FLOValve: Engineering an Origami-Inspired Expandable Heart Valve Prosthetic

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Congenital heart disease (CHD) affects 1.4 million newborns annually, with over 20% requiring a heart valve prosthetic. A major challenge in pediatric cardiac care is the absence of a long-lasting, expandable prosthetic that accommodates growth and reduces the need for multiple invasive open-heart surgeries. FLOValve, an origami-inspired heart valve prosthetic, addresses these challenges by expanding from pediatric to adult sizes while maintaining structural integrity and function. The valve was prototyped using a novel fabrication method combining 3D printing and dip molding with polyurethane rubbers possessing medical-grade mechanical properties, and material selection was refined through tensile strain testing. Testing confirmed valve performance under simulated static and dynamic heart conditions. Performance was evaluated using a Mock Heart Pressure Water Column (MHPWC) system, simulating prosthetic function under realistic heart valve blood pressures and flow rates. A Mock Porcine Heart Model, using a pig heart from a local butcher, was used to test and demonstrate FLOValve function under simulated real-world conditions. FLOValve achieves physiological peak valve blood flow rates (100–200, 200–300, and 300–400 mL in child, adolescent, and adult sizes, respectively) and minimal pressure drops (<5 mmHg) at simulated systolic pressures across all sizes. The prosthetic exhibits minimal regurgitation in both the MHPWC and porcine heart model. FLOValve achieves physiological average blood flow rates in the porcine model (20, 40, 70 mL per beat in child, adolescent, and adult sizes, respectively). FLOValve may offer a viable, minimally invasive alternative to current pediatric prosthetics and help reduce surgical burden for children with CHD.

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