Primary sutureless repair for "simple" total anomalous pulmonary venous connection: Midterm results in a single institution

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Objective: We have previously reported the use of an atriopericardial or ''sutureless'' repair for surgical management of postoperative pulmonary vein stenosis. The potential of avoiding geometric distortion of pulmonary venous suture lines and preventing post-repair pulmonary vein stenosis encouraged us to extend the use of this technique for primary ''simple'' total anomalous pulmonary venous connection repair.

Methods: Between January 1997 and July 2009, 57 consecutive patients (median age, 15 days; median weight, 3.4 kg) underwent sutureless or conventional total anomalous pulmonary venous connection repair.

Results: Types of total anomalous pulmonary venous connection included supracardiac in 31 patients (54%), cardiac in 15 patients (26%), and infracardiac in 11 patients (19%). Median follow-up time was 2.9 years. Preoperative mean pulmonary vein score, a composite measure of stenosis in all 4 pulmonary veins, was 0.3/0–12, and vertical vein obstruction was found in 35 patients (61.4%). A primary sutureless repair was carried out in 21 patients (36.8%; supracardiac, n = 12; cardiac, n = 4; infracardiac, n = 5). The sutureless repair group had proportionally greater high-risk infracardiac total anomalous pulmonary venous connection (24% vs 16%, $P = .05$). Primary outcomes of death or reoperation for pulmonary vein stenosis and postoperative pulmonary vein scores (0.2 ± 0.7 vs 0.7 ± 1.7, $P = .26$) were not different between the techniques.

Conclusions: The sutureless repair group had proportionally more infracardiac total anomalous pulmonary venous connection and a higher rate of decline in postoperative right ventricular systolic pressure. Despite increased preoperative risk, no difference was observed in primary outcomes of death and reoperation in the conventional repair group. (J Thorac Cardiovasc Surg 2011;141:1346-54)

Total anomalous pulmonary venous connection (TAPVC) is a congenital anomaly in which all 4 pulmonary veins do not connect directly to the left atrium. The 2 major risk factors for hospital mortality after surgical repair are pulmonary hypertension and development of pulmonary venous obstruction. Pulmonary venous obstruction can occur at the level of the pulmonary venous confluence to atrial connection or in the pulmonary veins.[1,2] Reports in the last few years have shown overall hospital mortality ranging from 2% to 18% after TAPVC repair.[3-7] Stenosis of pulmonary venous drainage is reported to occur in 6% to 9% of cases after repair of TAPVC and is particularly prevalent with young age at initial surgery, infracardiac connection type, and preexisting pulmonary vein stenosis (PVS).[5,6,8] Our group and others have previously described an atriopericardial connection repair for recurrent PVS that uses the pericardium in situ to create a neo left atrium. There are no suture lines on the native pulmonary vein tissue.[5,9] The repair is referred to as ''sutureless'' because there is no direct atrial to pulmonary vein or pulmonary venous confluence anastomosis. We use the terms ''atriopericardial'' repair and ''sutureless'' repair interchangeably. A potential advantage to this technique is a more limited reactive intimal proliferation because the suture line is not directly on the pulmonary vein. There are also advantages with respect to no direct suture line distortion or narrowing of the veins, particularly if they are small. Optimal flow characteristics for a given vein are therefore intact.

After repair of TAPVC, post-repair pulmonary venous stenosis can occur. Our group previously showed that the use of sutureless repair for post-repair PVS improved survival and reduced the need for reintervention for PVS.[10,11] Most of our previous discussion on this topic has focused on de novo PVS, after repair of TAPVC, and some primary sutureless repair of TAPVC in the case of right atrial isomerism. A few of the patients presented in this study were briefly mentioned and embedded within

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Abbreviations and Acronyms

ECMO = extracorporeal membrane oxygenation
LA = left atrial
LAVi = indexed left atrial volume
mPAP = mean pulmonary artery pressure
PVS = pulmonary vein stenosis
RVSP = right ventricular systolic pressure
TAPVC = total anomalous pulmonary venous connection

a previous article on effectiveness of sutureless repair for various pathology of the pulmonary veins.[11] The current report focuses on the primary use of an atriopulmonary connection for ''simple'' TAPVC.

Our initial ''primary use'' of sutureless repair was in 1998 in a case of infracardiac TAPVC with severe obstruction and a small pulmonary venous confluence. After conventional repair, a residual mean gradient of 2 mm Hg was found in all 4 pulmonary veins that did not resolve with revision. The child required extracorporeal membrane oxygenation (ECMO) support and could not be weaned 6 days later because of high mean pulmonary artery pressure (mPAP). The anastomosis was revised to a sutureless technique, and the patient was weaned from cardiopulmonary bypass with resolution of the gradient. Since that time, we have used an atriopericardial connection for all infracardiac TAPVCs. Our practice technique with regard to supracardiac and some cardiac TAPVCs, with mild obstruction at the connection of the confluence to the coronary sinus, has been evolving.

The rationale for an atriopericardial connection is to eliminate potential distortion or narrowing of the pulmonary veins for optimal flow characteristics for a given vein or confluence. Because post-repair pulmonary venous obstruction has been effectively managed with an atriopericardial connection, a second rationale is that it might prevent the development of post-repair PVS. We present our midterm results comparing outcomes of the atriopericardial procedure with a conventional repair for a subset of ''simple'' TAPVC during an interval of practice evolution. Outcomes with respect to mortality and development of pulmonary venous obstruction are evaluated.

PATIENTS AND METHODS

Patient Data

Data on patients with isolated TAPVC were collected at the Hospital for Sick Children, University of Toronto, between January 1997 and July 2009. Those with the following conditions were excluded: associated congenital cardiac lesions, such as right atrial isomerism and hypoplastic left heart syndrome, mixed-type TAPVC, syndromic, and single ventricle. We identified 57 consecutive patients with ''simple'' TAPVC. Ethics approval from our institutional review board was obtained. Patient demographic, operative and postoperative records, clinic notes, and echocardiographic imaging were studied. Baseline patient characteristics are listed in Table 1. The median age at time of initial surgical intervention was 15 days (range, 1–1157 days) and median weight was 3.4 kg (1.7–11.7 kg). Median follow-up was 2.9 years (range, 5 days to 11.7 years). Patients from earlier study years (1997–2004) were more likely to be repaired primarily with a conventional approach, and patients from later study years (2005–2009) were more likely to be repaired primarily with a sutureless repair (Figure 1).

Pulmonary Vein Score

The pulmonary vein score for each individual vein was calculated as previously reported.[11] Briefly, pre- and postoperative echocardiographic data were reviewed to quantify the degree of PVS: 0 = no stenosis (mean gradient < 2 mm Hg); 1 = mild stenosis (mean gradient 2.0–6.9 mm Hg); 2 = severe stenosis (mean gradient >7 mm Hg); and 3 = complete occlusion. The sum of the individual pulmonary vein scores is then used as a subjective measure of the overall degree of PVS ranging from 0 (no stenosis) to a theoretic maximum score of 12.

Echocardiographic Measurements

Echocardiographic images were evaluated in a blinded manner for type of repair and outcome. Right ventricular systolic pressure (RVSP) was evaluated using the tricuspid regurgitant jet, and mPAP was estimated from the early diastolic velocity of the pulmonary regurgitant jet. For both measurements, the modified Bernoulli equation was used. Left ventricular ejection fraction was measured from M-mode or 2-dimensional measurements of left ventricular end-diastolic and end-systolic dimensions using the Teichholz formula. Indexed left atrial volume (LAVi) was measured as 0.85*left atrial (LA) area in apical 4-chamber view*LA area in apical 2-chamber view/LA length/body surface area, as described previously.[12] The collecting chamber was included in the LA volumetric measurement in the postoperative study. Mean gradients of the Doppler traces of the individual pulmonary veins were also measured.

Statistical Analysis

Data are presented as frequencies, medians with ranges, or means with standard deviations. Survival data are represented by the Kaplan–Meier survival curve. Longitudinal data analysis was performed using mixed-effects models for analysis and to generate a graphic display of the averaged trend lines for the echocardiographic data. Statistical analyses were performed using SAS (Version 9.1; SAS Institute Inc, Cary, NC) and R (Version 2.10, R Project for Statistical Computing).

Surgical Technique

Surgical repair was performed on cardiopulmonary bypass (mean time, 88.0 ± 31.0 minutes) with bicaval cannulation. For cardiac TAPVC (n = 15 in total), the coronary sinus was unroofed in the conventional repair group (n = 11) and further included single- or 2-sided atriopericardial connection in the sutureless repair group (n = 4) if there was associated vein to confluence orifice stenosis. For sutureless repair of infracardiac and supracardiac TAPVC, incisions were made in the venous confluence and then extended into both upper and lower pulmonary veins separately if judged to be important for unobstructed flow (Figure 2). Small pulmonary venous confluences (ie, smaller than the normalized mitral valve size diameter), such as those seen in infracardiac TAPVC, were more likely to require incisions in the individual pulmonary veins out toward the pleural pericardial reflection. An atriopericardial anastomosis was created using the pericardium adjacent to the pulmonary vein entrance to the pericardium. A neo left atrium was thus created. The atriopericardial anastomosis avoids direct contact with the vein wall incision site and allows the free egress of blood from the lungs into the left atrium (Figure 2). The atrial septal defect or patent foramen ovale was closed or partially closed. Other details have been described in our previous report.[11]