LEFT VENTRICLE TO ABDOMINAL AORTA CONDUIT FOR RELIEF OF AORTIC STENOSIS

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Relief of left ventricular hypertension caused by aortic stenosis is often difficult to achieve by conventional methods. Aortic valvotomy, valve replacement, or annuloplasty may not provide adequate results, particularly in cases of severe congenital valvular stenosis when the annulus and leaflets are underdeveloped. Subvalvular and supravalvular stenoses may also complicate surgical correction. In most circumstances the surgeon must adopt a limited objective of relieving the stenosis to a reasonable degree without resorting to extensive valvuloplasty which might lead to aortic incompetence. Recently a patient with severe recurrent congenital aortic stenosis was relieved of the concomitant left ventricular outflow pressure gradient by an unusual surgical approach.

CASE REPORT

On August 13, 1975, a ten-year-old white female was admitted to the Texas Children's Hospital. A murmur was heard at birth, and when she was six years old aortic valvotomy was performed at another hospital. A bicuspid valve was noted at operation and only a limited valvotomy was possible. The patient was asymptomatic for the next four years. Three months prior to admission here she began to experience palpitations and was recatheterized. Cardiac catheterization performed elsewhere one week prior to admission revealed a peak systolic left ventricular pressure of 250-220 mm Hg with a peak systolic aortic pressure of 100 mm Hg (Fig. 1). Because of the transaortic gradient of 150 mm Hg, left ventricular strain and hypertrophy, and the episodes of precordial pain with palpitations, a second operation was recommended and she was referred to our hospital. Just prior to admission she had two episodes of dull precordial chest pain radiating to the left arm.

On physical examination a thrill was palpable in the suprasternal notch and carotid arteries. The point of maximum impulse of the heart was in the fifth intercostal space near the anterior axillary line. A harsh systolic murmur, Grade V/VI, was heard in the second intercostal space along the left sternal border radiating to the neck and back. No other remarkable physical findings were noted.

Roentgenograms of the chest revealed normal heart size and pulmonary vascular markings. The electrocardiogram showed left ventricular stain and hypertrophy. The hematocrit was 33.5% and the hemoglobin was 12.8 gm%. The white count was 6,900 with a normal differential. Urinalysis was also normal.

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Operation was performed on August 14, 1975, through the previous sternotomy incision. After separation of the pericardial adhesions, a single cannula was placed in the right atrium for collection of venous blood returning from the venae cavae; the ascending aorta was cannulated for return of oxygenated blood. Since the patient's parents were members of the Jehovah's Witness religious sect, no blood or blood derivatives could be administered either during or after operation. The extracorporeal circuit was primed with 1200 ml of 5% Dextrose-Lactated Ringer's solution. Cardiopulmonary bypass flow rates of 60 ml/Kg/min (2040 ml/min) were achieved by employing a centrifugal (constrained force-vortex principle) pump.* The ascending aorta was cross-clamped to obtain normothermic ischemic arrest; later the heart developed spontaneous ventricular fibrillation. The left heart was vented by inserting a sump suction through the right superior pulmonary vein into the left atrium.

A transverse aortotomy was made to explore the aortic valve; it was bicuspid with the larger unicusp composed of the right and left coronary leaflets. The aortic orifice was narrow and elliptical in shape. The anterior and posterior commissures could be opened only a few millimeters; further separation would have unhinged the leaflets, producing aortic regurgitation. Since adequate valvotomy was impossible, the decision was

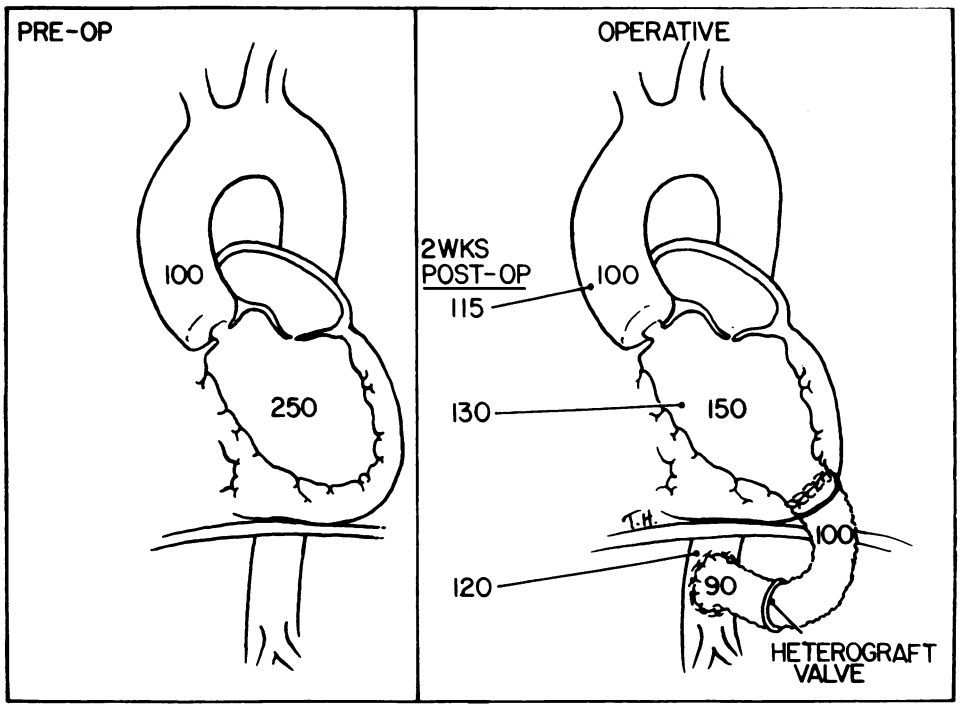

Fig. 1. Diagram showing manometric findings before operation, at operation, and after operation.

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made to create a double-outlet left ventricle by placing a conduit from the apex of the left ventricle to the abdominal aorta. The midline incision was therefore extended to a point just above the umbilicus.

The apex of the left ventricle was elevated and an ellipse of myocardium was excised. The proximal end of a 14-mm tightly woven Dacron graft* was tapered and then sutured to the ventricular ostium with a continuous suture of 3-0 braided polyester. Through the abdominal incision the liver was mobilized toward the right by dividing the triangular ligament. After incising the right crus of the diaphragm, the abdominal aorta proximal to the celiac axis was exposed. The aorta was cross-clamped proximally and distally and the distal end of a 14-mm composite Dacron graft containing a heterograft valve** was anastomosed to the aorta with a continuous suture of 4/0 polyester.

The ventricle with its attached graft was replaced in the pericardium. An ellipse of tissue was excised from the anterolateral aspect of the subpericardial diaphragm. The graft was then drawn through the opening and clamped. After air from the ventricle and graft had been aspirated, the heart was defibrillated with a single countershock. Normal sinus rhythm resumed immediately. The proximal graft was shortened to prevent kinking and the final step was graft-to-graft anastomosis. As soon as the cannulae for cardiopulmonary bypass were removed, pressures in the aorta, ventricle, and conduit proximal and distal to the valve were measured (Fig. 1).

The postoperative course was uneventful and the patient was discharged from the hospital on August 27, 1975, with a hematocrit of 28.5 percent and the hemoglobin 9.4 gms percent. As noted earlier, no blood or blood analogues were administered during or after surgery.

Ten days after operation cardiac catheterization was repeated (Fig. 1). Flow studies revealed a left ventricular output of approximately 3.2 L/min. If it had been possible to measure output through the pulmonary artery, a more accurate assessment of the performance of the double-outlet left ventricle could have been made. The size of the patient, however, precluded the use of a Swan-Ganz catheter. Distal flows were 1.5 L/min at the mid ascending aorta and 1.3 L/min below the conduit-abdominal aortic anastomosis. Left ventricular cine angiography showed movement of the dye from the left ventricle through the conduit into the abdominal aorta (Fig. 2-a). The heterograft valve functioned well and no retrograde flow was observed. The conduit and abdominal aorta appeared to fill from early to mid systole (Fig. 2-b). During late systole the left ventricular apex essentially occluded the entrance to the conduit and blood flowed through the stenotic aortic valve (Fig. 2-c).

DISCUSSION

Alexis Carrel[1] in 1910 described experiments in which bypasses were performed from the left ventricle to the thoracic aorta using vein grafts. In 1955 Sarnoff, Donovan, and Case[2] used a Lucite tube incorporating a

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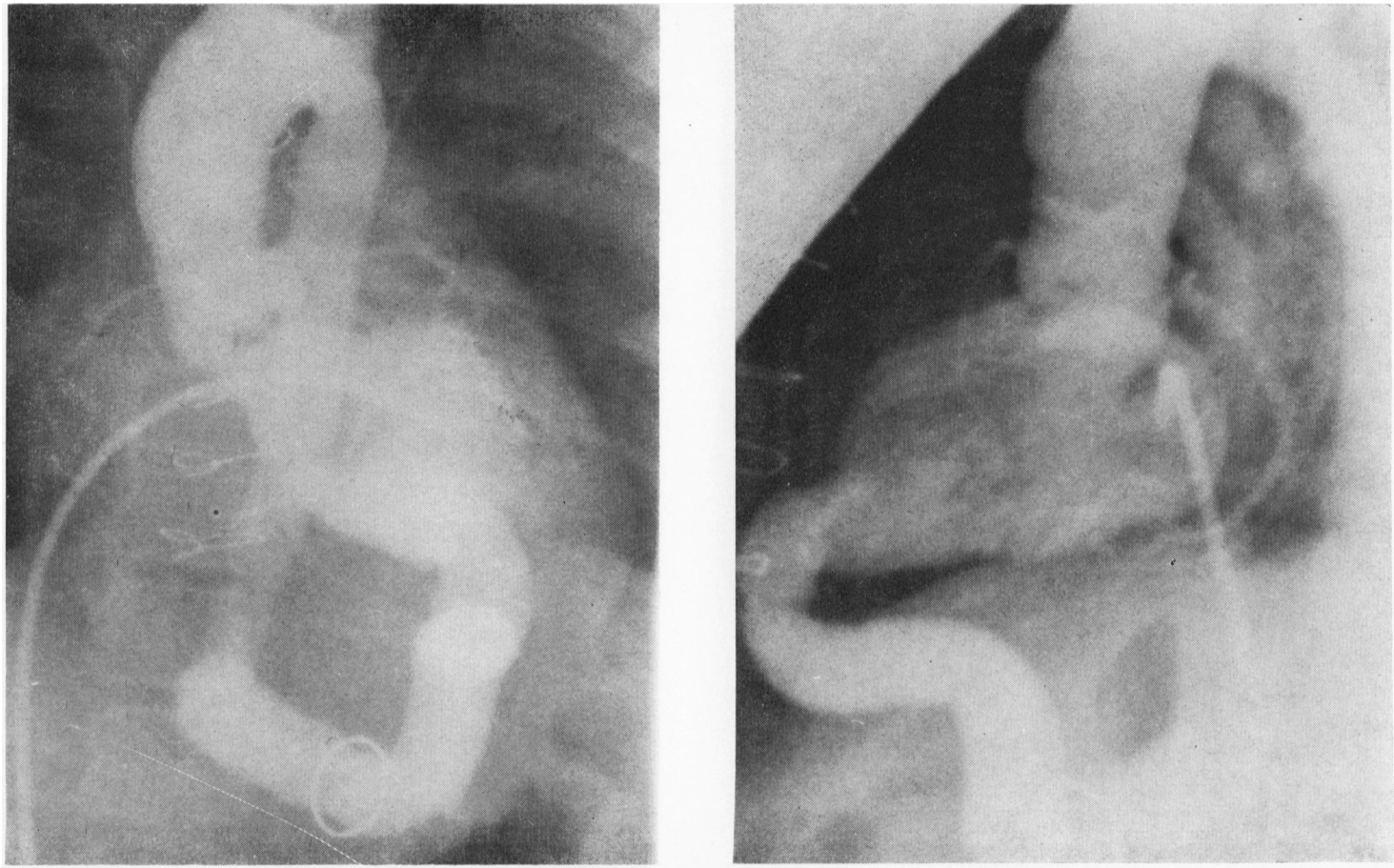

Fig. 2.(a) Cineangiograms in anteroposterior and lateral views made ten days after operation showing functioning conduit grafts between left ventricle and abdominal aorta. End-diastolic phase reveals open flow conduit graft.

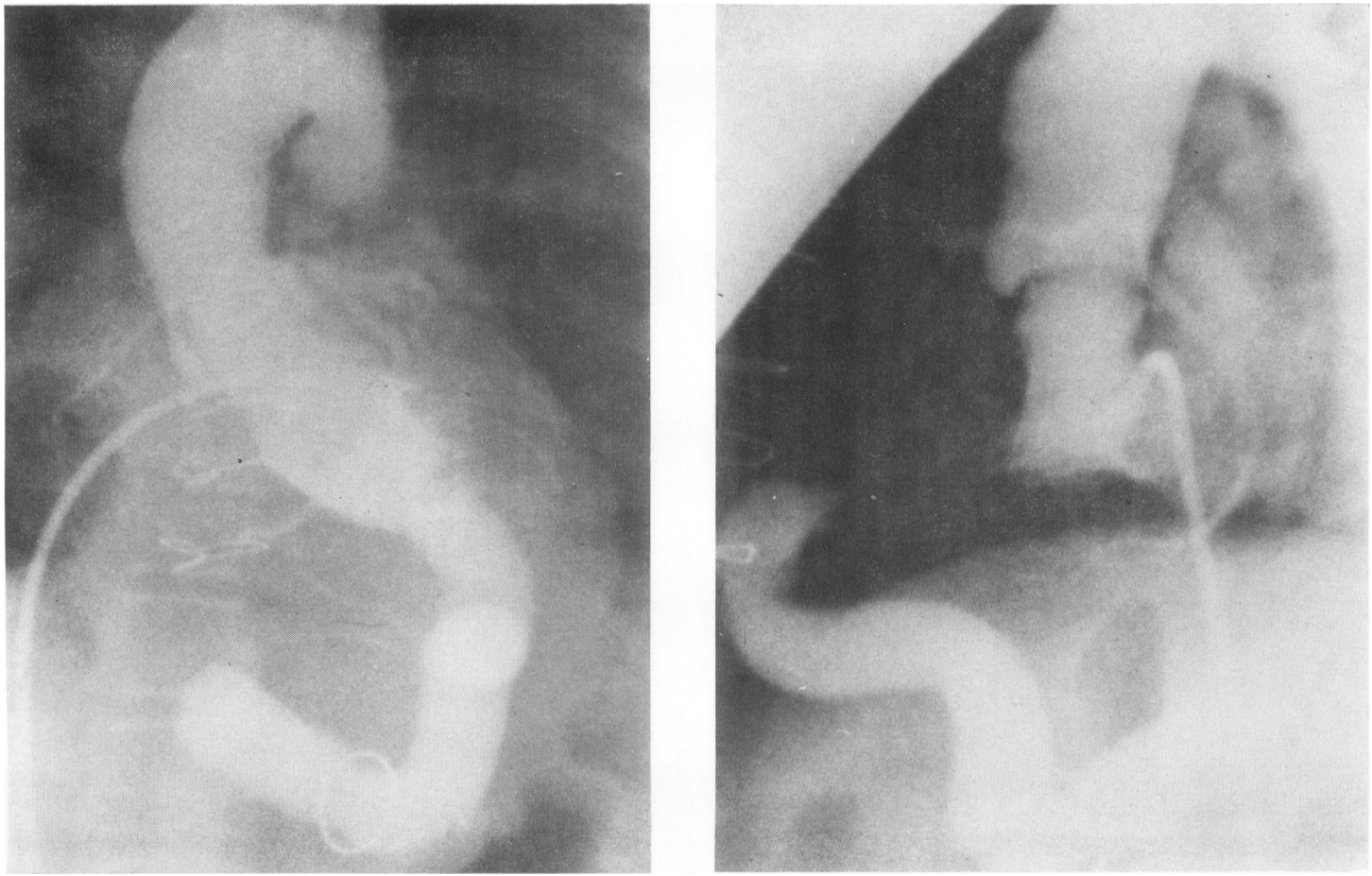

Fig. 2. (b) Mid systolic phase shows filling of conduit graft during early and mid systole.

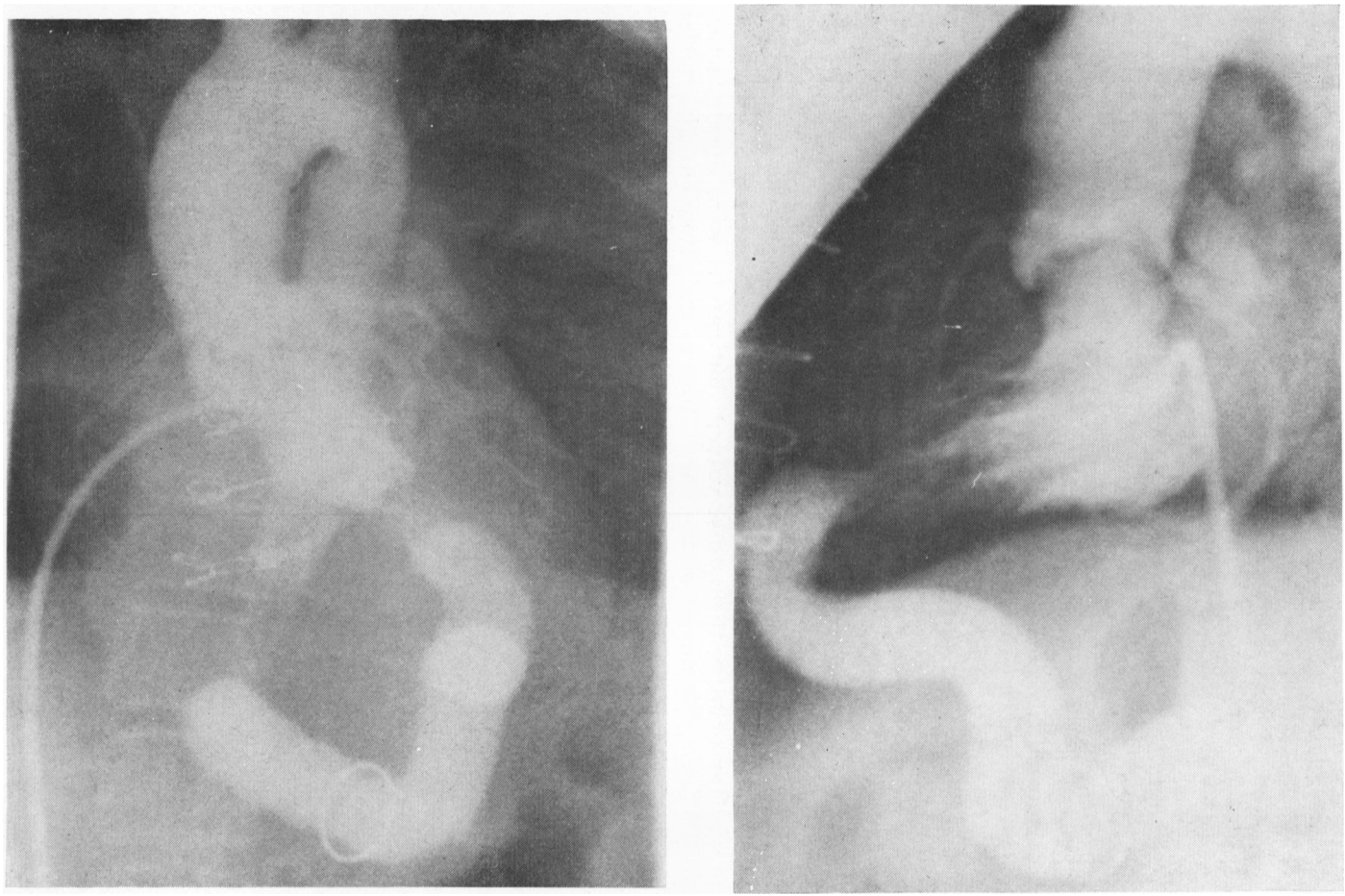

Fig. 2.(c) Late systolic phase—conduit orifice closed and flow continuing through stenotic aortic valve.

modified Hufnagel ball-and-seat valve[3] to direct the entire cardiac output from the left ventricle to the descending thoracic aorta. In these experiments they demonstrated that the ascending aorta could be totally and permanently occluded without any apparent impairment of the circulation. Regretably this test was not used in our patient to assess the effect upon cardiac hemodynamics. Sarnoff's animals exhibited no ill effects from the surgery and were not readily distinguishable from normal dogs. Al-Naaman[4] performed similar tests on dogs using the Hufnagel valve in a Teflon tube. Later Detmer, Johnson, and Braunwald[5] reported a similar experimental method of bypassing the left ventricular outflow tract utilizing fresh aortic allografts.

Clinical application of this technique was first made by Templeton[6] who performed five such operations. Though his findings have never been reported, we learned that his longest survival was thirteen years. As did Sarnoff, he used a rigid tube containing the Hufnagel valve, but he connected it to the abdominal aorta below the renal arteries rather than the descending thoracic aorta. In 1975, Bernhard[7] reported an operation in which a stainless steel conduit was connected to the descending thoracic aorta. The technique which was employed in this reported case was similar in concept to a method first described by us for restoration of right ventricular-pulmonary arterial continuity in which a Dacron tube containing a Starr-Edwards valve was used to repair a truncus arteriosus.[8,9] Subsequently, Rastelli et al[10] modified this approach and used an aortic homograft with aortic valve. We later employed a Dacron tube graft containing a Bjork-Shiley tilting disc valve,[11] but results were unsatisfactory because of late thrombosis of the valve. Due to the attendant difficulties, anticoagulants were not used in children. At present the Hancock composite graft and glutaraldehyde-treated porcine aortic valve seem satisfactory, at least for short-term use, and no anticoagulant therapy is necessary. We are currently preparing conduit grafts incorporating the Cooley-Cutter biconical disc valve,[12] which we hope will give good results.

We believe that the use of a soft fabric conduit has several advantages over a rigid one. Fabric grafts have performed well as conduits from the right ventricle to the pulmonary artery and, moreover, they are readily available. Furthermore, a fabric tube seems less likely to produce encroachment or erosion of adjacent organs. Attachment of the fabric graft to the apex of the left ventricle by simple continuous suture should be just as satisfactory as for the right ventricle.

The most obvious indication for this operation[13] is severe congenital aortic stenosis. This technique might also be useful, however, for some acquired problems such as a previous aortic valve replacement with an unusually small prosthesis, or in the presence of a badly damaged or cicatrized ascending aorta. In some situations the surgeon may wish to avoid sternotomy because of retrosternal adhesions and attachment of the aorta to the sternum. If the decision to bypass the ascending aorta is made prior to operation, part of the procedure could be performed before initiation of cardiopulmonary bypass. The distal graft could be inserted by doubly clamping the abdominal aorta. Using a limited thoracotomy, the right atrium would then be cannulated for venous return to the pump oxygenator and the femoral artery for return of oxygenated blood. The attachment of the graft to the left ventricular apex could then be done during cardiopulmonary bypass. Induction of ventricular fibrillation could

enhance this part of the operation. Once the graft was passed through an incision in the diaphragm and clamped, fibrillation could be reversed. The grafts could then be tailored to prevent distortion and kinking, and graft-to-graft anastomosis could be performed.

SUMMARY

Simple valvotomy or even valve replacement may not always provide adequate relief from severe congenital aortic stenosis and left ventricular hypertension. In a 10-year-old Jehovah's Witness, a technique was employed for relief of left ventricular hypertension after valvotomy. A conduit Dacron fabric graft containing a heterograft valve was used to connect the apex of the left ventricle to the abdominal aorta. Cardiac catheterization after operation revealed no significant pressure gradient between the left ventricle and the aorta. This technique should prove equally effective for acquired disease of the ascending aorta and aortic valve.

ADDENDA

(1) Since this report was submitted, a 7-year-old male underwent the same procedure with a successful result. His original diagnosis was congenital supra-aortic stenosis with stenosis of the entire ascending aorta. At a previous operation, a patch graft angioplasty was performed extending the patch to the level of the innominate artery. Subsequent angiographic and manometric studies revealed a residual stenosis adjacent to the innominate artery with a pressure gradient of 100 mm Hg. After the apico-aortic shunt with valved conduit was inserted, the left ventricular pressure was identical to the systemic arterial pressure.

(2) On November 4, 1975, a 15-year-old female underwent a similar operation with a successful result. Indication for an apico-aortic shunt was a non-correctable aortic stenosis.

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