Hybrid Techniques for Surgical Repair of Acute Type A Aortic Dissection

Hybrid repair of type A aortic dissection is a versatile approach that facilitates reconstruction at the level of the aortic arch and descending thoracic aorta.

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Acute type A aortic dissection (TAAD) is a common and highly morbid aortic emergency with a mortality rate of 1% per hour without surgical treatment. Many patients present with grave malperfusion syndromes such as myocardial infarction, stroke, and mesenteric or limb ischemia. The goal of surgery is to resect the primary intimal tear, reconstruct the proximal aorta and arch, and reinstitute distal organ perfusion. This usually requires replacement of the ascending aorta in addition to portions of the aortic root or arch, depending on the extent and location of the primary tears. Stent grafts deployed in the distal aorta may be used to complement open aortic intervention and allow for more complete distal aortic reconstruction. In this article, we describe our hybrid techniques for the surgical repair of acute TAAD.

OPERATIVE STRATEGIES

Open Technique

Patients with suspected or confirmed TAAD are emergently transferred to the hybrid operating room where a cardiac team has been gathered. General anesthesia is administered and appropriate monitoring catheters and lines are placed. Transesophageal echocardiography (TEE) is routinely used to confirm the diagnosis, evaluate ventricular function and valvular involvement, and identify the location of the true lumen. Continuous electroencephalography (EEG) and cerebral near-infrared spectroscopy are routinely used for brain monitoring.

In most patients, a period of circulatory arrest is planned to allow for open distal anastomosis at the level of the hemiarch or distal arch. In our experience, we have found that this approach allows for better evaluation and exclusion of any entry tears in the arch, as compared to the clamp-on technique. The cerebral protection strategy is usually either (1) deep hypothermia with retrograde cerebral perfusion through a superior vena cava (SVC) cannula, or (2) moderate hypothermia with antegrade cerebral perfusion with direct brachiocephalic cannulation or via an 8-mm Dacron graft sewn to the side of the artery prior to sternotomy. When axillary cannulation is used, this would also serve as an arterial cannula to go on cardiopulmonary bypass and avoid central aortic cannulation. A median sternotomy is performed and heparin is administered.

In the absence of axillary cannulation, our preferred approach is to directly cannulate the true lumen of the ascending aorta using the Seldinger technique with TEE guidance.[1] A dual-stage venous cannula is then placed in the right atrium. In the case where retrograde cerebral perfusion is planned, a SVC cannula is placed and Y-connected to the venous circuit and a cerebral perfusion line. A left ventricular venting catheter is placed through the right superior pulmonary vein while systemic cooling is initiated with continuous EEG monitoring. The aorta is clamped and cardioplegia is administered. Aortic valve or root pathologies are addressed while the patient is being cooled. When the root is spared and the aortic valve is structurally intact, the aortic valve commissures are resuspended at the level of the sinotubular junction. When EEG silence or goal core temperature is reached, the circulation is arrested, the aortic cross-clamp is removed, and antegrade or retrograde cerebral perfusion is initiated.

It is critical at this stage of the operation to carefully examine the arch and resect all intimal tears. The location of the most distal tear usually dictates the level of the distal anastomosis. A distal arch tear requires a total arch reconstruction. An ascending aortic tear can usually be excluded with hemiarch reconstruction. Once the distal anastomosis is completed, the system is deaired, cardiopulmonary bypass is resumed, selective cerebral perfusion is stopped, and rewarming is initiated.

The Role of Endovascular Techniques

The rationale to extend the distal repair to the distal arch or descending thoracic aorta (DTA) is based on two basic concepts. One is the absolute necessity to resect all primary entry points.[2] In fact, it is easy to overlook entry tears in the distal arch if the aortic cross-clamp is not removed. An isolated ascending aortic replacement in this case is not ideal, because the true lumen would still be pressurized with the potential of malperfusion syndrome or aortic rupture. The other concept is based on the knowledge that a persistent false lumen in the residually dissected aorta may degenerate into an aneurysm in the chronic phase and has been associated with increased late mortality.[3-5] In addition, surgical reconstruction at the level of the distal arch or DTA at the time of the index operation may simplify a future thoracoabdominal operation for aneurysmal degeneration.[6]

To address these issues, a more comprehensive and complete repair, particularly at the level of the distal anastomosis, is desired. The downside of a more extensive distal repair is that it adds to the morbidity of the operation in terms of:

- Longer circulatory arrest time
- Manipulation of the arch vessels with the associated risk of stroke
- Technically difficult distal anastomosis and the risk of bleeding
- Risk of injury to the left recurrent laryngeal nerve
- Coverage of the DTA with the associated risk of paraplegia

To overcome some of these difficulties, endovascular techniques may be used to limit the complexity of open reconstruction while achieving the same goals of primary tear resection and false lumen obliteration. The addition of an endovascular procedure to an open repair of TAAD is referred to as *hybrid repair.*

HYBRID REPAIR TECHNIQUES

An endovascular procedure may be done at the time of the index surgery (concomitant) or at a different time (staged, earlier or later) than the index open operation.

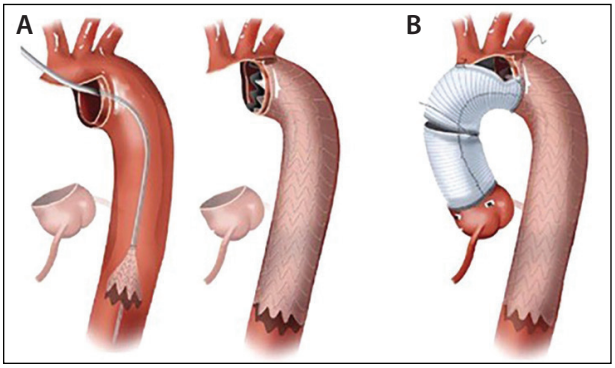

Figure 1. The ascending aorta and lesser arch curvature are resected and a stent graft is deployed antegrade into the descending thoracic aorta (A). Ascending and hemiarch reconstruction using two Dacron grafts with incorporation of the stent graft in the suture line at the lesser curvature (B). Reprinted with permission from Sultan I, Wallen TJ, Habertheuer A, et al. Concomitant antegrade stent grafting of the descending thoracic aorta during transverse hemiarch reconstruction for acute DeBakey I aortic dissection repair improves aortic remodeling. J Card Surg. 2017;32:581–592.

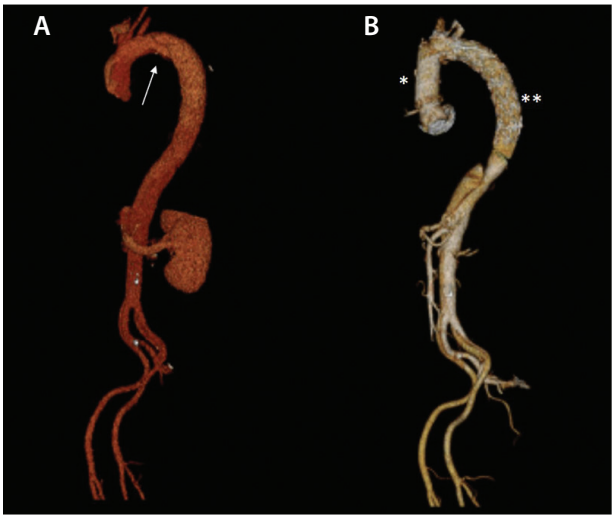

Figure 2. CT angiogram three-dimensional reconstruction of a patient with an intimal tear at the level of proximal DTA (arrow) resulting in a chronic type B dissection and acute retrograde type A dissection (A). Postoperative imaging after hemiarch replacement (*) with FET using a RelayPlus device (Terumo Aortic) placed antegrade at the time of circulatory arrest (**) (B). Note the residual thoracoabdominal dissection without malperfusion.

Concomitant Hybrid Procedures

Ascending and hemiarch replacement with antegrade frozen elephant trunk (FET) (Figure 1). The hemiarch reconstruction is best used for type I DeBakey dissec-

tion with primary tears in the ascending aorta or the lesser curvature of the proximal arch. The FET is used to exclude additional tears in the DTA. It is also ideal for retrograde TAAD originating from a proximal DTA tear (Figure 2). Additionally, in our experience, the FET improves distal aortic remodeling and decreases the rate of distal reoperation in DeBakey I dissection with tears limited to the ascending aorta.[7-9] The ascending aorta is resected and the proximal anastomosis is completed while the patient is being cooled to goal temperature. The circulation is then arrested, the aortic cross-clamp is removed, and cerebral perfusion is initiated. The aortic arch is examined and the lesser curvature is excised in a hemiarch configuration.[10] The true lumen of the DTA is visualized and a stent graft is advanced and deployed in a way so that the proximal landing zone at the level of the distal arch/proximal DTA junction without coverage of the left subclavian artery. Good proximal apposition of the stent graft is checked and may be reinforced with sutures. The diameter of the stent graft is usually oversized by 10% to 15% relative to the proximal DTA diameter. The length of the stent graft should be between 10 and 15 cm, depending on patient's size, to ensure appropriate coverage without impeding blood flow to the spinal cord. Following stent graft deployment, the distal anastomosis at the level of the hemiarch is constructed with a separate Dacron graft, and ideally, the stent graft is incorporated into the suture line along the lesser curvature. Upon completion of the distal anastomosis, the system is deaired and cardiopulmonary bypass is resumed. Then, both proximal and distal grafts are beveled and anastomosed together.[11] In our experience, using separate proximal and distal grafts allows for a better lay of the graft and avoids the risk of kinking, which is more relevant in the case of long aortas. The rest of the operation is conducted as previously described.

Ascending and total arch replacement with FET (Figure 3). This technique is best suited to treat intimal tears originating at the level of the aortic arch and involving arch branches. The arch vessels are divided just distal to their takeoff and the entire ascending aorta and aortic arch are resected. A stent graft is deployed antegrade, as previously described, and a multibranched Dacron graft is used to construct the distal anastomosis. Cardiopulmonary bypass is then resumed, and the arch vessels are anastomosed separately to the side branches of the graft. Finally, proximal to distal graft-graft anastomosis is completed.

Ascending and zone 2 arch replacement with retrograde branched thoracic endovascular aortic repair (TEVAR) (Figure 4). This is a variation on the standard total arch replacement where the distal anastomosis is constructed in zone 2 arch between the left common carotid and the left subclavian arteries. The left common carotid and the brachiocephalic arteries are debranched proximally on the Dacron graft, creating an ample landing zone for a stent graft. At the conclusion of the case, a branched stent graft is deployed retrograde, docking into the aortic graft and the left subclavian artery.[12] The zone 2 arch technique simplifies the technical complexity of the distal anastomosis with less risk of injury to the left recurrent laryngeal nerve.

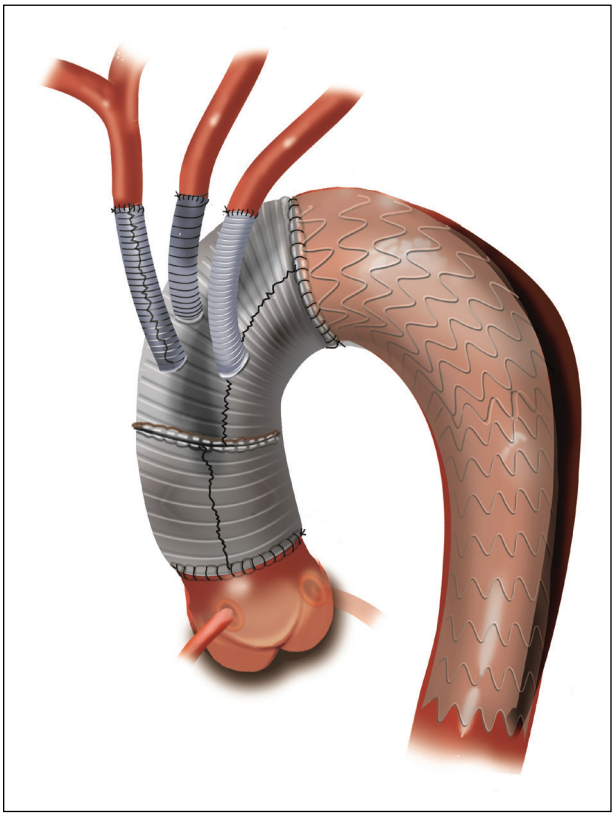

Figure 3. Total arch replacement and FET.

Staged Hybrid Procedures

Ascending aortic and hemiarch/total arch replacement followed by retrograde TEVAR or branched TEVAR. TEVAR is used to treat residual TAADs with a patent false lumen rather than a DTA entry tear. A traditional open repair at the level of the hemiarch and total arch is completed by excluding all entry tears. The patient is allowed to recover, and then few days later, standard retrograde TEVAR is completed to expand the true lumen. The left subclavian artery may be covered with or without a concomitant carotid-subclavian bypass. When a total arch replacement is

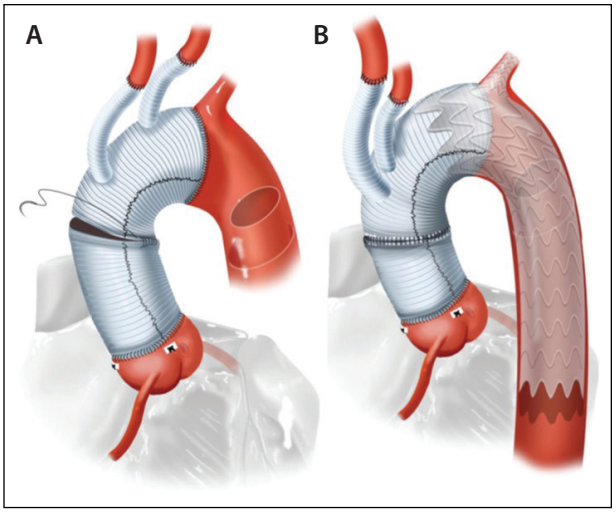

Figure 4. Open zone 2 arch reconstruction (A). Retrograde TEVAR docking into an aortic graft and left subclavian artery using a TAG thoracic branch endoprosthesis device (Gore & Associates) (B). Reprinted with permission from Desai ND, Hoedt A, Wang G, et al. Simplifying aortic arch surgery: open zone 2 arch with single branched thoracic endovascular aortic repair completion. Ann Cardiothorac Surg. 2018;7:351–356.

performed, it is crucial to debranch the arch vessels as proximally on the graft as possible to allow an ample proximal landing zone for TEVAR.

TEVAR to treat distal malperfusion syndrome, followed by open aortic replacement. Although the FET technique used at the time of proximal aortic reconstruction for TAAD with malperfusion syndrome improves survival,[11] this presentation remains one of the most lethal forms of acute TAAD.[13] A TEVAR-first approach is a relatively new strategy for the management of patients with mesenteric ischemia who are hemodynamically stable.[14] It allows for a very rapid reinstitution of perfusion to the visceral vessels by avoiding the time needed to perform a standard ascending and/or arch replacement first. This might be even more relevant for patients who had a previous sternotomy with difficult reentry into the chest. After visceral and limb reperfusion with retrograde TEVAR, an open proximal aortic replacement is performed either immediately or after a period of recovery in the intensive care unit.

FUTURE DIRECTIONS

Hybrid techniques have earned a growing role in the contemporary repair of acute TAAD. In many cases, the rapid and accurate deployment of a stent graft can simplify or expedite distal reconstruction at the level of the aortic arch. This is a very dynamic and evolving field, and there is no doubt that the technical applications of the stent graft are rapidly moving toward the proximal aorta and the aortic root. The age of routine total endovascular repair of acute TAAD is on the horizon. ■

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