Operative Techniques in
Thoracic and
Cardiovascular Surgery

Stage I Norwood: The Birmingham Children's Hospital Approach

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The technique of the Norwood operation at Birmingham Children's Hospital has evolved over the last several years.

Original Technique at Birmingham Without Artificial Supplementation of Aortic Arch

Figures 1 through 6 illustrate the early technique, which incorporated a Blalock Taussig shunt without aortic arch supplementation.

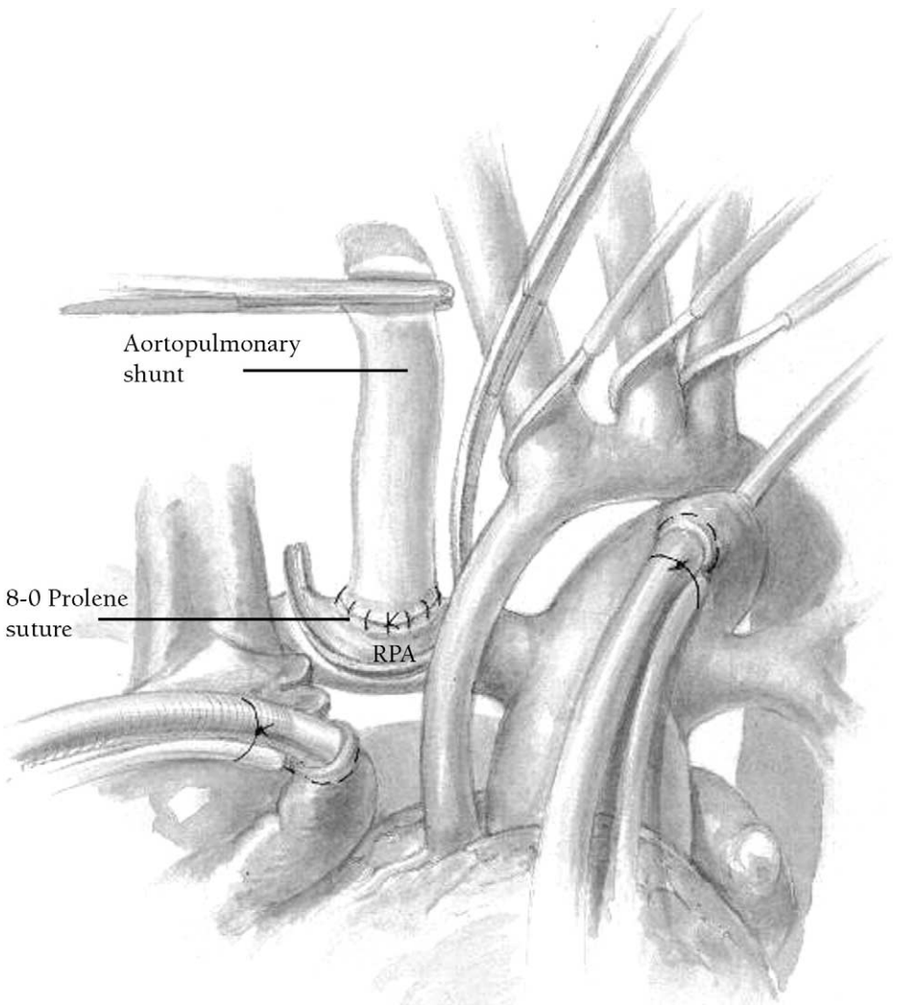

Figure 1 Arterial cannulation is performed in the distal ductus with venous return from the right atrial appendage. During cooling, the pulmonary artery end of the Blalock Taussig shunt is constructed as illustrated between the distal innominate artery and the right pulmonary artery using 8-0 Prolene. RPA = right pulmonary artery.

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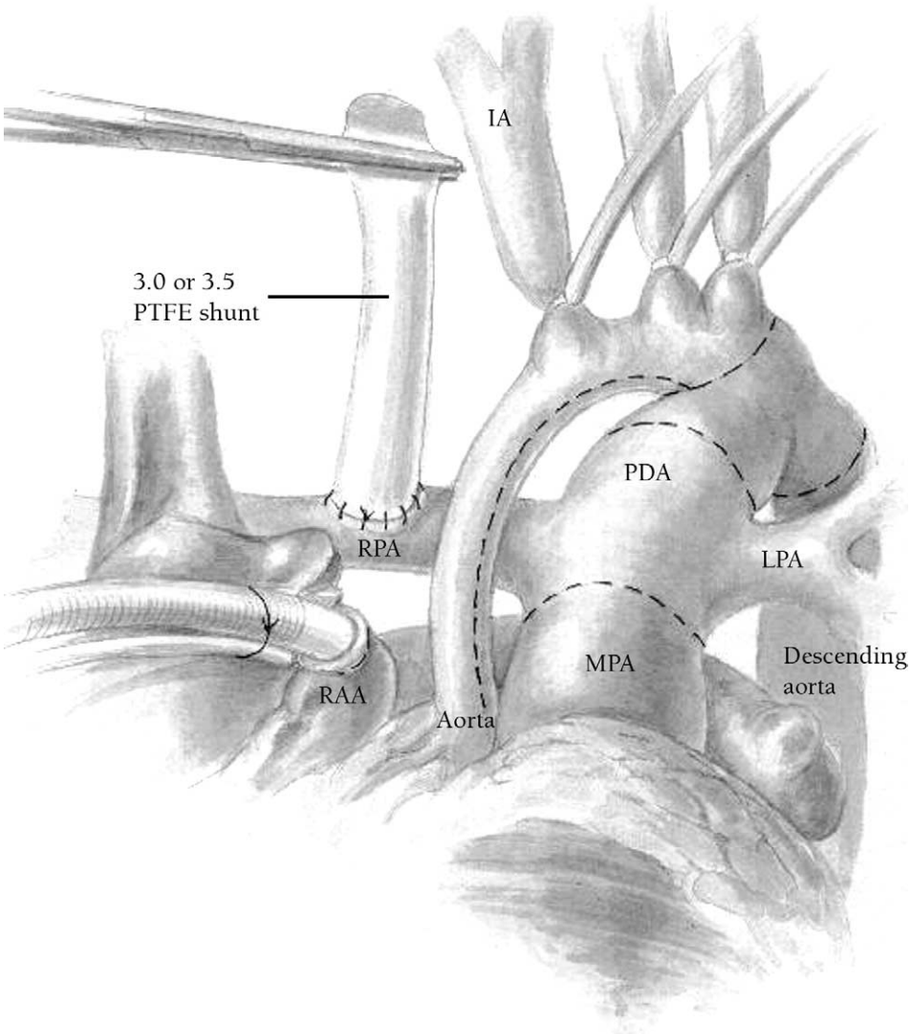

Figure 2 Location of incisions that will be made is indicated. Note that the juxtaductal coarctation area will be completely excised. Ao = aorta; Desc. Ao = descending aorta; IA = innominate artery; LPA = left pulmonary artery; MPA = main pulmonary artery; PDA = patent ductus arteriosus; PTFE = polytetrafluoroethylene; RAA = right atrial appendage; RPA = right pulmonary artery.

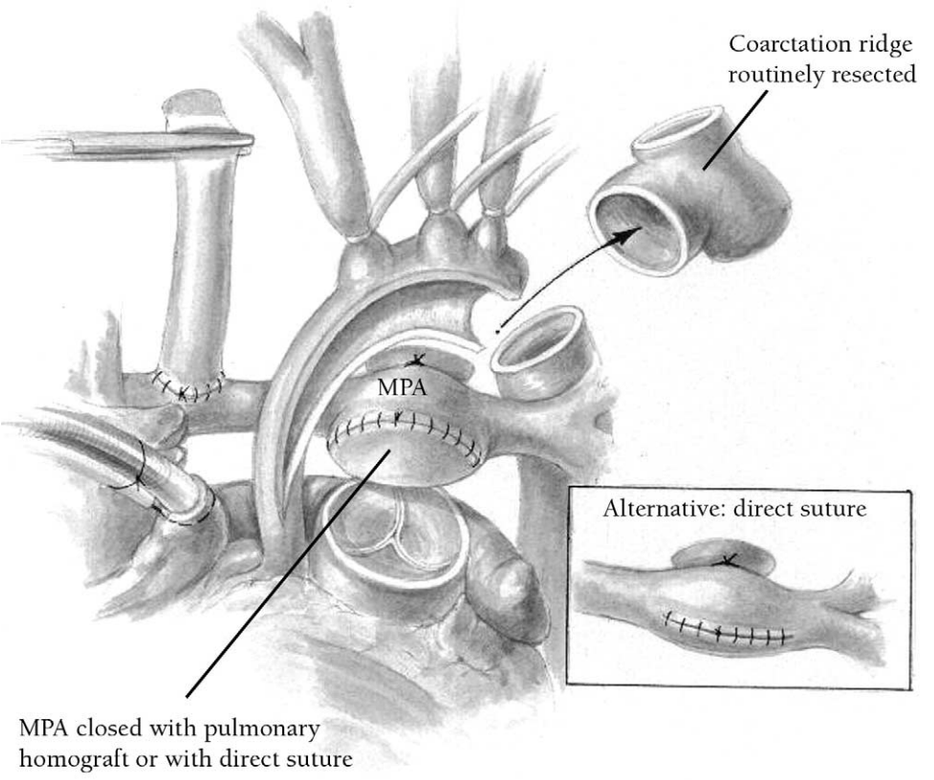

Figure 3 Excision of the juxtaductal coarctation region. The arch and ascending aorta have been filleted open. The distal divided main pulmonary artery is closed with a pulmonary homograft patch. MPA = main pulmonary artery.

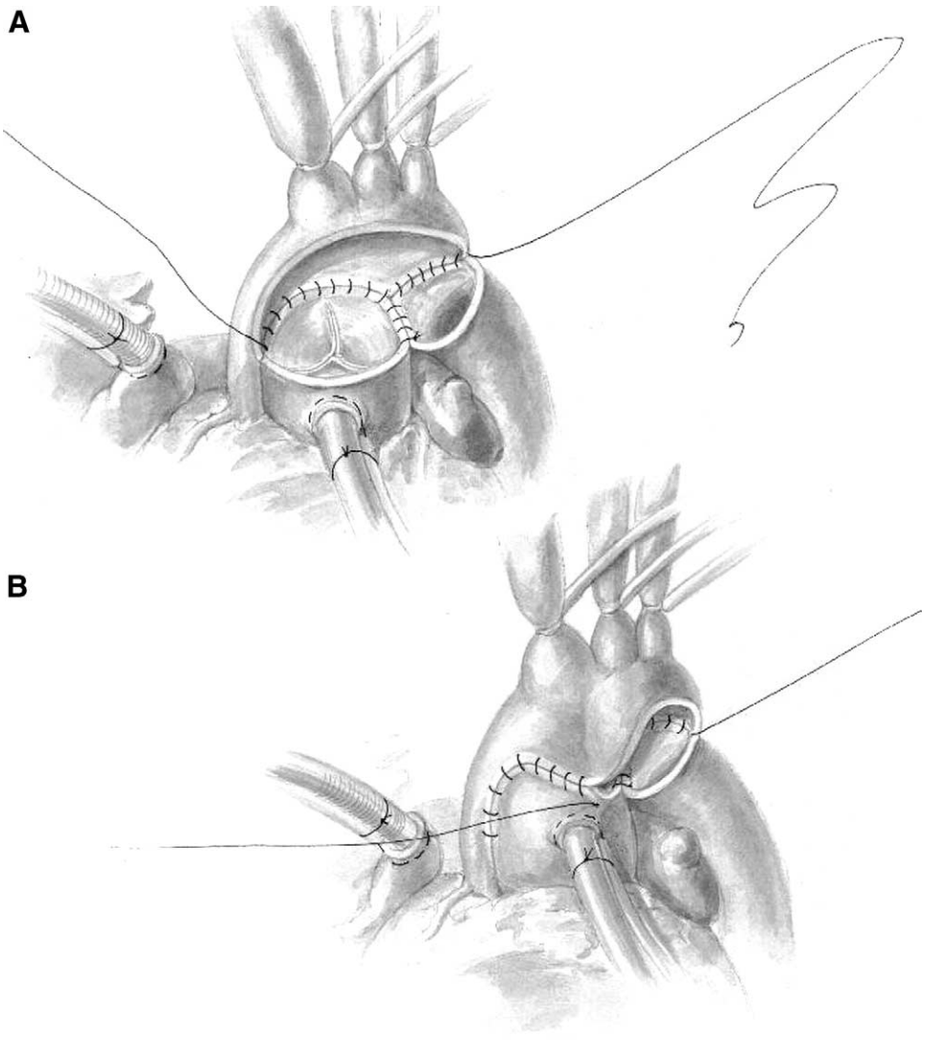

Figure 4 (A) A direct anastomosis is fashioned between the proximal divided main pulmonary artery, the descending aorta, and the arch and ascending aorta. (B) The anterior suture line is completed without use of supplementary tissue.

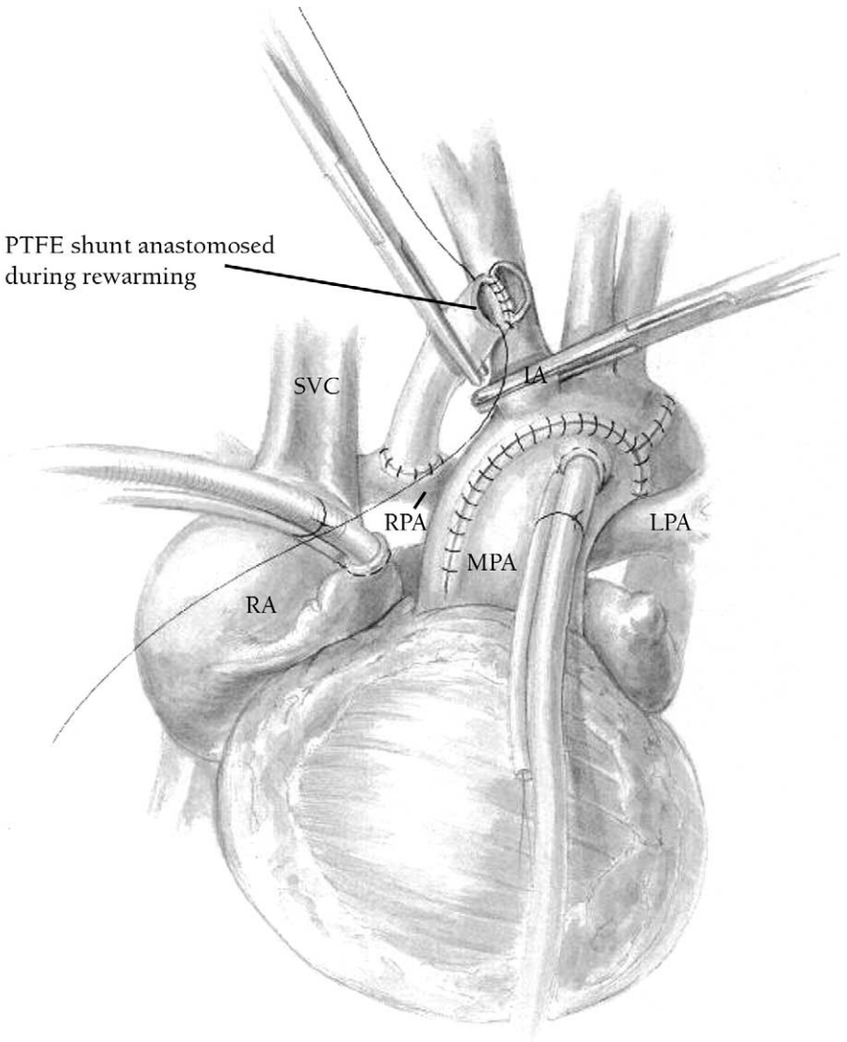

Figure 5 Cannulation method for the rewarming phase following completion of the Norwood reconstruction. Note that the atrial septectomy and arch reconstruction was performed under hypothermic circulatory arrest. IA = innominate artery; LPA = left pulmonary artery; MPA = main pulmonary artery; PTFE = polytetrafluoroethylene; RA = right atrium; RPA = right pulmonary artery; SVC = superior vena cava artery.

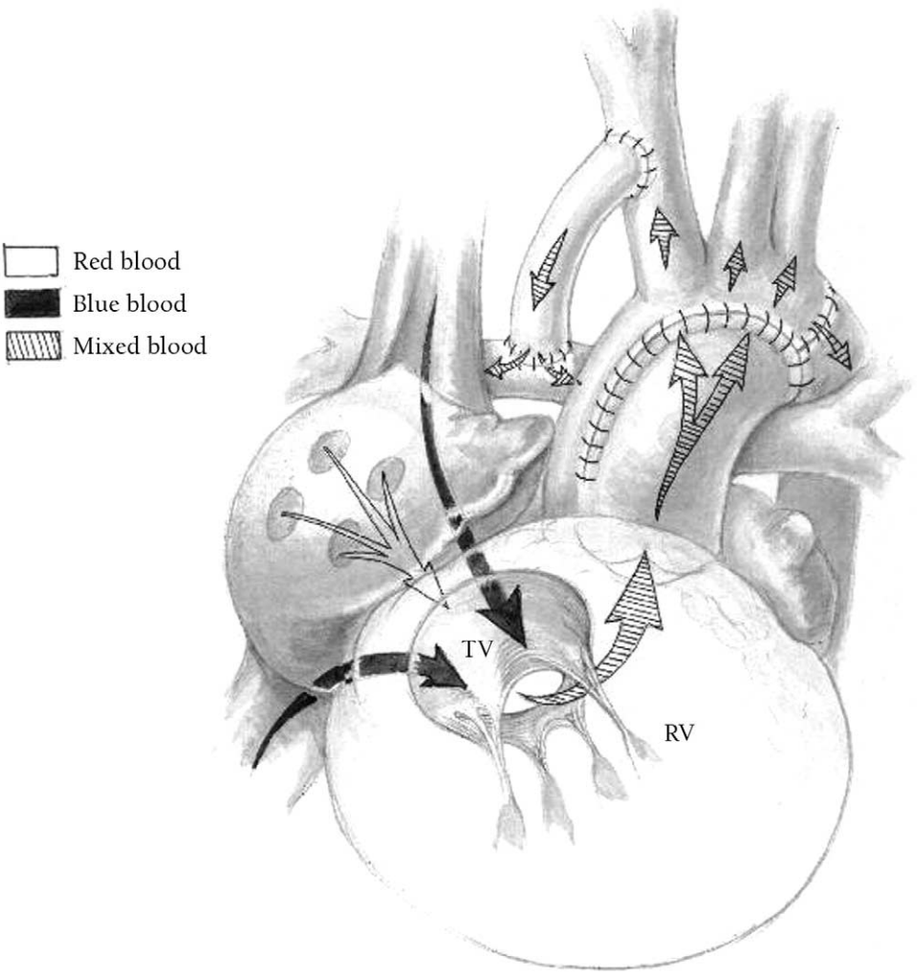

Figure 6 The completed Norwood procedure using no supplementary tissue for arch reconstruction. RV = right ventricle; TV = tricuspid valve.

Transitional Technique for Performance of the Norwood Procedure at Birmingham Children's Hospital

In a transitional period of approximately 2 years, an intermediate technique was applied in which the Blalock shunt was used but the aortic arch was supplemented with homograft tissue. The rationale for this change was that, particularly in patients in whom the ascending aorta was very small, ie, 1.5 to 2 mm, there was a risk with the initial technique of twisting or kinking of the ascending aorta when direct anastomosis was applied. It was hoped that the addition of supplementary tissue would maintain the ascending aorta in a more natural position, which would allow continuation of the preoperative level of coronary artery blood flow.

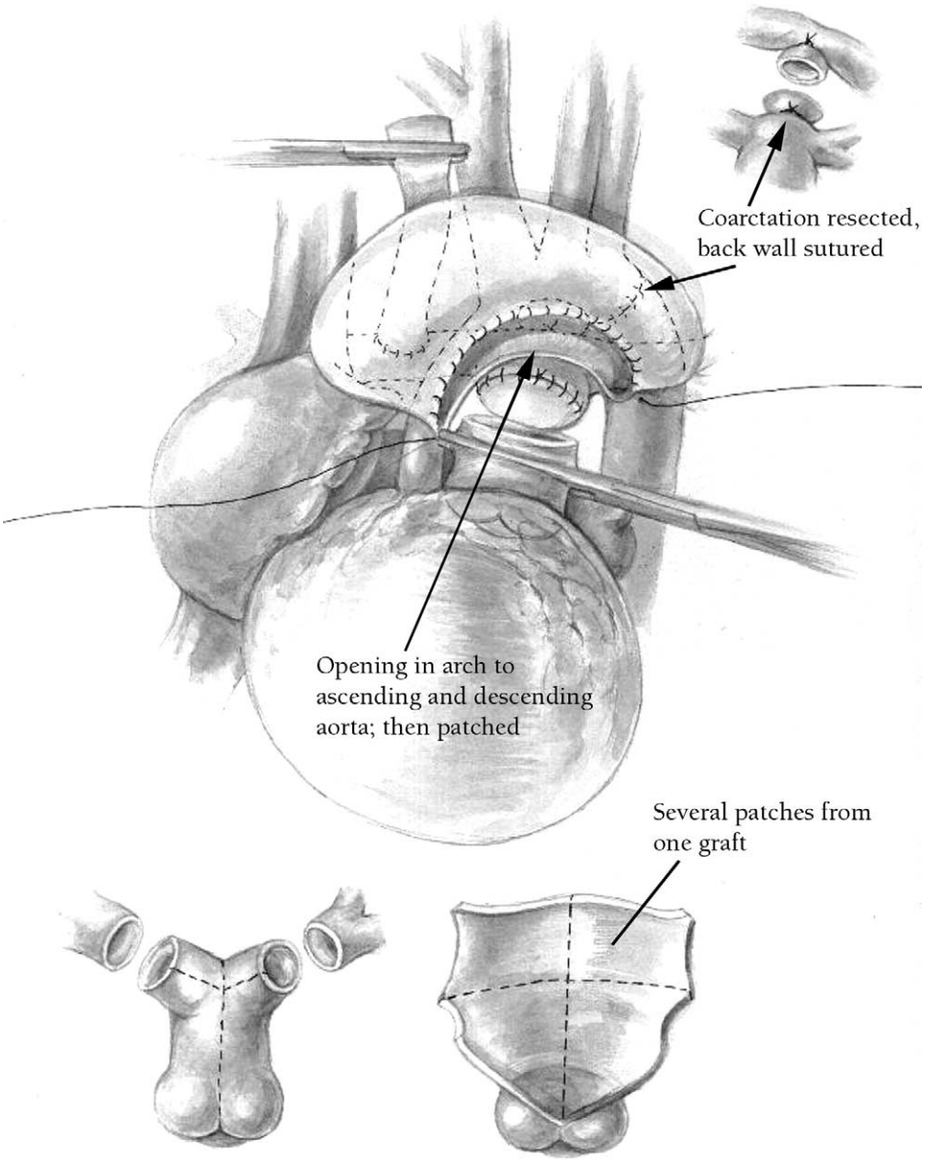

Figure 7 Several patches of pulmonary homograft are harvested from one pulmonary valve and stored separately so that 4 or 5 patients can be operated on using only one valve. The pulmonary homograft patch is sutured to the undersurface of the aortic arch with or without coarctation resection to supplement the arch and reconstruct it.

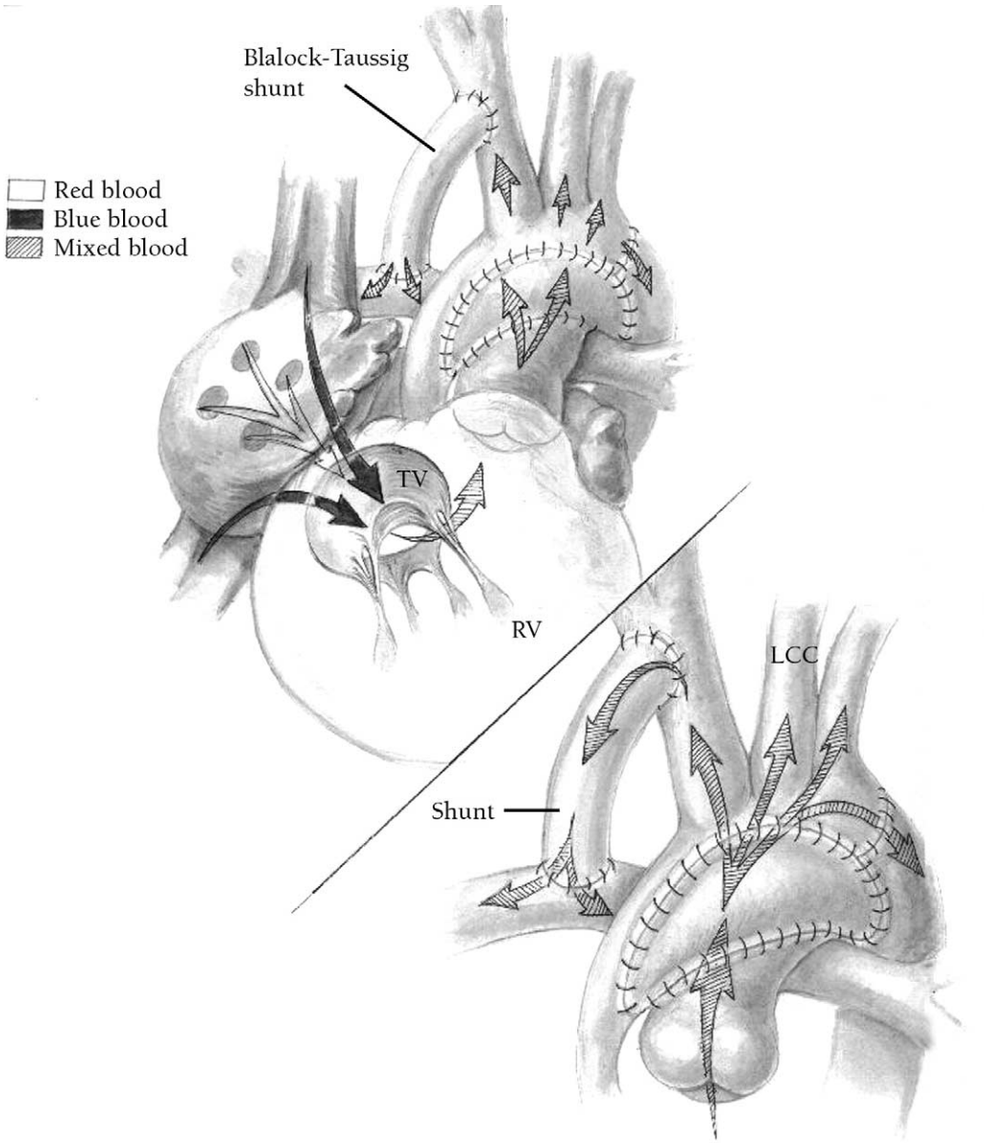

Figure 8 The pulmonary homograft is sutured entirely to the proximal main pulmonary artery. There is no direct anastomosis between the original main pulmonary artery and the ascending aorta. LCC = left common carotid artery; RV = right ventricle; TV = tricuspid valve.

Current Technique at Birmingham Children's Hospital

The current technique at Birmingham Children's Hospital involves use of a right ventricular to pulmonary artery Sano-type shunt rather than a Blalock shunt.

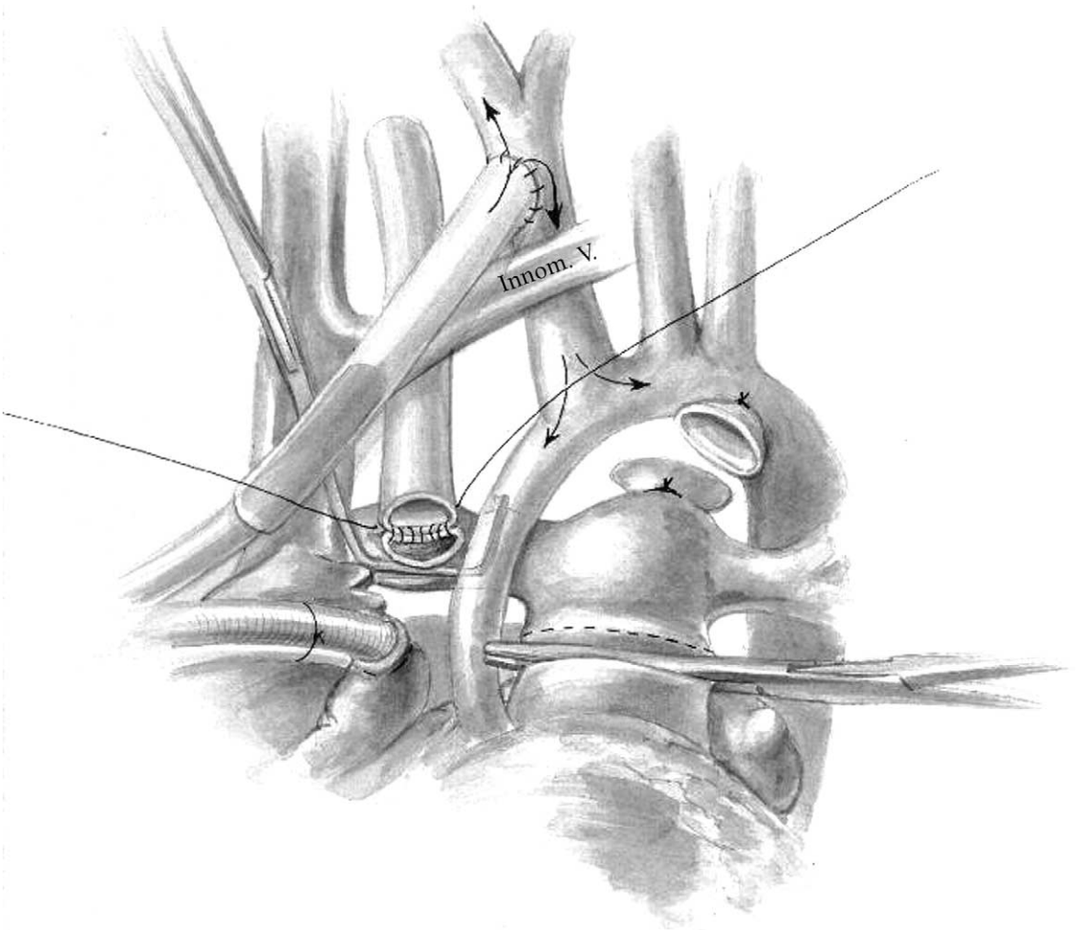

Figure 9 In the current technique at Birmingham Children's Hospital an initial 3-mm Gortex tube graft is sutured to the innominate artery to allow perfusion during reconstruction. A second 4- or 5-mm Gortex tube graft is sutured to the right pulmonary artery as illustrated and will function as the Sano shunt. Innom. V. = innominate vein.

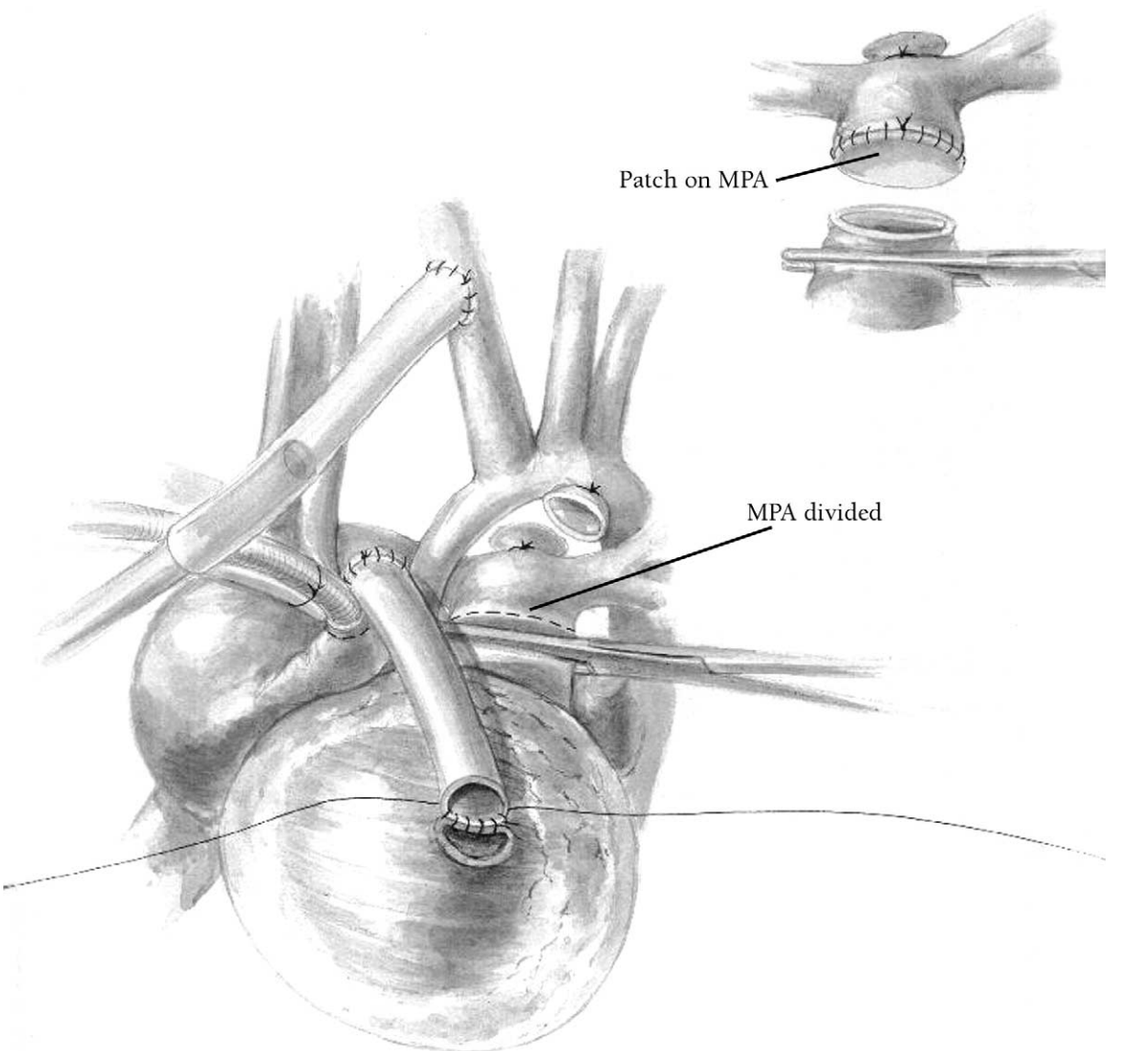

Figure 10 Although the technique initially involved anastomosis of the distal Sano shunt to the left side of the neoaorta, the technique has evolved so that presently the distal anastomosis is placed to the right side of the neoaorta. It was hoped that this technique would reduce the incidence of central pulmonary artery stenosis we observed with the left-sided Sano shunt and allow easier access to the central pulmonary arteries at the time of cavo-pulmonary shunt if pulmonary artery reconstruction was necessary. MPA = main pulmonary artery.

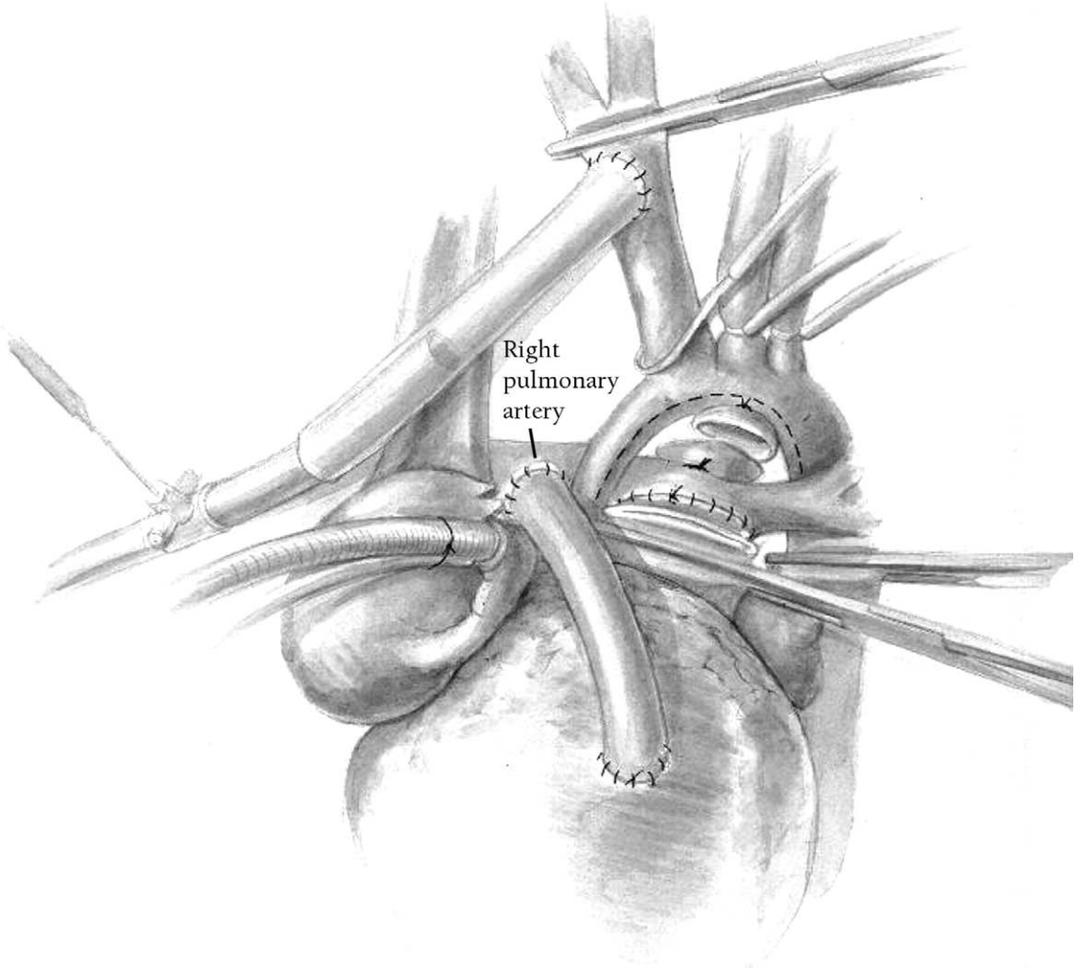

Figure 11 Both cerebral and coronary perfusion can be maintained by appropriate placement of tourniquets and clamps. Cardioplegia infusion can be infused as shown. The proximal main pulmonary artery is divided as shown and the distal divided main pulmonary artery is closed with a patch. If the coarctation tissue is exuberant and creates a marked coarctation ridge, then it is excised and the aorta reconstructed by suture.

Further Technical Points

With the current technique, we have had marked improvement in the results from our Norwood I procedure. We incorporated the use of cerebral perfusion, so that now we place a 3-mm Gortex tube end-to-side on the innominate artery, usually before opening the pericardium and usually above the innominate vein. Then we open the pericardium, dissect out the great vessels, place a purse-string suture in the right atrial appendage, heparinize, and run onto bypass, placing an arterial cannula in the Gortex tube as shown. While the patient is on bypass, we place a vascular clamp, like an aortic cross-clamp, on the main pulmonary artery and divide the main pulmonary artery from the distal left and right pulmonary arteries. We have already ligated the ductus arteriosus, usually with 5-0 Prolene ligatures; then we either patch or directly suture the opening in the distal pulmonary arteries to re-create continuity between the left and the right side. Then, with a side clamp on the anterior aspect of the right pulmonary artery, the Gortex tube is anastomosed with 8-0 Prolene. With the heart still beating but cooling the body to a nasopharyngeal temperature below 18°C, we perform a right ventriculotomy about 5 to10 mm below the pulmonary artery to avoid damaging the pulmonary valve leaflets; the other end of the Gortex tube is anastomosed to this point with 7-0 Prolene. If the anastomosis is made to the left side, the distal end of the Gortex tube is opened out, spatulated, and anastomosed with 8-0 Prolene directly to the open end of the left and right pulmonary arteries (Fig. 12). Then, as before, the other end is anastomosed to a right ventriculotomy with 7-0 Prolene.

This procedure can be done with the heart beating and with whole-body perfusion through the arterial cannula in the innominate artery. At this point, we usually infuse retrograde crystalloid cardioplegia through a three-way tap in the arterial line (Fig. 11). The head vessels are secured with a tourniquet. The left subclavian, left carotid, and then the innominate arteries are controlled distally so that we can infuse crystalloid cardioplegia through the innominate artery and into the ascending aorta and coronary arteries. The distal aorta is clamped at the same time to prevent runoff down the descending thoracic aorta. Once the heart is arrested, the open atrial septectomy is performed through the right atrial appendage, the heart is

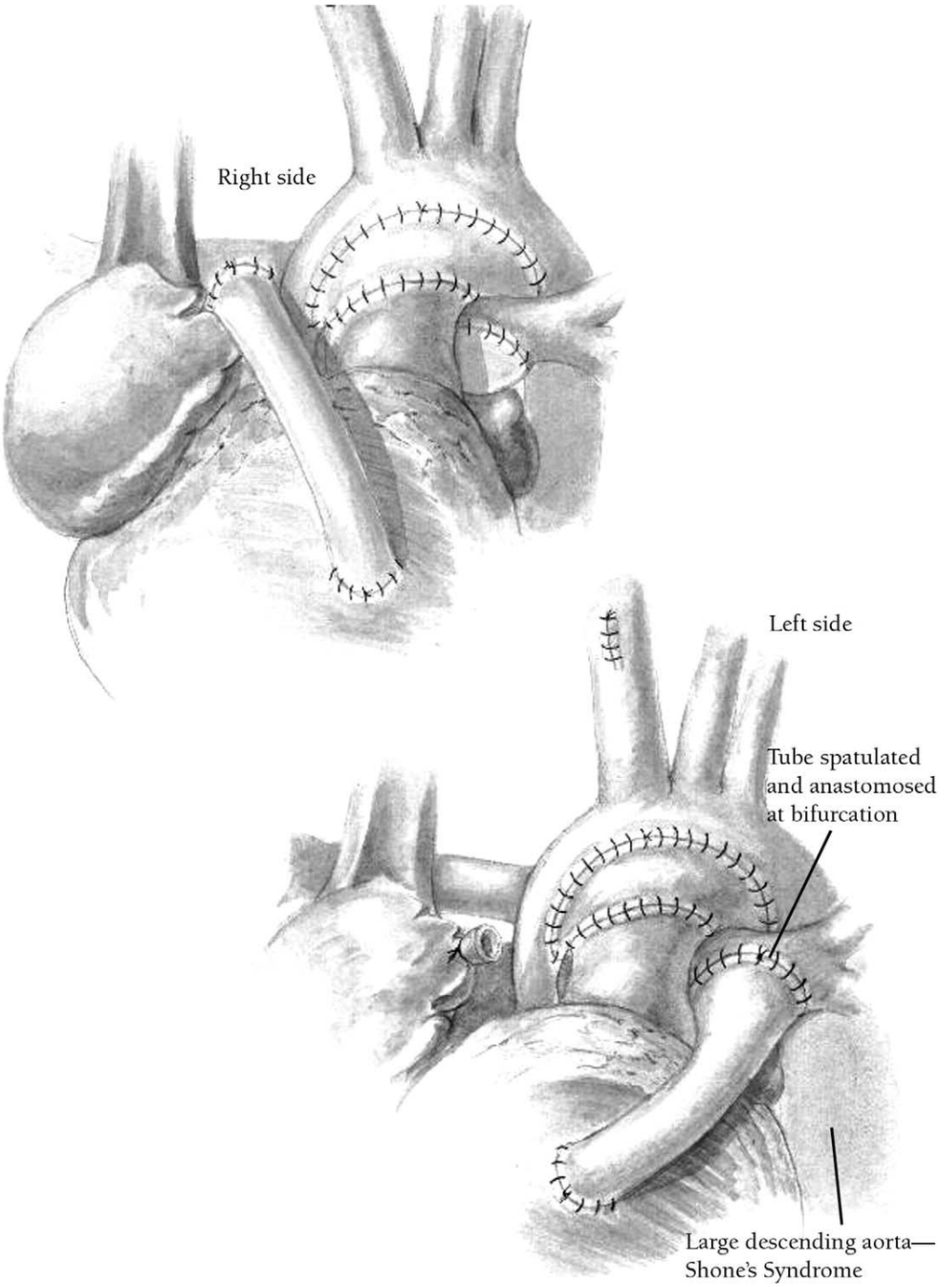

Figure 12 The current technique at Birmingham Children's Hospital continues to incorporate a homograft patch supplementing the neoaortic reconstruction. Different techniques for constructing a Sano type shunt are illustrated; however, the right-sided shunt is performed in the vast majority of patients.

recannulated, and the innominate artery is then secured with a tourniquet between the arch and the arterial 3-mm Gortex tube so that we can go on half-flow, perfusing the head vessels through the circle of Willis with the venous return through the right atrial appendage. At that point, duct tissue is excised from the descending thoracic aorta with or without the coarctation ridge; an incision is made down the descending thoracic aorta and back around the arch to the ascending aorta, and the repair of the aortic arch is performed as before with a supplemental pulmonary homograft patch.

When the reconstruction of the aorta is complete, the bypass rewarming is begun; we remove the silk tourniquets from the head vessels. We rewarm the body until the nasopharyngeal temperature is about 30°C. Circulation is arrested, and fibrin glue is placed around the suture lines. When the patient is fully rewarmed, bypass is discontinued; we check hemostasis and insert pacing wires, peritoneal catheter, and chest drain. We routinely perform an on-table epicardial echocardiogram to evaluate the pathways and ventricular function.

The operation is covered with an infusion of aprotinin (Trayslol). Neither the skin nor the sternum is closed. A fenestrated soft-tissue Gortex patch is placed in the skin; the sternum and skin are usually closed in 2 to 3 days in the intensive care unit.

Conclusions

The Norwood procedure remains a technical challenge with several options available for arch reconstruction, cerebral protection, and type of shunt for pulmonary blood supply. This article has chronicled the evolution of techniques that have occurred at Birmingham Children's Hospital. The results of these technical modifications have been published recently elsewhere.[1,2]

References

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