

Case Report

Tricuspid Valve Repair with a Bridging Technique Across the Valve for Tricuspid Stenosis and Regurgitation at the Norwood Procedure

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Moderate or severe tricuspid regurgitation is a poor prognostic factor for hypoplastic left heart syndrome (HLHS) and may require tricuspid valve repair at the time of the Norwood procedure. If complicated with tricuspid valve stenosis, a technique that does not worsen the stenosis must be selected. We present such a case; a male infant prenatally diagnosed with HLHS and underwent surgical repair of the valve on the 20th day of life. We performed a bridging technique across the tricuspid valve for repair of tricuspid regurgitation and stenosis associated with HLHS at the time of the Norwood procedure and successfully controlled regurgitation without worsening stenosis. This technique does not restrict the tricuspid valve inflow and is suitable for cases of combined tricuspid regurgitation and stenosis.

Keywords: hypoplastic left heart syndrome, Norwood procedure, tricuspid valve repair, inter-annular bridging technique, tricuspid stenosis

Introduction

Hypoplastic left heart syndrome (HLHS) with moderate or severe tricuspid regurgitation has a poor prognosis; if tricuspid regurgitation can be controlled to mild or less by tricuspid valve repair, the 5-year survival rate is comparable to that without tricuspid regurgitation.^{1, 2)} Commissuroplasty, indentation closure, and partial annuloplasty have typically been used for tricuspid valve repair. These conventional techniques, however, have limited use in patients with tricuspid stenosis as well as regurgitation, because of the risk of worsening tricuspid stenosis. A bridging technique across the tricuspid valve, called as the inter-annular bridge, has been introduced in 2020 by Kanno et al.³⁾ and circumvents this problem.

Our report is the first one to describe use of the bridging technique across the tricuspid valve treating regurgitation and stenosis at the time of the Norwood procedure in a neonate with HLHS.

Case Report

A male infant, born at 39 weeks of gestation and weighing 3,264g, had been diagnosed with HLHS (mitral stenosis and aortic atresia) and hydrops fetalis due to severe tricuspid regurgitation and mild tricuspid stenosis detected on fetal echocardiography. This was confirmed by postnatal echocardiography. The Apgar score at birth was 7, and he was immediately intubated due to respiratory failure. Transthoracic echocardiography showed that the tricuspid valve diameter was 12 mm

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(90% of normal), with severe regurgitation and mild stenosis due to a dysplastic septal leaflet. At 4 days of life, bilateral pulmonary arterial banding was performed, and prostaglandin E1 infusion was administered to maintain the ductus arteriosus patent. Heart failure progressed due to restrictive patent foramen ovale and gradual closure of the patent ductus arteriosus; hence, the Norwood procedure and tricuspid valvuloplasty had to take place on 20 days of life. During the surgery, cardiopulmonary bypass was established via brachiocephalic trunk and bicaval cannulations. Bilateral pulmonary arterial bands were removed, the aortic arch was reconstructed, and atrial septal defect was enlarged. The tricuspid valve was tested using a saline solution injection; it showed moderate regurgitation at the center of the valve due to a dysplastic septal leaflet attached directly to the interventricular septum. Upon moving the anterior leaflet towards the septal leaflet, regurgitation appeared less. A bridge was then placed between the annula of the anterior and septal leaflets using an expanded polytetrafluoroethylene strip (1.5 mm wide, 0.4 mm thick) fixing with 5-0 polypropylene (Figs. 1 and 2, Video 1). We aimed at the strip length 80% of the normal mitral valve diameter. For fine adjustment, one end of the strip was sutured to the annulus of the anterior leaflet first. Then, we performed an injection test while pulling the other end to determine the optimal anteroposterior diameter, and eventually sutured the septal leaflet side. The saline solution injection test was repeated; since regurgitation became significantly less, no additional valvoplasty was performed. The final diameter of the tricuspid orifice was 10 mm (representing 87% of the normal range of the mitral valve). A 5-mm ring-reinforced expanded polytetrafluoroethylene graft was then interposed between the right ventricle and the pulmonary artery. Weaning from cardiopulmonary bypass was smooth, and the sternum was splinted with stable hemodynamics. Delayed sternal closure was performed on postoperative day 3. Due to refractory pleural effusion, hospital admission was prolonged and the patient was discharged on postoperative day 206. Echocardiography at discharge illustrated trivial tricuspid regurgitation and mild tricuspid stenosis (trans-tricuspid blood flow velocity 1.8 m/s). The bidirectional Glenn procedure was performed 11 months after the Norwood procedure, and the patient is awaiting total cavopulmonary bypass. Mid-term echocardiography 19 months after the Norwood

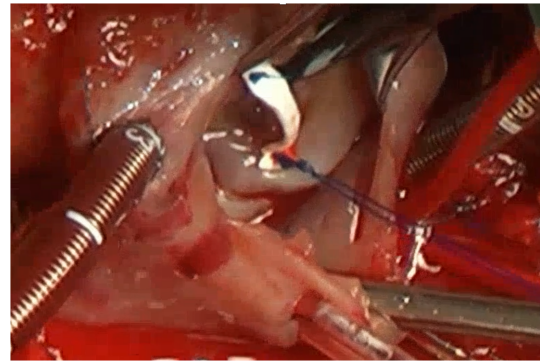


Fig. 1 A bridge is placed between the annular hinges of the anterior and septal leaflets using an expanded polytetrafluoroethylene strip (1.5 mm wide, 0.4 mm thick)

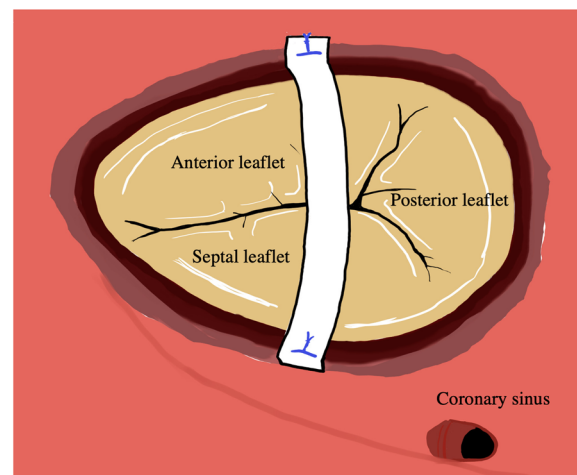


Fig. 2 Intraoperative photograph of a bridging technique across the tricuspid valve

procedure revealed no tricuspid regurgitation and mild tricuspid stenosis (trans-tricuspid blood flow velocity 1.2 m/s).

Discussion

The mortality rate of the Norwood procedure remains the highest among common congenital heart procedures, ranging from 7~19%.⁴⁾ Tricuspid regurgitation affects the early and long-term outcomes of staged surgical management of HLHS.^{2, 5-8)} Moderate or severe tricuspid regurgitation associated with HLHS has been reported in 8.5~16% of cases,^{5, 6, 9)} and the postoperative overall survival rate at the 20-month follow-up is reported as 67%.¹⁾ Kanno et al. reported a new method of tricuspid valve repair for tricuspid regurgitation associated with HLHS, called the inter-annular bridge.³⁾

This technique is different from conventional techniques such as annuloplasty (anteroseptal commissuroplasty, posterior leaflet obliteration, and partial De Vega annuloplasty) or papillary muscle-based repair. The bridging technique was originally used for common atrioventricular valve regurgitation.^{10, 11)} Its concept is to separate the common atrioventricular valve into two orifices to control regurgitation, while simultaneously maintaining the valve's original elliptical shape by fixing the distance between the anterior and posterior leaflets.²⁾ Kanno et al. pointed out the following advantages of this technique for tricuspid regurgitation: (1) it can improve coaptation without interfering with the leaflet or subvalvar tissues, (2) it can control central tricuspid regurgitation, and (3) it can prevent annular dilatation between the anterior and septal leaflets.⁶⁾ On the other hand, a potential disadvantage of this technique is that its long-term outcomes remain uncertain. Also, interventional strategy has not been established to avoid exacerbation of tricuspid stenosis associated with somatic growth.

HLHS with tricuspid stenosis is rare. Our search found only one case; unfortunately, the patient involved in that report did not survive.¹²⁾ During staged surgery for HLHS, the presence of tricuspid stenosis can cause post-capillary pulmonary hypertension, which can lead to failure of the Glenn circulation. Use of annuloplasty in HLHS patients with tricuspid stenosis has not been reported. It is speculated that conventional valve maneuvers cause progressive tricuspid stenosis after surgery due to shrinkage of the annulus. The technique by Kanno et al. does not change the annular circumferential length and minimizes the risk of postoperative tricuspid stenosis. This technique may be appropriate, as seen in our present case, in patients with steno-regurgitant lesions, in neonates with fragile valve leaflets, or in those with regurgitation through the center of the valve that is difficult to control with conventional tricuspid valvuloplasty. The postoperative course in our patient was uneventful; tricuspid regurgitation could be minimized without worsening tricuspid stenosis even after 19 months. This suggests that a bridging technique across the tricuspid valve is also characterized by its ability to control tricuspid regurgitation without exacerbation of tricuspid stenosis, providing an additional advantage of this technique, particularly for patients with mixed tricuspid lesions.

Conclusion

We used a bridging technique across the tricuspid valve for HLHS with tricuspid regurgitation and stenosis during the Norwood procedure, which avoided exacerbation of postoperative tricuspid stenosis while controlling regurgitation. This technique does not restrict the tricuspid valve inflow and is suitable for cases with tricuspid regurgitation and stenosis.

Conflicts of Interest

All authors have no conflicts of interest to declare.

Ethical Standards

This study was approved by Sakakibara Heart Institution review board (IRB 21-027), and all procedures were performed in accordance with our institutional guidelines for the protection of patient confidentiality. Informed consent for this report was obtained while preserving the anonymity of the patient.

Note

Supplementary movies are provided online for this article. Video 1: Brief video summarizing our bridge repair of the tricuspid valve orifice.

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