Dumb pumps, smart flow, and a genius

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In 1513, Leonardo da Vinci conducted a series of experiments to understand how blood flows through the aortic root and influences the motion and function of aortic valve leaflets.¹ With the use of grass seeds in glass aortic root molds, da Vinci's elegant and brilliant approach illuminated the complex physiology of the aortic root. Of note, he established that blood flow influences the conduit. The present work by Yoshida and colleagues² recreates this experiment using echocardiography and computational flow dynamics to characterize the complex relationship among the native blood flow, mechanical blood flow, and aortic root. The study highlights the possibilities of modern imaging and computational methods to help us understand the inconvenient truth that pushing blood to help failing hearts is an imperfect solution. Multiple left ventricular assist device (LVAD) complications have emerged to prevent truly widespread adoption. In particular, vascular complications, stroke, arteriovenous malformations, bleeding, and progressive aortic insufficiency have plagued investigators and clinicians. As highlighted by the current study, one possible source may be the flow characteristics in the aortic root itself. Blood is a complex fluid, and because of its mass creates interesting flow dynamics particularly at the boundary layer, that is, the interface between the fluid and the vessel wall. The study by the Osaka group demonstrates that early after LVAD support there are unique stresses on the aorta and the aortic valve. What is unclear is how this changes over time and, importantly, whether those changes are predictive of future complications. Although the patient in this case had an ischemic cardiomyopathy, she was only 43 years old. How would flow look in a 60- or 70-year-old aorta? Does the cause of heart failure matter? Do the different device designs have similar flow characteristics and does the angle of the outflow graft play a role in aortic flow dynamics? Ambardekar and colleagues³ have reported significant changes in aortic compliance after LVAD placement. They go on to speculate that there may an association with these changes and ongoing myocardial load and

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Central Message

The case report by Yoshida and colleagues highlights the important relationship among the aortic root, flow, and impact of continuous-flow LVADs.

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stress.³ There is also an emerging connection between genetically triggered aortopathy and heart failure.⁴ Therefore, it is intriguing to think about this interaction among flow in the aortic root, peripheral vasculature, and genetic maladaptive remodeling. Moreover, it suggests that *how* we propel blood as a function of time during the cardiac cycle may be a critical regulator of device biocompatibility. Perhaps pulsatility has a purpose after all. Yoshida and colleagues² have revisited Leonardo's extraordinary experiments and in turn have started an important line of inquiry that should challenge investigators and our industry partners to evolve these devices away from "dumb pumps" to respectful and physiologic ones.

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