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Commentary: In silico design of right ventricle to pulmonary artery conduits—confirmation of "in cerebral" design?

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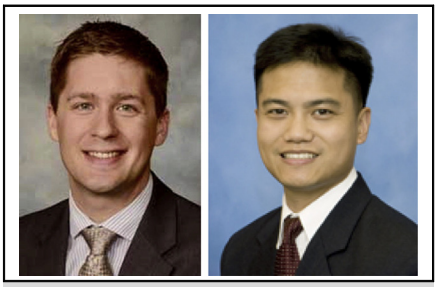

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CENTRAL MESSAGE

In silico design of right ventricle-to-pulmonary artery conduits yielded models that were expected from intuition or the "surgeon's eye" but may be useful for implants with more complex shapes.

The use of right ventricle-to-pulmonary artery conduits establishes hemodynamic continuity between the right ventricle and branch pulmonary arteries as well as provides early protection against retrograde flow from the pulmonary arteries into the lungs during diastole. Right ventricle-to-pulmonary artery conduits are thus critical in the repair of heart defects in which the native main pulmonary artery and pulmonary valve are absent, hypoplastic, or have been co-opted for use in the systemic circulation. As with any non-autologous (allogeneic, xenogenic, or synthetic) implanted material, right ventricle-to-pulmonary artery conduits lack the ability to grow, regenerate, and remodel. Consequently, these conduits eventually require replacement because of eventual failure to provide unobstructed antegrade flow as well as prevent significant retrograde diastolic flow.[1,2]

This clinical situation motivates the study by Ebrahimi and colleagues.[3] In this study, the authors generated a model for the optimal right ventricle-to-pulmonary artery conduit using computational fluid dynamics and 3-dimensional imaging data from 5 patients who presented with right ventricle-to-pulmonary artery conduit failure. The Central Figure and Figure 5 of their manuscript summarize the results nicely: the failed conduits requiring replacement are narrowed and stenotic whereas the predicted, optimal in silico model has a larger caliber and smooth contour. Further, these figures are color-coded for wall shear stress, which is greatest in areas of narrowing or curvature.

This study provides proof of concept for the use of in silico design and computational fluid dynamics to create an individualized right ventricle-to-pulmonary artery conduit in patients with congenital heart disease. It is important to note that the in silico–modeled conduits were compared with conduits in need of replacement. It would be of interest to compare the in silico models to the newly replaced right ventricle-to-pulmonary artery conduits to assess whether there remains a difference in the hemodynamic profiles between surgeon-tailored conduits and computer-modeled conduits. On careful inspection of the failed and modeled conduits in Figure 5 of the authors' manuscript, we would surmise that the surgeon likely envisioned the optimal conduit to be very similar to the in silico design.

However, the motivation for this study is to develop an approach that could be coupled with additive manufacturing technology such as 3-dimensional bioprinting, where implantable grafts and conduits are personalized to a specific patient's anatomy as determined by 3-dimensional imaging. This may be especially of great utility when designing more complex parts, such as branched grafts or patches with complex curvature in multiple dimensions. For more simple geometries, perhaps the "in cerebral" design is just as good. Lastly, if the fabrication of tissue-engineered grafts and conduits ever becomes a reality,

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then these living tissues would have the potential of remodeling to the appropriate and most efficient shape and caliber, thus making the initial, personalized design less important.

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