Published in final edited form as:

J Card Surg. 2011 May ; 26(3): 304–308. doi:10.1111/j.1540-8191.2011.01224.x.

Total Aortic Replacement in Loeys-Dietz Syndrome

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Abstract

Loeys-Dietz syndrome (LDS) is a recently identified genetic complex characterized in part by rapidly progressive aortic and branch vessel disease. We now describe total aortic replacement using an open Extent II thoracoabdominal repair followed by second stage redo-sternotomy for a valve-sparing aortic root replacement and hybrid aortic arch repair in a patient with this syndrome.

Keywords

Loeys-Dietz syndrome; total aortic replacement; aortic operation; aortic stent; aortic aneurysm

Loeys-Dietz syndrome (LDS) was first described in 2005 in 16 persons from 10 different families [1]. The syndrome is caused by heterozygous mutations in the genes encoding the type 1 or 2 transforming growth factor- β receptor (TGF- β -R1/2) [2]. LDS has to date been described in Caucasian and Asian patients, and demonstrates autosomal dominant inheritance. Physical stigmata of the syndrome include the triad of arterial tortuosity and aneurismal disease, hypertelorism, and bifid uvula or cleft palate. Because the natural history of Loeys-Dietz syndrome differs considerably from other heritable aortopathies, individualized surgical management strategies are needed.

We have previously published the index report of two-stage total aortic replacement for LDS [3]. That case involved a young male status post ascending aortic replacement at another institution for acute Type A aortic dissection. He subsequently underwent redo-sternotomy for aortic root and total arch replacement (stage I elephant trunk) at our institution followed by second stage open Extent II thoracoabdominal repair two months later. We now present an approach to total aortic replacement for an LDS patient requiring thoracoabdominal repair as the first stage operation and incorporating the combination of valve-sparing aortic root replacement and a hybrid approach to the aortic arch to avoid the need for deep hypothermic circulatory arrest (DHCA) at the second operation. Approval by the local institutional review board for case review was completed.

Case Report

A 29 year old Caucasian female was referred to our center in July 2009 with an enlarging thoracoabdominal aneurysm and a diagnosis of Loeys-Dietz syndrome, confirmed by molecular genetic testing. The patient had undergone supracoronary ascending aortic and proximal arch replacement with a 28 mm Dacron graft for a peripartum acute Type A aortic dissection at an outside facility in October 2008; the aortic root (sinus of Valsalva segment) was not replaced at the time. A genetic syndrome was suspected based on the patient's distinctive facies; however, genetic confirmation of Loeys-Dietz syndrome was achieved

subsequent to her recovery from the initial emergent procedure. In the short interval following her ascending aortic replacement, the patient developed severe, progressive aneurismal disease of the thoracoabdominal aorta. Upon presentation to our center she was asymptomatic and had returned to work.

CTA upon referral to our center (Figure 1) demonstrated residual dissection of the transverse arch and thoracoabdominal aorta extending to the aortic bifurcation with associated 6.7 cm Extent II thoracoabdominal aortic aneurysm. The patient also suffered a retained sinus of Valsalva segment aneurysm measuring 5.2 cm. Transthoracic echocardiogram (TTE) revealed a normal tri-leaflet aortic valve with no associated aortic insufficiency. Because the thoracoabdominal aorta appeared to be the most pressing issue based on absolute size as well as rate of growth, this was approached as a first stage with a plan to next address the aortic root and arch as a hybrid second stage utilizing both open and endovascular techniques.

SURGICAL TECHNIQUE

First Stage

In July 2009, the patient underwent open repair of the thoracoabdominal portion of her pan-aortic aneurysm using cardiopulmonary bypass (CPB) and DHCA. This repair included open reverse hemi-arch replacement proximally as well as individual celiac, superior mesenteric (SMA), and right and left renal artery re-implantation as buttons using a 22 mm Vascutek "Coselli" multi-branch Dacron graft (Vascutek Terumo, Ann Arbor, MI); an accessory left renal artery was anastomosed directly to the graft.

This procedure was done using continuous transesophageal echo (TEE), electroencephalographic (EEG), somatosensory (SSEP) and motor (MEP) evoked potential monitoring[4]. EEG was used to guide the duration of cooling for DHCA and the SSEP and MEPs were used to monitor for spinal cord ischemia. A lumbar CSF drain was placed preoperatively. The patient was intubated with a dual-lumen endotracheal tube and standard invasive hemodynamic monitoring, including separate upper extremity and lower extremity arterial pressure monitoring, was used.

Venous cannulation was performed with the patient supine using a #22-French multistage cannula passed percutaneously from the right common femoral vein up to the right atrium under TEE guidance; 4000 U of IV heparin were administered prior to venous cannula placement and the cannula was flushed and then filled with heparinized saline after positioning to prevent thrombosis. The cannula was maintained sterile and then brought onto the operative field after prep and drape. A left thoracoabdominal incision through the fifth intercostal space was performed. The aorta was exposed from the arch to bifurcation using a retroperitoneal dissection in the abdomen. After systemic heparinization, arterial cannulation was performed in the non-dissected infrarenal aorta just above the bifurcation. A left ventricular vent was placed through the apex of the heart for decompression.

Electrocerebral inactivity (ECI) by EEG occurred at a nasopharyngeal temperature of 14.4 °C and a core bladder temperature of 20.1 °C. At this point, the distal descending thoracic aorta was clamped above the diaphragm and the proximal descending thoracic aorta opened during a period of cerebral DHCA. Flow (12 °C) to the visceral segment and lower body was maintained during this period; flows were targeted to a femoral arterial line pressure of approximately 50 mm Hg. Under cerebral DHCA, the proximal reverse hemi-arch anastomosis was performed incorporating the origin of the left subclavian artery using running 2-0 polypropylene suture. The cerebral circulatory arrest time was 22 minutes. The graft was then re-cannulated and clamped just distal to the arch anastomosis and flow to the

brain and upper body resumed after careful de-airing. Flow to the lower body/viscera was stopped at this point, and the distal thoracoabdominal aorta opened down to the aortic bifurcation. A button containing the two largest intercostals at T9 was then anastomosed end to side to the graft using running 5-0 polypropylene. The clamp was then moved distal to this anastomosis and the intercostals reperfused. All of the remaining intercostals were small and not re-implanted. The celiac axis, SMA, and right and left renal arteries were next re-implanted as buttons into the corresponding limbs of the Coselli graft using running 5-0 polypropylene suture. The clamp was then moved distal to the visceral limbs of the graft and the gut and kidneys reperfused. The visceral HCA time was 94 minutes. Rewarming was initiated at this point. The distal end of the graft was then anastomosed to the aortic bifurcation using running 3-0 polypropylene suture and the pelvis and legs reperfused. A side biting clamp was then placed on the graft and an accessory left renal artery anastomosed as a button end to side to the graft using running 5-0 polypropylene. After rewarming, the patient was weaned from CPB, de-cannulated, and hemostasis obtained. EEG returned symmetric to baseline and SSEP and MEPs were intact at the completion of the procedure. Total CPB time was 228 minutes.

The patient did well following this procedure, although similar to our previously reported LDS patient [3], she did suffer a spinal headache related to cerebrospinal fluid drainage which eventually required a blood patch before resolving. Hospital discharge occurred on postoperative day 6.

Second Stage, Open Component

Three months later in October 2009, following an uncomplicated recovery, the patient underwent the second stage of her total aortic replacement. This included redo-median sternotomy, T. David-V valve-sparing aortic root replacement using a 30 mm Valsalva graft (Vascutek Terumo, Ann Arbor, MI), and ascending aortic graft to innominate artery and left common carotid artery bypass (arch debranching procedure) [5]. Aortic arch debranching was performed to address the residual arch dissection and allow for endovascular exclusion of the remaining aortic arch without the need for DHCA.

This operation was done under continuous TEE and EEG monitoring; EEG was used to monitor for cerebral ischemia during the arch debranching portion of the procedure. Because the aorta nearly abutted the posterior sternal table (Figure 1), cannulation was performed prior to sternal re-entry. As the right axillary artery was quite small, measuring <6 mm in diameter on preoperative CTA, we elected to perform open right femoral arterial and venous cannulation. Four thousand units of IV heparin were administered prior to cannulation. A redo-median sternotomy was performed with the incision extended along the anterior border of the sternocleidomastoid muscle on the left for a distance of several centimeters. After uneventful sternal re-entry, the patient was fully systemically heparinized and the mediastinal and arch vessel dissection completed on CPB. Moderate systemic hypothermia was used (28 °C).

The valve-sparing root replacement was performed first. The aorta of the markedly dilated sinus segments was excised leaving a 4-5 mm rim adjacent to the commissures and annulus. Left and right coronary buttons were fashioned. The root was dissected free circumferentially down to below the plane of the annulus. The entire root dissection was more difficult than usual due to dense adhesions related to the prior ascending dissection repair. The aortic annulus measured 23 mm and the valve leaflets were of good quality with no stress fenestrations. Using a universal aortic sizer to assess leaflet coaptation with the commissures suspended at the proposed height, it appeared that a 30 mm Valsalva graft for reconstruction of the root would create proper geometry and maintain central aortic valve leaflet coaptation. After completing the valve-sparing root reconstruction, cardioplegia was

administered down the “neoaortic root” with the distal end of the graft clamped. This maneuver demonstrated hemostatic suture lines as well as a competent aortic valve. The distal end of the Valsalva graft was then beveled and anastomosed to the existing ascending Dacron graft using running 3-0 polypropylene suture. De-airing was then carried out and the aortic cross-clamp released. Total cross-clamp time was 171 minutes.

The arch debranching portion of the procedure was performed next. A trifurcated Dacron graft with a 12 mm main body and 8 mm distal side-arms was used. The graft was trimmed such that the proximal 8 mm limb was removed. Using a partial occlusion clamp technique, the debranching graft was anastomosed end-to-side to the existing ascending aortic graft with running 3-0 polypropylene suture. After a 3 minute test clamp of the left common carotid artery was performed demonstrating no ischemic changes by EEG, the carotid was stapled proximally at its origin from the arch using a vascular stapler, clamped distally, and divided. The 8 mm side arm of the debranching graft was cut to length and anastomosed end-to-end to the carotid with running 5-0 polypropylene suture. After careful de-airing, the carotid was reperfused. This process was then repeated for the innominate artery. After completion of rewarming, the patient weaned off CPB on no inotropes. Total CPB time was 294 minutes. Post-CPB TEE revealed normal left ventricular function and no aortic insufficiency. EEG remained symmetric throughout the procedure. The patient recovered well following this operation and was discharged on postoperative day 5 (Figure 2).

Second Stage, Endovascular Component

The patient was then taken to the operating room for the final component of her total aortic replacement in March of 2010. She underwent endovascular exclusion of the residual dissected transverse arch using a 34/30 mm × 15.7 cm proximal taper Zenith TX2 device (Cook Medical Inc, Bloomington, IN) with intentional left subclavian artery coverage (Figure 3); adjunctive left common carotid to left subclavian artery bypass utilizing an 8 mm PTFE graft was performed immediately prior to the endograft portion of the procedure. Proximal and distal landing zones for the endograft were both within existing Dacron grafts rather than LDS aorta. Continuous neurocerebral monitoring with SSEP and MEPs was employed throughout the duration of the procedure. Continuous TEE monitoring was also utilized. Post-deployment SSEPs and MEPs were unchanged from baseline. The patient recovered uneventfully and was discharged on postoperative day number 2. The need for a second episode of circulatory arrest was avoided by utilizing landing zones, both proximal and distal, within Dacron graft. The patient continues to do well now 10 months status-post her completed total aortic replacement (Figure 4).

Comment

In comparison to the Marfan syndrome, Loeys-Dietz syndrome (LDS) manifests with an even more aggressive arteriopathy and total aortic replacement is certain to become a recognized treatment of this disorder, especially in those patients who are not diagnosed until after suffering an aortic dissection event. As such, this report describes a novel approach to total aortic replacement in an LDS patient status post prior Type A dissection repair and with descending/thoracoabdominal pathology that required treatment antecedent to root/arch pathology. We feel the approach described represents a viable option that avoids the need for DHCA as part of the second stage repair. Another option for this patient would have been a first stage open thoracoabdominal repair using a reverse elephant trunk technique [6], with the reverse elephant trunk subsequently used at the second operation for open total arch replacement in conjunction with root replacement. This represents a larger second stage procedure, which presumably carries a higher perioperative risk, even in a young otherwise healthy patient such as the one presented. The Zenith endograft utilized in this case is a Dacron-lined stent graft and thus functionally results in an identical result

albeit at a lower risk to the patient. However, we fully acknowledge the lack of long-term follow-up data after thoracic endovascular aortic repair to substantiate this approach.

Another novel aspect of this case was that a valve-sparing aortic root replacement was performed after prior supracoronary ascending replacement; this has not been previously reported in an LDS patient. Given the patient's young age and normally functioning trileaflet aortic valve, this was felt to represent the best treatment option for her root pathology. Similar to our previously reported case [3], the side branch technique for arch and visceral vessel re-implantation was used to avoid the known risk of patch pseudoaneurysm formation in other high-risk connective tissue disease populations [7]. The risk of continued arterial dilation due to the progressive nature of LDS predisposes to stent graft failure if native aorta is used for landing/fixation zones, and we consider Loeys-Dietz syndrome to be a contraindication to thoracic endovascular aortic repair [8] unless both proximal and distal stent graft landing zones are within existing Dacron grafts as in the case presented.

As individualized operative approaches are developed using modern adjuncts, and the natural history of LDS continues to be described, critical management strategies include genetic testing, screening of family members, and meticulous aortic surveillance with a low threshold for early surgical intervention.

References

1. Loeys BL, Chen J, Neptune ER, et al. A syndrome of altered cardiovascular, craniofacial, neurocognitive and skeletal development caused by mutations in TGFBR1 or TGFBR2. *Nat Genet.* 2005; (37):275–81. [PubMed: 15731757]
2. Loeys BL, Schwarze U, Holm T, et al. Aneurysm syndromes caused by mutations in the TGF-receptor. *N Engl J Med.* 2006; (355):788–98. [PubMed: 16928994]
3. Williams ML, Wechsler SB, Hughes GC. Two-stage total aortic replacement for Loeys-Dietz syndrome. *J Cardiac Surg.* 2010; 25:223–4.
4. Husain AMSM, McCann RL, Hughes GC. Neurophysiologic intraoperative monitoring during endovascular stent graft repair of the descending thoracic aorta. *J Clin Neurophysiol.* 2007; 24(4): 328–335. [PubMed: 17938601]
5. Hughes GC, Daneshmand MA, Balsara KR, et al. “Hybrid” Repair of Aneurysms of the Transverse Aortic Arch: Mid-term Results. *Ann Thorac Surg.* 2009; 88:1882–7. [PubMed: 19932255]
6. Coselli JS, LeMaire SA, Carter SA, Conklin LD. The reversed elephant trunk technique used for treatment of complex aneurysms of the entire thoracic aorta. *Ann Thorac Surg.* Dec; 2005 80(6): 2166–72. [PubMed: 16305865]
7. LeMaire SA, Carter SA, Volguina IV, et al. Spectrum of aortic operations in 300 patients with confirmed or suspected Marfan syndrome. *Ann Thorac Surg.* 2006; 81(6):2063–78. [PubMed: 16731131]
8. Hughes GC, Lee SM, Daneshmand MA, et al. Endovascular repair of descending thoracic aneurysms: results with “on-label” application in the post-FDA approval era. *Ann Thorac Surg.* 2010; 90:83–9. [PubMed: 20609753]

Figure 1. 3D (A) and axial (B, C) CTA images at initial presentation to our center. Residual dissection of the transverse arch and thoracoabdominal aorta with associated root and Extent II thoracoabdominal aortic aneurysm can be seen.

Figure 2.
3D CTA following thoracoabdominal and aortic root replacement and arch debranching.

Figure 3. Intraoperative fluoroscopic images pre- (A), during (B), and post- (C) Zenith TX2 deployment for endovascular exclusion of the residual dissected transverse arch, with intentional left subclavian artery coverage. A patent left carotid-subclavian artery bypass, performed immediately prior to endograft introduction, is well visualized in (C).

Figure 4.
3D CTA 6 months following completed total aortic replacement.