1%; McKeown 42.9%) (abdominal portion was either robot-assisted or laparoscopic)	Unadjusted LOS: 18.2 (15.4) ICU stay: 1.36 (1.97) 30-day mortality: 4 (1.7)	Unadjusted LOS: 16.5 (9.8) ICU stay: 1.08 (0.43) 30-day mortality: 0 (0)		IPTW-Adjusted 1-year disease-free survival: 53.2% 3-year disease-free survival: 45.6%	IPTW-Adjusted 1-year disease-free survival: 54.4% 3-year disease-free survival: 49.2%	
Zhang 2019[26] N	Robot-assisted Ivor-Lewis		LOS (med, IQR): 9 (8-12.3)	LOS (med, IQR): 9 (8-11.3)		NR	NR

Author Year Large Database (y/n) Study Design Propensity matching (y/n) #Institutions/ Surgeons US (y/n) VA (y/n)	**Comparisons (*eg*, open vs robot Ivor-Lewis; VATS vs robot McKeown, *etc*)**	**Short-term Outcomes** LOS, mean days (SD) Readmissions, (%) ICU stay Pulmonary complications (pneumonia, pneumothorax, PE, ARDS, pleural effusion) Chylothorax MACE Anastomotic leak, N (%) Reoperations, N (%) RLN palsy Mortality, N (%)			**Long-term Outcomes** Quality of life Overall survival Cancer-specific survival Follow-up time		
		Open	**Robot (RAMIE)**	**Other minimally invasive approach (VAMIE)**	**Open**	**Robot**	**Other minimally invasive approach (VAMIE)**
Retrospective Y Single institution/Single surgeon N N	(abdomen and thorax robot) vs thoraco-laparoscopic Ivor-Lewis		Total complications: 19 (28.8) Pneumonia: 4 (6.1) Chylothorax: 0 Anastomotic leak: 5 (7.6) RLN palsy: 4 (6.1) MACE: 5 (7.6) Wound infection: 1 (1.5) In-hospital mortality: 0 90-day mortality: 1 (1.5)	Total complications: 16 (24.2) Pneumonia: 5 (7.6) Chylothorax: 1 (1.5) Anastomotic leak: 3 (4.5) RLN palsy: 3 (4.5) MACE: 2 (3) Wound infection: 0 In-hospital mortality: 0 90-day mortality: 1 (1.5)			

APPENDIX H. OPERATIVE TECHNIQUES OF INCLUDED STUDIES

Study	Study Arm	Approach	Abdomen	Chest	Anastomosis
Chao 2018[16]	RAMIE	McKeown	Laparoscopic	Robotic	Circular stapled; cervical
	VAMIE	McKeown	Laparoscopic	VATS	Circular stapled; cervical
Chen 2019[17]	RAMIE	McKeown	NR	Robotic	Circular stapled; cervical
	VAMIE	McKeown	Laparoscopic	VATS	Circular stapled; cervical
Deng 2018[18]	RAMIE	McKeown	Robotic	Robotic	Circular stapled or handsewn; cervical
	VAMIE	McKeown	Laparoscopic	VATS	Circular stapled or handsewn; cervical
Espinoza-Mercado 2019[19]	RAMIE	NR	NR	NR	NR
	VAMIE	NR	NR	NR	NR
	Open	NR	NR	NR	NR
Gong 2020[34]	RAMIE	McKeown	Robotic	Robotic	Circular stapled; cervical
	VAMIE	McKeown	Laparoscopic	VATS	Circular stapled; cervical
	Open	McKeown	Laparotomy	Thoracotomy	NR
He 2018[20]	RAMIE	McKeown	Robotic	Robotic	End to side circular stapled; cervical
	VAMIE	McKeown	Laparoscopic	VATS	End to side circular stapled; cervical
He 2020[15]	RAMIE	McKeown	Robotic	Robotic	Cervical
	VAMIE	McKeown	Laparoscopic	VATS	Cervical
Jeong 2016[21]	RAMIE	McKeown	Laparotomy	Robotic	Cervical
	Open	Ivor-Lewis or McKeown	Laparotomy	Thoracotomy	Cervical or thoracic

Study	Study Arm	Approach	Abdomen	Chest	Anastomosis
Meredith 2019[27]	RAMIE	Ivor-Lewis	NR	NR	NR
	VAMIE	Ivor-Lewis	NR	NR	NR
	Open	Ivor-Lewis	NR	NR	NR
Motoyama 2019[30]	RAMIE	Ivor-Lewis	NR	Robotic	NR
	VAMIE	Ivor-Lewis	NR	VATS	NR
Naffouje 2019[22]	RAMIE	Ivor-Lewis	NR	NR	NR
	VAMIE	Ivor-Lewis	NR	NR	NR
Osaka 2018[32]	RAMIE	NR	NR	Robotic	NR
	Open	NR	NR	Thoracotomy	NR
Park 2016[31]	RAMIE	90% McKeown 10% Ivor-Lewis	58% robotic 42% open*	Robotic	90% cervical 10% thoracic
	VAMIE	81% McKeown 19% Ivor-Lewis	49% laparoscopic 51% open*	VATS	81% cervical 19% thoracic
Rolff 2017[33]	RAMIE	Ivor-Lewis	Robotic	Thoracotomy	NR
	Open	Ivor-Lewis	Laparotomy	Thoracotomy	NR
Sarkaria 2019[28]	RAMIE	62/64 Ivor-Lewis; 2/64 McKeown	NR	NR	NR
	Open	103/106 open Ivor-Lewis; 3/106 thoracoabdominal	NR	NR	NR
van der Sluis 2019[14]	RAMIE	McKeown	Laparotomy	Robotic	End to side handsewn; cervical
	Open	McKeown	Laparotomy	Thoracotomy	End to side handsewn; cervical
Tagkalos 2019[23]	RAMIE	Ivor-Lewis	Robotic	Robotic	Circular stapled; intrathoracic
	VAMIE	Ivor-Lewis	Laparoscopic	VATS	Circular stapled; intrathoracic

Study	Study Arm	Approach	Abdomen	Chest	Anastomosis
Washington 2019[29]	RAMIE	Transhiatal	Robotic	NA	Cervical
	VAMIE	Transhiatal	Laparoscopic	NA	Cervical
Yang 2019[24]	RAMIE	McKeown	Robotic	Robotic	Cervical
	VAMIE	McKeown	Laparoscopic	VATS	Cervical
Yun 2019[25]	RAMIE	57.1% Ivor-Lewis 42.9% McKeown	Robotic or Laparoscopic	Robotic	Circular stapled; cervical
	Open	54.4% Ivor-Lewis 45.6% McKeown	Laparotomy	Thoracotomy	Circular stapled; cervical
Zhang 2019[26]	RAMIE	Ivor-Lewis	Robotic	Robotic	End to end both circular stapled + handsewn; intrathoracic
	VAMIE	Ivor-Lewis	Laparoscopic	VATS	End to end circular stapled; intrathoracic

APPENDIX I. CITATIONS FOR EXCLUDED PUBLICATIONS

<u>Intervention (n=6)</u>

1. Luketich JD, Pennathur A, Franchetti Y, et al. Minimally invasive esophagectomy: results of a prospective phase II multicenter trial-the eastern cooperative oncology group (E2202) study. *Ann Surg.* 2015;261(4):702-707.

2. Miyasaka D, Okushiba S, Sasaki T, et al. Clinical evaluation of the feasibility of minimally invasive surgery in esophageal cancer. *Asian J Endosc Surg.* 2013;6(1):26-32.

3. Mu J, Yuan Z, Zhang B, et al. Comparative study of minimally invasive versus open esophagectomy for esophageal cancer in a single cancer center. *Chin Med J (Engl).* 2014;127(4):747-752.

4. Romero D. Hybrid minimally invasive surgery overtakes open surgery. *Nat Rev Clin Oncol.* 2019;16(3):144.

5. Xie MR, Liu CQ, Guo MF, et al. Short-term outcomes of minimally invasive Ivor-Lewis esophagectomy for esophageal cancer. *Ann Thorac Surg.* 2014;97(5):1721-1727.

6. Yanasoot A, Yolsuriyanwong K, Ruangsin S, et al. Costs and benefits of different methods of esophagectomy for esophageal cancer. *Asian Cardiovasc Thorac Ann.* 2017;25(7-8):513-517.

<u>Comparison (n=3)</u>

1. Mori K, Yamagata Y, Aikou S, et al. Short-term outcomes of robotic radical esophagectomy for esophageal cancer by a nontransthoracic approach compared with conventional transthoracic surgery. *Dis Esophagus.* 2016;29(5):429-434.

2. Na KJ, Park S, Park IK, et al. Outcomes after total robotic esophagectomy for esophageal cancer: a propensity-matched comparison with hybrid robotic esophagectomy. *J Thorac Dis.* 2019;11(12):5310-5320.

3. Worrell SG, Bachman KC, Sarode AL, et al. Minimally invasive esophagectomy is associated with superior survival, lymphadenectomy and surgical margins: propensity matched analysis of the National Cancer Database. *Dis Esophagus.* 2020.

<u>Small sample size (n=1)</u>

1. Raja K. Minimally invasive esophagectomy after neoadjuvant chemoradiotherapy using cross regimen for locally advanced esophageal cancer. *Gut.* 2019;68:A69.

<u>Not original research (n=1)</u>

1. Inderhees S, Dubecz A. [Hybrid minimally invasive esophagectomy for esophageal cancer-MIRO trial]. *Chirurg.* 2019;90(8):677.

Duplicate or studies with a large overlap of patients from the same data source (n=11)

1. Li B, Li Z. Early results of robot assisted esophagec-tomy compared with conventional thoracoscopic approach for esophageal cancer: A randomized clinical trial. *Diseases of the Esophagus.* 2018;31:2.

2. Tagkalos E, Goense L, Hoppe-Lotichius M, et al. Robot-assisted minimally invasive esophagectomy (RAMIE) compared to conventional minimally invasive esophagectomy (MIE) for esophageal cancer: a propensity-matched analysis. *Dis Esophagus.* 2020;33(4).

3. Lin Y, Deng H. Comparison of short-term outcomes between RAMIE and VAMIE in treatment middle thoracic esophageal cancer. *Diseases of the Esophagus.* 2018;31:112.

4. Grimminger PP, Tagkalos E, Hadzijusufovic E, et al. Change from Hybrid to Fully Minimally Invasive and Robotic Esophagectomy is Possible without Compromises. *Thorac Cardiovasc Surg.* 2019;67(7):589-596.

5. Deng HY, Huang WX, Li G, et al. Comparison of short-term outcomes between robot-assisted minimally invasive esophagectomy and video-assisted minimally invasive esophagectomy in treating middle thoracic esophageal cancer. *Dis Esophagus.* 2018;31(8).

6. Halpern AL, Friedman C, Torphy RJ, et al. Conversion to open surgery during minimally invasive esophagectomy portends worse short-term outcomes: an analysis of the National Cancer Database. *Surg Endosc.* 2019.

7. Meredith K, Blinn P, Maramara T, et al. Comparative outcomes of minimally invasive and robotic-assisted esophagectomy. *Surgical Endoscopy.* 2020;34(2):814-820.

8. Van Der Sluis PC, Van Der Horst S, May A, et al. Robot-assisted minimally invasive esophagectomy versus open transthoracic esophagectomy for esophageal cancer: A randomized controlled trial. *Surgical Endoscopy.* 2018;32:S475.

9. Weksler B, Sullivan JL. Survival After Esophagectomy: A Propensity-Matched Study of Different Surgical Approaches. *Ann Thorac Surg.* 2017;104(4):1138-1146.

10. Yerokun BA, Sun Z, Yang CJ, et al. Minimally Invasive Versus Open Esophagectomy for Esophageal Cancer: A Population-Based Analysis. *Ann Thorac Surg.* 2016;102(2):416-423.

11. Yun JK, Lee IS, Gong CS, et al. Clinical utility of robot-assisted transthoracic esophagectomy in advanced esophageal cancer after neoadjuvant chemoradiation therapy. *J Thorac Dis.* 2019;11(7):2913-2923.

Unavailable (n=1)

1. Götzky K, Jähne J. [Minimally invasive esophagus resection: Results of a prospective multicenter study]. *Chirurg.* 2015;86(9):898.