

Early and Long-term Outcomes After Surgical Repair of Isolated Total Anomalous Pulmonary Venous Connection: A Single-Centre Retrospective Cohort Study

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Abstract:

Background: Total anomalous pulmonary venous connection (TAPVC) is an uncommon congenital cardiac anomaly. Surgical correction is the definitive treatment, but outcome is influenced by pulmonary venous obstruction, age, weight, operative factors and postoperative pulmonary hypertension.

Aim: To retrospectively analyse the outcomes after isolated TAPVC repair.

Materials and Methods: This single-centre retrospective observational study included 242 patients who underwent surgical correction for isolated TAPVC between 1 January 2008 and 31 December 2018. Demographic features, TAPVC anatomy, pulmonary venous obstruction, pulmonary arterial hypertension, operative variables, vasoactive-inotropic score, intensive care stay, complications, mortality, reintervention and follow-up pulmonary venous flow were reviewed. Kaplan-Meier analysis and log-rank testing were used for survival comparisons.

Results: Among 242 patients, 157 (64.9%) were infants and 152 (62.8%) were male. Supracardiac TAPVC was most frequent in 127 (52.5%). Pulmonary venous obstruction was present in 111 (45.9%) and was particularly frequent in infracardiac TAPVC (34/35; 97.1%). Severe pulmonary arterial hypertension was present in 159 (65.7%). Primary suture less repair was used in 111 (45.9%). Mean clamp and bypass times were 72.9 ± 26.9 and 131.9 ± 41.7 minutes, respectively. Obstructed TAPVC had higher mortality than unobstructed TAPVC (15.3% vs 2.3%; $p < 0.001$). Lower weight was associated with higher 24-hour vasoactive-inotropic score and longer intensive care stay. Seven patients required reintervention. Kaplan-Meier survival differed by age ($p = 0.005$), pulmonary venous obstruction ($p < 0.001$) and weight below 3 kg ($p = 0.005$), but not by sex ($p = 0.778$). Outcomes after suture less and conventional repair were broadly similar.

Conclusion: Pulmonary venous obstruction was the strongest adverse preoperative feature in this cohort. Low body weight mainly affected the early postoperative course. Primary suture less repair did not show a clear advantage over conventional repair in postoperative outcome or reintervention.

Keywords: Total Anomalous Pulmonary Venous Connection; TAPVC; Pulmonary Venous Obstruction; Suture Less Repair; Congenital Heart Surgery.

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Introduction

Total anomalous pulmonary venous connection (TAPVC) is a rare congenital cardiac anomaly in which all pulmonary veins drain into the systemic venous circulation instead of the left atrium.[1] It accounts for about 0.7-1.5% of congenital heart disease and may present with marked cyanosis, pulmonary over-circulation or pulmonary venous obstruction. [1-3]

The anatomical pattern is commonly described as supracardiac, cardiac, infracardiac or mixed. The

drainage route has direct surgical importance. Obstruction can occur at different points in the anomalous pathway and may produce severe pulmonary venous hypertension, pulmonary oedema and a low cardiac output state. Infracardiac connections are particularly prone to obstruction. [4,5]

Surgical correction is the definitive treatment. Improvement in diagnosis, perioperative stabilisation, cardiopulmonary bypass, myocardial

protection and postoperative pulmonary vasodilator therapy has improved early survival.[6] Attention has therefore moved beyond operative mortality towards postoperative pulmonary venous obstruction, reintervention and long-term survival.[7]

Several factors may influence outcome after TAPVC repair. These include age and weight at operation, preoperative pulmonary venous obstruction, pulmonary arterial hypertension, acidosis, cardiopulmonary bypass variables and the surgical technique used. [6–8] Primary suture less repair has been increasingly used to reduce the risk of postoperative pulmonary venous stenosis, although its advantage over conventional repair remains uncertain across different series. [6–8]

The present study reviewed a large single-centre experience of isolated TAPVC repair over an 11-year period. It examined early postoperative course, mortality, reintervention, pulmonary venous flow and long-term survival in relation to preoperative and operative factors.

Aim: To retrospectively analyse the outcomes after isolated TAPVC repair.

Materials and Methods

This was a retrospective single-centre observational study conducted in the Department of Cardiovascular and Thoracic Surgery, Sree Chitra Thirunal Institute for Medical Sciences and Technology, Thiruvananthapuram. The study was approved by the institute research and ethics committee. Approval from the Technical Advisory Committee was also obtained before commencement. The thesis did not report a protocol number.

The study population consisted of patients who underwent surgical correction for isolated TAPVC during the study period. Isolated or simple TAPVC was defined as TAPVC occurring alone or with an atrial septal defect, patent ductus arteriosus, or both. Patients with associated complex cardiac anomalies, univentricular anatomy or heterotaxy were excluded. Patients lost to follow-up were also excluded. A total of 242 eligible patients were available for analysis. Because this was a retrospective review of all eligible patients treated during the defined period, no a priori sample size calculation was performed.

Data were obtained from the institutional hospital database. The review included inpatient and outpatient medical records, laboratory results, echocardiography, electrocardiography and other available non-invasive imaging. Where follow-up information was incomplete, patients could be contacted by telephone and invited for outpatient

review after consent. Data were entered in a structured spreadsheet.

Baseline variables included age, sex, weight, TAPVC anatomy, presence of pulmonary venous obstruction, severity of pulmonary arterial hypertension and preoperative blood pH. TAPVC anatomy was classified as supracardiac, cardiac, infracardiac or mixed. Obstructed and unobstructed pulmonary venous drainage were determined from clinical presentation, oximetry and preoperative transthoracic echocardiography. Pulmonary arterial hypertension was classified using echocardiographically derived right ventricular systolic pressure plus right atrial pressure as mild (20-40 mmHg), moderate (>40-60 mmHg) or severe (>60 mmHg).

Intraoperative variables included blood pH before institution of cardiopulmonary bypass, aortic cross-clamp time, cardiopulmonary bypass time, temperature strategy, use of total circulatory arrest, surgical technique and post-bypass pulmonary arterial pressure. Earlier operations included deep hypothermia or circulatory arrest, while later practice more often used mild to moderate hypothermia with reduced bypass flow when required.

The operative approach depended on the anatomical type. Conventional techniques included the posterior approach, right lateral approach, coronary sinus cut-back technique, Van Praagh technique and modified Schumacher-King repair. Primary suture less repair was also used, in which the anastomosis was created between the posterior pericardium and the left atrium rather than directly between the pulmonary venous confluence and the atrial wall.[9]

Postoperative assessment included the vasoactive-inotropic score (VIS) at 24 hours. The inotropic score was calculated from dopamine, dobutamine and epinephrine doses. VIS additionally incorporated milrinone, vasopressin and norepinephrine. VIS has been used as an indicator of haemodynamic support after paediatric cardiac surgery.[10]

The immediate postoperative outcomes were duration of intensive care unit stay, pulmonary arterial hypertensive crisis, arrhythmia, pulmonary haemorrhage and mortality. Pulmonary haemorrhage was identified from respiratory deterioration or increased ventilator pressures together with supportive chest radiographic findings. Mortality was classified as early when it occurred within 30 days of surgery and as late thereafter. Reintervention and its cause were recorded. Five-year and, when available, 10-year pulmonary venous flow were obtained from outpatient echocardiography.

Mortality and pulmonary venous flow were treated as the principal outcome variables. Descriptive data were reported as mean $\pm$ standard deviation for normally distributed quantitative variables and as median with interquartile range for non-normally distributed variables. Categorical variables were presented as frequency and percentage. Normality was assessed by histograms, Q-Q plots and the Shapiro-Wilk test. A p-value above 0.05 in the Shapiro-Wilk test was taken to support normal distribution.

For normally distributed quantitative variables, means across more than two groups were compared by analysis of variance. Non-normally distributed quantitative variables were compared using the Kruskal-Wallis test. Spearman rank correlation was used to assess associations involving non-normally distributed quantitative variables. Categorical outcomes were compared using the chi-square test or Fisher's exact test when expected cell counts were small. Univariate logistic regression was used for selected comparisons of obstructed versus

unobstructed TAPVC and suture less versus other techniques. Kaplan-Meier analysis was used to estimate survival. Survival distributions were compared by the log-rank test across age group, sex, obstruction status, weight, pH and use of total circulatory arrest. A two-sided p-value <0.05 was considered statistically significant. IBM SPSS version 25 was used for analysis.

Results

A total of 242 patients were included. Infants formed the largest age group and there was a male predominance. The mean weight was 4.57 ± 4.22 kg and 50 (20.7%) patients weighed less than 3 kg. Supracardiac TAPVC was the most frequent anatomical type. Pulmonary venous obstruction was present in 111 (45.9%) patients. Obstruction differed markedly by anatomy and was present in 34 of 35 (97.1%) patients with infracardiac TAPVC ($p<0.001$). Severe pulmonary arterial hypertension was present in 159 (65.7%) patients. Baseline characteristics are shown in Table 1.

Table 1: Characteristics of participants (N=242)

Characteristic	Value
Age group	Neonate 62 (25.6%); infant 157 (64.9%); child 23 (9.5%)
Sex	Male 152 (62.8%); female 90 (37.2%)
Weight	4.57 ± 4.22 kg; median 3.80 kg
Weight <3 kg	50 (20.7%)
TAPVC anatomy	Supracardiac 127 (52.5%); cardiac 57 (23.6%); infracardiac 35 (14.5%); mixed 23 (9.5%)
Pulmonary venous obstruction	111 (45.9%)
Severe pulmonary arterial hypertension	159 (65.7%)
Pre-CPB pH	7.37 ± 0.10
pH <7.35	86 (35.5%)

Table 1 shows that most patients were infants and male. Supracardiac TAPVC was the commonest anatomical pattern. Nearly half of the cohort had pulmonary venous obstruction and about two-thirds had severe pulmonary arterial hypertension.

Primary suture less repair was the most frequently used technique. Mean cross-clamp time was 72.92 ± 26.92 minutes and mean bypass time was 131.89 ± 41.73 minutes. The mean 24-hour VIS was 9.62 ± 8.09 and mean ICU stay was 9.09 ± 11.78 days. Pulmonary arterial hypertensive crisis occurred in 9 (3.7%) patients. Seven patients required reoperation or reintervention. At five-year follow-up, pulmonary venous flow was laminar in 231 patients, turbulent in 10 and obstructed in one.

Table 2 shows that suture less repair was used in almost half of the cohort. Postoperative pulmonary

hypertensive crisis, arrhythmia and reintervention were uncommon. Most patients had laminar pulmonary venous flow at five-year follow-up.

Pulmonary venous obstruction was strongly associated with mortality. Mortality was 15.3% in obstructed TAPVC and 2.3% in unobstructed TAPVC ($p<0.001$). Preoperative acidosis below pH 7.35 was not significantly associated with mortality ($p=0.158$). Use of total circulatory arrest showed a higher crude mortality, but the difference did not reach statistical significance ($p=0.056$). Neonates required longer clamp and bypass times and had higher VIS and longer ICU stay than older groups. Lower body weight correlated with higher VIS ($rs=-0.359$, $p<0.001$) and longer ICU stay ($rs=-0.550$, $p<0.001$). Lower operative temperature was also associated with higher VIS and longer ICU stay.

Table 2: Operative and postoperative outcomes

Outcome	Value
Surgical technique	Suture less 111 (45.9%); cut-back 60 (24.8%); modified Schumacher-King 36 (14.9%); posterior approach 35 (14.5%)
Cross-clamp time	72.92 ± 26.92 min
Cardiopulmonary bypass time	131.89 ± 41.73 min
Postoperative PA pressure	24.39 ± 8.18 mmHg
24-hour VIS	9.62 ± 8.09
ICU stay	9.09 ± 11.78 days
Pulmonary hypertensive crisis	9 (3.7%)
Arrhythmia	9 (3.7%)
Pulmonary haemorrhage	1 (0.4%)
Reintervention/reoperation	7 (2.9%)
Five-year pulmonary venous flow	Laminar 231 (95.4%); turbulent 10 (4.1%); obstructed 1 (0.5%)

Table 3: Factors associated with early postoperative course and mortality

Comparison	Finding	p-value
Obstructed vs unobstructed TAPVC mortality	17/111 (15.3%) vs 3/131 (2.3%)	<0.001
pH <7.35 vs ≥7.35 mortality	10/86 (11.6%) vs 10/156 (6.4%)	0.158
TCA vs no TCA mortality	2/5 (40.0%) vs 18/237 (7.6%)	0.056
Clamp time: neonate vs infant	81.32 ± 29.27 vs 69.46 ± 25.65 min	0.003
Bypass time: neonate vs infant	149.9 ± 40.52 vs 125.65 ± 40.32 min	<0.001
VIS by age group	Neonate: 10 (6–15); Infant: 6.62 (5–13); Child: 2.5 (0–9)	<0.001
ICU stay by age group	Neonate: 10 (7.5–14.5); Infant: 6 (4–8); Child: 2 (2–4) days	<0.001
Weight vs VIS	$r_s = -0.359$	<0.001
Weight vs ICU stay	$r_s = -0.550$	<0.001
Temperature vs VIS	$r_s = -0.368$	<0.001
Temperature vs ICU stay	$r_s = -0.251$	0.001

Table 3 shows that pulmonary venous obstruction had a clear association with mortality. Younger age and lower body weight were mainly associated with a more intensive early postoperative course.

When suture less repair was compared with other techniques, cross-clamp time, bypass time, five-year

pulmonary venous flow and reintervention were not significantly different. Mortality was 5/111 (4.5%) after primary suture less repair and 16/131 (11.5%) after other techniques; the reported p-value was 0.050. Reintervention occurred in 3 (2.7%) suture less and 4 (3.1%) non-suture less repairs (p=1.000).

Table 4: Suture less versus other surgical techniques

Parameter	Suture less (n=111)	Other techniques (n=131)	p-value
Cross-clamp time	76.14 ± 24.09 min	70.20 ± 28.91 min	0.089
Bypass time	135.42 ± 36.16 min	128.90 ± 45.85 min	0.226
24-hour VIS	7 (5-10)	9 (5-15)	Not reported
Turbulent PV flow at 5 years	3	7	0.234
Reintervention	3 (2.7%)	4 (3.1%)	0.871*
Mortality	5 (4.5%)	16 (11.5%)	0.050

*The thesis also reports Fisher's exact p=1.000 for the direct reoperation comparison. Table 4 shows no consistent advantage of one technique for reintervention or follow-up pulmonary venous flow.

The Kaplan-Meier analysis showed significant differences in survival by age, pulmonary venous obstruction and weight below 3 kg. Survival did not differ by sex. The reported censored survival

proportion was 84.7% for obstructed TAPVC compared with 97.7% for unobstructed TAPVC. Patients weighing less than 3 kg had a lower survival proportion than those weighing 3 kg or more. Seven patients underwent reintervention; all had obstructed anatomy. Three had mixed TAPVC, two had cardiac TAPVC and one each had supracardiac and infracardiac TAPVC.

Table 5: Kaplan-Meier survival comparisons

Factor	Survival/censored proportion	Log-rank p-value
Age	Neonate 82.3%; infant 94.3%; child 100%	0.005
Sex	Male 92.1%; female 91.1%	0.778
Pulmonary venous obstruction	Obstructed 84.7%; unobstructed 97.7%	<0.001
Weight <3 kg	<3 kg 82.0%; ≥3 kg 94.3%	0.005

Table 5 shows that age, obstruction status and low body weight were associated with different survival distributions. Sex was not associated with survival.

Discussion

The present study describes outcomes after isolated TAPVC repair in 242 patients treated at a single tertiary cardiac centre over 11 years. The cohort was dominated by infants, and supracardiac TAPVC was the most frequent anatomical form. Pulmonary venous obstruction was present in 45.9% of patients and was the most important adverse preoperative feature. It was associated with higher mortality and a clearly poorer Kaplan-Meier survival distribution. These findings are clinically plausible because obstruction raises pulmonary venous pressure, worsens pulmonary oedema and increases right ventricular afterload before correction.

The distribution of anatomical types was broadly similar to published experience. Supracardiac TAPVC accounted for 52.5%, followed by cardiac, infracardiac and mixed forms. Shi et al. reported a large paediatric cohort and showed that contemporary outcome depends strongly on anatomy and the presence of obstruction. Fu et al. also reported long-term institutional experience in which pulmonary venous obstruction remained an important concern. In the present cohort, obstruction was especially striking in infracardiac TAPVC, where 34 of 35 patients were obstructed. This pattern is consistent with the long anomalous pathway and the potential for intrinsic or extrinsic narrowing in infracardiac drainage. [2,6]

Severe pulmonary arterial hypertension was common. It was present in 92.8% of patients with obstructed TAPVC, but it was also present in 42.8% of those classified as unobstructed. This observation is useful because absence of an obvious obstructive gradient on echocardiography does not necessarily imply mild haemodynamic disease. Increased pulmonary blood flow and a functionally restrictive anomalous pathway may still produce severe pulmonary hypertension. The thesis also noted that postoperative pulmonary hypertensive crisis and sudden cardiac deterioration were important causes of mortality.

Low body weight mainly influenced the early postoperative course. Fifty patients weighed less than 3 kg. Lower weight correlated with higher 24-hour VIS and a longer ICU stay. Neonates also had higher VIS, longer ICU stay and longer bypass times

than older patients. These findings suggest greater perioperative physiological vulnerability in smaller children. The long-term signal was less straightforward. Kaplan-Meier survival differed by the below-3 kg threshold, but the thesis interpretation emphasised an early hazard rather than a persistent independent long-term effect. This distinction should be tested in an adjusted survival model in any final publication.

Cross-clamp and bypass times were longer in obstructed TAPVC. However, clamp time did not correlate significantly with VIS or ICU stay in the overall cohort. The thesis interpreted this as supporting careful construction of a wide, unobstructed anastomosis even if additional operative time is required. Temperature showed a stronger relation with early postoperative support. Lower operative temperature correlated with higher VIS and longer ICU stay. This is in keeping with the broader move away from prolonged deep hypothermia and total circulatory arrest when satisfactory exposure can be obtained using moderate hypothermia and controlled low-flow perfusion.[11]

Primary suture less repair was used in 45.9% of patients. It was introduced to reduce postoperative pulmonary venous stenosis by avoiding a direct suture line on the pulmonary veins or venous confluence. Lacour-Gayet et al. described the suture less concept for progressive pulmonary venous obstruction, and later evidence has examined its use as a primary strategy. In the present study, the suture less group did not show a clear reduction in reintervention or abnormal follow-up pulmonary venous flow. Mortality was numerically lower after suture less repair, but the reported p-value was exactly 0.050 and the groups were not randomised. Selection by anatomy and surgical era may therefore have influenced this comparison. [9,12]

Seven patients underwent reintervention and all had obstructed anatomy. Mixed TAPVC represented three of these seven cases. This reinforces the importance of the underlying venous anatomy rather than surgical technique alone. White et al. identified postoperative obstruction as a major determinant of later outcome after TAPVC repair. Ricci also described adverse outcomes after postoperative pulmonary venous obstruction and the difficulty of treating recurrent stenosis. [7,13] In the present cohort, however, five-year pulmonary venous flow was laminar in more than 95% of recorded patients,

which suggests that most survivors had satisfactory intermediate follow-up anatomy.

The crude mortality recorded in the descriptive results was 21 patients, close to 9%. The thesis discussion compared this with reported mortality rates of approximately 6% in Shi et al., 9% in Fu et al. and 23.3% in Choudhary et al. Differences between series may reflect era, referral patterns, obstruction burden, patient weight and postoperative intensive care resources. [2,3,6] Eighteen deaths in the thesis were classified as early. Sudden cardiac death associated with pulmonary hypertensive crisis and sepsis were leading causes. The thesis also observed that many deaths occurred during an earlier period when inhaled nitric oxide and sildenafil infusion were not routinely available.

Long-term survival was strongly influenced by pulmonary venous obstruction. Kaplan-Meier analysis showed a survival/censored proportion of 84.7% in obstructed and 97.7% in unobstructed TAPVC, with $p < 0.001$. Age also affected survival, while sex did not. These results support early recognition of high-risk anatomy and careful postoperative surveillance. They also suggest that outcome assessment should extend beyond hospital mortality to pulmonary venous flow, reintervention and late survival. A future analysis using multivariable Cox regression would be useful to separate the effects of obstruction, weight, age, surgical era and operative technique.

Limitations

The study was retrospective and depended on the completeness of hospital records. Pulmonary vein scoring could not be included because it had not been recorded consistently. Longer and more uniform follow-up would provide a better estimate of late pulmonary venous obstruction and the need for reintervention.

Conclusion

Pulmonary venous obstruction was the most important adverse preoperative feature after isolated TAPVC repair and was associated with worse survival. Low body weight and younger age were linked mainly with a more difficult early postoperative course. Primary suture less repair did not show a clear advantage over conventional techniques for reintervention or follow-up pulmonary venous flow. Careful anatomical assessment, adequate relief of obstruction and long-term surveillance remain central to outcome.

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References

1. Reardon MJ, Ott DA, Sweeney MS. Total anomalous pulmonary venous return: report of 201 patients treated surgically. *Tex Heart Inst J*. 1985;12(2).
2. Fu CM, Wang JK, Lu CW, Chiu SN, Lin MT, Chen CA, et al. Total anomalous pulmonary venous connection: 15 years' experience of a tertiary care center in Taiwan. *Pediatr Neonatol*. 2012;53(3):164-170.
3. Choudhary SK, Bhan A, Sharma R, Mathur A, Airan B, Saxena A, et al. Repair of total anomalous pulmonary venous connection in infancy: experience from a developing country. *Ann Thorac Surg*. 1999;68(1):155-159.
4. Anderson RH, editor. *Paediatric Cardiology*. 3rd ed. Philadelphia: Elsevier Churchill Livingstone; 2010.
5. Kao CC, Hsieh CC, Cheng PJ, Chiang CH, Huang SY. Total anomalous pulmonary venous connection: from embryology to a prenatal ultrasound diagnostic update. *J Med Ultrasound*. 2017;25(3):130-137.
6. Shi G, Zhu Z, Chen J, Ou Y, Hong H, Nie Z, et al. Total anomalous pulmonary venous connection: the current management strategies in a pediatric cohort of 768 patients. *Circulation*. 2017;135(1):48-58.
7. White BR, Ho DY, Faerber JA, Katcuff H, Glatz AC, Mascio CE, et al. Repair of total anomalous pulmonary venous connection: risk factors for postoperative obstruction. *Ann Thorac Surg*. 2019;108(1):122-129.
8. Wu Y, Wu Z, Zheng J, Li Y, Zhou Y, Kuang H, et al. Suture less technique versus conventional surgery in the primary treatment of total anomalous pulmonary venous connection: a systematic review and meta-analysis. *J Cardiothorac Surg*. 2018;13(1):69.
9. Lacour-Gayet F, Zoghbi J, Serraf AE, Belli E, Piot D, Rey C, et al. Surgical management of progressive pulmonary venous obstruction after repair of total anomalous pulmonary venous connection. *J Thorac Cardiovasc Surg*. 1999;117(4):679-687.
10. Gaies MG, Jeffries HE, Niebler RA, Pasquali SK, Donohue JE, Yu S, et al. Vasoactive-inotropic score is associated with outcome after infant cardiac surgery. *Pediatr Crit Care Med*. 2014;15(6):529-537.
11. Bellinger DC, Jonas RA, Rappaport LA, Wypij D, Wernovsky G, Kuban KCK, et al. Developmental and neurologic status of children after heart surgery with hypothermic circulatory arrest or low-flow cardiopulmonary bypass. *N Engl J Med*. 1995;332(9):549-555.
12. Kelle AM, Backer CL, Gossett JG, Kaushal S, Mavroudis C. Total anomalous pulmonary venous connection: results of surgical repair of 100 patients at a single institution. *J Thorac Cardiovasc Surg*. 2010;139(6):1387-1394.e3.

13. Ricci M. Management of pulmonary venous obstruction after correction of TAPVC: risk factors for adverse outcome. *Eur J Cardiothorac Surg.* 2003;24(1):28-36.
14. Morales DLS, Braud BE, Booth JH, Graves DE, Heinle JS, McKenzie ED, et al. Heterotaxy patients with total anomalous pulmonary venous return: improving surgical results. *Ann Thorac Surg.* 2006;82(5):1621-1628.
15. Rudolph AM. *Congenital Diseases of the Heart: Clinical-Physiological Considerations.* 3rd ed. Chichester: Wiley-Blackwell; 2009.
16. Yun SW. Congenital heart disease in the newborn requiring early intervention. *Korean J Pediatr.* 2011;54(5):183-191.
17. Liufu R, Shi G, Zhu F, Guan Y, Lu Z, Chen W, et al. Superior approach for supracardiac total anomalous pulmonary venous connection. *Ann Thorac Surg.* 2018;105(5):1429-1435.
18. Koshy S, Kumar RK, Gururaja RS, Shivaprakasha K. Novel repair for obstructed total anomalous pulmonary venous connection to coronary sinus. *Ann Thorac Surg.* 2005;79(2):711-713.
19. Garg P, Talwar S, Rajashekar P, Saxena A, Airan B. Repair of total anomalous pulmonary venous return to the coronary sinus. *Asian Cardiovasc Thorac Ann.* 2012;20(2):221-224.
20. Stark J, De Leval M, Tsang VT. *Surgery for Congenital Heart Defects.* 3rd ed. Chichester: John Wiley & Sons; 2006.
21. Valiathan MS. Sree Chitra Thirunal Institute for Medical Sciences and Technology. *Artif Organs.* 1984;8(2):232-233.