Clearing the next hurdles in the treatment of acute ascending aortic syndrome

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Improvements in the treatment of acute ascending aortic dissection have occurred slowly. In our institution, the mortality rate dropped from around 30–15% in the mid-1980s as we learned to standardize repair with the use of circulatory arrest and improved techniques for obtaining haemostasis [1]. Since that time, further improvements in care have led to acute mortality rates consistently between 5 and 10% for all comers at the Cleveland Clinic. Other centres of excellence have demonstrated similar improvements in survival, but the pace of improvement has not occurred as quickly or extensively one would like, as evidenced by recent reviews of the International Registry of Aortic Dissection (IRAD) and large national administrative databases [2–4]. The mean mortality has decreased by ~4% over a decade, but the national average is still greater than 20%. Analysis of these large databases is important because it demonstrates that larger volume centres and more experienced surgeons have significantly better outcomes. The problem with these databases is that they lack the granularity to assess details critical to making those improvements.

Something that has consistently been found to be the most important factor in predicting survival is the presence of malperfusion at presentation [2]. In an analysis of acute outcomes after emergency type A dissection repair from Geirsson et al., the overall mortality rate was 12.7%, and was strongly associated with malperfusion. In patients with malperfusion, it was 25.8% compared with only 3.1% in those without [5]. We have also seen increased mortality in patients presenting with malperfusion. It is possible that, as a tertiary referral centre drawing from a large region, there may be an element of selection such that patients with the worst cases of malperfusion do not get transferred. Nonetheless, we have seen that as many as 40% of patients referred for DeBakey type 1 dissection will have an element of malperfusion to distal vascular beds [6]. This is consequence of the acute dissection process that seems to be the most malignant contributor to the pathophysiology of acute dissection. Fortunately, timely treatment can relieve associated tamponade, correct acute aortic valve insufficiency and re-establish coronary and brain perfusion so that most patients will recover from the acute event. This has been the standard of care for over two decades and has led to an increasing appreciation for what happens to patients in the chronic state [7]. Although we have seen some improvement in early survival at centres of excellence, long-term survival after emergency repair of type A dissection is still poor with a 10-year survival of ~60% at 10 years for a group of relatively young (mean age 45–62 years) patients [2–5, 8].

Regarding malperfusion of distal vascular beds, a majority of this will also recover with re-establishment of central vascular (i.e. thoracic aortic true lumen) perfusion. However, there is still a significant number of patients who will have persistent distal malperfusion secondary to static branch vessel compromise (Fig. 1) and this represents another one of the important hurdles to clear next if we are to see further improvement in survival from ascending aortic dissection.

The hybrid approach to repair has the promise to address some of these issues [6]. Improvements in imaging and our understanding of the natural history of this disease during both the hyperacute and chronic phases of hazard, and the development of multidisciplinary teams able to provide expeditious care using novel techniques can provide the boost that is needed in the race to defeat this fatal disease. In the following editorial, I will describe in more detail some of the steps we are currently taking to clear the hurdles to better outcomes.

COLLABORATIVE CARE

The complexity of this disease requires a multidisciplinary approach to achieve the best outcomes. For multiple reasons specific to aortic dissection and the changing landscape of healthcare delivery, we are seeing a centralization of complex aortic care. When treating patients with an acute aortic dissection, time is of the essence. Like acute coronary syndrome, expeditious delivery of care improves outcomes for acute aortic syndrome, but for aortic disease the important increments of time are hours rather than minutes as is the case for coronary disease. The success of the heart team approach for treating high-risk aortic valve disease with transcatheter aortic valve replacement (TAVR) has brought familiarity to the concept of multidisciplinary collaboration for the delivery of complex care [9]. Acting as a unit, we can optimize efficiency at multiple levels from the time a referral is made, to the operating room, and during long-term follow-up.

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It is important that, once the diagnosis of acute ascending dissection is made, a team be made available to receive that patient and deliver care in a timely manner. In our institution that begins in our cardiac intensive care unit (CICU). The CICU in our hospital is no longer just a coronary care unit but a place where all cardiovascular emergencies arrive and are triaged to care. Our CICU specialists work closely with our surgical team and have recently begun studying in more detail the hospital transfer process [10]. Interestingly, throughout the various phases of transport, the segment of time with the greatest potential for improvement is the handover time period occurring between arrival of our emergency transport team at the referring hospital and departure to return to Cleveland. Efforts are underway to improve this process and expedite the delivery care.

Once anti-impulse therapy has begun and the diagnosis has been confirmed, patients are taken preferentially to the hybrid operating room where all treatment options are readily available. Another benefit of the dissemination of TAVR is that many centres now have hybrid operating rooms (ORs).

MORE TREATMENT CHOICES

With the adoption of novel strategies for treating acute dissections, the decision-making process has expanded as shown in the consort diagram in Fig. 2. What used to be a decision between a trip to the operating room for conventional ascending repair under circulatory arrest or relegating a patient to medical therapy and palliative care, has now expanded to include the options of performing a hybrid frozen elephant trunk repair or ascending stent grafting.

In summary, the frozen elephant trunk repair entails conventional surgical repair of the most proximal thoracic aorta using circulatory arrest through a sternotomy combined with direct antegrade delivery and suturing of a stent-graft device to extend the repair through the aortic arch and into the upper portion of the descending aorta. I believe the frozen elephant trunk repair is an ideal way to address acute DeBakey type 1 dissections and others do too, but there are shortcomings to the current procedure [1, 6, 11–15].

One important concern with this technique is that a risk for spinal cord injury has been described in up to 6% of patients [13, 15]. This is a rare complication after repairs that are limited to the ascending aorta only. Many variations to the frozen elephant trunk technique have been described previously, and most often include the creation of multiple anastomoses in the aortic arch.

![Figure 1: A contrast-enhanced CT image demonstrating acute DeBakey type 1 dissection complicated by ischaemia with dynamic obstruction of the true lumen (long arrow) and static obstruction of the superior mesenteric artery (short arrow).](image1)

![Figure 2: The Cleveland Clinic’s approach to decision-making in acute aortic syndrome of the ascending aorta circa 2014. TEVAR: thoracic endovascular aortic repair.](image2)
More anastomoses may contribute to a greater risk for bleeding and lengthen both the time of the operation and the circulatory arrest period. Bleeding and longer OR times have been associated with worse acute outcomes. One reason for this may be that a longer operation delays the correction of distal malperfusion. This is particularly true if the patient presents with static branch occlusion that may require additional intervention [16]. Coverage of longer segments of the descending aorta by the stent graft combined with longer periods of circulatory arrest may contribute to the risk of spinal cord injury. These are important considerations but they are not reasons to abandon the frozen elephant trunk repair treatment option for these patients. The technique should be tailored to the indication.

The frozen elephant trunk technique that we prefer for acute ascending dissections is different from the approach we use for chronic aortic disease [6, 17]. For chronic indications like degenerative aneurysms or chronic dissection, we prefer a multianastomotic technique similar to that described by Sun [11]. For acute aortic dissection, however, the operation is performed using a simplified technique with a single anastomosis in the arch that is accomplished by bringing the stent graft more proximally within the aortic arch (Fig. 3). The device is then secured within the arch with a few interrupted sutures near the branch vessels and the rest of the stent-graft device is included in the anastomosis to the proximal surgical graft. Sometimes this modified approach includes the creation of a fenestration in the stent-graft device to maintain flow into the left subclavian artery. The device length is limited to 10 or 15 cm so as to avoid coverage extending beyond the eighth thoracic vertebral level. This simplified approach to performing the arch anastomosis in acute dissection has kept the circulatory arrest times within a reasonable range with a median time of 28 min.

This technique has continued to be very safe with an exceptionally low mortality rate despite nearly one-third of patients presenting with ischaemia. Updated outcomes on our series of 40 patients receiving this operation are given in Table 1. The one hospital death occurred in a patient who was comatose and most likely brain dead at the time of arrival but was young with an unclear history and so was taken for repair. The patient with paralysis had a sudden bleed postoperatively that required open chest massage and emergency return to the operating room for rescue with severe hypotension that contributed to the spinal cord injury.

After completing the operation, we routinely perform an aortogram to assess true lumen flow and distal perfusion. This is performed using contrast that is diluted by 50% with a pigtail catheter in the proximal aorta during the rewarming phase. Sometimes this requires a second injection in the more distal aorta, but the overall contrast load never exceeds 25 ml. This portion of the procedure is safe and easy to perform in the hybrid operating room environment and allows for expedited stenting of static branch vessel occlusion. This additional early intervention has led to successful rescue of some of the sickest patients. Further developments in the procedure and the creation of disease-specific devices are needed to expand adoption and assure reproducibility of this technique.

**FOLLOW-UP AND THE CHRONIC STATE**

Supporters of a conservative, isolated, ascending repair strategy cite high durability, low risk of reintervention and good outcomes after reoperation using this approach [18, 19]. However, many of these earlier studies included mixed populations (both DeBakey type I and II dissections), and not all patients were followed-up routinely, with many deaths attributable to sudden causes (aortic complications may have contributed to these).

In a recent review of our experience with repair of residual dissections in patients who survived an emergency ascending repair, we found that these late operations can be done safely but commonly lead to morbidity [7]. From 1993 to 2010, 305 patients

![Figure 3: Postoperative volume-rendered CT scan demonstrating simplified (single anastomosis) frozen elephant trunk repair for acute DeBakey type I dissection. Arrows signify the anastomosis of the stent graft in the arch to the surgical graft and the proximal anastomosis at the aortic root [6].](image)

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**Table 1:** Updated experience with the single anastomosis frozen elephant trunk repair for acute aortic syndrome at the Cleveland Clinic, 2008–14

<table>
<thead>
<tr>
<th>Single anastomosis frozen elephant trunk repair</th>
<th>n = 40 (%)</th>
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</thead>
<tbody>
<tr>
<td>Mean age (years ± SD; range 29–88)</td>
<td>61.8 ± 16.5</td>
</tr>
<tr>
<td>Female</td>
<td>12 (30)</td>
</tr>
<tr>
<td>Ischaemia at presentation</td>
<td>13 (33)</td>
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<tr>
<td>Acute outcomes</td>
<td></td>
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<tr>
<td>Hospital mortality</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Stroke</td>
<td>4 (10)</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Temporary paraparesis</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>5 (12.5)</td>
</tr>
<tr>
<td>New haemodialysis</td>
<td>3 (7.5)</td>
</tr>
<tr>
<td>Intermediate outcomes (mean follow-up 20.6 ± 19 months)</td>
<td></td>
</tr>
<tr>
<td>Late deaths</td>
<td>5 (12.5)</td>
</tr>
<tr>
<td>Reintervention</td>
<td>7 (17.5)</td>
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</tbody>
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underwent 429 distal aortic operations at the Cleveland Clinic at a median of 3.8 years after their initial type A dissection repair. The hospital mortality rate was 6.1% for all operations and was higher for the first intervention (8.2%) than the subsequent ones. These operations are commonly associated with morbidity with a 10% risk for tracheostomy, 12% risk of bleeding and 4% risk of renal failure. Patients who required a combined arch and descending repair had a five times greater risk of in-hospital death. More than one-third of patients required additional reinterventions and the cumulative number of reinterventions per 100 patients was 55 by 10 years.

Not only do many of these patients require late aortic reoperations, but the operations are complicated and relatively high risk [20, 21]. Furthermore, we have found that the more advanced the degenerative process, the worse are the outcomes, and this has been repeatedly demonstrated in several studies of chronic dissection populations [7, 22, 23].

Why not remove this risk factor from the equation by addressing the potential pathology of the arch and isthmus at the time of the initial dissection repair?

In our series of patients who underwent frozen elephant trunk repair for acute type A dissection, 88% demonstrated positive remodelling with thrombosis of the false lumen and aortic shrinkage in the treated segment [6]. During later follow-up, 18% have required late aortic reoperations, but all have been performed using the less invasive endovascular approach. This emphasizes the point that all patients who survive the acute phase of aortic dissection require regularly scheduled imaging follow-up regardless of how the aorta is initially addressed.

Follow-up is routinely scheduled at 3 months with an office visit with the surgeon and a multiphase contrast-enhanced CT scan of the entire aorta. Recommended follow-up is recommended when the aortic diameter exceeds 5.5 cm or growth occurs at a rate greater than 5 mm/year.

CONCLUSION

In the race to improve outcomes after aortic dissection, several improvements in care are addressing the current shortcomings. By creating collaborative networks of multidisciplinary teams around high-volume aortic centres of excellence, we can deliver better care. This team approach will allow for more expedient diagnosis, transfer and treatment. Use of hybrid repair techniques to more easily perform extended repair will optimize aortic remodelling that will translate into improved late outcomes. Performing these operations in hybrid operating rooms using endovascular techniques should also improve perfusion of downstream vascular beds during the hyperacute phase of disease. Standardized imaging follow-up performed at aortic centres will improve our understanding of the natural history of disease and allow for further advances in care.

REFERENCES