Thoracic endovascular aortic repair versus open surgery for type-B chronic dissection

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An aging population, increased awareness, high-resolution imaging, and improving access to care all mean that more people are being diagnosed with acute aortic dissection. A better understanding of the role of initial medical therapy, improved surgical techniques, and the addition of endovascular approaches to the treatment algorithm, have resulted in more patients surviving the acute phase of disease. During the chronic phase, patients with residual dissection are challenged by the competing risks of reoperation or death. Open repair for chronic type-B dissection can be performed safely but is a relatively morbid operation. For this reason, surgery is often postponed until patients develop very late complications. Despite encouraging results for thoracic endovascular aortic repair of acute type-B dissection, chronic type-B dissection poses unique challenges that make application of endovascular technology more difficult. As our understanding of the disease and its natural history evolves, the ways in which these 2 methods of treatment complement each other need to be better understood. The benefits and limitations of each therapy, and how and when to apply each in the setting of chronic distal dissection, are discussed. (J Thorac Cardiovasc Surg 2015;149:S163-7)

See related commentary on pages S168-9.

No patient should be considered cured of the disease.

—E. Stanley Crawford, MD, on aortic dissection

Although great strides have been made in the past 50 years of treating aortic dissections, many of the early lessons learned by Dr Crawford and other pioneers hold true today.¹ Descending aortic dissection is a lifelong disease and carries high morbidity and mortality. In the chronic state, dissections are managed medically with close imaging surveillance until complications such as aneurysmal degeneration warrant surgical intervention.

At first glance, thoracic endovascular aortic repair (TEVAR) and open surgery have been assessed as competitive therapies to treat distal aortic disease.² More surgeons, and aortic centers of excellence, now have the skill set to offer both types of intervention. In the past year, TEVAR has received US Food and Drug Administration approval for the treatment of both acute and chronic aortic dissection. As our understanding of the disease and its natural history evolves, the ways in which these 2 methods of treatment complement each other need to be

better understood. The benefits and limitations of each therapy, and how and when to apply each in the setting of chronic distal dissection, are discussed.

CHRONIC DISTAL DISSECTION PATIENTS

An aging population, increased awareness, high-resolution imaging, and improving access to care all mean that more people are being diagnosed with acute aortic dissection. A better understanding of the role of initial medical therapy, improved surgical techniques, and the addition of endovascular approaches to the treatment algorithm, have resulted in more patients surviving the acute phase of disease. Previously, the time course of aortic dissection was understood to be acute if it was within the first 14 days of the initial event; afterward, it was considered chronic. Appreciation is now growing for the multiple phases of hazard associated with dissection; as a result, hyperacute is now defined as within the first 24 hours, acute as within the first week, subacute as within the first 30 to 90 days, and chronic as after that.

A great majority of patients surviving acute events are left with a residual dissection. A subset develop complications resulting from disease progression that manifests as aneurysmal degeneration, rupture, or end-organ malperfusion.^{3,4} These complications occur in 20%-50% of patients, whether they initially present with a DeBakey type-3 dissection or survive the emergency proximal repair of a type-1 dissection. One study reported a 60% incidence of progressive aortic dilatation, and a risk of rupture as high as 20% at a mean follow-up of 44.6 ± 25.4 months.⁵ These patients with complicated chronic descending thoracic dissection should be managed surgically, or with interventional therapy.³ Patients with uncomplicated chronic dissections are typically treated medically and followed until they develop 1 of these complications or die. The goal of each treatment modality is to prevent late aorta-related deaths.

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Abbreviations and Acronyms

ADSORB	= acute dissection: stent graft or best
INSTEAD	= investigation of stent grafts in aortic dissection
TEVAR	= thoracic endovascular aortic repair

The nature of the disease in its chronic state is varied, and so the population is heterogeneous, making a fair comparison among treatment modalities difficult. Additionally, patency and degree of patency (ie, thrombosis, partial thrombosis, fully patent) of the false lumen are predictors of the need for reoperation, and of late survival.^{6,7}

OPEN-REPAIR OUTCOMES

In a recent study of our experience at the Cleveland Clinic, we evaluated the results of open repair performed between 2000 and 2008 in 169 patients with descending aortic dissection who were deemed to be anatomically amenable to TEVAR.⁸ Most operations were performed with circulatory support and cerebrospinal fluid drainage. Resection was limited to the aneurysmal segment, and approximately half underwent thoracoabdominal repair. Many of these patients had undergone previous ascending, arch, and first-stage elephant trunk reconstruction. Operative mortality was 8%, and neurologic complications occurred in 2.4%. Survival at 1, 2, and 3 years was 82%, 78%, and 75%, respectively, and 14% required re-intervention. At 5 years, an estimated 50% were either dead or had undergone a reintervention (Figure 1). The strongest risk factor for the occurrence of 1 of these composite adverse events was a larger-diameter aorta at the level of the diaphragm, suggesting that patients with late-stage disease or a more aggressive form of disease do worse.

Similarly, Koli and colleagues⁹ described their experience with 104 patients who underwent open repair of descending aortic dissection between 1994 and 2007. The mortality was 9.6%; stroke occurred in 5.8%, renal failure in 4.8%, and tracheostomy was required in 14%. The open approach is a morbid procedure. The estimated survival was 68% at 5 years, and although the authors stated that the survival approached that of age- and gender-matched controls after 1 year by landmark analysis (ie, eliminating the 22% first-year mortality), the survival curves separate again at about 4-5 years, with chronic dissection patients doing worse than the controls.

IMPORTANCE OF A COMPETING-RISK ANALYSIS

These late follow-up results emphasize the fact that chronic dissection patients have a lifelong disease. During the chronic phase, patients with residual dissection after

acute surgical, medical, or endovascular therapy are challenged by the competing risks of reoperation or death. Open repair for chronic type-B dissection can be performed safely but is a relatively morbid operation. Many physicians and surgeons are hesitant to recommend surgery until it is deemed absolutely necessary, and patients fear open distal aortic repair. For this reason, surgery is often postponed until patients develop very late complications. This deferred approach to treating chronic aortic dissection should change if we are going to make progress in changing the long-term outcomes for patients who survive the acute phase of aortic dissection.

TEVAR FOR COMPLICATED CHRONIC DISSECTION

As experience with TEVAR has grown, its use has been expanded to patients with complicated chronic dissections, although the devices have only recently been approved for that indication. This approval was based mostly on data demonstrating a lower acute risk of the endovascular procedure as compared with open repair. Late outcome data for TEVAR in chronic aortic dissection are limited. In a study that was concurrent with the previously mentioned open series, we published our outcomes after TEVAR in patients with complicated chronic type-B dissection.¹⁰ Patients in the open surgical series were younger compared with those treated with TEVAR, but they were more likely to have extensive dissection extending through the abdominal aorta.⁸ The TEVAR series included many patients with the dissection limited to the thoracic aorta.

Operative mortality in our TEVAR patients was 5%, and survival at 1, 2, and 3 years was 86%, 82%, and 80%, respectively, but reintervention was required in 22%. In both the open repair and TEVAR studies, freedom from adverse events (ie, death or vascular reoperation) was similar—about 55% at 5 years in the TEVAR paper, and 50% in the open series. The diameter of the aorta at the level of the diaphragm was predictive of the risk of death or reintervention in the TEVAR experience, just as was seen in the open series.

Despite encouraging results of TEVAR for acute type-B dissection, chronic type-B dissection poses unique challenges that make application of endovascular technology more difficult. The delivery and deployment is usually carried out using a transfemoral approach under fluoroscopic guidance. The primary objective is to cover the proximal entry tear and expand the dissected true lumen. Achieving this objective usually requires positioning of the device in the distal aortic arch, and left subclavian artery coverage is necessary about 40% of the time.¹¹ Coverage of the proximal entry tear and expansion of the true lumen promote thrombosis of the false lumen, with the hope of reverse remodeling of the aorta, but this process is inconsistent. Many

FIGURE 1. Kaplan–Meier estimate of event-free survival (freedom from all-cause mortality and vascular reintervention) by extent of repair, expressed as probability with number at risk. Reprinted with permission.⁸

authors have confirmed this inconsistency in the occurrence of thromboexclusion.¹²⁻¹⁴

With time, the dissection flap thickens and becomes less mobile, and the distal re-entry tears mature into stable communications between the 2 lumens. Although the process of thrombosis may occur slowly over time, evidence has shown that it needs to be complete to lead to aortic shrinkage and a reversal of the natural history of the disease.^{15,16} In our series of TEVAR for chronic dissection, complete false lumen thrombosis occurred in 78% of those in whom the dissection was limited to the thoracic aorta, but in only 13% of those with more-extensive dissection (Figure 2).¹⁰

The incomplete healing of the aorta after TEVAR accounts for the need for reintervention. In a recently published compilation of data from several prospectively

FIGURE 2. Percentage of false lumen complete thrombosis after thoracic endovascular aortic repair for chronic aortic dissection by extent of aorta dissected. Limited extent (ie, thoracic aorta only) is shown in blue and extensive dissection is shown in red. Reprinted with permission.¹⁰

collected registries, the diagnosis of aortic dissection as an indication for TEVAR was correlated with a much higher need for reintervention than the diagnosis in those with degenerative aneurysm.¹¹

TEVAR FOR UNCOMPLICATED CHRONIC DISSECTION

In an effort to determine whether earlier treatment with stent grafting could improve outcomes for patients with uncomplicated chronic (albeit early, ie, 2-52 weeks) aortic dissection, the INSTEAD (investigation of stent grafts in aortic dissection) trial was designed as a randomized controlled trial comparing TEVAR ($n = 72$) with optimal medical management ($n = 68$). More false lumen thrombosis and aortic remodeling occurred in TEVAR patients, but the treatments did not have a statistically significant differential impact on survival during the initial 2 years of follow-up. At 2 years, there was a 20% cross-over rate from medical therapy to TEVAR.¹⁷ The follow-up of these patients has been extended to 5 years in the recently published INSTEAD XL trial and has again demonstrated aortic remodeling to have occurred in 79% of TEVAR patients versus only 10% of those in the medical therapy group ($P < .0001$).¹⁸ The all-cause mortality was still not significantly different between groups at this 5-year analysis point ($P = .140$), but the curves appear to cross at about 3 years.

There was a statistically significant benefit to TEVAR with regard to aortic-related deaths, and in all of the landmark analyses. These studies are probably underpowered, because the authors underestimated the benefits of optimal medical therapy, which is less commonly delivered in real-world situations. Furthermore, the potential complications associated with early stent grafting may be difficult to overcome during a short period of follow-up. The patients in this early study received older-generation devices, and the procedures were performed at multiple centers with variable levels of experience and quality. Fortunately, the devices and delivery systems, as well as the understanding of potential complications, have improved since this early experience. With additional studies, such as the ADSORB (acute dissection: stent graft or best) trial, and increasing experience with modern dissection-approved devices at centers of excellence, it is likely that a subset of patients will be identified who have uncomplicated dissection, are at high risk for early complications, and will benefit from TEVAR during the subacute phase of disease.

RETROGRADE DISSECTION

From the growing experience with TEVAR in dissections, it has become apparent that retrograde ascending

aortic dissection is an important life-threatening complication of this procedure. It must be recognized as such and avoided if possible. A large systematic review¹⁹ of more than 40 studies and nearly 10,000 patients reported the occurrence of this complication in 1.7%, and mortality after its occurrence of 33.6%. These findings were consistent with prior studies of the same problem.^{20,21} It was much more common when the indication for TEVAR was descending dissection (4%) rather than degenerative aneurysm (0.9%), and during the acute phase (8.4%) versus chronic (3%).¹⁹ The average amount of oversizing in those with retrograde dissection was 22%, versus only 10.3% in the others ($P < .0001$). Risk-factor analysis of the data demonstrated that the occurrence of retrograde dissection was directly correlated with the extent of oversizing of the devices in relation to the proximal landing zone such that for each percentage point of oversizing greater than 9%, the risk for retrograde dissection increased by 14%.

In addition, we have found an incidence of retrograde dissection after TEVAR in about 1.8% of our patients, and this was most commonly found in patients treated for dissection. In our experience with this complication, however, only 1 patient died, and this death occurred before transfer to the operating room. In the 14 patients who were stable enough for operative intervention, no deaths occurred, and the stent-graft device was maintained in all patients using a reverse frozen elephant trunk repair strategy.²²

NEED FOR ADJUNCTIVE THERAPY AND BETTER DEVICES

The most common complications after descending stent grafting for chronic aortic dissection relate to issues at the landing zones. Proximally, this may manifest as retrograde dissection as described, or type-1 endoleak. Distally, the most common late problem is due to persistent perfusion of the false lumen from distal re-entry tears, which can promote further aneurysmal degeneration and eventual rupture of the at-risk aorta (Figure 3). To address these complications, we have used both the open and endovascular approach, or a combination. These options include the use of custom, branched graft devices, off-label delivery of devices into the false lumen for occlusive purposes, visceral bypasses with extended aortic coverage, open distal aortic fenestration in combination with elephant trunk creation to optimize landing zones, and direct conversion to open repair.²³⁻²⁸

CONCLUSIONS

As our understanding and standardized treatment for acute dissection improve, we will see a growth in late survivors and an increase in the need for treatment of dissection during the chronic phase. A growing body of data suggests

FIGURE 3. Illustration demonstrating the problem of retrograde false lumen perfusion that commonly occurs in patients with chronic aortic dissection and prohibits complete healing and reverse remodeling. Reprinted with permission.²³

that patients will fare better with earlier and more-aggressive therapy. The use of stent grafting may safely expand these treatment options to more patients at an earlier phase of degeneration. The development of better disease-specific stent grafts and adjunctive devices should make endovascular treatment the primary option, even for patients with later-stage chronic disease. As our appreciation for the limitations and benefits of open and endovascular repair improves, so should our understanding of how these approaches serve as complementary methods to treating a very complex pathology.

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