Small-Caliber Expanded Polytetrafluoroethylene Conduits with Curved Shape and a Hand-Sewn Bileaflet Valve for Right Ventricular Outlet Tract Reconstruction

Objective: We have crafted curved shape and a bileaflet valve in pulmonary expanded polytetrafluoroethylene conduits (diameter, 10-16 mm) for small pediatric patients, which are supposed to keep its valve function competent even in heterotopic implantation. This study reviewed our clinical experience with this conduit and tested its hydrodynamic performance on in vitro experiment.

Methods: All patients who received this conduit between 2010 and 2022 were evaluated. Patients using the conduit as a palliative right ventricle-to-pulmonary artery shunt were excluded. Hydrodynamic characterization experiments including particle image velocimetry were conducted using the 16-mm conduit in a pulmonary circulatory simulator at 3 cardiac output levels (1.5 L/min, 2.7 L/min, and 3.6 L/min) and 3 bending angles (130°, 140°, and 150°).

Results: There were 50 consecutive patients. The median operative age and weight was 17 [range, 0.33-55] months and 8.4 [range, 2.6-12] kg, respectively. Ten-mm, 12-mm, 14-mm, and 16-mm conduits were used in 1, 4, 6, and 39 patients, respectively, and implanted heterotopically in a total of 34 patients. Overall survival was 89% at 8 years with 3 non-valve-related deaths. During a median follow-up time of 3.7 [range, 0.26-11.8] years, 10 patients underwent conduit replacement due to pulmonary stenosis, 5 of whom had had 16-mm conduits and received adult-sized conduits longer than 8 years later. Freedom from conduit replacement was 89% and 82% at 5 and 8 years, respectively. Liner mixed-effect models with echocardiographic data implied that the 16-mm conduit was durable with a peak velocity less than 3.6 m/s and without moderate or severe regurgitation until patient's weight reached 25 kg. On in vitro experiments, peak transvalvular pressure gradients were between 16 mmHg (cardiac output, 1.5 L/min) and 31 mmHg (cardiac output, 3.6 L/min). Almost all of valve regurgitation was composed of closing volume in any condition, calculated at 2.2 mL/beat to 4.4 mL/beat. Particle image velocimetry revealed that peak values of Reynolds shear stress at mid-systolic phase were between 161 Pa (cardiac output, 1.5 L/min; bending angle, 140°) and 457 Pa cardiac (output, 2.7 L/min; bending angle, 140°).

Conclusions: Our valved conduits with curved and bileaflet design can eliminate valve regurgitation in any implant position and serve as a reliable bridge to subsequent conduit replacement with proven clinical durability and hydrodynamic profile.

Shunsuke Matsushima (1), Hironori Matsuhisa (1), Kohki Wakita (2), Takanori Tsujimoto (3), Naohisa Takagaki (2), Itsuo Honda (2), Yoshihiro Oshima (1), Osamu Kawanami (2), Kenji Okada (3), (1) Department of Cardiovascular Surgery, Kobe Children's Hospital, Kobe, Japan, (2) Department of Mechanical Engineering, University of Hyogo, Himeji, Japan, (3) Department of Cardiovascular Surgery, Kobe University Graduate School of Medicine, Kobe, Japan
A retrospective study
- June 2010 - July 2022
- 50 consecutive patients
- Weight, 8.4 [2.6-12] kg
- Conduit size, n
  10-mm, 1; 12-mm, 4;
  14-mm, 6; 16-mm, 39.

In vitro experiment
- Pulmonary circulatory simulator
- Cardiac output, 1.5 - 3.6 L/min
- With particle image velocimetry
- 16-mm conduit was tested.

89% at 5 years
82% at 8 years

Liner mixed-effect models

Peak transvalvular pressure gradients, 16 - 31 mmHg
Closing volume, 2.2 - 4.4 mL/beat
Peak Reynolds shear stress at mid-systolic phase, 161 - 457 Pa

This valved conduit with curved and bileaflet design can serve as a reliable bridge to subsequent conduit replacement with proven clinical durability and hydrodynamic profile.