FUNCTIONAL EVALUATION OF STRUCTURAL CHARACTERISTICS OF A PEDIATRIC PULMONARY VALVED CONDUIT

Kenji Suzuki (1), Hirohito Sumikura (2), Yuki Oikawa (2), Shun-ichiro Sakamoto (1)

1. Department of Cardiovascular Surgery, Nippon Medical School Musashikosugi Hospital, Japan;

2. Graduate school of Science and Engineering, Graduate School of Tokyo Denki University, Japan

Background

Pulmonary valved conduits are used for reconstructing the right ventricular outflow tract in infancy. However, valve dysfunction often arises from stenosis and regurgitation caused by thrombus formation around the valve and decreased mobility of the valve leaflet. To address this, we developed a valved conduit based on the ePTFE bicuspid valve [1], which has a hinge in the center of the posterior wall of the right ventricular outflow tract and opens when the valve leaflet folds into the center and closes when the valve leaflet widens and adheres to the conduit wall; the following two structures were added: 1) A bulging sinus was formed in the anterior portion of the conduit to capture diastolic blood flow and promote adequate closure of the valve leaflet. 2) A fenestration at the right ventricular end of the valve leaflet was added to relieve blood stasis and prevent thrombus formation.

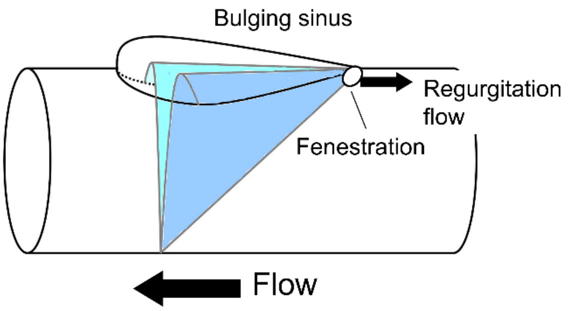

Figure 1: Schema of the proposed conduit.

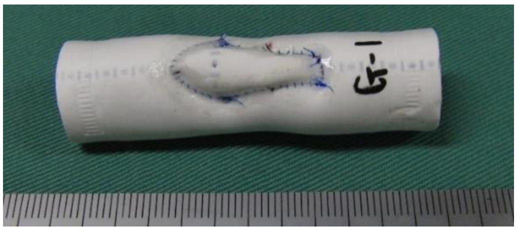

Figure 2: Appearance of the proposed conduit.

Objective

To evaluate the function of the bulging sinus and fenestration in the conduit using the developed pulmonary valve.

Methods

The developed conduits (14-mm-diameter ePTFE conduit with a 0.1-mm ePTFE seat valve leaflet sewn on; with bulging sinus and fenestration: SF valve, with bulging sinus and without fenestration; SN valve, without bulging sinus and with fenestration; NF valve, without bulging sinus and fenestration; NN valve, all n = 3) and the ePTFE tricuspid-valved conduit used at our institute (TC valve, n=3) were observed. Each conduit was incorporated into a right heart simulated mock circulation (flow rate, 700 mL/min; pulmonary artery pressure, 20–30/7–8 mmHg) to simulate hemodynamics in infancy, and the regurgitation rate (leakage volume/progressive flow) and pressure gradients before and after the valve were evaluated.

Results

At heart rates of 100/min, 120/min, and 140/min, the regurgitation rates (%) were 6.1, 5.3, and 3.4 for SF valve; 4.1, 2.6, and 0.9 for SN valve; 6.9, 5.7, and 3.7 for NF valve; 4.1, 3.1, and 1.7 for NN valve; and 7.0, 3.4, and 1.2 for TC valve, respectively.

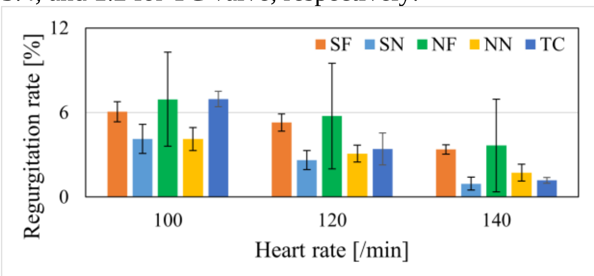

Figure 3: Regurgitation rate.

Pressure gradients (mmHg) were 4.1, 5.8, and 6.3 for SF valve; 1.5, 3.3, and 3.9 for SN valve; 3.6, 4.1, and 4.1 for NF valve; 4.4, 5.1, and 7.2 for NN valve; and 4.7, 5.2, and 5.8 for TC valve, respectively.

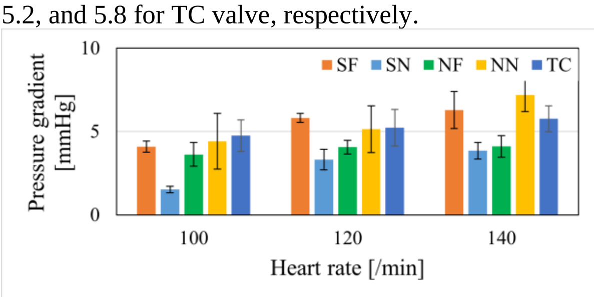

Figure 4: Pressure gradient.

Conclusion

The presence of fenestration was correlated with a relatively high regurgitation rate, while a bulging sinus tended to lower the regurgitation rate. Pressure ranges remained low and acceptable for clinical use, although the trend was not constant. The valve leaflets and conduit geometry can improve valve function.

References

1. Nunn GR et al, J Thorac Cardiovasc Surg, 136:290-296, 2008.