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EDITORIAL COMMENT

Concurrent Balloon Dilation of Stenosed Aortopulmonary Gore-Tex Shunts and Branch Pulmonary Arteries*

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Cyanotic congenital heart defects (CCHD) with severe pulmonary stenosis or atresia exhibit hypoxemia and cyanosis secondary to pulmonary oligemia and right-to-left shunt. Even though a substantial proportion of these patients can be surgically corrected at presentation, such correction is not feasible in some patients either because of the age and size of the patient at presentation or because of anatomic complexity of the CCHD. In such patients, pulmonary blood flow may be augmented by creation of a systemic-to-pulmonary artery anastomosis; such palliative procedures improve hypoxemia and allow the infant to grow to an age and size when "corrective" surgery could be performed. Following the description by Blalock and Taussig (1) in 1945 of anastomosis of subclavian artery to the ipsilateral pulmonary artery, a number of other systemic-to-pulmonary artery shunt procedures, reviewed elsewhere (2), have been

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described. However, the classic Blalock-Taussig (BT) shunt (1) or a modified version with an interposition Gore-Tex® tube graft between the subclavian artery and the ipsilateral pulmonary artery, described by deLeval et al. (3), stood the test of time and remained the palliative procedures of choice for augmenting pulmonary blood flow. Although these shunts have generally been useful, stenosis of the shunt can develop, causing recurrence of hypoxemia and cyanosis. If shunt stenosis develops before the child reaches suitable age and size for safe surgical correction, an additional palliative shunt may have to be performed. Balloon angioplasty of the BT shunt is useful in such situations.

Balloon angioplasty of narrowed BT shunt was first reported by Fischer et al. (4); they balloon-dilated a stenosed classic BT shunt in a four-year-old, with resultant improvement of systemic arterial oxygen saturation from 68% to 80%. Subsequently, a number of other investigators, reviewed elsewhere (5,6) and in the report by Wang et al. (7), have reported their experience with this procedure. The majority of reports describe dilation of classic BT shunt and some involve modified BT shunts.

In this issue of the *Journal*, Wang et al. (7) present the results of balloon angioplasty of stenosed-modified BT or central aortopulmonary shunts in 46 patients. The procedure was deemed effective (defined as an increase in shunt diameter ≥20% or an increase in systemic arterial oxygen saturation ≥3%) in 42 (91%) of 46 patients. Obstructive lesions were present in the subclavian artery, tube graft, and/or at the anastomotic sites. Balloon angioplasty of stenosed branch pulmonary arteries with the balloon catheter introduced through the BT shunt was performed concurrently. The latter procedure was effective (defined as increase in stenotic diameter >50%) in 14 (56%) of 25 vessels in whom balloon angioplasty was feasible. The systemic arterial oxygen saturation increased, though modestly, from the mid-70s to low 80s. No major complications related to the procedure were observed. At a mean follow-up of 12 months in 29 patients, recurrence of obstruction was seen in three (10%) patients. In the remaining 26 (90%) patients, the size of the stenotic segment did not significantly change. Improvement of McGoon ratio occurred. The next stage of surgery was undertaken in 26 patients. Thus, a substantial clinical benefit was accrued in a good number of these patients. Based on these data, the investigators concluded that balloon angioplasty is an effective alternative to a second shunt and that concurrent dilation of branch pulmonary artery stenosis is feasible.

Whereas both the feasibility and the efficacy of balloon angioplasty of classic BT shuts (i.e., without Gore-Tex grafts) have been well documented, balloon dilation of the stenoses associated with Gore-Tex grafts has not been well studied, save for a few case reports (8–11). One group of workers (12) advocated the use of classic BT shunts in preference to modified BT shunts in the palliation of CCHD based on: 1) success they observed in dilating stenosed classic BT shunts, and 2) theoretical assumption that a modified BT shunt is not suited for balloon angioplasty because of the "sharp" angle that the graft forms with the subclavian artery. This myth is dispelled by the success of modified BT shunt angioplasty reported by Wang et al. (7). In addition to presenting a large series of modified BT shunt dilations, the investigators also demonstrate feasibility and effectiveness of dilating branch pulmonary arteries via the BT shunts. However, the definition of effectiveness used by the investigators is somewhat lax—for example, an increase in O_2 saturation of 3%. Similarly, requirement for another shunt in eight (17%) patients during the same admission should not be considered "effective" dilation. Only 37 (80%) of 46 patients were discharged home without additional procedures.

Furthermore, the investigators (7) did not make an attempt to identify characteristics of stenotic lesions that are likely to respond favorably to balloon angioplasty. Despite

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these limitations, the authors' data, along with the previously published reports, are useful to the pediatric cardiologist in assessing the feasibility, safety and effectiveness of balloon angioplasty of modified BT shunts and of the branch pulmonary artery accessed through the BT shunts. Furthermore, the report affords an opportunity to discuss several issues germane to balloon angioplasty of BT shunts and branch pulmonary arteries.

Indications. The indication for performing balloon angioplasty used by Wang et al. (7) is that the child is not a suitable candidate for definitive repair, but at the same time requires palliation of pulmonary oligemia, very similar to what we have used for balloon angioplasty of BT shunts (5,6,13) and balloon pulmonary valvuloplasty (5,6,14,15) in the late 1980s. Recently, however, total corrective operations are being performed in increasing numbers of patients during the neonatal period and during early infancy at increasing numbers of institutions. Thus, the need for performing BT shunts becomes less frequent. Consequently, the necessity for performing balloon angioplasty is even less. Furthermore, patients with univentricular physiology (for example, tricuspid atresia, double-inlet left ventricle and hypoplastic left heart syndrome) can undergo the bidirectional Glenn procedure as early as three months of age followed later by total cavopulmonary connection. Following the initial experience with the procedure (13), we used to perform balloon angioplasty frequently, whereas during the last five years we performed this procedure only occasionally, thus attesting to the change in the need for performing the procedure. Given these considerations, it is prudent to evaluate carefully the indications for the procedure and use it only if reparative procedures for correctable lesions or the bidirectional Glenn procedure for univentricular physiology patients could not be undertaken safely.

A substantial proportion of these CCHD patients have associated pulmonary atresia or the pulmonary artery cannot be catheterized directly either because of severe stenosis or because of abnormal or atypical position. Demonstration of pulmonary arterial anatomy and measurement of pulmonary artery pressure are of obvious value in the overall management of the patient. This is an additional indication for balloon angioplasty of the BT shunt, to facilitate access into the pulmonary artery.

Technique. The technique has been described in the past. We have used a multipurpose or a right coronary artery catheter (Cordis, Miami, Florida) to gain access into the BT shunt. Others use Cook Cobra or Headhunter catheters (Cook, Bloomington, Indiana). These catheters, with the help of soft-tipped guide wires, can be advanced into the pulmonary artery via the BT shunt. If this is not possible, a balloon-on-a-wire (13) may be used to dilate the shunt initially, followed by a more appropriate size balloon for angioplasty. The size of the balloon employed to dilate the shunt should be two or more times the narrowed segment diameter or the size of the Gore-Tex graft utilized in the BT shunt. The balloon diameter need not exceed the size of the subclavian artery feeding the shunt. With the availability of low-profile catheters that track well such as Tyshak-II balloons and more recently Tyshak Mini balloons (NuMed, Nicholville, New York), it is likely that positioning the balloon catheters across the stenotic lesion is easier than in the past.

There is a concern with the potential for development of acute hypoxemia during balloon angioplasty of BT shunt because of complete occlusion of it during angioplasty. We have not observed such a problem in our own case material (6,13). Wang et al. (7) observed a transient drop in O_2 saturation, which promptly improved by O_2 administration by mask or hood and withdrawal of the balloon catheter. Lack of a significant problem may be related to alternative pulmonary blood flow through bronchial collateral vessels, contralateral BT shunt or anterograde flow through the stenotic pulmonary valve. Our observation is that the more severe the degree of BT shunt stenosis, the less is the probability for developing acute hypoxemia during BT shunt angioplasty.

Use of heparin during the procedure is generally recommended. We continue the heparin overnight until the next morning to prevent thrombosis (16) of freshly catheterized BT shunt.

Balloon angioplasty of pulmonary artery. Balloon dilation was attempted by Wang et al. (7) in 28 branch pulmonary arteries. The procedure was accomplished in 25 (89%) arteries, a remarkable success. In the remaining three patients either a guide wire (n = 2) or a balloon angioplasty catheter (n = 1) could not be advanced distal to the obstruction.

Effective dilation was accomplished in 14 (56%) of the 25 vessels dilated, not too different from that (58%) reported with conventional anterograde technique (17). Perhaps the use of stents to expand stenotic pulmonary artery segments may be an answer to achieve greater success. Unfortunately, the currently used Palmaz stents (18), because of the requirement of large delivery sheath and longitudinal rigidity, would not be suitable for implantation through the BT shunts. It is possible that the newer stents, such as bridge stents (19) or IntraStent which can traverse a tortuous course, may become suitable for implantation. Favorable experience with such stents is necessary prior to general use.

Summary and conclusions. The interesting study by Wang et al. (7) is the largest series reporting balloon angioplasty of modified BT shunt and demonstrates feasibility, safety and effectiveness of balloon angioplasty of stenosed-modified BT shunts. It also illustrates feasibility of concurrent dilation of branch pulmonary artery through the BT shunts. With the recent trend toward early reparative and staged surgery, the need for BT shunts and, consequently, the need for balloon angioplasty of narrowed BT shunts become less. Whereas balloon angioplasty of branch pulmonary artery can be performed, the success rate continues to be low. The feasibility of implanting flexible stents

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in the branch pulmonary artery through the BT shunts should be explored in the future.

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REFERENCES

1. Blalock A, Taussig HB. The surgical treatment of malformations of the heart in which there is pulmonary stenosis or atresia. JAMA 1945;128:189–202.
2. Rao PS, Covitz W, Chopra PS. Principles of palliative management of patients with tricuspid atresia. In: Rao PS, editor. Tricuspid Atresia. 2nd ed. Armonk, New York: Futura Publishing, 1992:297–320.
3. deLeval M, McKay R, Jones M, et al. Modified Blalock-Taussig shunt: use of subclavian orifice as a flow regulator in prosthetic systemic-pulmonary artery shunts. J Thorac Cardiovasc Surg 1981;18:112–9.
4. Fischer DR, Park SC, Neches WH, et al. Successful dilatation of stenotic Blalock-Taussig anastomosis by percutaneous transluminal balloon angioplasty. Am J Cardiol 1985;55:861–2.
5. Rao PS. Transcatheter management of cyanotic congenital heart defects: a review. Clin Cardiol 1992;15:483–96.
6. Rao PS. Transcatheter treatment of pulmonary outflow tract obstruction: a review. Progress Cardiovasc Dis 1992;35:119–58.
7. Wang J, Wu M, Chang C, Chiu I, Lue H. Balloon angioplasty of obstructed modified systemic pulmonary artery shunts and pulmonary artery stenoses. J Am Coll Cardiol 2001;37:940–7.
8. Rheuban KS, Carpenter MA. Diagnostic cardiac catheterization, angiography and interventional catheterization. In: Lake CL, editor. Pediatric Cardiac Anesthesia. Norwalk, Connecticut: Appleton & Lange, 1988:55–67.
9. Parsons JM, Ladusan EJ, Qureshi SA. Balloon dilatation of a stenosed modified (polytetrafluoroethylene) Blalock-Taussig shunt. Br Heart J 1989;62:228–8.
10. Ormiston JA, Neutze JM, Calder AL, Chan W, Hak CWNS. Percutaneous balloon angioplasty for early postoperative modified Blalock-Taussig shunt failure. Cathet Cardiovasc Diagn 1993;29: 31–4.
11. Marasini M, Dalmonte P, Pongiglione G, et al. Balloon dilatation of critically obstructed modified (polytetrafluroethylene) Blalock-Taussig shunts. Am J Cardiol 1993;73:405–7.
12. Marks LA, Mehta AV, Marangi D. Percutaneous transluminal balloon angioplasty of stenotic standard Blalock-Taussig shunts: effect on choice of initial palliation in cyanotic congenital heart disease. J Am Coll Cardiol 1991;18:546–51.
13. Rao PS, Levy J, Chopra PS. Balloon angioplasty of stenosed Blalock-Taussig anastomosis: role of balloon-on-wire in dilating occluded shunts. Am Heart J 1990;120:1173–8.
14. Rao PS, Brais M. Balloon pulmonary valvuloplasty for congenital cyanotic heart defects. Am Heart J 1988;115:1105–10.
15. Rao PS, Wilson AD, Thapar MK, Brais M. Balloon pulmonary valvuloplasty in the management of cyanotic congenital heart defects. Cathet Cardiovasc Diagn 1992;25:16–24.
16. Rajani RM, Dalvi BV, Kulkarni HL, Kale PA. Acutely blocked Blalock-Taussig shunt following cardiac catheterization: successful recanalization with intravenous streptokinase. Am Heart J 1990;120: 1238–9.
17. Rothman A, Perry SB, Keane JF, Lock JE. Early results and follow-up of balloon angioplasty for branch pulmonary artery stenosis. J Am Coll Cardiol 1990;15:1109–17.
18. Rao PS. Interventional pediatric cardiology: state of the art and future directions. Pediatr Cardiol 1998;19:107–24.
19. Rao PS. Bridge stents in the management of vascular obstructive lesions in children. Paper presented at the Midwest Pediatric Cardiology Society meeting, Milwaukee, Wisconsin, September 15–16, 2000. Abstract booklet p. 22.