The first integrated aortic turbine venous-assist system is born

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Central Message

The first aortic turbine assist device to support a failing Fontan circulation passes in-vitro laboratory testing.

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Staged surgical palliation of patients to a single-ventricle pathway has become among the most standardized approaches, with continuous improvement of outcome regardless of the diversity of the underlying cardiac anatomy. The last stage of single-ventricle palliation is the establishment of the total cavopulmonary connection, known as the Fontan-Kreutzer operation.^{1,2} Nowadays, several modifications of this operation are among the armamentarium of congenital heart surgeons.³ Despite excellent surgical outcomes of Fontan completion, its long-term outcome is compromised due to failure of the passive-flow venous circulation, known as Fontan failure.⁴ The name Fontan failure does not address the underlying cause of the failure, but rather describes the end state of different potential causes. Medical and surgical attempts have been implemented to overcome a failing Fontan circulation; however, cardiac transplantation remains the gold standard in the absence of contraindications.^{5,6} Evolving technology may offer potential treatment modalities, such as a mechanical circulatory support, to optimize flow dynamics in a failing Fontan circulation, depending on the underlying cause.^{5,7}

Pekkan and colleagues⁸ present an in vitro feasibility study of an integrated aortic turbine venous-assist system (iATVA) in a mock Fontan circuit in that the aortic bloodstream has been used as a source of kinetic energy to reduce the venous pressure and augment the flow in a Fontan circulation. The iATVA creates a dual-inlet and dual-outlet pump configuration to assist the venous flow in the Fontan pathway using aortic flow. This is the first blood turbine device in the literature to support a failing Fontan circulation. The authors have extensive experience in research with Fontan hemodynamic parameters and should be congratulated for this novel achievement to assist a failing Fontan circulation.

A steal of around 25% from the systemic circulation is required with iATVA to decrease the Fontan pressures in the 3 to 5 mm Hg range. Because the device has been tested in a mock circuit with fixed circulatory parameters and

limited variation rather than in the dynamic nature of human circulation, the results should be accepted with caution. The decrease in cardiac output in a failing Fontan circulation may indeed complicate management, especially in a marginal single ventricle with systolic and/or diastolic dysfunction or a significant atrioventricular valve regurgitation.

Before testing in an appropriate animal model, we can barely answer the question of the efficacy of the pump in the real world. Even when that happens, only a glimpse of the hemodynamic changes that take place within a patient with chronically failing Fontan circulation with multiorgan dysfunction can be noted in an animal model in an acute experimental setup.⁹ However, the authors' strategy has been declared for implantation of the pump in the early stages of Fontan failure to prevent an end-stage disease.

As with all artificial surfaces, thrombogenicity will always remain a concern in the bloodstream because a low-rotational-speed turbine device is connected to a passive venous circulation. Taking the example of thrombotic complications after aortopulmonary shunt operations, it is reasonable to expect a high-level anticoagulation/antiplatelet therapy requirement with the available pump design. With further testing and application in animal experiments, we may get close to answering this question for the proposed pump. In a classic Fontan patient, factors such as blood viscosity and higher hematocrit levels will have to be added into the hydrodynamic calculations for the pump performance and thrombogenicity.^{10,11} Similarly, at this stage the size of the pump hinders a wide variety of applications, particularly in small children. However,

alternative pump designs in the future may overcome this issue.

Despite the mentioned challenges, this novel approach may offer one more way to improve outcomes for patients with a Fontan failure physiology in future. We congratulate the authors for their commitment to long years of research to understand and solve the problems in Fontan circulation.

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