Author's response to reviews

Title: An ex-vivo quantitative assessment to determine the optimal aortotomy closure technique

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Author's response to reviews: see over
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Dear Mr Zamvar and Prof Taggart,

We are pleased to resubmit for publication our manuscript entitled: ‘An ex-vivo quantitative assessment to determine the optimal aortotomy closure technique’.

Once again we are happy to address the useful comments provided by Dr Okita:

The revised manuscript did not cleared my concerns. The leakage amount is not solely determined by the suture line itself. Bleeding is coming from suture holes, loosened suture line, or characteristics of the contact surface of the aorta. There was no data regarding mechanical properties, such as horizontal or longitudinal tensile strength of the suture line.

We will address each concern individually.

1. The revised manuscript did not cleared my concerns.

We believe this to be a reference to Dr. Okita’s previous comment:

This is an experimental study regarding aortotomy closure by Holloway et al, Calgary. The mattress and over and over technique was proved to be superior. However, numerous surgeons have used a single over & over technique for closing aortotomy since birth of cardiac surgery. The authors should explain this.

As noted in the previous revision, we acknowledge that the single and double layer baseball closures are routinely used with success. In the introduction we state:

Although all of these techniques are commonly used successfully in clinical practice, there is a lack of objective evidence to determine if one technique is superior. Currently, there are no published studies comparing aortotomy closure techniques or recommendations for which approach to take in a given clinical scenario. Each surgeon’s preference appears to be based on their training and personal experiences. Even though they all work well enough to be used clinically, this does not necessarily mean they are all equal in performance. Is there one technique which is most suited for a clinical scenario with very challenging hemostasis such as profound coagulopathy, or an elderly aorta with considerable calcification or stiffness?
Furthermore, is there a technique which is most resistant to rupture and would be best suited for scenarios where extreme hypertension is a concern?

We believe this question raised in the introduction is fair, and remains unanswered in the current literature as there have been no previous studies directly comparing aortotomy closure techniques. The fact that the three techniques are being used clinically is also an integral part of the discussion:

This study has compared three techniques that are routinely being used to close aortas. These techniques all work well enough to be used clinically but this does not mean they are equal. The two layer horizontal with baseball stitch was clearly superior on this static ex-vivo model. The question remains as to whether this superiority translates to the operating room with a benefit for the patient. In clinical scenarios such as profound coagulopathy, thin diseased aorta, or atherosclerotic non-compliant fragile aortas where hemostasis can be challenging, it may be advantageous to use the technique with the most inherent resistance to leakage. With the absence of platelets, absence of clot, and using saline with a lower viscosity than blood, this ex-vivo model subjected the aorta to a challenging environment for hemostasis. In this environment the horizontal mattress with baseball closure technique exhibited the most inherent resistance to leakage. Aside from a slightly longer duration to perform it, there does not appear to be a significant disadvantage of this technique. For these reasons it appears to be the best choice of technique for challenging conditions and also a reasonable choice for routine aortotomy closure.

To reiterate, although the three techniques are used routinely, one technique was clearly superior in this ex-vivo study. We postulate in the discussion that the inherent traits which make this technique superior in the ex-vivo setting may also be beneficial during clinical scenarios such as profound coagulopathy.

2. The leakage amount is not solely determined by the suture line itself. Bleeding is coming from suture holes, loosened suture line, or characteristics of the contact surface of the aorta.

This is correct, bleeding does come from all areas of the surgical site. However, this study was designed to account for all bleeding and delineate the differences produced by the closure technique. All leakage from the aorta outside of the aortotomy site is accounted for by measuring the baseline leakage rate for each segment of aorta at each pressure. The leakage rate after aortotomy repair is then calculated as the difference compared to the baseline value. As stated in the methods:

The baseline leakage rate was calculated by measuring the volume of leaked saline over a period of 5 minutes at a constant pressure. For each segment of aorta, the baseline leakage rate was determined at 8 pressures: 110, 150, 185, 225, 260, 300, 335, and 375 mmHg.

Using the technique of measuring all baseline leakage rates, we believe we were successful in accounting for the inherent leakage of the aorta outside of the aortotomy. This is supported by the results which show statistically significant differences between the aortotomies grouped by closure technique. As all segments of aorta were investigated exactly the same except for the closure technique, it is reasonable to conclude that the closure technique was the driving factor in the differences in post-closure leakage rate.

In regards to loosened suture line, we state that if any technical errors were made during the suturing, then the segment of aorta was discarded and replaced. All the aortotomies included in this study had intact suture-lines with reasonably placed sutures. From the text:
If a closed aortotomy was believed to have a significant technical error (i.e. a misplaced suture) creating leakage greater than 1000 mL/5 minutes at any pressure, then that aorta was discarded and replaced. Secondary repair sutures were not utilized. Using this exclusion criteria, two aortas were discarded and replaced.

In regards to bleeding from suture holes, we believe this is a very important aspect of this model and aortotomy closure in general. Bleeding from suture holes is clinically relevant and as your readership knows, it can be encountered during times of profound coagulopathy. We believe and state in the discussion that one of the possible reasons for the measured superiority of the horizontal mattress with baseball stitch technique is the fact that the second layer suture-line is excluded from the aortic lumen and thus bleeding is minimized from this line of suture holes. From the discussion:

... unlike the other techniques where all the needle holes are exposed to blood at the aortic intraluminal pressure, the top layer in this technique is isolated and therefore reinforces tissue approximation without additional needle holes into the aortic lumen. We believe this isolated suture line to be a major contributor to the superiority of this technique.

3. There was no data regarding mechanical properties, such as horizontal or longitudinal tensile strength of the suture line.

Dr. Okita correctly notes a limitation of this study. We did not attempt to measure the mechanical properties of the suture-lines or the porcine tissue. The discussion has been amended to include this limitation. However, as we did not encounter any instances of frank rupture of the suture-line, dehiscence, or suture breakage, it is clear that the tensile strength of all suture closures exceeded the demand placed by this static pressure model. As noted in the discussion, the results of this study suggest that a pulsatile model may be more useful for determining which closure technique is most resistant to rupture or dehiscence.

We appreciate the insightful comments of Dr Oommen:

The conclusions reached are valid and does confirm anecdotal experience and general consensus. However though I don’t think the paper will change practice, as surgeons will continue to use their preferred technique for aortotomy closure.

It is a point well taken that surgeons will be inclined to continue using their preferred technique. It is likely that each surgeon’s preferred technique will be based on their anecdotal experience and training; this is fair and understandable. However, in the era of evidence based medicine it is prudent to present surgeons with information so that they may integrate it into their practice as they see fit. This study does add some objective data that was previously lacking. We offer the clinical scenarios of profound coagulopathy or diseased aortic tissue as examples of when this information may help surgeons tailor their techniques. Furthermore, we believe it would be reasonable for a surgical trainee such as a resident or fellow to question which technique is superior in a given scenario as they develop their surgical preferences. Once again, this study offers some objective data to help the trainee form their opinion.

Once again, we would like to thank our reviewers for taking the time to comment on this study. We appreciate the opportunity to clarify and amend the manuscript. We offer the revised manuscript back for consideration of publication in the Journal of Cardiothoracic Surgery.
Best regards,

Daniel Holloway, MD, MSc