

Valve Sparing Aortic Root Replacement in Children with Loeys-Dietz Syndrome

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Loeys-Dietz syndrome (LDS) is an autosomal dominant connective tissue disorder that is characterized by aggressive arterial and aortic disease, often involving the formation of aortic aneurysms. We describe the cases of two children with LDS who were diagnosed with aortic root aneurysms and successfully treated by valve-sparing aortic root replacement (VSRR) with a Valsalva graft. VSRR is a safe and suitable operation for children that avoids prosthetic valve replacement.

Key words: 1. Loeys-Dietz syndrome
2. Aortic root
3. Aortic valve, surgery
4. Aneurysm
5. Aorta

CASE REPORT

1) Case 1

A three-year-old girl who had been diagnosed with an aortic root aneurysm was admitted for surgical treatment. She weighed 14 kg (51st percentile), and her height was 105 cm (97th percentile). She had been diagnosed with Loeys-Dietz syndrome (LDS) one year previously at another clinic and was referred to Asan Medical Center due to an enlarged aortic root. She had undergone ligation of a patent ductus arteriosus six months previously. She had hypertelorism, a cleft palate, and a bifid uvula, which are characteristic features of LDS. She had been put on an angiotensin converting enzyme inhibitor and followed up with echocardiography.

Preoperative echocardiography revealed a dilated aortic root

and trivial aortic regurgitation. In a cardiac computed tomography (CT) exam, the diameter of the aortic annulus was found to be 17.3 mm (z-score=3.21), the diameter of the aortic sinus was found to be 42 mm (z-score=8.19), and the diameter of the sinotubular junction (STJ) was found to be 27 mm (Fig. 1A, B). The fact that the diameter of the aortic sinus had increased by 4 mm over the previous six months, as shown by serial CT scans, was of particular importance. She underwent valve-sparing aortic root replacement (VSRR), in which the root reimplantation technique was applied.

A median sternotomy was performed and total thymectomy was carried out. Cardiopulmonary bypass was achieved via the distal ascending aorta and bicaval cannulation, and the patient was cooled to 26°C. A left atrial vent was placed via the right upper pulmonary vein. After the aorta was cross-

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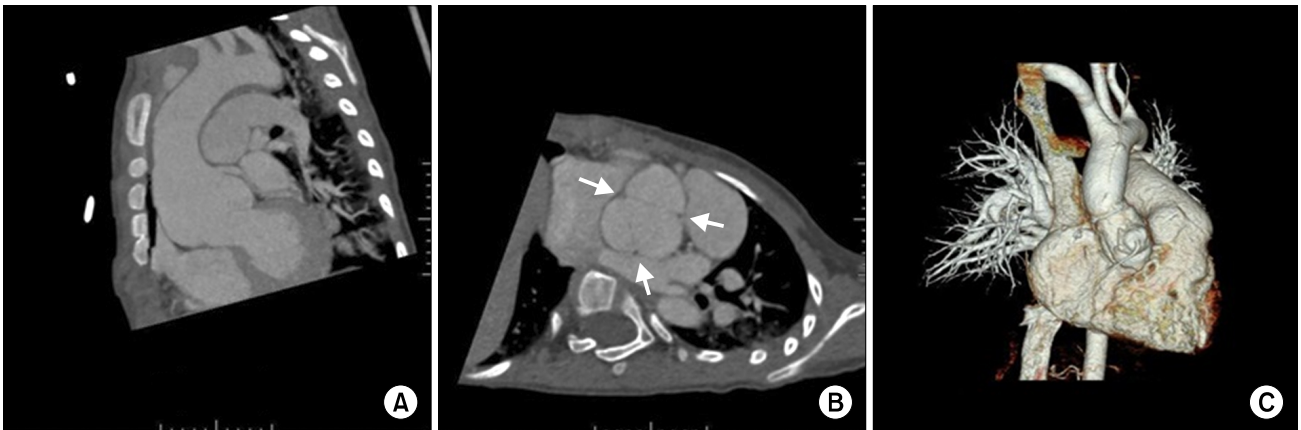


Fig. 1. (A, B) Preoperative cardiac computed tomography showing a dilated aortic root. Each sinus was dilated symmetrically. (C) Postoperative cardiac computed tomography showing the aortic root replaced by a 24-mm Gelweave Valsalva graft (case 1). Arrows indicate each commissure of aortic the valve.

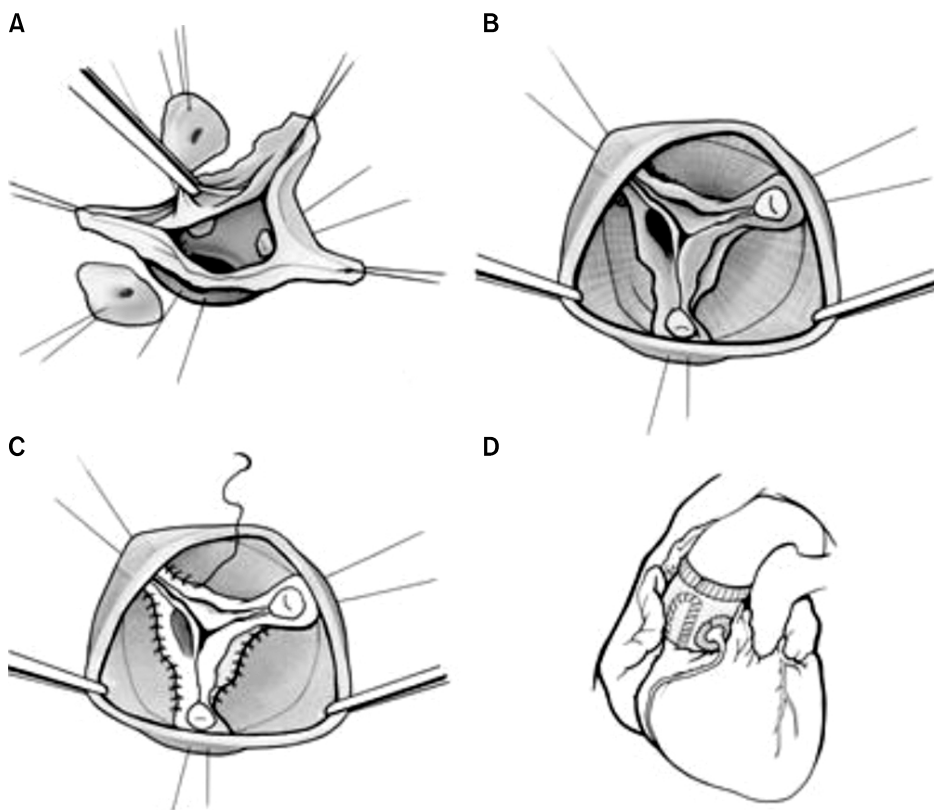


Fig. 2. Operative techniques of valve-sparing aortic root replacement. (A) Three stay sutures were placed at each of the three commissures, and subannular sutures were placed below the nadir of the annulus in each of the three sinuses. (B) After a graft was placed on the aortic annulus, three commissures were fixed to the sinotubular junction of the graft. (C) Hemostatic suture lines were formed by fixing the annulus and remnant sinus to the graft internally using 5-0 prolene sutures. (D) The coronary buttons were reimplanted into the graft, and the distal graft was anastomosed to the ascending aorta.

clamped, crystalloid cardioplegia was delivered via the aortic root. The aorta was transected 2 cm above the STJ and the ascending aorta was excised to the STJ. The aortic root was carefully mobilized to the annulus level. Three stay sutures of 3-0 black silk were placed at each of the three commissures

(Fig. 2A). After the diameters of the STJ and annulus were measured with valve sizers, the coronary arteries were detached from their sinuses and the dilated sinuses were excised, leaving about 4 mm of sinus tissue in place. Subannular sutures were placed below the nadir of the annulus in each of

Table 1. Preoperative and postoperative diameters of the aortic root and pulmonary artery root

		Aortic root			Pulmonary artery root	
		Annulus (mm) (z-score)	Sinus (mm) (z-score)	Sinotubular junction (mm) (z-score)	Annulus (mm) (z-score)	Main pulmonary artery (mm) (z-score)
Case 1 ^{a)}	Preoperative	17.3 (3.21)	42.0 (8.19)	23.0 (3.85)	19.0 (1.65)	26.0 (3.42)
	Postoperative	25.0 (5.03)	29.0 (3.16)	20.0 (1.45)	23.0 (1.51)	29.0 (2.85)
Case 2 ^{b)}	Preoperative	19.0 (2.80)	55.0 (9.47)	23.0 (2.88)	20.0 (0.99)	27.0 (2.75)
	Postoperative	25.0 (4.71)	29.0 (4.17)	18.0 (0.44)	28.0 (2.56)	24.0 (1.42)

^{a)}Figures reflect the most recent follow-up computed tomography scan, performed four years after surgery (24-mm Gelweave Valsalva graft). ^{b)}Figures reflect the most recent follow-up computed tomography scan, performed two years after surgery (26-mm Gelweave Valsalva graft).

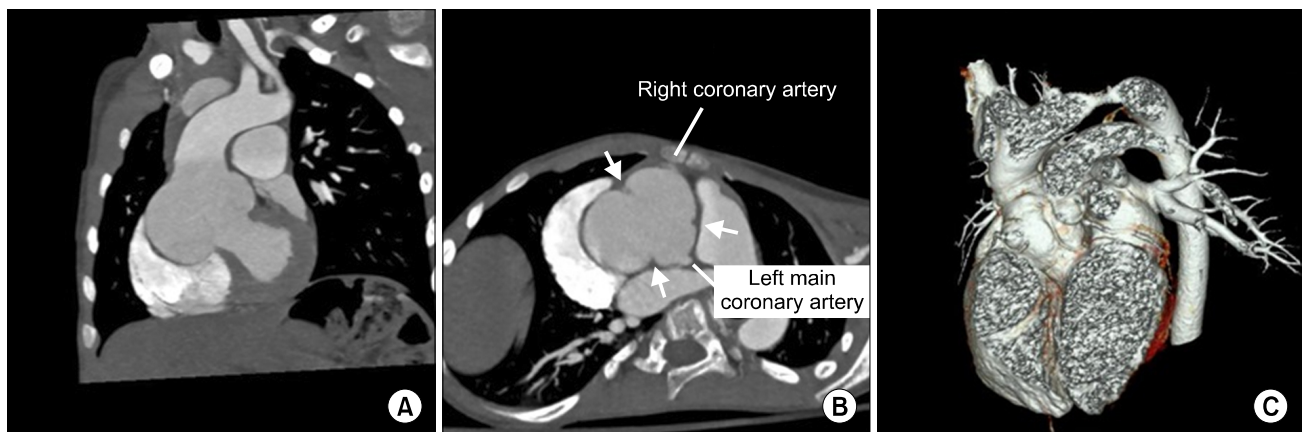


Fig. 3. (A, B) Preoperative cardiac computed tomography showing a severely dilated aortic root. The non-coronary sinus was asymmetrically dilated. (C) Postoperative cardiac computed tomography showing the aortic root replaced by a 26-mm Gelweave Valsalva graft (case 2). Arrows indicate each commissure of aortic valve.

the three sinuses using pledgeted mattress sutures of 3-0 ethibond (Fig. 2A). Subsequently, a 24-mm Gelweave Valsalva graft (Vascutek, Renfrewshire, Scotland) was placed on the aortic annulus using subannular sutures. Three commissures were fixed to the STJ of the graft using pledgeted 5-0 prolene sutures and the stay sutures were removed (Fig. 2B). Hemostatic suture lines were formed by internally fixing the annulus and remnant sinus tissue to the graft using 5-0 prolene sutures (Fig. 2C). The coronary buttons were reimplemented into the graft using a Teflon strip and 5-0 prolene sutures. The distal graft was anastomosed to the ascending aorta using a Teflon strip and 5-0 prolene sutures (Fig. 2D). The total cardiopulmonary bypass and aortic cross-clamp times were 202 and 156 minutes, respectively. Intraoperative transesophageal echocardiography revealed no aortic regurgitation.

The patient’s postoperative course was uneventful. She was discharged eight days after the operation and has remained in excellent condition over five years of follow-up. Pathologic examination of the resected aortic wall showed mucinous degeneration. The most recent follow-up CT scan, performed four years after surgery, showed no significant dilatation of the aortic sinus (Fig. 1C), and echocardiography performed five years after surgery showed no aortic regurgitation. The preoperative and postoperative aortic and pulmonary artery root diameters, together with the corresponding z-scores [1], are shown in Table 1.

2) Case 2

A seven-year-old boy who had been diagnosed with aortic root aneurysm was admitted for surgical treatment. He weigh-

ed 19.8 kg (43rd percentile), and his height was 120.8 cm (90th percentile). He had been diagnosed with LDS two years previously at our pediatric clinic and had undergone follow-up with echocardiographic monitoring and no medication. He had a bifid uvula, pectus carinatum, relative macrocephaly, and joint laxity, which are clinical features indicative of LDS, but he did not display hypertelorism.

Preoperative echocardiography revealed a dilated aortic root and mild aortic regurgitation. A cardiac CT exam showed that the diameter of the aortic annulus was 19.0 mm (z-score=2.80), the diameter of the aortic sinus was 55.0 mm (z-score=9.47), and the diameter of the STJ was 23.0 mm (Fig. 3A, B). The aortic sinus was dilated asymmetrically, especially in the non-coronary sinus. He underwent VSRR with a 26-mm Gelweave Valsalva graft (Vascutek). The operative techniques were identical to those described in case 1. The total cardiopulmonary bypass and aortic cross-clamp times were 215 and 140 minutes, respectively. Intraoperative transesophageal echocardiography revealed trivial aortic regurgitation.

The patient's postoperative course was uneventful. He was discharged nine days after the operation, and has remained in excellent condition over 30 months of follow-up. Pathologic examination of the resected aortic wall showed fibromyxoid changes in the intima. The most recent follow-up CT scan, performed two years after surgery, showed no significant dilatation of the aortic sinus, but did show a mildly dilated pulmonary artery sinus (Fig. 3C), and echocardiography performed two years after surgery showed grade I aortic regurgitation. The preoperative and postoperative aortic and pulmonary artery root diameters, together with the corresponding z-scores [1], are shown in Table 1.

DISCUSSION

LDS is a recently recognized connective tissue disease that shows an autosomal dominant pattern of inheritance, similar to Marfan syndrome. Compared to Marfan syndrome, LDS tends to involve a more generalized and aggressive form of vascular disease and presents in childhood or adolescence. This syndrome involves mutations of the type I or type II transforming growth factor β receptors. These defects lead to the overproduction of collagen, the loss of elastin content,

and disarray of elastic fibers, resulting in a weakened vascular media that eventually leads to dilatation and dissection of the vessel walls. The phenotypic findings associated with LDS include hypertelorism (90%), cleft palate/bifid uvula (90%), generalized arterial tortuosity (84%), craniosynostosis (48%), patent ductus arteriosus (35%), atrial septal defect (23%), Chiari type I malformation (20%), developmental delay (15%), and hydrocephalus (15%) [2,3].

Two types of LDS are differentiated based on their characteristic phenotypes [3]. In type I LDS, craniofacial involvement is observed, consisting of hypertelorism, cleft palate/bifid uvula, or craniosynostosis, whereas type II LDS patients show no evidence of these findings, although some have an isolated bifid uvula. Type I LDS tends to involve a more severe cardiovascular course than type II LDS, but both types of LDS are associated with a more aggressive progression of vascular disease than other connective tissue diseases, such as Marfan syndrome. In this report, case 1 had type I LDS and case 2 had type II LDS.

In type I LDS, operative indications of aortic root aneurysms in children are an aortic root z-score >3.0 or a rapidly expanding aneurysm (>0.5 cm of expansion in one year). The primary indication for surgery in patients with type II LDS is an aortic root z-score >4.0 ; a higher aortic root z-score is used as an operative indication in type II LDS due to its milder course [4]. These indications were followed in our two cases.

Two techniques exist for VSRR: remodeling and reimplantation. Although the remodeling technique is physiologically superior to the reimplantation technique [5], the reimplantation technique is more feasible in connective tissue diseases such as Marfan syndrome, because it can stabilize the aortic annulus and prevent subsequent annular dilatation [6]. These operations can also help avoid the disadvantages of prosthetic valve replacement. However, the reimplantation procedure has the theoretical disadvantage of impacting the valve leaflets in the cylindrically reconstructed sinuses. A Valsalva graft can reduce this problem because it has out-bulging sinuses constructed as a part of the conduit. Patel et al. [7] have described excellent medium-term results of valve-sparing operations using Valsalva grafts in LDS patients.

LDS is an aggressive aortic aneurysm disease involving the possibility of rupture and dissection even in relatively young

patients with relatively small aortic diameters [4], and careful postoperative follow-up is therefore mandatory. According to the recommendations of Patel et al. [7], echocardiography should be performed every three to six months for one year after VSRR and every six months subsequently, in addition to a CT scan or magnetic resonance imaging six months post-operatively and annually thereafter, in order to check the aortic root diameter and valve competence. In addition, they recommended annual head-to pelvic CT scans to check for involvement of the arterial tree [7].

In Korea, one report has described an adult LDS patient who experienced aortic rupture and underwent ascending aorta replacement [8]. This is the first report describing pediatric LDS patients who underwent VSRR with a Valsalva graft in Korea [9]. In pediatric LDS patients with an aortic root aneurysm and intact leaflet morphology, VSRR with a Valsalva graft is a safe and feasible surgical option.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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