

The Neonatal Arterial Switch Operation: Technical Pearls



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The neonatal arterial switch operation has become the standard of care for transposition of the great arteries, including transposition with intact ventricular septum, transposition with ventricular septal defect with or without aortic arch hypoplasia, and double outlet right ventricle with subpulmonary ventricular septal defect (Taussig-Bing anomaly). While technically demanding, the operation is enormously gratifying and exciting for the congenital heart surgeon. In the current era, outcomes and expectations for the neonatal arterial switch operation are extremely high with many centers, including our own, reporting 30-day or hospital survivorship approaching 100%. Long-term results are also outstanding, although these patients do require lifelong follow-up and have the potential for need of remedial surgical intervention.

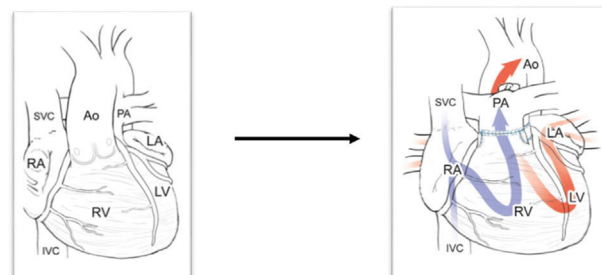
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Over the last 20 years at Texas Children's Hospital (Houston, TX), we have had a diverse and evolving experience in the newborn and infant arterial switch operation (ASO). This report will focus on assessing the intracardiac anatomy and complex coronary patterns. Our experience with the ASO at Texas Children's Hospital through April 2016 includes 371 infant arterial switches since 1995. The breakdown of patients has been characteristic of contemporary series, as noted in Table 1.¹ We began to perceive that our operative techniques have increasingly become better and we have not had an operative or hospital death for the ASO in this millennium. It also proves to be a very durable operation, with greater than 90% freedom from re-intervention over the entirety of our series.

We favor the "open-technique" for the ASO (Figure 1). The sequential basic steps are:

- Transect the ascending aorta;
- Create generous buttons for the coronary ostial translocation;
- Identify the location for the coronary translocation before dividing the neo aorta;
- Perform the usual LeCompte maneuver.

Liberal patches of untreated pericardium are used to reconstruct the neo-pulmonary sinuses of Valsalva. We



Completed ASO for correction of D-transposition of the great arteries.

Central Message

This is a report of a single center experience with the arterial switch operation. The surgical technique is discussed, providing insight into the significant long-term outcomes at our center.

complete the ASO with closure of the atrial septal defect with confirmation by echocardiography.

In the transposition of the great arteries with intact ventricular septum (TGA/IVS) population, the atrial septum or adequacy of atrial level communication is often underappreciated in terms of the acute management of these patients. A patient may occasionally present with suggestive low gradient across the atrial septum that leads to the conclusion of a non-restrictive atrial septal defect. However,

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Table 1 Breakdown of the Texas Children's Hospital ASO Experience (1995 – April 1, 2016) by diagnosis

Diagnosis	n	%
TGA/IVS	193	52
TGA/VSD	125	34
TGA/VSD + LVOTO	16	4
Taussig-Bing	37	10

Abbreviations: TGA, transposition of the great arteries; IVS, intact ventricular septum; VSD, ventricular septal defect; LVOTO, left ventricular outflow tract obstruction.

we prefer the liberal use of balloon atrial septostomy to optimize atrial level mixing. In the hands of experienced cardiologists, the balloon atrial septostomy is a very safe procedure and we have not seen an increase in incidence of neurologic insult in patients undergoing balloon atrial septostomy.

We are aggressive about dealing with concomitant arch lesions and favor the exclusive use of autologous arch reconstructions. One technical pearl in the Taussig-Bing relationship is that often times the patient has a very small ascending aorta with a side-by-side great vessel relationship. In that setting, along with the arch reconstruction, we find it important to reconstruct the neo-pulmonary connection out on one of the branch pulmonary arteries, typically out on the right pulmonary artery to avoid the potential for compression of the translocated coronaries.

It is, of course, important to assess the semilunar valves. When focusing on the bicuspid pulmonary valves, we proceed to with the ASO and thereby create bicuspid neo-aortic valves.

There is often the substrate for right ventricular outflow tract obstruction or neo-subpulmonary obstruction in the Taussig-Bing anomaly very nicely illustrated by the late Leon Schlossberg (Figure 2). In the Taussig-Bing anomaly, we typically perform a subpulmonary resection.²

The assessment of the left ventricular outflow tract requires detailed evaluation before the ASO. We frequently assess the left ventricular outflow tract through both the pulmonary valve and the aortic valve. We find the pulmonary valve to be quite normal during surgical repair is often misleading on the preoperative echo. Furthermore, it is very important to assess the presence of additional muscular ventricular septal defects, as this can also be very misleading, particularly when you have a dominant perimembranous ventricular septal defect.

In North America, left ventricular deconditioning is infrequent because of improvements in diagnosis and referral. Nonetheless, our own Texas Children's Hospital experience (Table 2) with patients with TGA/IVS presenting after 3 weeks

of life, including nine patients who presented as late as almost 100 days. We have had no operative mortality in this group. More commonly, patients many present with early involution of the left ventricle, and in such a patient, we would advise a lot of early caution about overloading the ventricle. Typically, if one is careful to avoid over distension of the left ventricle, it will gradually improve over the first few days after the ASO.

All coronary configurations are amenable to ASO. As such, we do not make pre-surgical delineation of coronary ostial origin or branching a criterion for surgery.

The basic principles for all branching patterns is to minimize axial rotation of the translocated coronary buttons as they are moved in an anterior-posterior direction. The artist rendition (Figure 3) illustrates the liberal use of flap incisions in the neo-aorta to facilitate coronary translocation in a more anatomic plane.

In the case of a patient with a functional single posterior ostium or a double barrel ostium, the adjacent aortic valve pillar may be problematic. The technique we have employed is to place a fine suture in the posterior pillar to help with the valve pillar off of the wall of the aorta and then to unroof the intramural left main coronary. In such a case, we have elected to reconstruct neo-aortic continuity, what some people term as the "closed technique," to establish where the coronary button should ideally be translocated. A useful technique is to briefly take the aortic cross clamp off to see where the button sits most naturally.³ An important adjunct is to mark the anterior commissure to avoid injuring the neo-aortic valve during the aortotomy.

Finally, an often asked question is "How small is too small?". Our colleague, Mohan Reddy, has shown us that we are justified in being aggressive with some of the smaller patients. If one does not take that approach an opportunity may be missed to have a good repair in some patients. The smallest patient that I personally have taken care of was a 760-g female with TGA/IVS who was languishing. She was 28 weeks gestation, progressively desaturated, and we believed surgery was her only hope. The care of this patient intraoperatively was not nearly as challenging as the perioperative care. The point being, in this child, as is true in many of these patients, despite small size one can readily proceed with the switch because everything is anterior and accessible. This child did not require much of an intracardiac repair except for an atrial septal defect closure, and she did remarkably well after surgery. This observation confirms what others have observed—that it is better to complete the switch early on when medically indicated.⁴

This brief synopsis of our approach is included to share some of the focal points we believe are useful in performing a predictable ASO. We believe, that through such focus, results

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