Work in progress report - Congenital

External subcommissural annuloplasty to prevent regurgitation in the pulmonary autograft

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Abstract

In pediatric patients, the further growth potential is a major advantage in using the pulmonary autograft (Ross procedure). The authors describe a modified annuloplasty technique that appears to prevent the development of undesirable aortic regurgitation associated with root enlargement while not affecting overall tissue growth in the autograft.

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1. Introduction

Aortic regurgitation (AR), due to size mismatch or root dilatation later on, is a feared complication of the Ross procedure. Reduction annuloplasty and/or aortoplasty methods have been used for size mismatch, and most recently, the inclusion root technique has been advocated by some to prevent graft dilatation in adults [1]. In children, however, preserving the autograft’s growth potential is of primary importance, and in most cases, the above techniques are not applicable. In our newly started pediatric Ross program, we have developed a modified annuloplasty method to prevent regurgitation on the neoaortic valve.

2. Surgical technique: external subcommissural annuloplasty

Using the mini-root ‘replacement’ Ross technique, the proximal suture line is completed as usual. Under systemic pressure, some degree of pulmonary root expansion is considered normal, but excessive dilatation, particularly at the sinotubular junction (STJ), could be deleterious. We believe, that in children, as long future growth potential is not affected, a reduction annuloplasty supporting valve coaptation could prevent undesired graft failure.

In our opinion, the three suture subcommissural annuloplasty technique described by Cabrol et al. [2] for symmetrically dilated aortic roots with leaflets pulled apart, and subsequently applied to rheumatic patients by Duran [3] fulfills the criteria mentioned above. We employ similar vertical mattress 4 ‘0’ Prolene sutures right below the tip of the commissures, however, with a modification of placing the pledgets on the outside in the thin-walled autograft (Fig. 1). With this method, injury to delicate leaflet tissue is avoided, while the commissures are supported on both sides by a sandwich layer of pulmonary artery wall and pledgets. Left coronary button is reimplanted in the usual way, then the autograft is sutured to the ascending aorta 4–5 mm distal to the commissuroplasty pledgets. Subsequently, the root is pressurized with cardioplegia, and with the three commissures marked externally (Fig. 2), the location of the right coronary button is conveniently selected.

The technique increases semilunar valve coaptation by increasing the cone-shape of the root (Fig. 2), and competence is also better maintained when systemic pressure dilates the autograft. Hence, these stitches are neither part of anastomotic suture lines nor are they circumferential, so root and STJ growth should not be affected in the long run.

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3. Discussion

Under physiologic conditions, semilunar valve competence is the result of a complex interaction among cusps, root wall and sinuses, and the truncated cone-shape of the root with a prominent sinotubular ridge also has particular importance. In the pulmonary root, these characteristics are less well defined [4], and expansion pattern is also different [5–7]. Under normal hemodynamic circumstances [7], STJ expansion in the aorta (systemic pressure) is restricted compared to the sinuses (37.0 ± 2.1 vs. 63.7 ± 3.6%), while in the pulmonary root (low pressure), the same degree of expansion is observed at these two levels (27.7 ± 1.4 vs. 29.0 ± 1.3%).

When the pulmonary root is subjected to systemic pressure, over-expansion is related to different structural and different dynamic properties of the graft [5,6,8]. In an experimental model using free standing (non-fixed proximal and distal ends) porcine pulmonary roots subjected to 100 cm H2O static pressure (and compared to similar measurements at 20 cm H2O static pressure), Okazaki et al. [8] have shown a moderate (12.9%) dilatation at the base, while STJ expansion was almost twice as much (24.6%). As a result, a central leak with valve leaflets pulled apart was observed. Subsequently, plicating STJ or base alone did not completely prevent regurgitation, but competence was maintained when plication at both levels was done. The above experimental model differs from clinical setting, when tight sutures to corresponding aortic structures (especially at annular level) limit free expansion of the autograft, but clearly underline the importance to reestablish and maintain normal dynamic geometry when the more compliant pulmonary root is utilized.

In a separate in vivo experiment, the same group [9] has examined the mechanism of AR by pulling sections of the aortic root horizontally at STJ level. Central regurgitation developed when straining was applied to the three commissural sutures or all sutures together, but valve coaptation was maintained when only sinus sutures were pulled apart. These findings suggest, that the principal cause of regurgitation associated with STJ dilatation is the outward deviation of the commissures. Consequently, preventing expansion of the STJ in these three locations should be the key to maintain valve competence.

Our method is targeting semilunar leaflet coaptation directly while commissural attachments are selectively supported, and by avoiding foreign material on anastomotic suture lines (including STJ) the autograft’s growth potential should also be preserved.

In our new pediatric Ross program (the first such program in Hungary), we have started using this technical modification in children over 2 years of age 18 months ago. Neoaortic valve competence was tested in the operating room with intraoperative transesophageal echocardiography after coming off bypass and the study confirmed perfect valve competence with not even a trace of regurgitation in all cases. However, at this point of time, our average follow-up is less than 1 year (1–18 months) and detailed transthoracic echocardiographic follow-up study is available on 13 children with only one child exhibiting trace of AI on color Doppler (Table 1). In spite of these promising results, no equivocal conclusions could be drawn from our data, because measurable autograft growth should not be expected so early and the lack of neoaortic regurgitation at
this stage may be unrelated to the technique described above. A longitudinal study is now underway to answer these questions and assess long-term results.

Acknowledgements

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References


Table 1
Patients’ characteristics and follow-up data (see explanation in the text)$^a$

<table>
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<th>Length of follow-up (months)</th>
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$^a$ TEE, transesophageal echocardiography; TTE, transthoracic echocardiography; AS, aortic stenosis; AI, aortic (neoaortic) regurgitation.