Peer Review File

Article information: https://dx.doi.org/10.21037/jtd-23-1570

Reviewer A

Comment 1.1: ***"****I would like to suggest some points to improve this paper."*

Response 1.1: We thank the reviewer for noting these specific points. We have edited the suggestions in the manuscript.

The following changes are made in the manuscript:

[Introduction, 2nd paragraph]: thoracic outlet syndrome (TOS)

[Methods, 1st paragraph]: TOS

[Robotic first rib resection for TOS, 1st paragraph]: TOS

[Robotic first rib resection, 2nd paragraph]: two-dimensional

[Robotic first rib resection, 3rd paragraph]: nTOS

[Robotic first rib resection, 3rd paragraph]: vTOS "*PSS procedure is the same as vTOS, so it was replaced with vTOS only"*

[Robotic chest wall resection, 3rd paragraph]: Many isolated case reports have shown the feasibility of this approach for treating other benign chest wall tumors, such as fibrous dysplasia of the second rib, as reported by Liu et al. They indicated an operative time of 135 minutes and a hospital stay of 2 days without complications.

[Lobectomy after neoadjuvant therapy, 1st paragraph]: non-small cell lung cancer (NSCLC)

[Esophagectomy and esophageal enucleation, 2nd paragraph]: Ivor-Lewis

[Robotic surgery for lung transplant, 1st paragraph]: chronic obstructive pulmonary disease (COPD)

[Robotic surgery for lung transplant, 2nd paragraph]: COPD

Reviewer B:

Comment 2.1: *"Concerning the definition of complex surgeries, why not having included "complex segmentectomies" with 2 intersegmental planes? Maybe we can regret the lack of paragraph dealing with complex segmentectomies which are the first complex disease encountered for thoracic surgeons. A paragraph dealing with the lack of a certified training program can be interesting to explain the difficult decision to validate a robotic approach for these diseases."*

Response 2.1: We thank the reviewer for the insightful input and addition. We agree and now have it as a subsection in the main body.

The following changes are made in the manuscript:

[Robotic complex segmentectomies across multiple segmental planes]: Recent trials have demonstrated the role of sub-lobar resections, particularly segmentectomy in the management of early-stage lung cancer.(61, 62) Anatomic segmentectomies are technically more challenging than lobectomies, and complex segmentectomy (also known as atypical segmentectomy) are more difficult than simple (typical) segmentectomy. The robotic approach facilitates performing complex segmentectomies especially those that have multiple intersegmental planes, due to the platform's increased dexterity and advanced imaging capability including the seamless integration of FireFly technology to visualize the intersegmental plane.

In one study from MD Anderson Cancer Center, Zhou et al. attributed the increased frequency of anatomic segmentectomy to the increase in their overall robotic operations, and demonstrated that the proportion of complex segmentectomies had increased concurrently. At their institution, the VATS approach was largely utilized for simple segments, and more complex segments were performed robotically.(63) The robotic approach was associated with longer operative times but had less estimated blood loss, shorter hospitalization, and required no conversion to VATS or thoracotomy.(63) Several other studies have found similar results.(64)

As is the case with complex operations, there is a learning curve to mastery. Zhang et al. analyzed the learning curve of complex robotic segments.(65) In their report, they found that technical competency ensuring safe and comparable outcomes can be achieved after the 40th operation. As experience increases, operative time and intraoperative blood loss decrease.

In terms of cost, some studies have shown the robotic approach to be more expensive while others have shown it to be cost effective.(11, 66-70) In one study from the University of Alabama at Birmingham, Nasir et al. demonstrated that the robotic approach is associated with lower direct costs but higher indirect costs, and although it is more costly overall, it remained profitable for the hospital.(67) Another study from Italy, showed similar results.(66) The majority of the cost burden appears related to upfront purchasing cost, maintenance, depreciation, and robotic disposables. The profitability is largely from the reduction of hospital stays and personnel cost which in turn results in robotic segmentectomy being cost-effective. All in all, the advantages of the robotic approach in allowing these technically complexity resections with minimal morbidity cannot be overstated.

Comment 2.2: *"Nevertheless, need to be more cautious about the study of Li et al. dealing with robotic airway surgery under non-intubated ventilation. Line 248 needs to start a new paragraph and to highlight the consequence of a longer surgery, longer anesthesia, longer time on lateral decubitus and its complications.*

Response 2.2: We thank the reviewer for the notice. We have reviewed the reference again, along with the editorials associated. As a result, we have added a new paragraph that mentions possible disadvantages of such a procedure with a lengthy operative time.

The following are changes made in the manuscript:

[Robotic airway and sleeve lung resection, 4th paragraph]: Notably, no postoperative complications were reported, and patients underwent satisfactory short-term follow-up (1 month). Although innovative, the non-intubated nature of their description introduces several challenges some of which may be viewed as unnecessary. These include physiologic and anesthesiologic concerns, such as hypoxia, hypercapnia, and uncontrolled cough. Not to mention, the risk of life-threatening bleeding from a thoracic operation in the absence of a secure airway.(52) As we discuss the role of emerging technologies, and adopt minimally invasive robotic approaches to complex operations, it is important not only to demonstrate feasibility, but also safety and reliability.(53)

Comment 2.3: *"But the true challenge is the lymph node dissection from vessels when there was a node invasion before the neoadjuvant therapy. In this condition, a surgical movie or picture are welcome."*

Response 2.3: We thank the reviewer for the detailed description and suggestion. We agree with the reviewer. We do note in our manuscript that >30% nodal regression is associated with increased difficulty. We have added a reference to a published video from our group for a lobectomy after neoadjuvant chemoradiation for cT3invasionN2 lung cancer. See comment response 2.5.

The following are changes made in the manuscript:

[Robotic chest wall resection, 2nd paragraph]: A step-by-step video for our technique is published elsewhere.(26)

[Robotic chest wall resection, 3rd paragraph]: Other examples include a robotic resection of rib—invasive paraganglioma in the posterior mediastinum, a solitary fibrous tumor, and a second rib osteochondroma.(28-30)

Comment 2.4: "*But in your review, you didn't' highlight the real and true advantage of the robotic platform for these complex diseases. Because as we have reported in some articles, the real advantage of the robotic platform is to allow the surgeon to be like in an open procedure but with a closed chest, and with the advantages of a minimally invasive approach including a lower morbidity and preserved long term surgery. Nevertheless, don't forget that the robot is just a tool, like the surgical knife, or scissors to perform the indicated gesture or act according international guidelines. For lung cancer surgery, we are first "cancer fighter" before "just technician"!"*

Response 2.4: We thank the reviewer for their insights and for directing us to the listed references. We now discuss this further in the summary.

The following are changes made in the manuscript:

[**Summary and Limitations, 1st paragraph]:** To summarize, robotic surgery provides a multitude of benefits when compared to VATS or open approaches across many types of operations. In each section of this narrative review, we highlight the strengths and advantages pertaining to that complex presentation. In addition to the aforementioned advantages of better visualization, enhanced maneuverability, and reduced surgeon fatigue, robotic surgery allows the surgeon to "mimic an open approach," and provide the surgeon with the rare ability to be inside the chest without opening it.(105-107)

Comment 2.5: *"More pictures and videos of each disease are welcome."*

Response 2.5: We thank the reviewer for their suggestion. We have added references to two video publications for chest wall resection and lobectomy following neoadjuvant therapy from our group. See references (26) and (28).

Reviewer C

Comment 3.1: *"The content of the paper is coherent and well described for current status of robotic surgery. This paper is worthy for accept."*

Response 3.1: We thank the reviewer for their kind and encouraging input. We appreciate their acknowledgment and positive feedback.

Reviewer D

Comment 4.1; *"I have no doubt that Odeh and cowriters of this narrative review have worked extremely hard to put together this paper. My overall opinion is that the authors are ironically tackling too much in one setting. On several separate occasions I have tried to read and reread their paper. In general, it does represent a review of a considerable number of sources. However, it is not clear for each section, how they selected the articles to present. There is a certain systematic approach that is really missing. To report individual case reports among other meta-*

analyses and larger scale papers seems unusual. Furthermore, there is no clear understanding of which articles get cited and which do not. Why does a case report carry as much weight as a larger study or meta-analysis that was executed with more significant scientific rigor."

Response 4.1: We thank the reviewer for their constructive feedback. In writing this manuscript, we performed a narrative review focusing on several sections that we believe are complex thoracic operations, which was at the request and invitation by the journal. As this is a narrative review that is largely focused on innovation and the application of technological advancements to complex thoracic problems; it would actually be necessary to include case reports/series for more recent advancements (i.e., robotic transplant, robotic chest wall … etc) as these are not widely nor commonly performed just yet. Omitting case reports/series from this review would eliminate these sections as there are no larger scale studies. On the other hand, for things like robotic esophagectomy where there is an abundance of stronger data; meta-analyses would be the source material for this review.

We have now clarified our methods section. Following article selection from the primary database search, another search was done through the reference list of these articles to find more related literature. As to the weight of each article found, we found it more important to report findings found in each, regardless of type. Case reports serve well for more initial experiences or rare operations. As such, we have decided to add a couple of edits to the manuscript. Please see response 5.6 for full limitation paragraph.

The following changes are made in the manuscript:

[**Materials and Methodology, 1st paragraph]:** Databases searched included PubMed. Following retrieval of all relevant literature, a search in the reference list for each article was done. Anything that fit the inclusion criteria found in the reference list was added and screened.

[Summary and Limitations, part of 4th paragraph]: Finally, as this is a narrative review that is largely focused on innovation and the application of technological advancements to complex thoracic problems; we believe it necessary to include small case reports and case series for operations where the use of the robotic approach may have been innovative at the time, and limited data existed.

Comment 4.2: *"I understand that it is a narrative review, but a narrative review still requires some extent of methodology to present. Many paragraphs of from each section lack focus. As such, many of their concluding paragraphs for each section lacks any meaningful impact."*

Response 4.2: We thank the reviewer for their honest input. We have added a unifying summary section that also covers the limitations.

Please see Response 2.4 and 4.1 in addition to the below changes.

The following changes are made in the manuscript:

[**Summary and Limitations, 2nd and 3rd paragraphs]:** In addition, robotic surgery also offers better pain control, faster recovery rates with improved cosmesis. In most procedures, it proved to have comparable short-term outcomes with its VATS counterpart. For specific procedures, such as lobectomy following neoadjuvant therapy, and esophagectomy, robotic surgery allows for better lymph node harvest and handling of complex anatomy and nodal regression.

On the other hand, the robotic platform does have some important disadvantages. Across the majority of these complex operations, cost was a major concern, limitation and potential obstacle for increased adoption. Although some reports demonstrated a net profit at the hospital level, the upfront cost and other hidden costs need to be considered. For many applications, there is no data on cost yet. Although outcomes are comparable (or better), robotic surgery is associated with

longer operative times compared to other approaches, and a real learning curve that varies between indications. Although some require a few operations to start achieving similar outcomes, a few operations necessitate a large number before the surgeon reaches proficiency and comparable results.

Comment 4.3: *"They used specific words in their search, but for some searches massive omissions such as the words "oncology" or "cancer surgery" were missing. These glaring omissions make the reader concerned as to how comprehensive their search was."*
Response 4.3: We thank the reviewer for this comment. The aim of this invited narrative review was largely technical and not limited to oncology or cancer. For each section in the manuscript, we used a procedure-oriented search strategy rather than a pathology-oriented strategy. The search strategy for each section is listed in **Table 1.**

Comment 4.4: *"What also detracts from their paper is that they have several grammatical and spelling mistakes throughout."*
Response 4.4: We thank the reviewer for their careful review. We apologize for those typographical errors and have fixed them throughout the manuscript.

Comment 4.5: *"One option is to limit the types of operations they are including (perhaps even author several different manuscripts) and perform a more rigorous review of them with hard criteria for inclusion, exclusion, and analysis. The other option is to frame each operation with the goal of highlighting how the robotic approach actually improves upon what already exists. It seems as though they have done the work, it is just that their presentation needs a substantial work in refining and polishing."*
Response 4.5: We thank the reviewer for their detailed feedback and thorough suggestions. The authors were invited to submit this narrative review with the current title spanning several topic areas. We believe that this review demonstrates the role of the robotic approach for all included operations and provides a comprehensive big-picture overview of the current complex robotic landscape. We hope this provides readers with inspiration for further research, and even perhaps clinical exploration of some of these indications. Please see responses 2.4 and 4.2.

Reviewer E

Comment 5.1: *"Consider incorporating a sentence that succinctly summarize the primary benefits of robotic surgery, as this is a noteworthy finding that would captivate readers. This summary could effectively highlight the key advantages observed consistently across the included studies. Providing two to three key statistics from the results, such as operative times, length of hospital stays, and complication rates, would offer readers valuable insights into the overall outcomes gleaned from various studies under review."*
Response 5.1: We thank the reviewer for their great input. We have modified our abstract to summarize the key findings.

The following changes are made in the manuscript:
[Abstract, Key Contents and Findings]: Robotic surgery has several advantages when compared to video-assisted and open thoracoscopic surgery. These include better pain control and aesthetic outcome, improved handling of complex anatomy, enhanced access to lymph nodes, and faster

recovery rates. Although it is associated with longer operative time, robotic surgery has comparable morbidity rates.

Comment 5.2: *"The introduction offers valuable context, but it could be enhanced by further detailing the hypothesized advantages of robotic surgery, particularly in handling complex cases. This addition will serve to reinforce the rationale for focusing on robotic approaches for complex cases. It is advisable to cite more sources when asserting the advantages of robotic surgery. This would add credibility to the claims and provide readers with supporting evidence."*
Response 5.2: We thank the reviewer for their suggestion. We have added more citations that discuss the advantages of robotic surgery, as well as hypothesized advantages that the literature would discuss later in the review. Please see response 5.3 for more of the added references.

The following changes are made in the manuscript:
[Introduction, 1st paragraph]: Notable improvements include unparalleled three-dimensional (3D) views with steady magnification, wristed instruments providing enhanced maneuverability across several degrees of freedom, which prove extremely useful in addressing issues within the 3D anatomy of the chest, lung, esophagus and mediastinum. Not to mention, the benefits on surgeon longevity, and reduced surgeon fatigue.(2-4) In theory, robotic surgery would also reduce postoperative pain, and in turn shorten hospital stays. It would also have similar, if not better, short and long-term outcomes.

Comment 5.3: *"It would be beneficial to briefly mention the common limitations in pertinent literature in order to emphasize the gaps that the current review aims to address. This will help readers understand the unique contributions of your work.*
Response 5.3: We thank the reviewer for their informative addition. We were invited by the journal to contribute this narrative review article. Although prior studies have demonstrated and established the role for the robotic approach in many of these complex operations and disease presentations, it has done so in isolated silos for each topic. It is prudent to review the application of the robotic approach across multiple operations within a discipline as there are many areas of overlap, and technical considerations that can be shared or improved upon.

The following changes are made in the manuscript:
[Introduction, 3rd paragraph]: Although prior studies have demonstrated and established the role for the robotic approach in many of these complex operations and disease presentations, it has done so in isolated silos for each topic.(1, 5-12) It is prudent to review the application of the robotic approach across multiple operations withing a single discipline with a collective eye, as there are many areas of overlap, and technical considerations that can be shared or improved upon.

Comment 5.4: *"Consider providing a brief description of the data items that were extracted from the included studies (e.g., year of publication, study design, sample size, specific outcomes of interest). Additionally, consider stating if any quality assessment was conducted. This level of detail would enhance the transparency and rigor of your review."*
Response 5.4: We thank the reviewer for their constructive suggestion. We have added general information about the references used in the table summary for each subtopic. It would be difficult to add individualized information about each reference, but adding specific outcomes of interest in the method section is a valuable input; therefore, we have added that to the manuscript. Quality assessment included screening of literature by 2 authors.

The following changes are made in the manuscript:

[Search Strategy, 2nd paragraph]: Specific keywords, most common being "robotic surgery" were incorporated with each subtopic. The "advanced" feature was utilized with every search, along with "AND" and "NOT" terms. Specific outcomes of interest included "operative time," "length of hospital stay," "complications," "lymph node harvest," and "30-day and 90-day mortality." If found, these would be reported. A table summary dictating the details of search criteria for each subtopic can be found in **Table 1**.

Comment 5.5: *"It would be beneficial to include the total number of studies included for each surgical procedure under review. This information would provide readers with a clear understanding of the breadth of evidence base. The overview of studies for each procedure is insightful. Consider presenting some results in tables to effectively summarize sample sizes, key findings, and relevant outcomes. This approach would assist readers in making comparisons across the various procedures examined."*

Response 5.5: We thank the reviewer for their valued suggestion and input. We have a created a new summary table. We condensed all tables into 1 table. This table reflects the search strategy and results. You can find all relevant information in **Table 1.**

Comment 5.6: *"Ensure the reporting of results is standardized across the different surgical topics. For instance, maintain consistency in reporting sample sizes and key statistics. This uniformity in reporting will enhance the clarity and accessibility of your findings for readers."*

Response 5.6: We thank the reviewer for their recommendation. Considering each study reports data differently, especially with mean and median values, it was difficult maintain uniform reporting. However, we have incorporated similar data, if found, in each section. We have also created a summary table. Please see response 5.5

Comment 5.7: *"To facilitate a more comprehensive interpretation of results, it is advisable to provide a detailed discussion of the limitations within the overall evidence base. Additionally, consider addressing limitations of the review process itself, such as the exclusion of non-English studies, to ensure transparency and thoroughness.*

Response 5.7: We thank the reviewer for their valuable suggestion. We agree and have now added a limitation section before the conclusion:

The following changes are made in the manuscript:

[**Summary and Limitations, 4th paragraph]:** This review has various limitations. Firstly, a good percentage of literature included retrospective studies. These studies are subject to both selection and confounding bias, which could alter the results reported. Some studies have mentioned this, but others did not, meaning there was no way to document if it was accounted for. Second, several studies in the same category are authored by the same author, as they followed up on their previous studies. This raises concerns about reporting bias, affecting the results reported. Third, our inclusion criteria may have been too general, with need to include more specific parameters for literature retrieval. For example, there was a huge variation in the sample size between some studies, meaning a clear definition of the minimum or maximum size could have been implemented. Also, the exclusion of non-English studies could have removed literature that was prominent and beneficial for this review. However, we believe our review encompasses the latest updates on robotic surgery implementation on various complex thoracic operations, with relevant and cohesive reports. Finally, as this is a narrative review that is largely focused on innovation and the

application of technological advancements to complex thoracic problems; we believe it necessary to include small case reports and case series for operations where the use of the robotic approach may have been innovative at the time, and limited data existed.

Comment 5.8: *"To offer valuable insights and direction for the field, consider expanding upon the future research needs in the domain of robotic surgery, specifically in the context of complex thoracic procedures. Such an exploration would contribute to the ongoing development of this area and provide a useful guide for researchers and practitioners."*
Response 5.8: We thank the reviewer for the beneficial advice. We have added a new section that discusses the future direction of robotic surgery.
[Future Direction]: First of all, the robotic platform used almost exclusively in this narrative review is the DaVinci platform by Intuitive. The newest product from this company is the Single Port (SP) system which has not yet become mainstream for thoracic operations.(95,108) The SP can introduce several advantages owing to its single port design, although it would most likely require sub-xiphoid placement rather than a trans-thoracic intercostal placement. Several other companies are also introducing their own robotic platforms such as Versius by CMR Surgical (Cambridge, UK), Hugo by Medtronic (Dublin, Ireland) and Ottave by Johnson & Johnson Auris (Redwood City, CA, USA) to name a few.(1)
The dramatic evolution of artificial intelligence over the past few years may even suggest a future where robots become autonomous during the entirety of the operation. Currently, as seen in Senhance surgical system (Durham, NC, USA), AI integration moves the camera in response to surgeon's movement, provides 3D measurement and digital tagging, and anticipates what the surgeon aims to locate and adjusts accordingly.(109) Other avenues of robotic surgery evolution include miniaturized platforms that allow for small robotic devices, and soft robotics that conform to curvilinear paths in space.

Reviewer F

Comment 6.1: *"I think this narrative review shows gross overview about the broad application of robotic technology in the fields of thoracic surgery."*

Response 6.1: We thank the reviewer for their kind words and input.