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Open-square technique using a novel pre-cuffed, spiral-ringed conduit for the Norwood procedure

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Abstract

To avoid stenotic conduit events, 2 modifications were added to Norwood reconstruction with a right ventricle-to-pulmonary artery conduit: open-square insertion of a proximal conduit end and use of a pre-cuffed, spiral-ringed conduit. Three consecutive patients treated with this technique successfully underwent bidirectional Glenn with no stenotic events. These modifications are beneficial and safe.

Keywords: Hypoplastic left heart syndrome • Norwood operation • Right ventricle-to-pulmonary artery shunt

INTRODUCTION

The optimal method for pulmonary route reconstruction during the Norwood procedure has not been determined for hypoplastic left heart syndrome. The right ventricle-to-pulmonary artery (RV-PA) conduit method [1] ensures better postoperative haemodynamics; however, lethal stenotic events related to RV-PA conduits were reported. Conduit stenoses are caused by adjacent myocardial hypertrophy in the proximal right ventricle (RV) [2] and intimal hyperplasia of expanded polytetrafluoroethylene in the distal pulmonary artery (PA) [3]. We modified a recently reported technique that uses a ring-reinforced conduit [4].

MATERIALS AND METHODS

The Distaflo® (Bard Inc., Tempe, AZ, USA) pre-cuffed, spiral-ringed expanded polytetrafluoroethylene conduit is used in vascular surgery (Fig. 1A) [5]. We have used 'open-square technique' with this novel conduit (diameter, 6 mm) for the Norwood since 2013.

Three consecutive patients were treated with this procedure. A boy with hypoplastic left heart syndrome underwent bilateral PA banding (BiPAB) at age 16 days; Norwood was subsequently performed at age 73 days (weight 3.5 kg). The second boy underwent BiPAB at age 10 days and the subsequent Norwood at age 45 days (weight 3.2 kg). The third boy underwent BiPAB at age 15 days and the subsequent Norwood at age 40 days (weight 2.8 kg).

Operative technique

Patients were placed on moderate hypothermic cardiopulmonary bypass. After mobilization of the PA confluence and bilateral PAs, the main PA was transected and the PA bands were released. First, the cone-shaped cuff with an oval opening ($30 \times 20 \times 20$ mm; thickness, 0.2 mm) at the distal conduit end was trimmed to fit the PA confluence, and the cuff was anastomosed to the PA orifice (Fig. 1B).

After neoaorta reconstruction, a 6.0-mm vascular punch was used to make a hole in the RV outflow. Four mattress stitches of CV-6 (WL Gore Inc, Flagstaff, AZ, USA) were placed between the first and second ring from the conduit end, so that the stitches penetrated out of the RV wall and formed a square (Fig. 2A). These stitches were pulled as the proximal conduit end was inserted into the RV cavity, and then tied (Fig. 2B). After 1 purse-string stitch was placed in the epicardium around the conduit, the Norwood was completed (Fig. 2C).

The oxygen saturation of the 3 patients after the Norwood procedure was 78–83%. All patients had acceptable PA sizes and indices greater than 145 mm^2/m^2 before bidirectional Glenn. At bidirectional Glenn, the RV-PA conduits were preserved for additional flow. When Case 1 reached total cavopulmonary connection, the RV-PA conduit was completely removed (Fig. 2D). All patients survived without stenotic events related to RV-PA shunt.

COMMENT

Use of this conduit has 2 benefits. First, a handmade cuff is unnecessary because the novel conduit is already equipped with a cone-shaped cuff. This simplifies the procedure. Second, because the transition from the pre-cuffed section with the 20-mm high cone to the tubular section is acutely angled, the PA anastomotic site is comfortably located diagonally right behind neoaorta. This geometric configuration is beneficial because the

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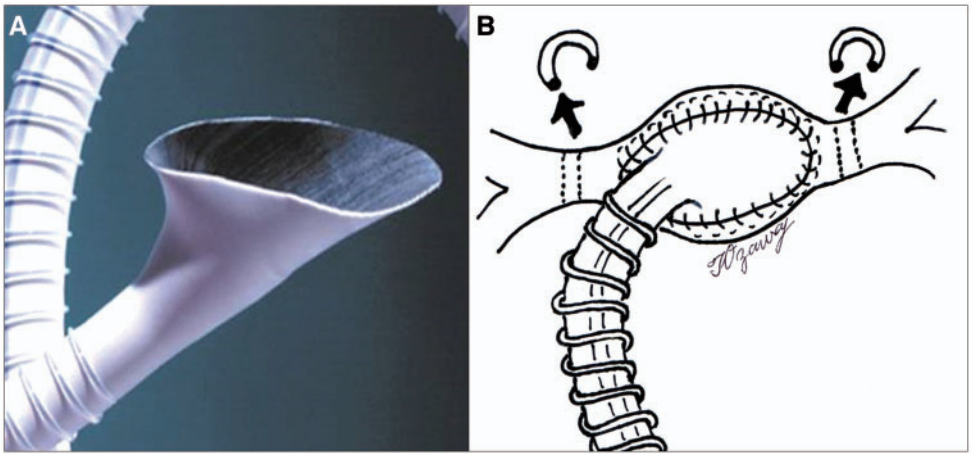

Figure 1: (**A**) Photograph of Distaflo® conduit. (**B**) After releasing pulmonary artery bands, the distal conduit end is anastomosed.

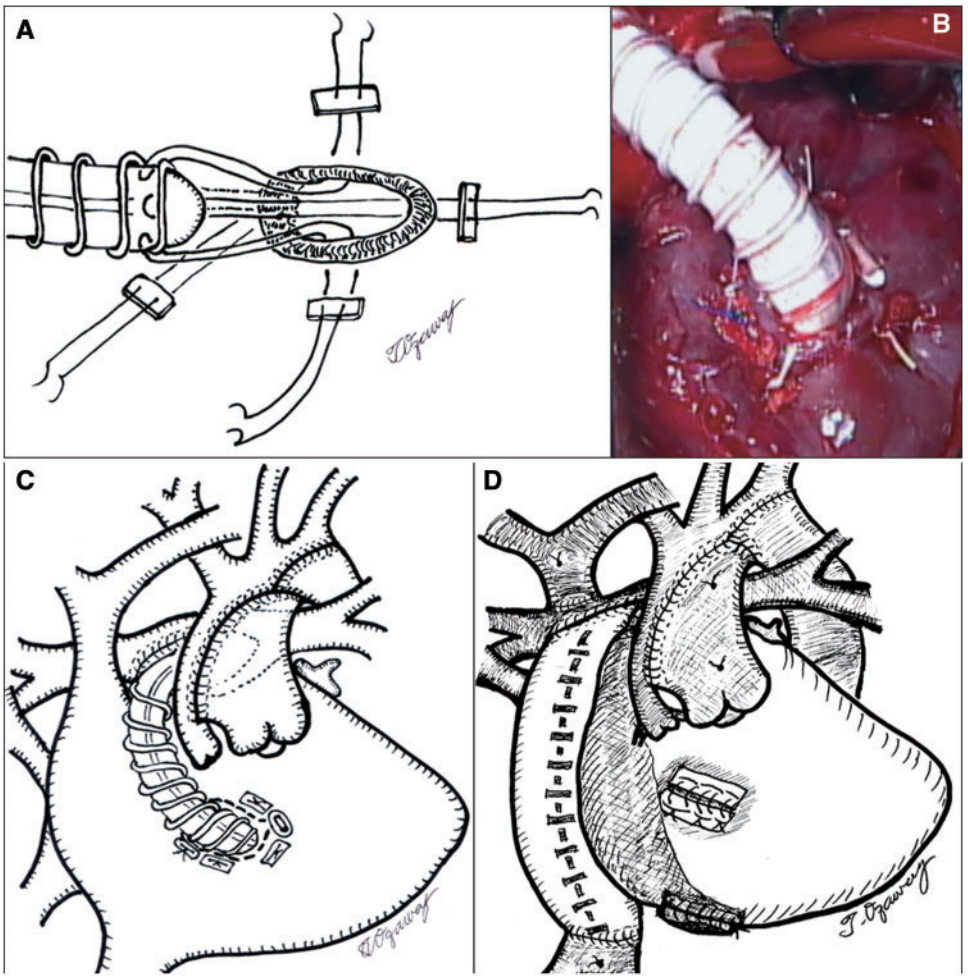

Figure 2: (**A**) Four mattress stitches placed at the proximal conduit end penetrate the right ventricle (RV) wall. (**B**) Intraoperative photograph showing the conduit inserted into RV. (**C**) Completion of Norwood procedure. (**D**) The right ventricle-to-pulmonary artery conduit is removed at total cavopulmonary connection.

cohesive vortex resulting from higher shear stress prevents intimal hyperplasia [3]. In contrast, conventional conduits with handmade cuffs may result in stenosis because of the right-angled connection.

Conventional dunking technique [4] is useful for proximal RV-side anastomosis; however, Stage 1 Norwood with dunking is typically performed in the early neonatal period. To ensure patient safety, our basic strategy resembles a rapid two-stage approach [6] and results in different conditions. Norwood was delayed in our patients; thus, the RV-wall had already thickened after BiPAB. We therefore modified the technique: 4 stitches securely guided the proximal conduit end and maintained the open-square configuration in the

thick RV. The spiral-ring was also effective in consistently protecting the conduit lumen from the myocardial wall.

Open-square technique with a pre-cuffed, spiral-ringed conduit is safe and beneficial for the RV-PA conduit method in the Norwood procedure.

Conflict of interest: none declared.

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