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Technical Modification of Nick's Posterior Aortic Root Enlargement with Aortic Valve Replacement to Improve Hemostasis (UKC's Modification): A Video Presentation

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Introduction

Despite the availability of advanced prosthetic valve models, aortic root enlargement may be required during aortic valve replacement to insert an adequate sized prosthesis and avoid prosthesis-patient mismatch[1]. Children and teenagers with a small aortic annulus may require aortic root enlargement to delay a redo aortic valve replacement after physical growth has occurred. This also includes potential candidates for a transcatheter aortic valve replacement[2,3].

The literature is divided on the surgical management of a small aortic root. On one hand, investigators have demonstrated superior left ventricular mass regression, improvement in postoperative functional class and exercise tolerance, and patient survival when small prosthetic valves disproportionate to body surface area are avoided[4-6]. Further, prosthesis-patient mismatch specifically has been shown by some investigators to adversely affect left ventricular mass regression and both early and late survival[7-14].

On the other hand, other investigators dispute the relevance of prosthesis-patient mismatch in the current era, reporting little or no relationship between valvular orifice size and outcome[15,16]. Hanayama and associates further suggested that prosthesis-patient mismatch in practice, is quire uncommon[16].

These contradictory observations are further complicated by varying definitions of prosthesis-patient mismatch in the published literature. Investigators who define prosthesis-patient mismatch most stringently as an indexed effective orifice area of less than 0.60 cm^2/m^2 report it to be a rare occurrence, whereas, others who define indexed effective orifice area of less than 0.85 cm^2/m^2 report little effect on late survival[15-17].

Even more confusion is engendered by the various uses of effective orifice area and geometric orifice area for each of the large number of valvular prostheses in clinical use. Regardless of all contradictions, it is intuitive that an operation performed to relieve valvular stenosis should leave the patient with the least possible residual obstruction to flow. In 2006, Pibarot and colleagues demonstrated that transvalvular gradients increased exponentially as the indexed orifice area decreased to <0.8 to 0.9 cm^2/m^2 [17].

Regardless of the academic arguments as enunciated above, the surgeon has a number of surgical options available when confronted with the small aortic root. The available options are: (a) posterior aortic root enlargement techniques described by Nicks and associates[10] and Manouguian and Seybold-Epting[18]; b) Konno-Rastan procedure[19,20]; c) autograft aortic root replacement (Ross procedure); and stentless aortic valves[21].

Many surgeons are reluctant to perform aortic root enlargement, out of concern that this adjunctive procedure will increase the operative morbidity and mortality[22,23]. Several investigators have investigated different aortic root enlargement procedures, namely, Manougian, Nicks and demonstrated relative success at the expense of increased mortality (7.1% vs 3.5%)[11-13,22,23].

The choice between Nick's and Manouguian's enlargement will depend on the degree of widening required and on the type of aortotomy preferred by the surgeon. A single extension of the oblique horse-shoe shaped aortotomy (Nick's procedure) will widen the aortic root by 5-10 mm, thus enabling to implant one size larger prosthesis. An extension of the transverse approach, as described by Manouguian will allow 10-15 mm aortic root enlargement. Both techniques cross the aortic annulus, although as commonly applied they might not. Although the Konno-Rastan procedure offers the greatest degree of root enlargement, it is technically more complicated, requires creation of right ventriculotomy, ventricular septal defect with double-patch closure of both. The surgical risks of this procedure include injury to the septal perforators, conduction system and places the patient at risk of intracameral fistulae[11-13,19,20].

It has been the authors practice to perform Nick's posterior aortic root enlargement for management of the small aortic root. We find unappealing the more complex alternatives promulgated today using homografts, stentless xenografts, autografts as mini root or full root replacements, the procedures associated with an almost 3-fold higher operative risk than simple aortic valve replacement in the STS database[24].

The posterior aortic root enlargement technique described by Nicks and associates and Manouguian and associates are technically straight forward procedures[9,18]. The concerns have been bleeding from the site of aortic root enlargement, periprosthetic leakage, impedance to outflow imposed by angular distortion of the left ventricular outflow tract with overriding of the prosthesis on the anterior mitral leaflet, restricted leaflet motion especially with the St. Jude Medical Regent model secondary to subvalvular muscular shelf of left ventricular outflow tract and iatrogenic mitral regurgitation.

With this background, the corresponding author introduced the hemostatic suture technique of the enlarged aortic root after performing Nick's procedure and replacing the aortic valve.

We describe here-in a 15-year old boy with severe congenital valvular aortic stenosis, small aortic root in New York Heart Association class II undergoing posterior aortic root enlargement (Nick's procedure) with aortic valve replacement using a St. Jude Mechanical Regent aortic prosthesis. The enlarged aortic root was repaired using a "tear drop" shaped autologous, untreated pericardial patch and a series of 3-4 interrupted Teflon felted 4-0 polypropylene suture (Johnson and Johnson Ltd., Ethicon, LLC, San Lorenzo, USA). The author's modification includes placement of a cuff of pericardium posteriorly over the prosthetic sewing ring which was doubly sutured along with the underlying subannular soft tissues. This technical modification has been applied in 175 consecutive patients requiring aortic root enlargement with aortic valve replacement with encouraging results and will be addressed in our subsequent communication. Mean ischemic time for aortic valve replacement and aortic root enlargement (Nicks) in our series (unpublished) was 54±19.56 min (range 39-106, median 61 min) and the mean cardiopulmonary bypass time was 116.6±27.32 min (range 96-194, median 121 min). The mean 12-hour postoperative drainage in our series of patients were 200±70 ml.

We report here-in our technical modification of the Nick's procedure in a 15-year-old male patient weighing 58.4 kg (body surface area 1.64 m^2) undergoing posterior aortic root enlargement (Nick's procedure) and aortic valve replacement using a St. Jude mechanical prosthesis for small aortic root with stenosis of the aortic valve. M and 2D Doppler echocardiography revealed left ventricular ejection fraction 0.5, left ventricle-to-aortic peak systolic gradient of 110 mmHg. Preoperative computed tomographic aortic root dimensions were: valve annular diameter 1.6 cm, sinotubular diameter 2.6 cm, aortic sinus 3.4 x 3.3 x 2.9 cm, mid-ascending aorta 4.1 cm, ascending aorta (opposite brachiocephalic artery) 3.5 cm, aortic arch 2.3 cm, descending thoracic aorta 1.5 cm.

In our patient, an extension of the oblique horse-shoe shaped aortomy widened the aortic annulus by 5 mm, thus enabled us to implant a 19 mm St. Jude Regent mechanical prosthesis avoiding prosthesis-patient mismatch. We repaired the enlarged ventriculo-aortic junction with a tear drop shaped pericardial patch and interrupted Teflon pledgeted mattress sutures. We retained a pericardial collar beyond the suture line and reinforced the ventriculo-aortic junction using continuous 4-0 polypropylene suture, thus ensuring perfect hemostatic suture lines.

Surgical Techniques

Following median sternotomy, the thymus was subtotally

excised taking care not to expose the brachiocephalic vein. The pericardium was incised to the right of midline and left in situ in between 4-0 silk stay sutures.

The operation was performed with moderately hypothermic cardiopulmonary bypass through an angled venous cannula into superior vena cava, a straight venous cannula into inferior vena cava and aortic cannulation.

The left heart was vented through the right superior pulmonary vein using a No. 14 sump suction vent. The left ventricular vent was inserted prior to aortic cross-clamp on a partially filled heart with the ventilation stopped to prevent intracardiac air suction.

The aorta was opened 2 cm above the right coronary sinus through an oblique horse-shoe shaped incision across the midportion of the non-coronary sinus into the fibrous subaortic curtain. Myocardial protection was achieved using selective ostial cold St. Thomas II (4:1) based blood cardioplegia and topical cooling with ice-cold saline.

The stenosed and calcified aortic valve was excised. The valve sizer was placed in the neoaortic annulus to confirm proper sizing and position of the valve in the sub-coronary position. Following excision of the aortic valve, the aortic annulus permitted insertion of a 16 mm valve sizer. Similar to an aortic valve replacement in a native annulus, the aortic valve was replaced using a No. 19 mm St. Jude Regent Mechanical Heart Valve (St. Jude Medical Inc, Saint Paul, Minnesota). We used interrupted pledgeted 2-0 braided coated Ticron Polyester Sutures (M/s Covidien, Santo Domingo, Dominican Republic, USA). In the non-coronary sinus, the pledgeted mattress sutures were placed from outside the aorta to the sewing ring of the prosthesis to facilitate proper implantation. The valve was seated in the intra-annular position ensuring no encroachment of the coronary ostia.

The enlarged aortic annulus in the non-coronary sinus was repaired using an unfixed autologous square shaped pericardial patch by a modified Nick's procedure developed by the corresponding author (UKC). Four 4-0 pledgeted polypropylene mattress sutures were passed from the sewing ring of the prosthesis to the pericardial patch ensuring they retain a 0.5 cm pericardial cuff. After seating the pericardial patch the newly constructed annulus over the non-coronary sinus was repaired using a second continuous layer of 4-0 polypropylene and the retained pericardial cuff, thus ensuring perfect hemostasis. The aortotomy opposite the patch was closed directly using 4-0 polypropylene suture. The patch was trimmed to the size of the remaining defect, and the original 4-0 polypropylene suture was continued around the patch to complete closure of the aortotomy.

The aortic cross-clamp was released, thus restoring myocardial perfusion and weaned off cardiopulmonary bypass with stable hemodynamics. The aortic cross clamp and bypass times were 40 min and 97 min respectively.

Short and Long-term Results

Postoperatively, the patient was hemodynamically stable on dopamine 5 μg/kg/min and nitroglycerine 0.5 μg/kg/min. He was extubated 8 hours after surgery with stable hemodynamics. Postoperative drainage was 150 ml in the first 24-hours. At 6 months follow-up, the child was asymptomatic, showed no evidence of congestive cardiac failure (New York Heart Association class I) without anti-failure medications and was on oral anticoagulation.

Postoperative echocardiography demonstrated good left ventricular ejection fraction of 0.60, with a mean transprosthetic gradient of 8 mmHg and unrestricted leaflet motion. Follow-up computed tomographic angiocardiogram demonstrated widened sinotubular junction. There was no aneurysm of the augmented non-coronary sinus.

Conclusions

We conclude that retention of a pericardial collar, at the site of enlarged ventriculo-aortic junction and Teflon buttressed suture avoids cut through of the friable, periaortic tissues. The interrupted, pledgeted and over and over aortic angle suturing is an expedient, safe and effective technique of obtaining perfect hemostasis.

Declaration of conflicting interests

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