about that. Is that still a problem in your hands? Do you worry about it, or do you not?

Dr Yerebakan. This is indeed a problem, but we don't worry about that. This is a problem for all people; however, this is not a frequent problem. There are some patients who have this. We have 2 strategies to handle these patients, one is to band them, give them prostaglandin for a longer time, and wait until stage II.

Dr Bacha. So who is the typical patient you will do that strategy in, you would not band the duct?

Dr Yerebakan. For example, a patient who has a obstruction toward the aortic arch.

Dr Bacha. But they're on prostaglandin E by definition at the time when you see them, so you don't necessarily

know that they have a retrograde obstruction of the arch. Right? How do you diagnose that obstruction toward the arch?

Dr Yerebakan. After pulmonary arterial banding, these patients come to the intensive care unit before ductal stenting and we have 2 side arterial monitoring, a right radial artery and femoral artery. You can see in the arterial measurements whether there is a problem toward the arch. Second, you can apply a Doppler on the brachiocephalic trunk and see if there is a retrograde problem. Third, the ventricular function on transthoracic echocardiography will give you another hint whether they have a problem in the perfusion of the coronaries or the head vessels.

EDITORIAL COMMENTARY

Hybrid therapy for hypoplastic left heart syndrome: Myth, alternative, or standard—neither Minotaur nor Midas

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The development of a hybrid procedure for palliation of hypoplastic left heart syndrome (HLHS) was prompted by limited early success of the Norwood procedure.^{1,2} The hybrid procedure—stenting of the arterial duct combined with banding of the pulmonary arteries (PAs) and atrial septectomy—appeared to reawaken some of the presumed errors of early pediatric cardiac surgery; for example, bilateral PA banding, and seemed contrary to the trend toward earlier aggressive reparative neonatal cardiac surgery. Contemporaneously, results with stage I surgical palliation continued to improve, with experienced centers soon reporting in-hospital survival rates of 85% to 90% in standard-risk patients.³ However, patients deemed to be at higher risk as a result of prematurity, very-low birth weight, chromosomal abnormalities, or pulmonary venous obstruction continued to experience mortality rates ranging from 25% to 40%. The hybrid procedure, by virtue of its avoidance of cardiopulmonary bypass and myocardial

ischemia, was offered to these high-risk patients with surprisingly good results.⁴ A few centers continued to refine the hybrid technique and offered it routinely to their patients with HLHS.⁵

Myths?

Central Message

This large, single center study supports the hybrid technique for patients with hypoplastic left heart syndrome. Surgical versus hybrid palliation is in evolution.

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See Editorial page 909.

The current study by Yerebakan and colleagues⁶ represents 1 of the largest single-center series of patients with HLHS routinely treated using a hybrid strategy. The Giessen Hybrid involves bilateral PA banding via sternotomy, followed 1 to 10 days later by ductal stenting and creation of a nonrestrictive atrial septal defect in the cardiac catheterization lab. Delaying the catheterization portion of the procedure, they believe, helps them to more accurately place the patent ductus arteriosus stent, assess the atrial defect, and allow for balloon enlargement of the previously placed PA bands if necessary. The current report is the latest update in their unselected patient population, with a median follow-up of more than 4.5 years. From a strictly survival standpoint (97.5% survival after stage I palliation and estimated 10-year survival of 79%), their results rival the best of centers performing the standard Norwood palliation.⁷ Although the hybrid stage I palliation avoids significant reconstructive surgery during the neonatal period and likely leads to overall better early survival, this strategy despite its simplicity necessitates a more involved comprehensive stage II reconstruction often further complicated by the presence of significant branch PA stenosis and a difficult aortic arch reconstruction. This is evidenced by the greater than two-thirds of patients who required reinterventions on their branch PAs and 17% on the aortic arch. Furthermore, the interstage mortality remains appreciable at 12.2%. Although Yerebakan and colleagues⁶ purport to present “operative results, mortality, and morbidity” the only morbidities included relate to PA stenosis or recoarctation. Not included are the important parameters such as renal or respiratory insufficiency, rates of infection, and neurologic outcomes among others.

Despite the above criticisms the authors should be applauded. Through their persistence and collective experience they have achieved commendable results in this difficult patient population. Proponents of the hybrid strategy have clearly outlined its potential benefits.⁸ Yet a number of potential problems with this strategy persist:

1. Bilateral PA banding, although often successful in limiting pulmonary blood flow, remains a crude procedure with little ability to adjust its effects. As borne out by the early history of congenital cardiac surgery, when left in situ for longer than a few weeks, it may have significant and long-lasting negative effects on the branch PAs.
2. Stenting of the arterial duct, while avoiding an involved neonatal arch reconstruction, can in certain circumstances, lead to important retrograde aortic arch obstruction.⁹ This can, in concert with PA banding, lead to suboptimal cerebral and coronary blood flow.¹⁰ The presence of the stent complicates the aortic arch reconstruction in comprehensive stage II palliation.

3. Despite the potential benefits to neonates, interstage mortality remains significant.

At this juncture although few centers favor the hybrid approach routinely,¹¹ it appears that the concrete results of both the standard surgical Norwood palliation and hybrid approaches are strikingly similar. Both approaches can produce nearly equivalent early and intermediate-term survival rates.^{12,13} Much of the mortality and morbidity from the surgical Norwood palliation procedure is concentrated in the neonatal period. Survivors appear to have less likelihood of developing PA stenosis and critical aortic arch obstructions. The hybrid approach likely lowers neonatal mortality but may impose important intermediate- and long-term consequences predicated upon the need to closely observe and intervene, especially on the branch PAs.¹⁴ Mortality aside, a better characterization of the morbidity associated with the hybrid approaches is needed. Although not the standard, certainly the hybrid procedure is now a legitimate alternative to surgical Norwood palliation. With time it is likely that both the Norwood and hybrid approaches will be part of our armamentarium to deal with HLHS. A myth, no, but as is true with most innovations, at times it may be remembered as punitive or pure alchemy.

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