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Commentary: Aortic anatomy late after coarctation repair: Size matters

Joseph B. Clark, MD

With an elegant combination of clinical imaging and laboratory simulation techniques, Mandell and colleagues¹ have characterized the influence of aortic anatomy on late physiologic outcome in patients with repaired coarctation of the aorta. Their research correlates patient exercise capacity with aortic size and shape through 2 separate but linked studies: a retrospective review of patient aortic anatomy using cardiac magnetic resonance imaging and a prospective mock flow experiment using 3-dimensional (3D)-printed aortic models.

For the imaging component, the authors present several poignant findings. First, patients with a smaller descending aorta demonstrated decreased exercise capacity. Second, the ratio of ascending to descending aorta diameter, newly termed “aorta size mismatch,” was even more predictive of impaired exercise capacity. Third, patients with relative flow maldistribution (ie, decreased fractional flow in the descending aorta at rest) also demonstrated decreased exercise capacity. For the in vivo study, these results appear to be collectively intuitive; exercise capacity was associated with the size of the descending aorta, aorta size mismatch, and flow fraction to the descending aorta at rest.

For the flow simulation, multiple approximations were implemented to conduct the experiment. Among other limitations, the 3D-printed aortic models were constructed of a rigid, noncompliant polymer, and the size was scaled down to accommodate pump capability. Nevertheless, the in vitro circulatory simulation corroborated and supplemented the in vivo findings. In the laboratory studies, aorta size mismatch was associated with decreased flow fraction in the descending aorta at

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Aorta size mismatch, the ratio of the ascending to descending aortic diameter, predicts decreased flow distribution to the lower body and decreased exercise tolerance.

simulated conditions of rest and exercise. Perhaps unexpectedly, aorta size mismatch was also associated with a proportionately greater increase in lower body flow fraction between rest and exercise, and this increased augmentation was associated with worse exercise capacity. Although the authors offer plausible explanations for this counterintuitive observance, the fact remains that aorta size mismatch resulted in overall compromised lower body flow distribution at both rest and with simulated exercise. Irrespective of the relatively greater increase, persistent flow maldistribution apparently translated into impaired exercise capacity.

The studies are also notable for the negative findings. Although much attention was given to the geometry of the aortic arch, no significant correlation was appreciated between arch shape (eg, Romanesque, Crenel, or Gothic) and flow distribution or exercise capacity. Aortic caliber proved more influential than curvature. In addition, exercise capacity was not associated with resting cardiac index or absolute indexed flow rates to the descending aorta.

In summary, aorta size mismatch, exemplified by a larger ascending aorta coupled with smaller descending aorta, was shown to predict decreased flow fraction to the lower body and was the strongest identified predictor of decreased exercise tolerance. As the authors highlight, the percentage of flow going to the descending aorta was positively correlated with exercise capacity. Although this study may not necessarily impact the immediate surgical goals of relief of focal stenosis and promotion of optimal

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aortic growth, these findings help inform an understanding of the relationship between late aortic anatomy and exercise performance in patients with repaired coarctation.

Reference

1. Mandell JG, Loke YH, Mass PN, Opfermann J, Cleveland V, Aslan S, et al. Aorta size mismatch predicts decreased exercise capacity in patients with successfully repaired coarctation of the aorta. *J Thorac Cardiovasc Surg.* 2021;162:183-92.e2.

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Check for updates

Commentary: Exercise capacity after coarctation repair: When size finally matters!

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Aortic coarctation is a life-long problem that unlike many other congenital heart defects does not end by its repair, even if it is successful, and even if it is done early in life. Data suggest these patients remain at risk of increased mortality¹ and morbidity.² The study of exercise intolerance and the hypertensive response to exercise after coarctation repair has gained wide popularity in recent years.³

I read with interest the study by Mandell and colleagues,⁴ where the authors evaluated aortic size mismatch (ascending-to-descending aortic diameter ratio, D_{AAo}/D_{DAo}) and its impact on exercise capacity after coarctation repair. The authors used several aortic measurements (diameter, arch height-to-diameter ratio) and percent descending aorta (% D_{Ao}) flow from cardiac magnetic resonance imaging and exercise stress testing in 15 patients who underwent successful coarctation repair. They also generated mock circulatory flow loops with the help of printed 3-dimensional models of the aortae. They identified that aortic size mismatch and ratio of % D_{Ao} flow in exercise-to-rest negatively correlated with oxygen consumption.

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CENTRAL MESSAGE

Exercise capacity after coarctation repair is not only affected by residual gradient; other factors that control fluid dynamics, such as aortic size mismatch and arch geometry, may play a role.

These findings beg the following interesting and practical questions:

1. How to define success after coarctation repair? It looks like it is not just the mere absence of a gradient anymore.
2. What is the optimal repair technique? Native tissue-to-native tissue with no prosthetic material? Now, we do not know if this will be sufficient to preserve normal geometry. Proponents of direct end-to-end or extended end-to-end repair may need a second look. Maybe it is better to have normal arch geometry with added patch material to minimize tension and maintain normal flow dynamics rather than focusing on avoiding it. And if we will use a patch, what type?
3. What is a significant gradient means? Are we delaying interventions because of random numbers?
4. In absence of significant gradient, will geometry and size mismatch be the only factors that affect exercise capacity in these patients? How about wall stiffness? I think

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