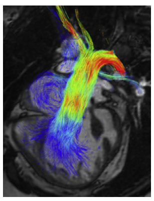
The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.



REPLY FROM AUTHORS: THE UNBEARABLE WEIGHT OF SHAPE AND FLOW QUALITY

Reply to the Editor:

We read with great interest the commentary by Asada and colleagues[1] discussing the role of neoaortic shape in patients undergoing the Norwood procedure. Since the advent of the Norwood procedure, much attention has been paid to the ideal shape of the reconstructed neoaorta, and several iterations of the original procedure have been proposed. Recently, there has been a growing interest in evaluation of postsurgical outcomes using either computational flow dynamics (CFD) or 4-dimensional flow magnetic resonance imaging. Both imaging techniques enable a comprehensive qualitative and quantitative assessment in patients with complex congenital anatomy. The 2 primary vascular research avenues focus on (1) interactions between flow-mediated hemodynamic forces (wall shear stress) and tissue remodeling and (2) interactions between observed flow patterns and geometry or geometry-dependent mechanical properties (stiffness, distensibility, etc). An additional novel and exciting field of clinical flow hemodynamics focuses on patient-specific surgical planning and how different boundary conditions influence flow hemodynamic patterns.[2]

Asada and colleagues[1] have recently developed a new procedural variant, the "Chimney" technique, with the intention of designing neoaorta with gradual tapering of the ascending diameter without the use of homograft patch.[3] Their initial promising results revealed a recoarctation rate similar to those encountered when using the more prevalent interdigitating technique, although a larger cohort study is necessary for further validation and evaluation of long-term outcomes. The authors further reenforced their results through postoperative CFD analysis demonstrating cohesive systolic flow without excessive formation of secondary flow formations in the ascending aorta and arch. In our recent study, we demonstrated that gradual neoaortic tapering is associated with smaller viscous energy loss and, therefore, better flow quality.[4] We analyzed flow hemodynamics directly in vivo using 4-dimensional flow magnetic resonance imaging, hence eliminating some of the physiologic and geometric boundary condition constraints associated with CFD.

Cumulatively, CFD findings from Asada and colleagues[1] and our study complement each other and underlie the importance of gradual neoaortic tapering to generate optimal flow trajectory from the neoaortic valve to the descending aorta. The clinical utility of flow hemodynamics is yet to be determined and will require a prognostic longitudinal study. Meanwhile, we suggest collecting as much as flow hemodynamic data as possible to retrospectively evaluate the most ideal aortic shape. Currently, we are exploring principal component analysis, a dimensionality reduction and feature extraction technique, as an unbiased statistical method to investigate basic geometric modes and their association with flow hemodynamics and clinical outcomes. This approach has been already explored in patients with surgically repaired aortic coarctation where specific arch features have been well correlated with the left ventricular function.[5] Overall, we would like to thank Asada and colleagues[1] for their iterative engineering-based approach toward Norwood reconstruction and for indirectly confirming our results. Let's continue to go with the flow.

Michal Schäfer, PhD[a]
Michael V. Di Maria, MD[a]
Matthew L. Stone, MD, PhD[b]
James Jaggers, MD[b]
Max B. Mitchell, MD[b]
[a]*Division of Cardiology*
Heart Institute
Children's Hospital Colorado
University of Colorado Denver
Anschutz Medical Campus
Aurora, Colo
[b]*Section of Pediatric Cardiothoracic Surgery*
Department of Surgery
University of Colorado Denver
Anschutz Medical Campus
Aurora, Colo

References

1. Asada S, Yamagishi M, Itatani K. Gradual caliber transition of the neoaortic arch after the Norwood procedure can prevent neoaortic dilation and right ventricular deterioration. *J Thorac Cardiovasc Surg Open*. 2022;10:350-1.
2. Qian Y, Liu JL, Itatani K, Miyaji K, Umezu M. Computational hemodynamic analysis in congenital heart disease: simulation of the Norwood procedure. *Ann Biomed Eng*. 2010;38:2302-13.
3. Asada S, Yamagishi M, Itatani K, Maeda Y, Taniguchi S, Fujita S, et al. Early outcomes and computational fluid dynamic analyses of chimney reconstruction in the Norwood procedure. *Interact Cardiovasc Thorac Surg*. 2019;29:252-9.
4. Schäfer M, Di Maria MV, Jaggers J, Stone ML, Ivy DD, Barker AJ, et al. High-degree Norwood neoaortic tapering is associated with abnormal flow conduction and

elevated flow-mediated energy loss. *J Thorac Cardiovasc Surg*. 2021;162:1791-804.

5. Bruse JL, Khushnood A, McLeod K, Biglino G, Sermesant M, Pennec X, et al. How successful is successful? Aortic arch shape after successful aortic coarctation repair correlates with left ventricular function. *J Thorac Cardiovasc Surg*. 2017;153:418-27.

https://doi.org/10.1016/j.xjon.2022.04.038