Again, by using mechanical support to increase arch perfusion (through the left CCA), we were able to restore myocardial function consistent with reversed myocardial hibernation. Conversion to a Norwood procedure with arch reconstruction eliminated any further myocardial malperfusion. It is important to note that the MPA-IA shunt did not provide adequate flow in the aortic arch to preserve myocardial function, suggesting that larger shunts might be required.

In conclusion, the MPA-IA shunt and ECMO support with arch cannulation are tools available to prevent or treat retrograde arch malperfusion.

References

1. Bacha EA, Daves S, Hardin J, Abdulla RI, Anderson J, Kahana M, et al. Single-ventricle palliation for high-risk neonates: the emergence of an alternative hybrid stage I strategy. *J Thorac Cardiovasc Surg.* 2006;131:163-71.e2.
2. Schranz D, Bauer A, Reich B, Steinbrenner B, Recla S, Schmidt D, et al. Fifteen-year single center experience with the “Giessen hybrid” approach for hypoplastic left heart and variants: current strategies and outcomes. *Pediatr Cardiol.* 2015;36:365-73.
3. Caldarone CA, Benson LN, Holtby H, Van Arsdel GS. Main pulmonary artery to innominate artery shunt during hybrid palliation of hypoplastic left heart syndrome. *J Thorac Cardiovasc Surg.* 2005;130:e1-2.
4. Machii M, Becker AE. Nature of coarctation in hypoplastic left heart syndrome. *Ann Thorac Surg.* 1995;59:1491-4.
5. Akintuerk H, Michel-Behnke I, Valeske K, Mueller M, Thul J, Bauer J, et al. Stenting of the arterial duct and banding of the pulmonary arteries: basis for combined Norwood stage I and II repair in hypoplastic left heart. *Circulation.* 2002;105:1099-103.

EDITORIAL COMMENTARY

Management of retrograde aortic arch malperfusion after hybrid stage I palliation: Good save. Learn anything?

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Newborn infants with aortic atresia are dependent on retrograde blood flow to their coronary and cerebral circulations. Primary palliation for these critically challenged patients must ensure adequate delivery of oxygenated blood to these vital areas. When the hybrid approach to hypoplastic left heart syndrome was introduced, the importance of assessing the potential for retrograde aortic arch obstruction was emphasized.¹ The risk of retrograde arch obstruction, however, may not be sufficiently appreciated before the procedure. Such was the situation in the case report described by Mewhort and colleagues² in this issue of the *Journal*.

Soon after the implantation of the ductal stent, the patient's condition became unstable. As Mewhort and colleagues² were preparing to place a stent in the obstructed arch segment, cardiac arrest occurred and resuscitation required the emergency institution of extracorporeal membrane oxygenation. When cardiac function did not improve, Mewhort and colleagues² astutely placed a second arterial cannula into the right carotid artery, reversing the myocardial compromise. To permit subsequent extracorporeal

membrane oxygenation decannulation, Mewhort and colleagues² inserted a 3.5-mm polytetrafluoroethylene conduit from the main pulmonary artery to the right carotid artery, a technique previously introduced by this group and often referred to as a “reverse modified Blalock-Taussig shunt.”³ Placement of that shunt, of course, was impeded by the cannula in the carotid artery, but this was successfully addressed with the innovative approach well illustrated in the current report.

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Central Message

A hybrid strategy is poorly suited for hypoplastic left heart syndrome when there is a risk of retrograde aortic obstruction.

See Article page e87.

Interestingly, the story did not end with the challenging but successful shunt placement. Inadequate coronary blood flow became a problem again for this infant at 5 months of age, immediately after catheter relief of a restrictive interatrial septum. Once again extracorporeal membrane oxygenation was required (this time with left carotid cannulation). Was the reverse shunt too small, or did the sudden relief of pulmonary venous obstruction result in too little flow through the shunt for the coronary circulation? Fortunately for the patient, Mewhort and colleagues² did not try to answer those questions but proceeded to a Norwood procedure.

When retrograde aortic arch obstruction is a concern, the options include adding a retrograde arch stent⁴ or placing a retrograde shunt.⁵ Notably, one center with significant experience with the hybrid approach used those approaches in a set of patients but concluded that these patients are better served by not performing the hybrid stage I at all but by proceeding to the Norwood procedure as probably the best option.⁶

In an editorial in the *Journal* earlier this year, the senior author of this case report (C.A.C.) indicated that the hybrid strategy is “an important tool in our clinical armamen-

tarium for managing patients with single-ventricle physiology. We simply need to figure out how best to use it.”⁷ This case, and the experience of Stoica and colleagues,⁶ would suggest that the hybrid stage I is best *not* used when the coronary circulation is threatened by retrograde aortic arch obstruction.

References

1. Bacha EA, Daves S, Hardin J, Abdulla RI, Anderson J, Kahana M, et al. Single-ventricle palliation for high-risk neonates: the emergence of an alternative hybrid stage I strategy. *J Thorac Cardiovasc Surg.* 2006;131:163-71.e2.
2. Mewhort HE, Haller C, Caldarone C. Management of retrograde aortic arch malperfusion following hybrid stage I palliation. *J Thorac Cardiovasc Surg.* 2015;150:e87-9.
3. Caldarone CA, Benson LN, Holtby H, Van Arsdel GS. Main pulmonary artery to innominate artery shunt during hybrid palliation of hypoplastic left heart syndrome. *J Thorac Cardiovasc Surg.* 2005;130:e1-2.
4. Schranz D, Bauer A, Reich B, Steinbrenner B, Recla S, Schmidt D, et al. Fifteen-year single center experience with the “Giessen hybrid” approach for hypoplastic left heart and variants: current strategies and outcomes. *Pediatr Cardiol.* 2015;36:365-73.
5. Baba K, Honjo O, Chaturvedi R, Lee KJ, Van Arsdel G, Caldarone CA, et al. “Reverse Blalock-Taussig shunt”: application in single ventricle hybrid palliation. *J Thorac Cardiovasc Surg.* 2013;146:352-7.
6. Stoica SC, Philips AB, Egan M, Rodeman R, Chisolm J, Hill S, et al. The retrograde aortic arch in the hybrid approach to hypoplastic left heart syndrome. *Ann Thorac Surg.* 2009;88:1939-46; discussion 1946-7.
7. Caldarone CA. W(h)ither the hybrid? Up the “slope of enlightenment” *J Thorac Cardiovasc Surg.* 2015;149:7-8.