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Peer Review File

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Reviewer 1

Performing a complete endoscopic surgery using only port incisions is an excellent operation with a high degree of difficulty, and I would like to commend the authors for the successful operation and good video. The most distinctive feature of this operation is that the procedures were made easily by using a barbed suture such as V-loc.

However, as mentioned earlier, the reduction of total hospital costs thanks to the fact that robot surgery shortens the hospitalization period cannot be generalized because the situation is different in different countries. Moreover, it seems that cost analysis should be included to prove such a point.

There are many groups that perform totally endoscopic mitral valve repair without using the da Vinci robot, so it is difficult to say that this is a very unique case. Also, it seems that the authors think of NeoChords as a special instrument, but it is probably mistaken for the NeoChord (transapical device) product. In the video, the neochords they used are the commonly used Gore-Tex suture with pledget that most mitral repair surgeons use.

Reply: Thank you for this clarification. We have adjusted the spelling to “neochords” throughout the manuscript to better reflect the artificial chords we describe here.

Reviewer 2

Good Case and excellent technique. However, the paper does not provide anything novel that is known in the field of minimally invasive surgery. These techniques have been already described.

Reply: Thank you for the observation. In this invited manuscript, we were asked to outline our approach to totally endoscopic robotic mitral valve surgery. As such, we hoped to educate the reader as to our approach, particularly with respect to similar surgeries with an open thoracotomy or sternotomy approach.

Reviewer 3

thank you for sharing with us your novel and certainly impressive technique. Several aspects of the content as well as the language used will need major revisions before considering for publication.

I. Video

- Port placement picture –please, add the location of the various ports (not mentioned anywhere in the manuscript either)

Reply: This is an important clarification; thank you for this comment. We have added commentary to the video in our port placement slide detailing the specific spaces for port placement. We have also added the following to our manuscript for clarification:

“In preparing the patient for the robotic console, an eight-millimeter robotic camera port was placed in the right 4th or 5th intercostal space just anterior to the anterior axillary line. The importance of the specific space is secondary to the importance of centering the camera port between the sternal notch and xyphoid process. Four additional eight-millimeter ports were placed: a robotic right arm port (7th intercostal space at anterior axillary line), left arm port (3rd intercostal space just anterior to anterior axillary line), atrial retractor port (5th intercostal space just medial to midclavicular line), and air-seal working port (5th intercostal space at anterior axillary line).”

- We suggest more titles or slides describing the various steps in the video to allow the viewers to better follow (as the commissural plication stitch sign)

Reply: In the updated version of our video, we have provided titles for most all of the major steps of the procedure to alert the viewer. We hope this makes the video easier to follow.

Abstract

Please, consider completely revising the abstract in order to optimize the content as well as the sentence structures to allow better flow when reading.

Reply: Thank you for this feedback. The structure of the abstract has been dramatically overhauled to better reflect the technical aspects of the procedure.

Manuscript

Suggested abbreviation of totally endoscopic mitral valve repair – teMVR

Reply: All appearances of the original rMVR (robotic mitral valve repair) have been adjusted to reflect the recommendation (see first paragraph of Introduction for the first appearance of this abbreviation).

“Finally, totally endoscopic robotic mitral valve repair (teMVR) remains the least invasive of the several approaches to MVR.”

In the introduction, you briefly mention the learning curve. While there is no doubt that the advanced totally endoscopic approach offers the least invasive way to operate on the mitral valve, could you please add some more details about the learning curve?

Reply: See new commentary in Introduction on page 4 regarding the learning curve in teMVR. In most studies, this is concluded based on improving length of cardiopulmonary bypass and aortic cross clamp times as the robotic team gains experience. We also cite a 2021 Toolan et al. study noting the increased learning curve on the robotic platform.

“Despite these benefits, there does appear to be a learning curve associated with the implementation of a robotic program as measured by longer cardiopulmonary bypass and aortic cross-clamp times early in program implementation (5). As such, case volume is essential for success of teMVR to successfully navigate the learning curve (6).”

Line 92 – please revise “in this piece…the approach of…”

Reply: Revised for better efficiency and clarity (see final line of Introduction).

“Here we describe the approach to teMVR, an evolving option for the management of degenerative mitral valve disease and mitral regurgitation (Video 1).”

Since you describe a single particular technique – we suggest the heading to be a surgical technique as a singular and not plural as techniques
Reply: Section heading adjusted to singular.

In the initial description of the port placement – besides the camera port – please indicate where you elect to place the remaining robotic ports (intercostal space, etc)
Reply: Each port placement is now more specifically described in the “Surgical Technique” section (see second paragraph of “Surgical Technique” section on page 5).

“In preparing the patient for the robotic console, an eight-millimeter robotic camera port (which serves as the working port) was placed in the right 4th or 5th intercostal space just anterior to the anterior axillary line. The importance of the specific space is secondary to the importance of centering the camera port between the sternal notch and xyphoid process. Four additional eight-millimeter ports were placed: a robotic right arm port (7th intercostal space at anterior axillary line), left arm port (3rd intercostal space just anterior to anterior axillary line), atrial retractor port (5th intercostal space just medial to midclavicular line), and air-seal working port (5th intercostal space at anterior axillary line).”

Line 109 should be “via Seldinger technique”
Reply: Revised accordingly (see “Port placement” section).

Please, elaborate on the eligibility of the patients – who can and who cannot receive a totally endoscopic mitral valve repair (body habitus, comorbidities, re-do, etc)

Reply: A paragraph of commentary has been added on eligibility considerations for patients (see second paragraph of “Comment” section.)
“There are some eligibility considerations for who should undergo teMVR …”

Please, elaborate on the experience and technique of using endoballoon versus a formal crossclamp of the aorta. Do you use endoballoon on all patients – what if they have moderate to severe aortic regurgitation? Do you maintain particular mean arterial pressure when using endoballoon? Do you request any particular preoperative preparation or imaging study when use the endoballoon?
Reply: Thank you for this comment; we have expanded our discussion of endoballoon use by adding a paragraph outlining contraindications, preoperative imaging, and mean arterial pressure during its use.

“Due to its ability to facilitate an entirely transcatheter approach to CPB…”

Regarding mean arterial pressure, we attempt to maintain it between 60-90 mmHg. This is secondary to the importance of administering antegrade cardioplegia at a rate that keeps aortic root pressure less than systemic pressure to avoid distal migration of the endoballoon. Likewise, we

have added this note to the "Induction of cardioplegia, atriotomy, and left atrial appendage closure" section:

"Antegrade cardioplegia was delivered at a rate to avoid distal migration of the endoballoon by keeping the aortic root pressure less than the systemic pressure."

Where do you elect to open the pericardium?
Reply: Thank you for this comment. We have added the following to the "Intercostal cryoablation and pericardiectomy" section of the manuscript to elaborate on our approach to pericardiotomy.

"The right lateral surface of the pericardium was incised, with specific attention paid to avoiding phrenic nerve injury."

Over aorta down to diaphragm >2cm from phrenic
Line 125 - "CPB is initiated with endoballon" – likely the CPB is initiated first and subsequently the heart is arrested with endoballoon
Reply: Adjusted for clarity; see commentary on page 6 ("CPB was initiated and the heart was arrested…")

What sutures are used for the neocords and what technique is used (figure of eight?)
Reply: Thank you for this comment. We have revised the spelling in the manuscript to "neochords."

Please, comment on the sizing of the annuloplasty band – do you use true size or you prefer to downsize and why?
Reply: Our approach to sizing has been added to the "Mitral valve repair" section:

"True sizing is performed in cases of mitral prolapse. However, the decision is made on a case-by-case basis with the overall goal of avoiding systolic anterior motion."

Please, comment about your process of deairing the heart – how and when are you doing it? Is the endoballon sufficient to deair considering the small lumen compared to the conventional antegrade needle?

Reply: Thank you for this comment. Insufflation utilized by the totally endoscopic port-only approach creates a nearly complete CO_2 environment in the intrathoracic operating field.

For clarity, we have added the following discussion of de-airing to the "Mitral valve repair portion of the manuscript:

"Afterwards, the heart was de-aired. On the robotic platform with a totally endoscopic approach, it should be noted that insufflation occurs in a near-complete CO_2 environment, which should be protective of stroke. Moreover, positioning patients in reverse Trendelenburg elevates the ascending aorta in relation to the rest of the heart. As the atrium was closed, the aorta was passively de-aired. A vent was placed in the left apex and left until no air remained. It was at this point that the…"

Could you please add a single short sentence about your rational to perform loose pericardial closure and what to pay attention when doing so (phrenic nerve injury etc.)
Reply: Thank you for this comment. We have added the following sentence to the "Mitral valve repair" portion of the manuscript:

"When performing loose pericardial re-approximation, which is used to create a well-identifiable landmark in the case that re-operation is required, it is crucial to avoid phrenic nerve injury."

What is the rational to remove the arterial cannula during the administration of protamine versus after complete heparin reversal?
Reply: The answer to the posed questions has been noted in the "Decannulation and completion" section:

"The rational for removing the arterial cannula during the administration of protamine versus after complete heparin reversal reflects an effort to avoid ischemia or potential clot in the leg. Leaving the wire inserted allows the cannula to be re-inserted should a protamine reaction occur."

What type and size chest tube do you use at the end of the procedure?
Reply: The type and size of chest drain was inserted into the "Decannulation and completion" section of the manuscript:

"…and a 24 French Ethicon BLAKE® silicone drain was inserted at the end of the procedure."

Line 160 - "discharged on postoperative day one or two"
Reply: Thank you for this catch; the revision has been made (see first paragraph of "Comment" section on page 7).

Line 162 – are the quality of life improvements secondary to the short hospital stay or because of the lack of sternotomy and associated morbidity and associated with chest wall destabilization?
Reply: Thank you for this clarifying comment. Both aspects contribute to quality-of-life improvements, however in this context we were referring specifically to length-of-stay considerations. We have revised this sentence to reflect that sentiment. This is supported by the Bush et al. paper cited in our manuscript, which has been added to this sentence for reference.

Line 180 – from reading the manuscript the robotic MVR is certainly viable but rather needs to become more popular
Reply: Revised for specificity (see final sentence of manuscript).

"As popularity grows and more surgeons utilize the robotic approach to cardiac surgery, it is our hope that teMVR becomes a more readily available option for patients."

Reviewer 4

Thank you for providing your manuscript to me for review. In it, you describe your technique for totally endoscopic mitral valve repair with several innovative techniques such as:
1. percutaneous cannulation
2. use of V-loc barbed sutures
3. Cryo analgesia of T3-9
4. the largest port being 8mm

My comments are as follows:
1. I would like to see something about your results for this technique in your series, including information such as how many cases you have done, operative times, intra and post-operative complications such as CVA and MI, proportion discharged with >1+ MR, annuloplasty band dehiscence etc.

Reply: Thank you for this comment. In our opinion, readers should learn how to do this procedure instead of what the results are. The results should be part of a separate publication that focuses on outcome. We have not modified the manuscript to include results.

2. By using cryo down to T9, have you noticed any bulging of the abdominal musculature in the RUQ? Any complications of cryo, such as pain flares as the nerve regenerates?

Reply: Thank you for this comment. We have added the following to the "Intercostal cryoablation and pericardiectomy" section to address this:

"At our institution, there have been a small number of cases in which patients experienced transient bulging of the right upper quadrant abdominal musculature as a result of cryoanesthesia and/or temporary pain flares at approximately 3-6 months postoperatively (which aligns with nerve regeneration)."

3. Line 25, I think you mean 'robotic mitral valve surgery'
Reply: Thank you for this catch; the appropriate adjustment was made (see second line of abstract).

4. Line 119 - presumably injury to the liver, not the chest wall
Reply: This was an important clarification. The change has been made in the "Intercostal cryoablasion and pericardiectomy" section.

5. Line 125 - CPB was initiated with the endoballoon? Presumably you mean myocardial arrest. Please add details of cardioplegia technique.
Reply: Thank you for this comment. We have revised the "Cardiopulmonary bypass" section as specified below to include more detail on the endoballoon technique.

"CPB was initiated and the heart was arrested with the endoballoon. Antegrade cardioplegia was delivered at a rate to avoid distal migration of the endoballoon by keeping the aortic root pressure less than the systemic pressure. Once arrest was achieved…"

Moreover, we included further details on the cardioplegia technique in the "Induction of cardioplegia, atriotomy, and left atrial appendage closure" section:

"Antegrade cardioplegia was delivered at a rate to avoid distal migration of the endoballoon by keeping the aortic root pressure less than the systemic pressure. Once arrest was achieved, a left atriotomy was performed at Waterston's groove"

6. Line 127 - the retraction suture - please describe this better, where on the pericardium is it anchored?
Reply: Thank you for this comment. We have modified the *** section of the manuscript, as specified below.

"After the pericardium was opened, two retraction sutures were placed through the lateral edge of the pericardiotomy site and exteriorized through the 14-gauge angiocatheters."

7. Line 134 - I don't think the words 'lumen sterile late free' are necessary
Reply: This adjustment was made (see paragraph on annuloplasty band fixation on page 6).

8. Line 138 - an anterolateral commissural plication stitch - this is clearly not what you did - in the video you describe this as posterior commissural plication - to me it looked like you sutured P2 to P3 maybe because there was a small step there due to the length of the medial set of neochords.
Reply: Thank you for this comment; the text and video have been revised to clarify that this step demonstrates a cleft closure between P2 and P3:

"A cleft closure between P2 and P3 was performed. Afterwards, static testing revealed a competent valve"

9. Line 149 - what hemostatic agents?
Reply: This line was removed from the manuscript; thank you for asking for clarification. In the event of a bleed, hemostatic agents are given. However, this bleeds anecdotally happen less frequently when using the robotic platform. However, they can be more difficult to deal with when they due occur, so keep awareness must be given to potential bleeding scenarios.

10. Video at 1:47 - you say this is bileaflet prolapse which is clearly not the case, please correct
Reply: Thank you for this catch; the video script has been adjusted and re-recorded to reflect the proper pathology:

"Posterior prolapse with an eccentric, anteriorly directed jet can be seen by color flow doppler."

11. Video at 4:25 - spelling mistake of 'sided'
Reply: The spelling has been corrected in the video at 4:25.

12. Video at 5:05 - see #8 above - that does not look like a PC plication to me.
Reply: See response for #8 above. You are correct, this demonstrates a cleft closure between P2 and P3.

Overall, well written with a clear video and good narration.

Reviewer 5
My perspective is as belows:

For the reader it would be helpful if the section on surgical technique is divided into procedure segments e.g.

Anesthesia

Prepping and Draping

Port placement

Cannulation

Induction of cardioplegia

…… continue in this manner

Reply: We agree this structure will help aid the organization of the manuscript. Subheadings have been added to the "Surgical Technique" section as recommended.

Specific advantages of the port only approach can be pointed out as compared to robotic MVR as compared to an adjunct minithoracotomy

Reply: We believe the primary advantage of the port-only approach to be associated with the lack of rib spreading. Intuitively, post-operative pain should be reduced, and we have indeed observed this anecdotally at our center. This is especially true in instances where "minithoractomy" involves more rib spreading and larger incisions than is potentially advertised. However, we are hesitant to make the firm claim of this being an advantage over minithoracotamy due to the lack of evidence in the literature. Hence, we have made note of this benefit, but have not set forth any firm claims that this is truly an advantage:

"The small port size in the absence of rib-splitting, combined with cryoablation to the intercostal nerves, helps reduce pain postoperatively and improve FEV1 recovery (7). This further supports an effort to reduce post-operative narcotic requirements."

The authors should elaborate on intraoperative challenges that the surgeon can face during this procedure and suggest solutions.

Reply: Several challenges a surgeon may face have been added to the comment section (see below). Thank you for this comment, we think it helps facilitate an honest an open discussion about the advantages and drawbacks of the port-only approach.

"Moreover, there are a number of intraoperative challenges which surgeons may encounter when employing a totally-endoscopic approach. Right chest wall access likely increases the incidence of liver injury compared to traditional open sternotomy approaches. It is important to alert the post-operative care team for signs of potential liver injury, as many do not naturally associate

liver injury with cardiac procedures. Lung injury also may occur, especially on re-ventilation. Finally, chest wall bleeding is a potential complication. In this case, it is important to recognize the signs of a chest wall bleed early to ensure proper blood products can be provided and any alternative access can be established."

Video – nice in general but correctly stated by reviewer # 4 that this is not bileaflet prolapse with a central jet but posterior leaflet prolapse with an anteriorly directed jet.

Reply: Thank you for this catch; the video script has been adjusted and re-recorded to reflect the proper pathology:

"Posterior prolapse with an eccentric, anteriorly directed jet can be seen by color flow doppler."

It should be mentioned in the video that cardiopulmonary bypass is started first so as to unload the heart followed by opening of the pericardium.

Reply: This is the singular comment which we have left untouched among all reviewer comments. Traditionally we open the pericardium and then initiate pulmonary bypass. To this end, we left the current terminology in this section of the video as originally written.

Also agree that the plication stitch is not commissural but rather between P2 and P3.

Reply: See response to #8 in Editor 4 above; you are correct, this is a cleft closure between P2 and P3.