Aortic root remodeling after surgical repair of acute type A aortic dissection using different anastomosis techniques

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PII: S2666-2507(23)00224-9
DOI: https://doi.org/10.1016/j.xjtc.2023.06.018
Reference: XJTC 1442

To appear in: JTCVS Techniques

Received Date: 9 January 2023
Accepted Date: 7 June 2023

Please cite this article as: Lin TW, Wu HY, Tsai MT, Hu YN, Wang YC, Roan JN, Luo CY, Kan CD, Aortic root remodeling after surgical repair of acute type A aortic dissection using different anastomosis techniques, JTCVS Techniques (2023), doi: https://doi.org/10.1016/j.xjtc.2023.06.018.

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Aortic root remodeling after surgical repair of acute type A aortic dissection using different anastomosis techniques

From January 2012 to December 2018
112 acute type A aortic dissection (aTAAAD) operations repaired with root-preserving ascending aorta replacement

66 continuous anastomosis
46 telescopic anastomosis

Telescopic anastomosis technique is associated with

Short-term

Longer CPB time
Longer cross clamp time
Larger graft size

Comparable early mortality & morbidity

Medium-term

Beneficial aortic root remodeling
Trend toward better aortic root adverse event-free survival

Lin, et al
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Conflict of interest statement and source of funding

This work was supported by E-DA Hospital (Grant: EDAHP110046). All authors declare no conflict of interest.
Institutional Review Board (IRB) approval and Informed consent statement

The institutional review board of the National Cheng Kung University Hospital (IRB No. A-ER-110-055) and E-Da Hospital (IRB No. EMRP-109-083) approved this retrospective study and waived the requirement for patients’ informed consent.

Conference presentation

Presented as a Presentation-on-Demand (POD) E-Poster at Aortic Symposium Workshop, May 13, 2022, Boston, MA.

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Article word count: 2624
Glossary of Abbreviations

41 aTAA: acute type A aortic dissection

42 CPB: cardiopulmonary bypass

43 SACP: selective antegrade cerebral perfusion

44 CTA: computed tomography angiography

45 GEE: generalized estimating equation

46 CI: confidence interval
Central Picture Legend

The telescopic anastomosis with interrupted, pledgeted, horizontal mattress sutures in aTAAD repair
Central Message

The telescopic anastomosis technique used for proximal anastomosis in aTAAD repair has similar early outcome and better aortic root remodeling at medium-term compared to the continuous technique.
Perspective Statement

Effective ways to facilitate better aortic remodeling and avoid late adverse aortic events following aTAAD surgical repair are of interest but have rarely been investigated. Our study demonstrated that different anastomosis techniques can affect the progress of aortic root dilation after aTAAD surgical repair and may result in different incidences of aortic root-related adverse outcomes.
Abstract

Objective

After surgical repair of acute type A aortic dissection, remodeling of the residual aortic segments is the key outcome parameter associated with late reoperation or aortic-related adverse events. In this study, we analyzed the surgical outcomes of acute type A aortic dissection using either telescopic or continuous anastomosis technique, focusing on their impact on aortic root remodeling during the longitudinal follow-up.

Methods

Between 2012 and 2018, 112 surgical repairs of acute type A aortic dissection with ascending aorta replacement and without aortic arch or aortic root replacement were performed. The medical records were retrospectively reviewed, and early and late outcomes were compared between the telescopic and continuous anastomosis techniques. A generalized estimating equation was used to analyze the effects of different anastomosis techniques on serial aortic root remodeling.

Results

The telescopic anastomosis technique was used in 46 (41.1%) cases, and the conventional continuous anastomosis technique was used in 66 (58.9%) cases. There was no difference in
in-hospital mortality or the incidence of major complications between the groups. The telescopic anastomosis group demonstrated stable postoperative regression of the aortic root diameter during follow-up. In contrast, the continuous anastomosis group showed a progressive dilatation of the aortic root. There was a trend toward better aortic root adverse event-free survival rates in the telescopic anastomosis group (p = 0.081).

Conclusion

The telescopic anastomosis technique is a safe alternative to the continuous anastomosis technique in the surgical repair of acute type A aortic dissection, with comparable early results. In addition, telescopic anastomosis resulted in beneficial aortic root remodeling in the medium-term compared with continuous anastomosis.
Keywords

Acute type A aortic dissection; anastomosis technique; aortic root remodeling
Objective

Studies on surgical outcomes of acute type A aortic dissection (aTAAD) repair have emphasized long-term complications such as adverse aortic remodeling and late aortic events, while early outcomes after aTAAD repair have shown significant improvement in recent years.1-4 A supra-commissural ascending aorta replacement is an anastomosis of a graft and the native aorta at the sinotubular junction, which has been a reasonable alternative to the more technically complex aortic root replacement in patients with aTAAD without existing aortic root aneurysm or intimal tear at the sinuses of Valsalva.5-13 Studies have demonstrated that the late outcomes related to an unreplaced aortic root are favorable, with a low incidence of re-intervention for either the root or aortic valve. Nevertheless, progressive root dilation was also observed and remained a concern for supra-commissural anastomosis.6, 7, 9, 10, 12, 13

We previously introduced a novel telescopic anastomosis technique that facilitated hemostasis during aortic surgery.14, 15 In this study, we aimed to compare telescopic versus continuous anastomosis in supra-commissural anastomosis for patients with aTAAD. We analyzed their medium-term outcomes and effects on aortic root remodeling during longitudinal follow-up.

Methods
Study Population

Since the introduction of the telescopic anastomosis technique in 2012, it has been used in aTAAD repair in two medical centers based on surgeon preference. We thus retrospectively reviewed the charts of patients who received surgery for aTAAD between January 2012 and December 2018 in both institutes. Only those undergoing ascending aorta replacement with the proximal anastomosis at the level of sinotubular junction were included, such as patients who did not require aortic root replacement. Those requiring replacement of the aortic arch or its branches were also excluded.

The institutional review board of the National Cheng Kung University Hospital (IRB No. A-ER-110-055, 7/27/2021) and E-Da Hospital (IRB No. EMRP-109-083, 8/5/2021) approved this retrospective study and waived the requirement for patients’ informed consent.

Operative Technique

Except for the anastomosis techniques, the other operative techniques of aTAAD repair in both institutes have been standardized as previously described. Right axillary artery cannulation was performed for most cases who did not need emergency cardiopulmonary bypass (CPB) cannulated via femoral vessels. We performed distal aorta to graft anastomosis first with an open technique, in accordance with the latest guidelines from
We employed selective antegrade cerebral perfusion (SACP) at a flow rate of 10 ml/kg/min, which maintained arterial pressure between 50 to 70 mmHg under moderate (25 °C) hypothermic circulatory arrest during the distal anastomosis. Transcutaneous cerebral oximetry was continuously monitored throughout the operation. In both the telescopic and continuous anastomosis techniques, the modified sandwich technique was used to obliterate the false lumen. A tailored Teflon patch was placed into the dissected space between the media and adventitia, followed by external reinforcement using a Teflon strip surrounding the entire circle of the aortic anastomosis site. Continuous anastomosis was done using either 3-0 or 4-0 polypropylene sutures with a conventional continuous running technique (Figure 1A). For the telescopic anastomosis technique, a vascular graft with a diameter 2–3 mm larger than the aortic diameter at the sinotubular junction was used. Twelve to 15 interrupted, pledgeted, horizontal mattress sutures with 3-0 or 4-0 polypropylene sutures were passed inside-out across the reinforced aorta 5 mm below the transected border circumferentially and through the graft with adequate spacing. After tying down the stitches, the vascular graft was “parachuted” down and seated outside the aorta, and the aortic wall was “telescopéd” into the vascular graft (Figure 1B). Tissue adhesive agents were used according to the surgeon’s preference and judgment of hemostasis satisfaction.
Statistical Analysis

Categorical variables were evaluated using the $\chi^2$ or Fisher’s exact tests, and numerical variables were evaluated using the Student $t$-test. At medium-term follow-up, overall survival and adverse aortic root event-free survival were evaluated using the Kaplan–Meier survival curve and log-rank test. An adverse aortic root event was defined as the aortic root aneurysm ($\geq$50 mm), pseudoaneurysm or residual dissection, presence of moderate or severe aortic insufficiency, or any reoperation related to the aortic root or aortic valve.

Longitudinal data of the aortic root diameter were accessed via postoperative annual contrast-enhanced computed tomography angiography (CTA) scans. The maximal diameter of the aortic root, measured perpendicular to the axis of the aorta, was determined by the radiologist who produced the report, and subsequently verified by the author (TW Lin) of this study.

Further analysis was conducted using a generalized estimating equation (GEE) with a first-order autoregressive correlation model. All statistical analyses were performed using PASW Statistics for Windows (version 18.0; SPSS Inc., Chicago, Ill, USA).

Results

A total of 112 patients with aTAAD underwent surgical repair by ascending aorta replacement
without arch vessel or aortic root replacement during the study period. The classical 
continuous anastomosis technique was used in 66 patients (58.9%), and the telescopic 
anastomosis technique was used in 46 patients (41.1%). More patients had chronic kidney 
disease in the continuous anastomosis group than in the telescopic group (30.3% vs. 13.0%, p 
= 0.041). Otherwise, there was no significant difference in the other baseline characteristics 
between the two groups (Table 1).

The procedural characteristics of both groups were significant because CPB time was longer 
in the telescopic anastomosis group than in the continuous anastomosis group (271.00 ± 
65.52 vs. 209.42 ± 89.35 mins, p < 0.001). The former also had a significantly longer aortic 
cross-clamp time (164.22 ± 26.93 vs. 143.18 ± 50.69 mins, p = 0.005) and a longer SACP 
time (62.28 ± 11.48 vs. 55.68 ± 29.10 mins, p = 0.101). However, there were no differences 
in short-term major complications and in-hospital mortality rates between the groups (Table 
2). The diameter of the implanted graft was larger in the telescopic anastomosis group than in 
the continuous anastomosis group (28.69 ± 2.07 vs. 26.46 ± 2.32 mm, p < 0.001), although 
there was no difference in the preoperative diameters of the aortic root and aortic arch 
between the two groups.

Ninety-eight (87.5%) of the 112 patients survived until hospital discharge. An aortic CTA was
available in 79 (81.4%) out of 97 patients who remained followed at 1 year postoperatively, and for 50 (87.7%) out of 57 patients at 5 years. During follow-up, there was progressive dilation of the aortic root in the continuous anastomosis group, with a mean dilation rate of approximately 0.2 mm per year. In contrast, the diameter of the aortic root decreased by approximately 2 mm one year after the initial aTAAD repair using the telescopic anastomosis technique and remained stable without dilation during follow-up. The changes in diameter between the two groups at each postoperative year were statistically different using the GEE model (Figure 2A). At 5 years, the mean aortic root diameter decreased by 2.20 mm (95% confidence interval [CI]: 0.70-3.70 mm) in the telescopic anastomosis group, while the continuous anastomosis group experienced an increase in aortic root diameter with a mean of 1.21 mm (95% CI: 0.25-2.17 mm) (p < 0.001). In the subgroup of patients with moderate preoperative aortic root dilation (≥ 40 mm), the root diameter in the telescopic anastomosis group at one year postoperatively was 3 mm less than the preoperative measurements and remained steady at follow-up. Although the continuous anastomosis group had a decreased root diameter at one year, these patients had a higher rate of root dilatation afterward, at a rate of approximately 0.35 mm per year. As a result, the difference between the two groups in patients with preoperative moderate aortic root dilation was even more significant (Figure 2B). After 5 years, in the subgroup with preoperative aortic root diameter ≥ 40 mm, the mean diameter of the aortic root increased by 1.02 mm (95% CI: -0.28-2.31 mm) in the continuous
anastomosis group, while the telescopic anastomosis group demonstrated a stable decrease in
aortic root diameter with a mean of 3.40 mm (95% CI: 1.30-5.49 mm) (p < 0.001).

Seven (11.7%) of the 60 patients in the continuous anastomosis group developed moderate or
severe aortic insufficiency during follow-up, while 3 (7.9%) of the 38 patients in the
telescopic anastomosis group had ≥2+ aortic insufficiency. One (2.6%) patient in the
telescopic anastomosis group developed an aortic root aneurysm requiring re-operation 1 year
after the initial repair. No interventions were performed in the continuous anastomosis group.
There was no difference in the overall survival rate at medium-term (p = 0.391, Figure 3A),
in which the estimated 5-year survival rates in the telescopic and continuous anastomosis
groups were 82.6 ± 5.6% and 87.9 ± 4.0%, respectively. Among the patients who survived
until hospital discharge, the aortic root adverse event-free survival rate at 5 years was 93.5 ±
4.4% for the telescopic anastomosis group and 87.7 ± 4.8% for the continuous anastomosis
group, and there was a trend toward a better medium-term aortic root adverse event-free
survival rate in the telescopic anastomosis group (p = 0.081, Figure 3B).

Discussion

We demonstrated that telescopic and continuous anastomosis during aTAAD repair achieved
good and comparable results in the short term in selected patients not requiring root
replacement. Although telescopic anastomosis is associated with a longer CPB time, the choice of technique was not an independent factor related to in-hospital mortality or morbidities. Standardized approaches to aTAAD, such as perfusion strategy, indications for the extent of aortic replacement, and associated hybrid procedures, have been established in both hospitals participating in this study. We believe that these standardizations contribute to the consistency of our short-term outcomes which are not affected by the modification of the surgical procedure and minimize possible detrimental effects of the longer CPB time associated with the use of telescopic anastomosis technique. However, because prolonged CPB time is a known risk factor for unfavorable early outcomes, the decision to perform time-consuming telescopic anastomosis in patients with aTAAD who required and have undergone more complex distal aortic procedures or concomitant intracardiac procedures should be judicious. While we did find a higher number of re-explorations in the group that underwent telescopic anastomosis, the difference was not statistically significant. Furthermore, none of the patients who required re-exploration had surgical bleeding. A possible explanation for this higher rate of re-exploration could be a more significant coagulopathy due to the longer CPB run in the telescopic group, though we did not perform comprehensive post-bypass coagulation function analysis in these patients to confirm this presumption. The priority of surgical repair of aTAAD is patient survival and minimizing operative complications. Thus, we emphasize that modifications to existing surgical
procedures should depend on the surgeon’s experience and confidence. This is especially true when a complex distal arch reconstruction is necessary.\textsuperscript{17, 20}

Along with previous studies, our results showed that in patients without indications for root replacement during aTAAD repair, ascending aorta replacement with anastomosis at the level of the sinotubular junction, i.e., supra-commissural anastomosis, could provide favorable outcomes with a low incidence of re-intervention.\textsuperscript{5-13} The indications for aortic root replacement are standardized in our institute and include intimal tears within the aortic root and aortic root diameter $\geq 50$ mm. For most aTAAD patients with aortic valve insufficiency, ascending aorta replacement with valve resuspension can restore the competent aortic valve.

In patients with existing aortic valve pathologies that are not repairable but not associated with new-onset dissection, aortic valve and ascending aorta replacement can be an alternative to the replacement of the entire root. Although controversies remain, aggressive root replacement has been advocated for those with extensive dissected aortic roots, specifically for those with more than two sinuses of Valsalva.\textsuperscript{21} Notably, the extent of the sinus of Valsalva involved in the dissection flap is not an indication for aortic root replacement in our practice. We routinely used a modified sandwich technique to obliterate the false lumen before graft interposition during aTAAD repair, regardless of the anastomosis technique.

Residual aortic root dissection or pseudoaneurysm formation was not observed following the
use of this approach. However, the aortic root was replaced in some patients due to weak aortic tissue at the sinotubular junction, which made anastomosis difficult to perform. Conversion to root replacement after the initial attempt at ascending aorta replacement also occurred. In both above situations, the patients did not meet the standard indication for but underwent root replacement eventually, and were not included in this analysis. Despite the incidence of re-intervention for the aortic valve or root was low in both groups in the medium-term, our results showed preferable aortic root remodeling after root-preserving aTAAD repair using the telescopic anastomosis technique. In the telescopic anastomosis group, a decrease in root diameter was observed within the first year after surgery, which was also stable during follow-up. In contrast, progressive dilation of the aortic root was found in the continuous anastomosis group. Nonetheless, the rate of dilation was only 0.2 mm per year, which was similar to that in previous studies. The telescopic anastomosis technique was also associated with a trend of decreased incidence of moderate or severe aortic insufficiency during follow-up. These findings were more apparent in patients with moderately dilated aortic roots (≥ 40 mm). Previous studies have shown that the preoperative root diameter may be the most crucial risk factor for postoperative aortic root dilation, aortic insufficiency, and re-intervention. Thus, the use of the telescopic anastomosis technique could be a more valid option in aTAAD repair for patients with existing moderate root
dilation when there is no absolute indication for aortic root replacement. We propose some hypotheses for the beneficial effect of the telescopic anastomosis technique during aTAAD repair. First, using the telescopic anastomosis technique, the vascular graft was “parachuted” down and placed outside the aorta at the level of the sinotubular junction. The graft surrounding the aorta may not only directly downsize the ST junction, but also have a stabilizing effect that prevents the progression of aortic root dilation and aortic valve regurgitation, similar to the ring placed at the sinotubular junction when managing aortic insufficiency associated with ascending aortic dilation. Second, compared to continuous sutures, interrupted mattress sutures may serve as a buffer or cushion against the radial force generated by heart contractions. Nevertheless, the abovementioned standpoints are all speculated, as we did not obtain aortic root tissue for histopathological examination since reoperations were rarely performed. Additionally, we observed that the size of the graft used in the telescopic anastomosis group was larger than that used in the continuous anastomosis group. However, graft size itself was not associated with any difference in postoperative aortic root diameter change in this study. Further simulated hemodynamic studies may help to investigate whether graft size has an impact on root remodeling after surgical repair of aTAAD.
Limitations

The major limitations of this study include the limited number of cases and the relatively low incidence of aortic root-related adverse events during follow-up. It is necessary to collect more aTAAD surgical cases with the use of telescopic anastomosis technique with longer follow-up to provide stronger evidence supporting the beneficial effect of late aortic root remodeling. Surveillance for connective tissue disease was not routinely conducted in the aTAAD patients in our study. Additionally, preoperative echocardiography was not comprehensive for every patient in the emergency setting, which may have resulted in some possible variables associated with late aortic root dilation or aneurysmal formation being missed in this retrospective study.

Conclusion

The telescopic anastomosis technique is a safe alternative to the conventional continuous anastomosis technique for surgical repair of aTAAD. Despite longer CPB and aortic cross-clamp times, the telescopic anastomosis technique was not associated with increased early adverse outcomes. In the medium-term, the incidence of adverse outcomes of the aortic root, such as reoperation, aneurysmal dilatation, or significant aortic insufficiency, was low in both groups. Compared to continuous anastomosis, telescopic anastomosis results in beneficial aortic root remodeling in the medium-term by preventing progressive aortic root dilation.
following aTAAD repair during follow-up (Figure 4).
References


<table>
<thead>
<tr>
<th></th>
<th>Continuous anastomosis</th>
<th>Telescopic anastomosis</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 66)</td>
<td>(n = 46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, year</td>
<td>60.97 ± 13.17</td>
<td>61.10 ± 10.12</td>
<td>.954</td>
</tr>
<tr>
<td>Male sex</td>
<td>42 (63.6)</td>
<td>31 (67.4)</td>
<td>.840</td>
</tr>
<tr>
<td>Hematocrit, %</td>
<td>38.41 ± 6.70</td>
<td>39.04 ± 5.37</td>
<td>.597</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>7 (10.6)</td>
<td>3 (6.5)</td>
<td>.522</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>20 (30.3)</td>
<td>6 (13.0)</td>
<td>.041</td>
</tr>
<tr>
<td>Hemodynamic instability</td>
<td>19 (28.8)</td>
<td>17 (37.0)</td>
<td>.414</td>
</tr>
<tr>
<td>Cardiac tamponade</td>
<td>14 (21.2)</td>
<td>11 (23.9)</td>
<td>.819</td>
</tr>
<tr>
<td>CPCR</td>
<td>3 (4.5)</td>
<td>2 (4.3)</td>
<td>&gt; .999</td>
</tr>
<tr>
<td>Malperfusion</td>
<td>19 (28.8)</td>
<td>13 (28.3)</td>
<td>&gt; .999</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>2 (3.0)</td>
<td>3 (6.5)</td>
<td>.400</td>
</tr>
<tr>
<td>Cerebral malperfusion</td>
<td>12 (18.2)</td>
<td>6 (13.0)</td>
<td>.603</td>
</tr>
<tr>
<td>Extremity malperfusion</td>
<td>9 (13.6)</td>
<td>4 (8.7)</td>
<td>.554</td>
</tr>
<tr>
<td>Mesenteric malperfusion</td>
<td>2 (3.0)</td>
<td>3 (6.5)</td>
<td>.400</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Maximal aortic root diameter, mm</td>
<td>39.08 ± 4.92</td>
<td>39.74 ± 6.01</td>
<td>.523</td>
</tr>
<tr>
<td>Maximal aortic arch diameter, mm</td>
<td>34.05 ± 5.06</td>
<td>34.93 ± 5.00</td>
<td>.360</td>
</tr>
</tbody>
</table>

Data are presented as mean ± standard deviation or n (%).

aTAAD, acute type A aortic dissection; CPR, cardiopulmonary cerebral resuscitation.
Table 2. Procedural variables and early outcomes of patients undergoing ascending aorta replacement for aTAAD from January 2012 to December 2018 (n = 112)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Continuous anastomosis (n = 66)</th>
<th>Telescopic anastomosis (n = 46)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPB time, min</td>
<td>209.42 ± 89.35</td>
<td>271.00 ± 65.52</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Aortic cross-clamp time, min</td>
<td>143.18 ± 50.69</td>
<td>164.22 ± 26.93</td>
<td>.005</td>
</tr>
<tr>
<td>SACP time, min</td>
<td>55.68 ± 29.10</td>
<td>62.28 ± 11.48</td>
<td>.101</td>
</tr>
<tr>
<td>Graft size, mm</td>
<td>26.46 ± 2.32</td>
<td>28.69 ± 2.07</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ECMO</td>
<td>5 (7.6)</td>
<td>3 (6.5)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Re-exploration for bleeding</td>
<td>4 (6.1)</td>
<td>5 (10.9)</td>
<td>.484</td>
</tr>
<tr>
<td>Sternal wound infection</td>
<td>1 (1.5)</td>
<td>0 (0)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Newly developed dialysis</td>
<td>7 (10.6)</td>
<td>7 (15.2)</td>
<td>.565</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>6 (9.1)</td>
<td>3 (6.5)</td>
<td>.735</td>
</tr>
<tr>
<td>Permanent stroke</td>
<td>11 (16.7)</td>
<td>7 (15.2)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Major complication</td>
<td>16 (24.2)</td>
<td>13 (28.3)</td>
<td>.666</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>6 (9.1)</td>
<td>8 (17.4)</td>
<td>.248</td>
</tr>
</tbody>
</table>
Data are presented as mean ± standard deviation or n (%).

aTAAD, acute type A aortic dissection; CPB, cardiopulmonary bypass; SACP, selective antegrade cerebral perfusion; ECMO, extracorporeal membrane oxygenation.

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Figure Legends

Figure 1. (A) Continuous anastomosis technique and (B) telescopic anastomosis techniques used in surgical repair of aTAAD. The telescopic technique involves "parachuting" the vascular graft down and seating it outside the aorta, after which the aorta is "telescoped" into the graft. The figures on the right-hand side are longitudinally cut-away illustrations that demonstrate the luminal side of the aorta. Note the interrupted horizontal mattress sutures enforced with pledgets used in the telescopic technique.

Figure 2 GEE analysis of the change in aortic root diameter after surgical repair of aTAAD with ascending aorta replacement during longitudinal follow-up. (A) All of the patients in the study, and (B) patients with initial aortic root diameter ≥ 40mm. The change in aortic root diameter differed significantly (with all p-values < 0.05) between the different anastomosis groups in every year during the follow-up period, both for all patients and for patients with preoperative moderate aortic root dilation.

Figure 3. Kaplan-Meier survival curves of (A) overall survival of all of the patients, and (B) adverse aortic root event-free survival of patients who survived to hospital discharge after initial aTAAD operation. The survival curves are truncated when fewer than 10 patients at risk remain in either group.

Figure 4. Compared to the continuous anastomosis technique, telescopic anastomosis techniques used for proximal supra-commissural anastomosis in aTAAD repair has
comparable early outcomes, beneficial aortic root remodeling and a trend toward better aortic root adverse event-free survival in the medium-term.
Error bars indicate the 95% confidence intervals

- **Continuous anastomosis technique**
- **Telescopic anastomosis technique**

**Y-axis**: Change of aortic root diameter (mm)

**X-axis**: Follow-up (Years)

Legend:
- Blue circles: Continuous anastomosis technique
- Red squares: Telescopic anastomosis technique
Error bars indicate the 95% confidence intervals

- Continuous anastomosis technique
- Telescopic anastomosis technique

Change of aortic root diameter (mm)

Follow-up (Years)
$p = 0.391$ by Log-Rank test

Shaded areas indicate the 95% confidence intervals

Number at risk
- Continuous anastomosis technique
  - 66
  - 58
  - 40
  - 20
- Telescopic anastomosis technique
  - 46
  - 38
  - 29
  - 24
$p = 0.081$ by Log-Rank test

Shaded areas indicate the 95% confidence intervals

Number at risk

- **Continuous anastomosis technique**
  
  - 60
  - 58
  - 42
  - 20

- **Telescopic anastomosis technique**
  
  - 38
  - 32
  - 29
  - 24
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**Telescopic anastomosis technique** is associated with:

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  - Longer CPB time
  - Longer cross clamp time
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**Medium-term**

**Beneficial aortic root remodeling**

**Trend toward better aortic root adverse event-free survival**

$\rho = 0.081$ by Log-Rank test

Error bars indicate the 95% confidence intervals.

Lin, et al.