

Peer Review File

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Reviewer A

The authors present a discourse of pearls and pitfalls gleaned from a series of 950 TECABs performed over 15 years. The paper is well written with excellent standard of English and a technical style that is commensurate with the requirements for a peer-reviewed publication.

There are a few minutiae that might be amenable to clarification:

1. The size of the ports is not outlined in all cases
2. The use of a urinary catheter is also not stated
3. The anesthetic protocol is also of import here
4. How far behind the phrenic is the pericardiectomy
5. The rates of complications in the initial description could be referenced
6. The energy source settings would be helpful
7. Concentration and volume of papaverine would be helpful
8. 7/0 needs a slash not a colon separating
9. Line 245 - in this paper, not the following paper
10. That TECAB is the most versatile approach is debatable, depending on the definition of the word.

My main question is how the authors have identified an additional ~400 patients compared to the 570 who were published by the same senior author less than one year previously. Would it be appropriate to describe and credit the second institution for the purposes of demonstrating the infrastructural and multidisciplinary resources required?

Another further request would be for the pitfalls to be more clearly identified. It is likely that there were occasional complications, near misses or other difficulties along this process that will have helped lead to the refined process that the authors describe. Would they be willing to share these, also?

Overall, however, I would recommend publication with minimal changes.

Answer:

-We use standard Robotic platform Si (Intuitive, Sunnyvale, CA, USA) with standard and widely adopted 8mm ports. We have added the size of the standard ports in the manuscript. All ports that differ from the standard 8mm have been mentioned and highlighted in the body of the manuscript:

- “Fourth 12- mm subcostal robotic port is placed between the xyphoid process and the midclavicular line (MCL) that will be used for the fourth robotic arm equipped with the EndoWrist (Intuitive, Sunnyvale, CA, USA) coronary stabilizer. Finally, a 12-mm sealed working port is placed in the second ICS at the MCL”

-Use of urinary catheter is standard for all open as well as minimally invasive cardiac surgery in our institution

-The anesthesia set up has been described in details in the initial portion of the manuscript. In the manuscript we focus on the surgical/technical details as initially instructed by the journal. The induction and maintenance of anesthesia is priority of our anesthesia team and varies between patients.

-The posterior pericardiotomy is done approximately 2cm posterior to the phrenic nerve, although there is some variation between patients. That has been added in the manuscript

-While this is purely technical paper and no outcomes are intended to be reported or present we did reference several of our recent papers that give detail description of complications and outcomes (reference 3, 6, 7)

- Peev MP, Nisivaco S, Torregrossa G, Arastu A, Shahul S, Balkhy HH. Robotic Off-Pump Totally Endoscopic Coronary Artery Bypass in Patients With Low Ejection Fraction. *Innovations (Phila)*. 2022;17(1):50-5.
- Torregrossa G, Amabile A, Balkhy HH. Totally robotic sutured coronary artery bypass grafting: How we do it. *JTCVS Tech*. 2020;3:170-2.
- Balkhy HH, Nisivaco S, Kitahara H, Torregrossa G, Patel B, Grady K, et al. Robotic off-pump totally endoscopic coronary artery bypass in the current era: report of 544 patients. *Eur J Cardiothorac Surg*. 2022;61(2):439-46.

-The energy source settings are variable (btw 10-30) depending on patient and tissues

-As mentioned in the abstract the senior author has developed the TECAB technique over a period of 15 years between two institutions. Other publications from the senior author refer to different and specific scientific questions. This paper has been invited with the intention to share our technical experience and focus on the technical pearls and pitfalls of performing TECAB as the busiest and most experienced center in the United States.

-We outlined the various pitfalls not only in the written manuscript but also in the officially submitted video. The challenges our team has faced within the 15 years of experience have been described in great details in previous publications of the senior author. An excellent example is the referenced article:

- Torregrossa G, Amabile A, Balkhy HH. Totally robotic sutured coronary artery bypass grafting: How we do it. *JTCVS Tech*. 2020;3:170-2.

Reviewer B

The paper presented describes in very specific detail the surgical steps of multi-vessel totally endoscopic coronary surgery. The author needs to be complimented for the rich description of several parts of the procedure. this paper highlights the standardization of a highly demanding procedure, become a standard operation in the hand of the pioneer of TECAB.

Answer: N/A

Reviewer C

In their article ‘Multi-vessel Off-Pump Total Endoscopic Coronary Artery Bypass – Pearls and Pitfalls’, the authors present their technical approaches to robotic TECAB. Since the last author is a renowned expert and pioneer in robotic cardiac surgery, the aim of this article to provide advice regarding robotic surgery is very authentic, and it was my pleasure to review the manuscript.

The description of the applied surgical techniques is clear and concise, and reflects the strong experience of the authors with robotics.

Further comments:

- Ll.68-73: The authors state and suggest that robotic TECAB is the own option to harvest both ITAs and to revascularize multiple coronary targets without sternotomy. This is not correct, as multi-vessel MICS-CABG (or “MVST”) is conducted by many coronary excellence centers worldwide since nearly two decades – allowing for BITA harvesting and complete revascularization via mini-thoracotomies (see e.g., Ginn et al. *Circulation* 2009; Lapierre et al. *EJCTS* 2011). This aspect and the potential advantages of robotic TECAB over BITA-MICS-CABG should be discussed.

- Ll.74-76: The authors state that robotic TECAB has “proven advantages (...long-term outcomes ... reduction in postoperative pain, shorter intensive care and hospital length of stay, early return to work”). It seems to me that the body of existing literature does not support such a strong statement. Could the authors please reference articles that actually prove the superiority of robotic TECAB regarding the above-mentioned outcomes?

Answer:

- The main goal of our manuscript is to outline the technical details including pitfalls and pearls that we face in order to safely conduct a multivessel TECAB. That was the task as well as our invitation to participate in this particular journal. We do not intend to report or compare our outcomes to MIDCABs or other minimally invasive revascularization techniques. Our team does not imply in any way that using the robotic platform is the only way to safely utilize bilateral internal mammary vessels. However, based on our experience the DaVinci platform is a versatile way to minimally invasively harvest both IMAs while using three 8 mm ports only without need for thoracotomy or other additional incisions that potentially increase the “invasiveness” of the procedure.
- We have extensively published our results and outcomes. We have references several of those articles that present our morbidity, mortality, hospital length of stay etc:
 - Peev MP, Nisivaco S, Torregrossa G, Arastu A, Shahul S, Balkhy HH. Robotic Off-Pump Totally Endoscopic Coronary Artery Bypass in Patients With Low Ejection Fraction. *Innovations (Phila)*. 2022;17(1):50-5

- Balkhy HH, Nisivaco S, Kitahara H, Torregrossa G, Patel B, Grady K, et al. Robotic off-pump totally endoscopic coronary artery bypass in the current era: report of 544 patients. Eur J Cardiothorac Surg. 2022;61(2):439-46
- As mentioned before the goal of this paper is not to report or compare outcomes but rather to focus on technical details, exactly following the invitation instructions to participate in the journal scientific session

Reviewer D

Thank you very much for reporting your TECAB techniques and pitfalls. I enjoyed reading your article, and I respect the achievement of your robotic cardiac surgery team. This manuscript only focuses on how to do TECAB. Thus, surgical technique may be a suitable article type for this manuscript.

I think you should describe surgical results on survival rate, in-hospital death, perioperative myocardial infarction, conversion rate to sternotomy or direct-vision MICS CABG, graft patency rates, and so on.

Answer:

- As mentioned before the goal of this paper is not to report or compare outcomes but rather to focus on technical details, exactly following the invitation instructions to participate in the journal scientific session. For exact description of our TECAB outcomes, refer to the referenced articles from our group.

Reviewer E

I enjoyed reviewing this review article. I think this review will be useful for many readers who are interested in minimally invasive CABG.

Answer: N/A

Reviewer F

I would like to congratulate you with the manuscript. My raised questions relate to contradictions as BMI, spine or skeletal diseases? Would be interesting if you could provide your long-term results.

Answer:

- We do not have any BMI restrictions or restrictions related to spine or musculoskeletal diseases. As mentioned in the body of the manuscript our absolute and relative contraindications are as follow:
 - **Absolute exclusion criteria:**
 - > Emergency surgery

- > Cardiogenic shock
- > Significant left pleural adhesions secondary to previous lung surgery
- **Relative exclusion criteria:**
 - > Very poor pulmonary function (including patients who are not expected to tolerate single lung ventilation)
 - > Previous cardiothoracic surgery with no available Internal Thoracic Artery (ITA) conduit

Reviewer G

Comment: Please add more details about why a focus on multi-vessel TECAB not a single vessel in the Introduction section.

Answer: We have introduced in the Introduction section of the manuscript an additional text that reveals the rationale for the use of multivessel TECAB:

- *” The ability to fully utilize the robotic platform for surgical revascularization allows the conduct of totally endoscopic multivessel revascularization. It is a unique advantage that facilitates not only the safe dissection of both internal thoracic vessels but also allows access to the various portions of the heart and coronary vessel targets while using the same ports. While Minimally Invasive Coronary Artery Bypass (MIDCAB) represents the most widely adopted minimally invasive revascularization technique, it is limited by the ability to use a single ITA as well as to only graft the Left Anterior Descending artery (LAD).”*

Comment: Please have more specific comments on TECAB before Conclusion, such as key issues, challenges, team training methods, learning curves and credentialing etc., which would bring readers and peers more inspiration.

Answer: In the main body of the manuscript, just before the Conclusion section we have integrated specific comments as a way to share our experience with robotic cardiac surgery:

- *“In the following paper we share pearls and pitfalls that we encountered and learned performing over 950 robotic TECABs in 2 institutions over the last 15 years. It is important to highlight that robotic cardiac surgery in general and in particular robotic revascularization requires the acquisition of a completely new set of surgical skills that widely differs from the ones used to conduct open heart operations. The associated steep learning curve is a function not only of the surgeon’s experience and dedication but also of the experience of the entire surgical team (nursing staff, cardiac anesthesia, perfusion etc). We have previously highlighted that dedicated robotic cardiac team that is highly involved is paramount in building robotic cardiac program. As mentioned in our previous work, we strongly believe that it is essential for surgeons to be aware of the need for complete paradigm shift from a limited and infrequent-procedure approach to the full and extensive adoption of the current robotic technology (3).”*