Periscope Modification of Right Ventricle-to-Pulmonary Artery Shunt in Norwood Operation

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Given the purported hemodynamic advantages of the right ventricle (RV) to pulmonary artery (PA) conduit, many surgeons have adopted it as their preferred source of pulmonary blood flow during stage I palliation for hypoplastic left heart syndrome. Potential disadvantages of the RV-PA shunt include ventricular dysfunction, pseudoaneurysm formation, arrhythmia, and conduit obstruction, which can lead to a higher rate of unplanned reinterventions. The “dunk” technique was described to reduce the RV incision and proximal conduit obstruction; however, insertion of the ringed graft from the epicardium can be cumbersome and risk RV injury. We introduce a simplified, alternative method of placing the conduit, which we call the periscope technique, whereby the graft is withdrawn from within the RV cavity.

Since surgical palliation was introduced by Norwood in 1983 [1], numerous refinements in technique and postoperative management have led to a significant improvement in outcomes of hypoplastic left heart syndrome. One such modification is the reintroduction of the right ventricle (RV) to pulmonary artery (PA) shunt, or the so-called Sano shunt [2]. The Sano shunt is thought to improve postoperative hemodynamics by reducing aortic diastolic runoff, thereby improving coronary perfusion [3]. Unfortunately, potential disadvantages of the Sano shunt include proximal and distal conduit obstruction, RV dysfunction, pseudoaneurysm formation, and early unplanned reinterventions [4]. In an attempt to reduce these complications, a ringed PTFE graft has been used and inserted from outside into the RV cavity—the “dunk” technique [5]. This method of insertion can be cumbersome because the rings often are caught up on the RV myocardium. Alternatively, we have found that the conduit can be brought out through the RV cavity more easily. We describe the details of this portion of the technique as follows.

### Technique

Before establishment of cardiopulmonary bypass, the distance between the presumed site of the ventriculotomy and pulmonary artery bifurcation is measured, and a stretch vascular graft (5 or 6 mm; Gore-Tex, W.L. Gore and Associates, Flagstaff, AZ) with removable rings is trimmed to this length. In advance, we have found that the conduit can be brought out through the RV cavity more easily. We describe the details of this portion of the technique as follows.

1. **Step 1: Measurement**
   - Measure the distance from the ventriculotomy site to the pulmonary artery bifurcation.

2. **Step 2: Graft Preparation**
   - Trim a stretch vascular graft (5 or 6 mm) to the measured length.
   - Mark the proximal end of the graft at a distance from the proximal end, normally approximately three rings.
   - Cut the proximal end of the graft flush with one of the rings.

3. **Step 3: Cardiopulmonary Bypass**
   - Establish cardiopulmonary bypass.
   - Snare the branch PAs and begin systemic cooling.
   - Snare the arterial cannula in the ductus arteriosus, and divide the main pulmonary artery just proximal to the bifurcation.
   - Patch the pulmonary artery bifurcation with a portion of pulmonary allograft tissue.

4. **Step 4: RV Incision**
   - Make an incision with a No. 11 blade in the infundibulum of the right ventricle and gently stretch with a clamp.
   - Pass the trimmed graft with a right angle clamp through the divided pulmonary artery, neoaortic valve, and out the right ventricle until the mark is visible and the proximal end is flush with the endocardium.

5. **Step 5: Graft Anchoring**
   - Secure the epicardial ring of the graft with a four-quadrant and a circumferential 6-0 polypropylene purse-string stitch as described previously.

6. **Step 6: Arch Reconstruction**
   - Make the distal Sano connection to a punch hole in the previously placed allograft.

7. **Step 7: Postoperative Imaging**
   - Postoperative echocardiographic imaging of the insertion site of the ring-enforced graft shows a ring at the end of the graft anchoring on the endocardial surface of the RV and a wide patent RV-PA shunt.

### Comment

Right ventricle-to-pulmonary artery shunt as a source of pulmonary blood flow in the first stage palliation for hypoplastic left heart syndrome was reintroduced by Sano and colleagues [2]. The early postoperative physiologic benefits of the RV-PA shunt have increased its use.
A multiinstitutional randomized clinical trial under the auspices of the Pediatric Heart Network demonstrated higher transplantation-free survival at 12 months with RV-PA shunt than Blalock-Taussig shunt [6]. However, the RV-PA shunt group required more unintended interventions, including balloon dilation or stent placement in the shunt or pulmonary artery branches. In addition, an adverse effect of ventriculotomy on the right ventricular function has been reported [4].

It has been suggested that the causes of conduit obstruction are multifactorial and include suboptimal resection of the subendocardial muscle, substernal compression, stenosis at the proximal or distal anastomosis site, and muscle ingrowth. To overcome conduit obstruction, Schreiber and colleagues [7] proposed the use of a ring-enforced polytetrafluoroethylene RV-PA shunt and reported minimized extent of conduit stenosis at the substernal portion of the graft. The dunk technique was introduced to reduce further the extent of RV incision and to simplify its placement. Although useful, the introduction of the rings into the RV cavity through the limited incision can be difficult, particularly in the heart of a small neonate.

In our modification of RV-PA shunt, which we call periscope technique, the ringed graft is placed “prograde” from within the RV. The graft is more easily advanced in this manner, minimizing the possible risk of tearing the fragile myocardium. This maneuver can be performed with the heart beating when using either a continuous perfusion or circulatory arrest strategy. Our technique shares the theoretical advantages of the dunk modification and includes: (1) improved right ventricular function by limiting ventriculotomy, (2) reduction in proximal conduit obstruction by virtue of the externally supported graft, and (3) reduced incidence of pseudoaneurysm formation by eliminating myomectomy.

References