

Article

Sung technique versus conventional trans annular patch augmentation of right ventricular outflow tract in Tetralogy of Fallot

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Abstract: The objective of this study was to compare the outcomes of repairing Tetralogy of Fallot (TOF) using two different techniques: trans-annular patch alone versus pulmonary valve cusp augmentation (Sung technique) with pericardium. A total of sixty TOF patients underwent successful surgical repair using either the traditional trans-annular patch or Sung's technique. Parameters such as postoperative use of inotropes, duration of recovery, and residual pulmonary insufficiency (PI) were compared between the two groups. The results showed that the age, weight, pulmonary valve annulus diameter, and Nakata index were similar in both groups. The mean aortic clamp time and median cardiopulmonary bypass time were also comparable. However, the patients who underwent Sung's repair had a lesser requirement for inotropes and faster recovery compared to the trans-annular patch group. Postoperative 2D echocardiography revealed a lower incidence of moderate or more pulmonary insufficiency in patients who underwent Sung's pulmonary valve augmentoplasty. Based on these findings, it was concluded that the augmentation of the pulmonary valve cusp reduces the occurrence of clinically significant postoperative pulmonary insufficiency. Therefore, this technique may improve the early outcome for patients with TOF who require a trans-annular patch.

Keywords: Tetralogy of Fallot; Trans-annular patch; Pulmonary valve cusp augmentation; Pulmonary insufficiency; Surgical repair.

1. Introduction

Tetralogy of Fallot (TOF) is one of the most prevalent congenital heart conditions encountered in clinical practice. Extensive research has been conducted worldwide to understand and address the complexities associated with this cyanotic heart condition. Over time, significant advancements have been made in surgical techniques for TOF repair, with the goal of achieving optimal anatomical correction and physiological compliance. Successful repair of TOF is considered a milestone procedure for cardiac surgeons, as it involves addressing both the structural abnormalities and the functional aspects of the heart.

Postoperative management plays a crucial role in the outcomes of TOF repair. One of the major concerns following surgery is the development of pulmonary insufficiency (PI), which arises from the right ventriculotomy and the abrupt transition from a pressure-overloaded to a volume-overloaded right ventricle. To mitigate this potential negative impact on right ventricular function, the Right Atrium Pulmonary Artery (RA PA) technique has been proposed as a safer alternative. However, in cases where division of the annulus is unavoidable, a limited ventriculotomy over the right ventricular outflow tract (RVOT) is performed, followed by reconstruction using a trans-annular patch. This approach allows for the preservation of the patient's own pulmonary valve tissue and aims to minimize the risk of complications associated with pulmonary regurgitation.

In our study, we focused on comparing the outcomes of TOF repair using the pulmonary cusp augmentation technique advocated by Sung et al. in 2003 [1] with the conventional trans-annular patch. The primary objective was to evaluate the effectiveness of utilizing the patient's own pulmonary valve tissue to reduce the incidence and severity of postoperative pulmonary insufficiency. By employing this innovative

technique, we aimed to improve the early outcomes and long-term prognosis for patients with TOF who require a trans-annular patch. Through a comprehensive analysis of clinical data and follow-up assessments, we sought to gain valuable insights into the potential benefits and limitations of this approach in optimizing surgical outcomes and enhancing patient quality of life.

2. Patient and methods

In our study from 2016-2021, we included 60 patients of TOF who underwent successful surgical repair using trans-annular patch. Thirty patients had pulmonary valve cusp augmentation with an autologous pericardial patch using Sung's technique. Remaining thirty patients underwent traditional trans-annular patch repair and were used as controls. The patients were randomized, and both primary surgeons in the study used both techniques. There was not a clearly defined indication for one procedure or the other.

Operative technique entails establishment of cardio pulmonary bypass (CPB) through aorto-bicaval cannulation. Systemic to pulmonary artery (PA) shunts, if present, are ligated after the beginning of CPB. The heart is arrested with antegrade cold blood Delnido cardioplegia. The right atrium is opened, and the left heart is vented through inter atrial septum stab. A longitudinal incision is made in RVOT and extended to the annulus of the pulmonary valve (PV). PV Commissurotomy is done whenever necessary. Posterior pulmonary cusp is un-tethered whenever required. Excision of the parietal extension of the infundibular septum is performed through the tricuspid valve (TV) and RVOT as required. Hegar dilators are passed through the TV toward the main PA. The ventricular septal defect (VSD) is closed through the TV using a dacron patch.

Usually, the pulmonary valve will be bicuspid with commissures at the 3 and 9 o'clock positions. Hence, an incision is made in the middle of the anterior cusp. When the commissures are located at the 6 and 12 o'clock positions or the commissures are anterior and posterior but located off the midline, we divide the pulmonary valve at or near the anterior commissure to preserve as much valve tissue as possible, as described by Sung *et al.*, [1].

For pulmonary valve reconstructions a triangular autologous pericardial patch is sutured to the endocardium from the most inferior aspect of the right ventriculotomy all the way up to the hinge point of the anterior cusp and then along the divided edge of the valve on either side. A second patch is used to close the RVOT and the pulmonary arteriotomy, thus recreating a sinus over the augmented valve leaflet. The extent of annular enlargement is decided by probing the PV with a Hegar dilator. Our target annular size in the arrested heart is 2 mm larger than the mean normal sized pulmonary annulus for patient's BSA. Left atrium is deaired, inter atrial septum closed and right atrium sutured. Patient is weaned off CPB after adequate rest time.

Post surgery, all patients underwent 2D echo and findings recorded.

3. Results

In our study, a total of 60 patients with Tetralogy of Fallot (TOF) underwent right ventricular outflow tract (RVOT) release procedures. Among these patients, 30 received a combination of trans-annular patch and pulmonary valve cusp augmentation, while the remaining 30 underwent trans-annular patch alone. The two groups were comparable in terms of median age (3.2 vs 2.8 years) and weight (12.1 vs 11.5 kg). Additionally, there were no significant differences observed in the diameter of the pulmonary valve annulus (7.4 vs 7.6) and the Nakata score (116 vs 128), indicating similar baseline characteristics between the two groups. The mean duration of aortic clamp time (139 minutes vs 136 minutes) and median cardiopulmonary bypass time (178 minutes vs 163 minutes) were also comparable, suggesting comparable intraoperative management.

Table 1 presents the patient characteristics and intraoperative data, providing a comprehensive overview of the demographic information and procedural details. The table highlights the similarities in baseline characteristics and procedural parameters between the two groups.

Furthermore, Table 2 presents the postoperative data and 2D echocardiographic findings. This data provides insights into the outcomes following the surgical interventions. The table illustrates the occurrence and severity of postoperative complications, including pulmonary insufficiency, in the two groups. By examining these findings, we can gain a deeper understanding of the impact of the different surgical approaches on postoperative outcomes and identify any notable differences between the groups.

The results presented in Tables 1 and 2 contribute to our understanding of the surgical outcomes and provide valuable information for evaluating the effectiveness of the trans-annular patch with pulmonary valve cusp augmentation technique compared to the trans-annular patch alone. These findings will be further analyzed and discussed in the subsequent sections to draw meaningful conclusions and implications for clinical practice.

Table 1. Patient characteristics and intra operative data

	Sung technique	Trans-annular patch
No of cases (n)	30	30
Median age of patient (yrs)	3.2	2.8
Median weight of patient (in Kg)	12.1	11.5
Pulmonary Valve annulus (mm)	7.4	7.6
Nakata score	116	128
Cross clamp time	139	136
CPB time	178	163

Table 2. Post operative data and 2D Echo findings

	Sung technique	Trans-annular patch
Duration of ventilation (in days)	1.8	3.2
Duration of inotropic support (in days)	3.4	5.5
Duration of hospital stay (in days)	10	14
Post op PR	24 mild, 6 moderate	10 mild, 18 moderate, 2 severe
Post op RVOT gradient (mean in mmHg)	26.8	24.0
Complications		1 RV failure, 1 expired

Patients with a pulmonary valve cusp augmentation had a shorter duration of intubation (1.8 vs 3.2 days) and hospital stay (10 vs 14 days). Patients who underwent repair by Sung's technique required inotropes for a lesser duration (3.4 vs 5.5 days). Echocardiograms at the time of discharge demonstrated moderate pulmonary insufficiency in 6 patients with a pulmonary valve cusp augmentation and moderate/severe in 10 patients with a trans-annular patch. Mean RVOT gradients in post operative 2D echo were comparable (26.8 vs 24 mm Hg). One patient in trans-annular patch group showed signs of severe RV failure. One patient with trans-annular patch expired due to multi organ dysfunction.

In Figure 1, the step-by-step procedure of RVOT augmentation using the Sung technique is depicted, highlighting the meticulous surgical steps involved in achieving optimal results. This technique offers a valuable alternative to the conventional trans-annular patch approach and has the potential to enhance patient outcomes and reduce complications associated with pulmonary insufficiency.

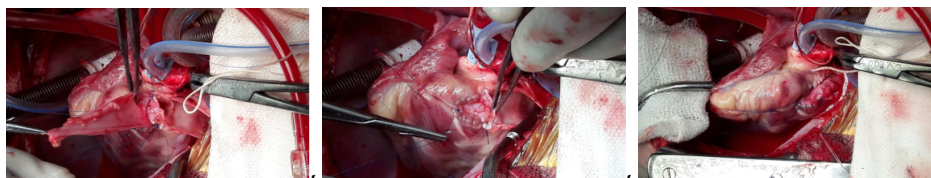


Figure 1. RVOT augmentation using Sung technique

4. Discussion

The use of a trans-annular patch may result in free PI, which causes RV dilation that in turn compresses the left ventricle. The functional reserve and myocardial contractility of the right (and possibly left) ventricle decrease. This physiology is well tolerated in the majority of patients for a prolonged period of time, but some will eventually experience decreased exercise tolerance and progressive right ventricular dilation and failure. The chronic volume load to the right ventricle after TOF repair leads to dilation of the ventricle and predisposes the patient to late life-threatening ventricular arrhythmias and sudden death.

The acute change from a pressure-loaded to a volume loaded right ventricle in addition to the right ventriculotomy after a transannular patch reconstruction can adversely affect the performance of the right ventricle in the immediate postoperative period. Our patients who underwent pulmonary valve cusp augmentation had a far better postoperative course when compared with the patients with a transannular patch reconstruction.

Sung's technique preserves the native hinge mechanism of the valve cusps, especially when the pulmonary valve is bicuspid and the commissures are located in the 3 and 9 o'clock positions. The use of native valve tissue also offers the theoretic potential of growth. The pulmonary valve cusp augmentation technique effectively reduces the degree of postoperative PI.

Of 30 patients who had relief of RVOT obstruction with the use of the pulmonary valve cusp augmentation technique, 6 (20%) had moderate or severe PI at discharge. In contrast, 66% of the patients with transannular patch reconstruction had clinically significant PI at discharge. In the series published by Sung and associates, all 18 patients had absent or mild PI at discharge. The higher incidence of PI in our series may be attributed to technical reasons ie, a learning curve.

Anagnostopoulos *et al.*, [2] in their study in 2007 concluded that augmentation of a pulmonary valve cusp reduces the incidence of clinically significant postoperative pulmonary insufficiency. They reported moderate to severe pulmonary insufficiency in 17% cases which underwent pulmonary valve augmentation with Sung technique against 88% with traditional trans-annular patch.

Turrentine and associates [3], using a polytetrafluoroethylene monocusp valve for RVOT reconstruction, effectively decreased the degree of PI compared with their patients who received a nonvalved transannular patch.

We will continue to follow these patients to determine whether this reconstruction is durable or not.

5. Limitations

Because the early results of the present technique mostly depend on the effective orifice area achieved by the commissurotomies, the technique cannot be applied to cases with a poorly developed annulus. Cusp augmentation using pericardial patch may be difficult for hypoplastic or dysplastic cusps. All the cusps are stretched out by extension of the annular ring, and therefore central coaptation may be a little compromised. Durability of the extended cusps has not yet been determined and right ventricular dysfunction or arrhythmia may also be a concern as right ventriculotomy is inevitable, even if not large.

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