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EDITORIAL: MANAGEMENT OF THE CONGENITALLY ABNORMAL RIGHT VENTRICULAR OUTFLOW TRACT—WHAT IS THE RIGHT APPROACH?

Frank L. Hanley, MD

One measure of progress in medicine is the introduction of new and superior treatment options, which naturally replace older forms of therapy. Sometimes, newly introduced treatment options compete against, rather than replace, older more established treatments. This is especially true when different forms of therapy for the same disease have their origins in different disciplines. In line with recent trends in the management of congenital heart disease, percutaneous catheter-based procedures have recently been introduced for managing the obstructed right ventricular outflow tract (RVOT). Under certain circumstances, these procedures may be considered as an alternative to “open heart” reconstructive operations. Such innovations are a welcome addition; however, their efficacy should be carefully evaluated. There are many benefits to a medical environment in which the development and introduction of new procedures is given high priority. Most obvious-

ly, when a new form of therapy is shown to be superior, the entire field is advanced. Substantial benefits can also be gained, however, even when newly introduced treatment options are shown to be no better than, or possibly even inferior to, more established forms of therapy. Under these circumstances we are forced to reevaluate our more established procedures and management philosophies in the light of the newly introduced competition.

With respect to both surgical and interventional procedures directed at the congenitally obstructed RVOT, therapy is often initiated in response to detected hemodynamic abnormalities that reach a predetermined threshold. The short-term goal of these procedures is to improve the hemodynamic status of the patient. Furthermore, the success of a given procedure is usually judged by the degree to which the abnormal hemodynamics are improved. An RVOT valved conduit operation is considered successful if the patient's hemodynamics are changed from a preoperative RVOT gradient of 70 mm Hg with moderate pulmonary insufficiency to a postoperative status of no gradient with trivial pulmonary insufficiency. These short-term hemodynamic measures, however, are not the true yardstick of success. Successful elimination of deranged hemodynamics is important, not in and of itself, but only for what it implies with respect to the long-term health of the right ventricular myocardium. The real reason to

From the Division of Cardiothoracic Surgery, University of California—San Francisco, San Francisco, Calif.

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Address for reprints: Frank L. Hanley, MD, Division of Cardiothoracic Surgery, University of California—San Francisco, 505 Parnassus Ave, M593, San Francisco, CA 94143-0118.

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intervene is to improve life expectancy of the right side of the heart. To be sure, normalization of the deranged hemodynamics will go a long way to accomplish this long-term goal. Numerous studies in both human beings and animal models suggest that even moderate hemodynamic derangements (both pressure and volume loads), if chronic, can cause irreversible changes in the myocardium, including increased collagen content in the interstitium, ischemic myocyte loss, and dysfunction of the atrioventricular valve.¹⁻⁵ Such changes in the ventricular myocardium are not reversible, and the long-term viability of the ventricle will inevitably be affected negatively if they are allowed to occur.

When a given intervention only partially normalizes the hemodynamic derangement or trades one hemodynamic derangement for another, it is less clear that the long-term outlook for the ventricular myocardium will be improved. Recently, Ovaert and colleagues⁶ reported on the use of percutaneously introduced intravascular stents to relieve RVOT gradients in existing surgically placed conduits in patients with lesions such as tetralogy of Fallot, tetralogy of Fallot with pulmonary atresia, truncus arteriosus, transposition of the great vessels, and double-outlet right ventricle. Their patients had significant conduit stenosis, such that they would otherwise be considered candidates for surgical conduit revision. (In the authors' institution, the traditional criterion for conduit revision is a right ventricular pressure that equals two thirds the left ventricular pressure.) In this patient population, stent enlargement of the stenotic RVOT conduit at the level of the valve was performed, rather than subjecting the patient to an operation. A review of the stent procedure in 42 patients shows that the RVOT obstruction was modestly relieved, with right ventricular pressure dropping from an average of 71 mm Hg to 48 mm Hg. The authors stated that the procedure lowered the right ventricular/left ventricular pressure ratio below their criterion for performing conduit replacement. As a result, surgical conduit revision or replacement was delayed substantially, with approximately 50% of the patients remaining free from surgical conduit revision at 3 years.

It is clear that stenting an obstructed conduit can reduce an RVOT gradient significantly and, in so doing, can delay the need for surgical conduit revision if the criterion for conduit revision is based solely on a specific gradient. What is less clear is whether stenting in this setting actually improves the long-term outlook for the right ventricular myocardium. According to Ovaert's data, residual gradients were present immediately after the stent procedure, with a reduction in right ventricular

systolic pressure of only 23 mm Hg. Furthermore, there are no data on whether the stent procedures resulted in increased conduit insufficiency. In almost all cases, the stents were placed at the level of the valve of the conduit. The cross-sectional area at the level of the stent was increased 133%. Given these observations, it seems reasonable to be concerned that stenting a valved conduit is likely to result in severe conduit insufficiency. One is left to ask how best to ensure the long-term health of a right ventricle that starts out with a 70-mm Hg systolic pressure and mild to moderate pulmonary insufficiency. Is it better to do a stent procedure that reduces the right ventricular systolic pressure to approximately 50 mm Hg, but in the process increases the pulmonary insufficiency to a severe level, or to do a surgical conduit replacement that eliminates the gradient and eliminates insufficiency?

Is pulmonary insufficiency an important issue? It is clear from the long-term follow-up of patients who received generous transannular patches for the treatment of tetralogy of Fallot and have severe pulmonary insufficiency and absent outflow gradients that severe pulmonary insufficiency can be very detrimental to the health of the right ventricular myocardium. On the other hand, the answer to the question of whether a stent or a conduit replacement is most appropriate in the example given above is not so clear. If the optimal early postoperative hemodynamics associated with a conduit replacement were sustainable, there would be little argument that conduit replacement would be considered the superior form of therapy. Unfortunately, all currently available conduits physically degenerate, and along with this process hemodynamics degenerate as well.

The stent versus surgery debate currently does not have a clear winner. However, the debate does underscore a more important dilemma. Given the available spectrum of limited therapeutic options for managing the congenitally abnormal RVOT, how hard should we work at maintaining ideal, or close to ideal, hemodynamics? All of the therapeutic options come at a price. Management strategies that accept significantly abnormal hemodynamics for long periods clearly will limit the long-term viability of the right ventricular myocardium. The advantage of this management scheme is that interventions (surgical or transcatheter) are kept to a minimum. Management strategies that use catheter-based percutaneous interventions improve certain hemodynamic variables modestly (outflow gradients) but certainly do not eliminate the gradient. Furthermore, other hemodynamic variables (pulmonary insufficiency) are likely to be made worse. The long-

term implications of this strategy for the right ventricular myocardium are not clear. The clear attraction of this strategy is the promise of delaying surgical intervention. The management strategy of surgical conduit replacement holds the best chance of normalizing RVOT hemodynamics. Unfortunately, the optimal hemodynamic performance of conduits is distressingly transient. The tradeoff for maintaining ideal, or close to ideal, RVOT hemodynamics, then, is frequent surgical procedures. How tightly should one control RVOT hemodynamics in this setting? Although the answer to this question is not known with certainty, logic would dictate that the answer is quite similar to that given to the patient with insulin-dependent diabetes who asks how tightly should one control serum glucose. The answer to the diabetic patient is that glucose should be controlled as tightly as possible while still maintaining an acceptable quality of life. Similarly, RVOT hemodynamics should be kept as close to normal as possible while still allowing the patient an acceptable quality of life. The difference between the two examples, of course, is that compulsive timing of meals, counting calories, and monitoring insulin use is generally thought to be more acceptable than submitting oneself to conduit replacements on a regular basis.

There is clearly no single correct solution to the dilemma of how frequently a patient should undergo conduit replacement or any other procedure for RVOT disease. Numerous individual physiologic considerations, as well as the patient's own philosophy with respect to quality of life and risk, enter into the decision at the individual level. Stenting an obstructed conduit to delay a more invasive surgical procedure certainly has a place among the therapeutic options that can be

presented to individual patients. It is relatively compelling to suggest a "new" procedure that is less invasive and that postpones surgery for 3 years, on average, when the alternative option is that the patient undergo a surgical procedure now. Many patients are sure to find the stent option attractive, especially if concerns about the long-term viability of the right ventricular myocardium are not discussed. On the other hand, patients should also be made aware that if their priority is to live as long as possible, or to avoid heart transplantation as long as possible, frequent conduit replacement with tight control of RVOT hemodynamics is probably the strategy of choice.

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