Failing Fontan assist: From tissue to turbine

Syed Bukhari, MD, Manan Desai, MD, Lok Sinha, MD, and Can Yerebakan, MD

From the Department of Cardiovascular Surgery, Children's National Heart Institute, The George Washington University School of Medicine and Health Sciences, Washington, DC.

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Address for reprints: Can Yerebakan, MD, Cardiovascular Surgery, Children's National Heart Institute, The George Washington University School of Medicine and Health Sciences, 111 Michigan Ave NW, Washington, DC, 20010 (E-mail: cyerebakan@childrensnational.org).

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Left to right: Syed Bukhari, MD, Manan Desai, MD, Lok Sinha, MD, and Can Yerebakan, MD

Central Message

The search for an effective treatment for a failing Fontan circulation is in persistent evolution.

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There have been significant advances in the performance of Fontan completion after its first description by Fontan.^{1,2} Contemporary changes have failed to fix the ultimate failing Fontan physiology with its various reasons, however, rendering a significant patient population into a state of debilitated illness that places a major burden to families and economy.³⁻⁵ Despite the significant challenges and constant effort, the search for ideal fourth-stage management of single-ventricle palliation continues.⁶

In this issue of the *Journal*, the excellent report by Broda and colleagues⁷ offers an overview of potential treatment options to support a failing Fontan circulation, extending from tissue-engineered products to turbine devices, some of which have already been used in the clinical setting. Broda and colleagues⁷ are to be congratulated on their clear and comprehensive description of support options in patients with a failing Fontan circulation. Several novel ideas in search of an ideal support in a failing Fontan physiology give a glimpse of hope on the horizon.

Among different causes of Fontan failure, the missing subpulmonary ventricle is the subject of ongoing efforts to find a reliable substitute for long-term effective and simple assistance in cases of a preserved cardiac function. The use of available mechanical ventricular assist devices in patients with a failing Fontan circulation in the low-pressure passive venous circulation is suboptimal. Despite the challenges with each of these models mentioned by Broda and colleagues,⁷ moving forward with philosophical skepticism, these novel approaches may offer a way to improve the outcome for patients with Fontan failure physiology in the future. A prime example of an in vitro model of turbine pump is the feasibility study of an integrated aortic turbine venous-assist system in a mock Fontan circuit presented recently in the *Journal* by Pekkan and colleagues.⁸ In this ingenious model, the aortic bloodstream is used as a source of kinetic energy to reduce the venous pressure and augment the flow in a Fontan circulation, similar to a turbine used in hydropower to generate electricity. Even with the device in

its early developmental phase, the approach whispers the key elements of how an ideal support device should look in the future. One of the most promising devices as of today is Rodefeld's von Karman pump.⁹ The challenge with this pump is to convert it into an actual implantable device and to test it biologically with a reliable long-term animal model of Fontan circulation.

Being optimistic about the future perspectives that are offered by ongoing research efforts today's reality will keep us in continuous skepticism. Thrombogenicity will remain a major concern, weighed against the risk of bleeding, because the right-sided low-pressure system will require higher therapeutic levels of anticoagulation with the use of mechanical support devices that are exposed to blood. Alternatively, external counterpulsation devices and tissue engineering remain significant alternatives.^{7,10} Recent advances in technology with wireless and transcutaneous charging feasibility, however, provide hope that the ideal miniature and less thrombogenic assist devices without a driveline will also be in the pipeline as primary competitors of tissue-engineered support alternatives.¹¹

Although the progress in last 2 decades has been in the direction of continuous improvement, regardless of the diversity of ideas and challenges, the search for ideal support system for a failing Fontan circulation should be encouraged to achieve the ultimate beyond the known. The ultimate therapy for a failing Fontan may just be its prevention by novel surgical and medical means in the future. We congratulate Broda and colleagues⁷ on their comprehensive summary of today and anticipated future of failing Fontan treatment.

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