Outcome of Right Ventricle to Pulmonary Artery Conduit for Biventricular Repair

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Background. **The objective of this study was to assess the outcomes of the right ventricle to pulmonary artery conduit for biventricular repair.**

Methods. **This is a retrospective review of all right ventricle to pulmonary artery conduit operations for biventricular repair of congenital heart disease between 1982 and 2013 at a single institution. Results were compared among the conduit size and materials.**

Results. **A total of 476 physiologic right ventricle to pulmonary artery conduit operations were identified, with 195 pulmonary homografts, 105 handmade valved expanded polytetrafluoroethylene conduits, 103 Medtronic Hancock (Minneapolis, MN) bioprosthetic valved conduits, 38 non-valved expanded polytetrafluoroethylene tubes, and 35 others. The actuarial survival was 92.4% and the freedom from conduit reoperation was 33.0% at 20 years. The freedom from conduit reoperation was significantly different among conduit materials (76.8%, 92.1%, 81.9%, 80.6%, and 63.8% for pulmonary homograft, valved expanded polytetrafluoroethylene conduit, Hancock conduit, non-valved expanded polytetrafluoroethylene tube, and others at 5 years, $p = 0.0001$). The Cox proportional hazards model showed that age ($p < 0.001$ and $p = 0.04$), preoperative diagnosis ($p < 0.001$ and $p < 0.001$), conduit size ($p < 0.001$ and $p < 0.001$), and conduit material (the valved expanded polytetrafluoroethylene conduit versus combined other materials; $p = 0.01$ and $p = 0.02$, respectively) were significant factors for the freedom from conduit reoperation both when treating conduit size as a categoric predictor and as a quantitative predictor.**

Conclusions. **The handmade valved expanded polytetrafluoroethylene conduit showed excellent early outcome as a right ventricle to pulmonary artery conduit for biventricular repair. A longer follow-up and a randomized study will be necessary to explore the advantages of the valved expanded polytetrafluoroethylene conduit.**

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The placement of a right ventricle to pulmonary artery (RV–PA) conduit has been standard surgical treatment for patients with right ventricular outflow tract (RVOT) atresia or hypoplasia, and for patients with the Ross procedure. Since the first report of aortic homograft placement in RVOT by Ross and Somerville [1], a variety of prosthetic conduits, including cryopreserved homograft, xenograft, and non-valved tube graft, have been developed and applied for clinical use [2–7].

The pulmonary homograft (PH) has been the most commonly used material for the RV–PA conduit with good long-term outcomes [2, 3]. However, the PH is prone to become calcified and stenotic over time with deterioration of valve function, especially for small children [8, 9]. Moreover, the availability of small PH can be limited at small institutions. The xenografts (Medtronic [Minneapolis, MN] Hancock bioprosthetic valved conduit [4], Carpentier-Edwards [Edwards Lifesciences, Irvine, CA] bioprosthetic valved conduit [5], and Medtronic Contegra pulmonary valved conduit [6]) are also commonly used materials for the RV–PA conduit. However, they were also prone to have calcification and deterioration of valve function as well as conduit-specific problems [10]. The expanded polytetrafluoroethylene (ePTFE) has low tissue affinity with minimal cellular and fibrous deposition [7, 11, 12], and the good outcome of a handmade valved ePTFE conduit for RVOT reconstruction has been reported from several institutions [13, 14]. Our institution began using the handmade valved ePTFE conduit in 2008.

In an effort to understand the best RV–PA conduit for the biventricular repair of congenital heart disease, we retrospectively reviewed the outcome of RV-PA conduit operation at our institution. Major outcomes studied included patient survival, need for conduit reoperation, and mode of conduit failure.

Material and Methods

Study Design

All consecutive patients who had an RV–PA conduit placement or replacement as part of biventricular repair for congenital heart disease in pediatric and congenital

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cardiothoracic surgery at Arkansas Children's Hospital between January 1982 and December 2013 were included in this retrospective study. Patients who had a physiologic right ventricle (anatomic left ventricle) to pulmonary artery conduit for corrected transposition of great arteries were included in this study, and those who had a RV–PA conduit placement for single ventricle physiology were excluded. This study was approved and monitored by the Institutional Review Board and the need for patient consent was waived due to its retrospective nature.

Medical records were reviewed and the following data were retrieved and analyzed: basic demographic data, anatomic information, surgical history, intraoperative data, and postoperative outcomes including immediate and late mortality and morbidity. Follow-up data were obtained from the last clinic visit.

Statistical Analysis

Descriptive statistics were expressed as median (range) for continuous variables and as frequency (percentage) for categoric variables. The distributions of the continuous variables and ordinal variable were compared between the 2 conduit groups using the Mann-Whitney *U* test and the proportions of the categoric variables were compared by the χ^2 test or Fisher exact test.

The time from the surgery date to the date of death, conduit reoperation, or last follow-up was considered the patient survival time. For the patient survival outcome, the patients with reoperation were treated as censored. The time from the surgery date to the date of conduit reoperation or last follow-up was considered the time of freedom from conduit reoperation. For the freedom from conduit reoperation outcome, the patients who died were treated as censored. Kaplan-Meier estimates of the survival function were computed for the patient survival and the freedom from conduit reoperation, based on all the surgeries and subgroups of surgeries. Log-rank tests were carried out to evaluate the difference in the survival distribution among subgroups.

Two Cox proportional hazards models were fitted for the time of freedom from conduit reoperation as a function of age, different era (1982 to 1992, 1993 to 2002, 2003 to 2012), preoperative diagnosis, surgery type (primary conduit placement versus conduit replacement), conduit size, conduit materials (valved ePTFE conduit versus combined other materials), and surgical technique (orthotopic versus heterotopic placement). This model specification was designated to evaluate the difference in the survival distribution for time of freedom from conduit reoperation between the valved ePTFE conduit and combined other materials after adjusting for the potential confounding effects from other covariates, which were prespecified to be included in the models based on their clinical significance. When fitting the 2 models, the conduit size was treated as categoric predictor with 3 levels (small, medium, and large), and quantitative predictor, respectively. When the conduit size was treated as quantitative predictor, a restricted cubic spline was applied with 3 knots to relax the linear relationship between conduit size and the survival outcome. We included the interaction term between the conduit size and age to assess its significance, and the interaction term was removed if the *p* value for the interaction term was greater than 0.2. The robust variance estimates were obtained because some patients contributed more than 1 observation. We also tested for the proportional hazards assumption after fitting each model.

All the data were analyzed using R software v3.0.2 (R Foundation for Statistical Computing, Vienna, Austria) and STATA v13.1 (StataCorp LP, College Station, TX), and *p* values less than 0.05 were considered to indicate statistical significance. No adjustment was made for multiple testing.

Results

Patient Profile

Four hundred seventy-six RV–PA conduit operations for 345 patients were identified as part of biventricular repair for congenital heart disease during the study period. The median age and weight at the time of operation were 6.7 years (0 to 54.6 years) and 20.0 kg (2.0 to 139 kg), respectively.

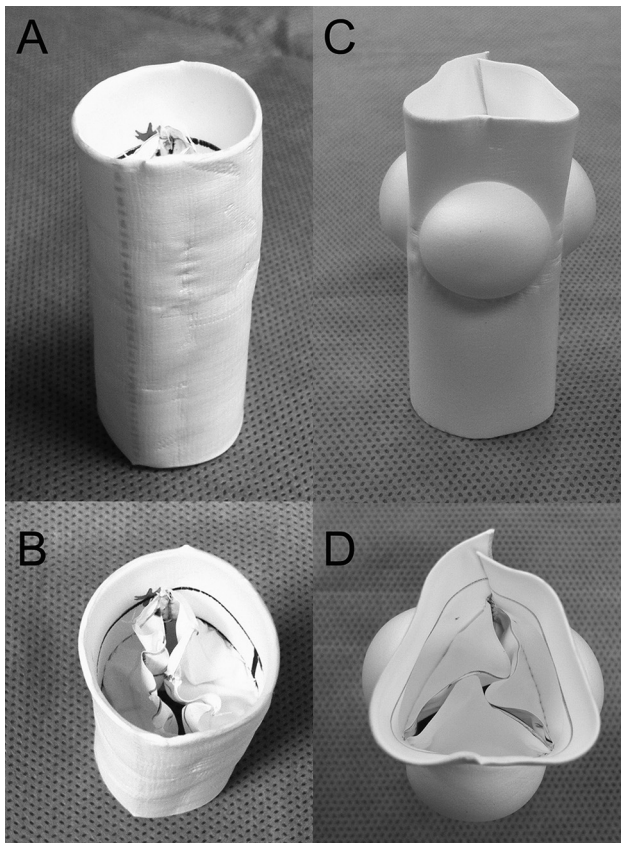

Fig 1. The pictures of valved expanded polytetrafluoroethylene (ePTFE) conduit showing the following: (A) and (B) the side and top views of initial bicuspid valved conduit; and (C) and (D) the side and top views of modified tricuspid valved conduit with bulging sinuses.