children who were going to do poorly with SV palliation and changing their strategy toward transplantation. We often persist in our SV strategy until a patient is so ill that even VAD support cannot resuscitate him or her. The authors' improved results with SV palliation is because they moved to VAD support early—before the children were on extracorporeal membrane oxygenation. In all but 2 patients, the surgeons avoided the common scenario of failed neonatal palliation resulting in extracorporeal membrane oxygenation and then VAD support and salvage VAD, the results of which are dismal: <20% survival.⁴ This series is an important report for our field because it is the first to describe elective VAD therapy as a bridge to transplant in a series of SV patients before any palliation using the Excor device. Despite size, device, or diagnosis, good patient selection and timing of support can result in acceptable results even in infants with SV physiology.

This study is limited by its small sample size and further study is needed, especially because multiple reports have demonstrated that support of neonates/infants with SV physiology has been improving with the use of

paracorporeal continuous flow devices.⁵ However, there may be advantages to pulsatility in this cohort.^{5,6} This series is a promising step to improving survival in this high-risk patient population, begging the question: Have we again found promise with pulsatility?

References

1. Weinstein S, Bello R, Pizarro C, Fynn-Thompson F, Kirklin J, Guleserian K, et al. The use of the Berlin Heart EXCOR in patients with functional single ventricle. *J Thorac Cardiovasc Surg*. 2014;147:697-704.
2. Conway J, St Louis J, Morales DLS, Law S, Tjossem C, Humpl T. Delineating survival outcomes in children <10 kg bridged to transplant or recovery with the Berlin Heart EXCOR ventricular assist device. *JACC Heart Fail*. 2015;3:70-7.
3. Philip J, Powers E, Machado D, Colon DL, Gupta D, Shih R, et al. Pulsatile ventricular assist device as a bridge to transplant for the early high-risk single-ventricle physiology. *J Thorac Cardiovasc Surg*. 2021;162:405-13.e4.
4. Morales DL, Zafar F, Rossano JW, Salazar JD, Jefferies JL, Graves DE, et al. Use of ventricular assist devices in children across the United States: analysis of 7.5 million pediatric hospitalizations. *Ann Thorac Surg*. 2010;90:1313-8.
5. Gazit AZ, Petrucci O, Manning P, Shepard M, Baltagi S, Simpson K, et al. A novel surgical approach to mechanical circulatory support in univentricular infants. *Ann Thorac Surg*. 2017;104:1630-6.
6. Philip J, Reyes K, Ebraheem M, Gupta D, Fudge JC, Bleiweis MS. Hybrid procedure with pulsatile ventricular assist device for hypoplastic left heart syndrome awaiting transplantation. *J Thorac Cardiovasc Surg*. 2019;158:e59-61.

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Commentary: Ventricular assist device support in an early infancy with single ventricle: Transformation from salvage to elective

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CENTRAL MESSAGE

Mechanical circulatory support for stage I single-ventricle patients is most challenging. The unique strategy Philip and colleagues reported may be a game-changing solution for this population.

Recent Pedimacs (Pediatric Interagency Registry for Mechanical Circulatory Support) data showed significant outcome differences in ventricular assist device (VAD)

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Disclosures: Dr Adachi reported consultant/proctor for Berlin Heart, Inc, Medtronic, Inc, Jarvik Inc, BiVACOR Inc, and Sony-Olympus Medical Solutions, Inc. Dr Moon 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.

Received for publication Oct 11, 2020; revisions received Oct 11, 2020; accepted for publication Oct 14, 2020; available ahead of print Oct 17, 2020.

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J Thorac Cardiovasc Surg 2021;162:416-7

0022-5223/\$36.00

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<https://doi.org/10.1016/j.jtcvs.2020.10.045>

support for single ventricle (SV), depending on the stages of SV palliations; 6-month survival was 30% for Stage I, 40% for Stage II, and 95% for Stage III.¹ Although poor outcomes for Stage I and II are likely multifactorial, the unique physiology specific to Stage II predominantly responsible for unfavorable outcomes has been recognized (ie, dichotomous systemic venous return²). Such recognition has led to VAD implant procedure modifications and ongoing outcome improvement.^{3,4} In contrast, VAD support for Stage I remains a serious challenge.⁵ Exceedingly poor outcomes are primarily attributed to critical status at VAD implant, as evidenced by substantially greater proportion (59%) in INTERMACS (Interagency Registry for Mechanically Assisted Circulatory Support) profile 1, compared with 29% for Stage II, and 21% for Stage III.¹ In other words, the most tenuous patients (neonates/infants with SV physiology) received VAD support at the most suboptimal timing (critical cardiogenic shock). While the “salvage” nature of VAD support for Stage I is the major reason for poor outcomes, it could represent, in turn, the potential moving target to alter the dismal outlook of VAD support for this challenging cohort.

In this issue of the *Journal*, Philip and colleagues⁶ enlighten us on the new strategy of VAD use for Stage I. Their series included 6 patients with hypoplastic left heart syndrome, 2 with pulmonary atresia with intact ventricular septum, and 1 with double-inlet left ventricle. Of note, 6 (67%) of the 9 patients were bridged to cardiac transplant using the EXCOR VAD (Berlin Heart, Inc, The Woodlands, Tex), with a median (range) support duration of 64 (11-167) days. The novelty of their strategy is to use VAD support not as “salvage” following failed Stage I palliation. Rather, the VAD implantation was performed as an index procedure in 5 (56%) of the 9 patients. As has been witnessed over the last decade, earlier initiation of VAD support and avoidance of INTERMACS 1 profile is critical for outcome improvement.⁷ In this regard, Gainesville’s strategy is

consistent with the overall trend in the VAD society (ie, earlier deployment for better outcome). Needless to say, such strategic changes in the most tenuous patients is not without courage. The Gainesville team was brave enough to explore the endeavor, which would reflect their confidence in their clinical capability in VAD management. Although their preliminary experience is encouraging and certainly more favorable than the historical data, the support strategy’s sophistication would lead to further outcome improvement. Given the current lack of realistic support solutions in this challenging population, nonetheless, their successful experience represents a ray of light in the complete darkness that exists in the field of pediatric VAD support. Phillip and colleagues’ report will be remembered as a landmark article that facilitated the establishment of Stage I support strategies, which would ultimately usher in an era of VAD support for the entire spectrum of SV population.

References

1. Peng DM, Koehl DA, Cantor RS, McMillan KN, Barnes AP, McConnell PI, et al. Outcomes of children with congenital heart disease implanted with ventricular assist devices: an analysis of the pediatric interagency registry for mechanical circulatory support (Pedimacs). *J Heart Lung Transplant*. 2019;38:420-30.
2. Adachi I. Ventricular assist device support for complex congenital heart disease: inspiration from history of surgical evolution. *J Heart Lung Transplant*. 2019;38:431-2.
3. Maeda K, Nasirov T, Yarlagaadda V, Hollander SA, Navaratnam M, Rosenthal DN, et al. Single ventricular assist device support for the failing bidirectional Glenn patient. *Ann Thorac Surg*. 2020;110:1659-66.
4. Adachi I. Ventricular assist device implantation for single ventricle. *Op Tech Thorac Cardiovasc Surg*. 2020;25:74-84.
5. Miller JR, Lancaster TS, Callahan C, Abarbanell AM, Eghtesady P. An overview of mechanical circulatory support in single-ventricle patients. *Transl Pediatr*. 2018;7:151-61.
6. Philip J, Powers E, Machado D, Lopez Colon D, Gupta D, Shih R, et al. Pulsatile ventricular assist device as a bridge to transplant for the early high-risk single-ventricle physiology. *J Thorac Cardiovasc Surg*. 2021;162:405-13.e4.
7. Kormos RL, Cowger J, Pagani FD, Teuteberg JJ, Goldstein DJ, Jacobs JP, et al. The Society of Thoracic Surgeons intermacs database annual report: evolving indications, outcomes, and scientific partnerships. *J Heart Lung Transplant*. 2019;38:114-26.