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INNOVATION AND SCIENCE: THE FUTURE OF VALVE DESIGN

Reply to the Editor:

Designing semilunar valves in children has been a constantly evolving and at the same time challenging field for both the clinicians and the engineers involved. Recent approaches embraced include analytic methods based on engineering principles promising a more scientific and precision-based approach. This requires a solid understanding of the precise mechanisms of normal valve operation, but superimposed on this is the constantly changing environment of the valve due to the growing child, a change of hemodynamics, or a disease process that evolves over time.

This article by Chen and colleagues¹ is another example of attempting to advance the science of designing valves using an analytic approach and engineering principles for which they need to be congratulated. They used a commercial stent graft as the scaffold for compositing handmade tri-leaflet expanded polytetrafluoroethylene valved conduits.

The work by Chen and colleagues¹ takes steps toward understanding the relationship between the 2-dimensional shape of the valve leaflets and the closed and loaded 3-dimensional shape of the valve for a given material using a computer-aided design. Understanding this relationship is essential for developing a repeatable procedure for valve reconstruction that achieves predictable valve function postoperatively. On the other hand, achieving predictable long-term valve function requires an understanding of several more complicated relationships. For example, the range of normal working stresses in the reconstructed valve and adjacent tissues must be known and related to the loads at which these materials and tissues fail. We are just beginning to compare the working stresses in the reconstructed valve with the stresses at which valve reconstruction materials fail,² although this work just scratches the surface. Tissue stresses are also hypothesized to drive long-term biological responses, such as calcification and fibrosis, to valve reconstruction materials. Considerable work lies ahead to quantify these relationships so that they can be used to directly drive design. Finally, in the pediatric patient, repairing a valve with long-term durability requires

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understanding of and strategy for accommodating patient growth. Several preliminary concepts have been proposed to address the challenge of growth accommodating valve repair,^{3,4} but, again, much work remains to be done.

Pushing the frontiers in valve reconstruction requires both innovation and application of science, analytic methods, and engineering principles, combined with an understanding of the way the tissues and materials used behave over time. The final test of such designs still remains the human body itself and the unique ways it handles both the design of such valves and the tissues of which they are composed. Although clinicians, surgeons, and engineers have pushed the frontiers in this field, it is the harmonious and synergistic efforts of all that will push the field to the next level and the future of precision designed medicine.

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