The Neonatal Arterial Switch Operation: How I Teach It

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The neonatal arterial switch operation (ASO) has become the standard of care for transposition of the great arteries, including transposition with intact ventricular septum (TGA-IVS), transposition with ventricular septal defect (VSD), with or without aortic arch hypoplasia, and double-outlet right ventricle with subpulmonary VSD (Taussig-Bing anomaly) [1, 2]. Although technically demanding, the operation is enormously gratifying and exciting for the congenital heart surgeon. In the current era, outcomes and expectations for the neonatal ASO are extremely high, with many centers, including our own, reporting 30-day or hospital survival approaching 100% [3]. Long-term results are also outstanding, although these patients do require lifelong follow-up and have the potential for need of remedial surgical intervention [4].

In describing my approach to teaching this operation, I limit my comments to pertain to the category of young surgeons, which includes congenital heart surgery fellows and young faculty surgeons. In the current era, the historical reference to a surgical "learning curve" for the ASO is no longer practically or ethically acceptable. In this context, it is very important for the young surgeon in training or early in his or her surgical career to have appropriate mentoring and senior surgeon support, guidance, and where necessary, direct technical assistance.

Preparation

Diagnostic Assessment Evaluation

During the prenatal consultation, the surgeon must conduct a general discussion of the perinatal management probabilities, such as initiation of prostaglandin, balloon atrial septostomy, and timing of the intervention. Specific postnatal management must be derived based on postoperative diagnostic studies and the clinical condition of the newborn.

Postnatal transthoracic echocardiography is the mainstay diagnostic study in these patients. Specific elements to emphasize include the ventricle-arterial relationship, the status of the semilunar valves, the presence of ventricular level communication, the size of the atrial level communication, atrioventricular valve size and morphology and corresponding ventricular size and function, and the presence or potential for aortic arch obstruction. Of note, this is not the case for confirming coronary ostial origin and coronary branching configuration. All coronary branching patterns and variations of ostial origin are amenable to a successful ASO, including a single ostium between the great vessels and intramural coronary arteries (Fig 1). The surgeon must be prepared to deal with any coronary branching configuration and should not rely too heavily on imaging and interventional studies because they may be misleading.

The aspiring congenital heart surgeon must learn to critically assess and challenge the completeness of the diagnostic studies. Particular concern should be given to semilunar valve quality, outflow tract obstruction, additional VSDs, potential for straddling atrioventricular valve attachments, or an underdeveloped ventricle. The surgeon must request additional diagnostic studies, when necessary.

There continues to be interinstitutional variability in the application of balloon atrial septostomy. Our experience has been that this is safely performed without an increased incidence of complications. In patients with uncertainty about the effectiveness of the atrial level communication, a safe balloon atrial septostomy may allow discontinuation of prostaglandin and thus a less urgent ASO. In transposition variant populations, TGA-IVS, exposure to hypoxemia may affect long-term neurodevelopmental outcomes. We therefore favor the elective ASO for TGA-IVS within the first week of life, where possible. Clearly, patients who remain dependent on prostaglandin or who present with intractable hypoxemia are in a more urgent cohort.

Technical Considerations

The surgical trainee must fully understand the operation's technical details (Fig 2) and be prepared to execute them before standing on the surgeon's side of the table. They must be in position of taking care of the elements of the operation, which by their nature may preclude the visibility (ie, difficult VSDs, ventricular outflow tract obstruction requiring resection, and eccentric ostium) of the assistant surgeon. In our practice, the trainee spends a considerable amount of time as an assistant surgeon. Regarding the intracardiac portion of the ASO, the primary operating surgeon should be able to close, as much as possible, significant VSDs, almost exclusively through the tricuspid valve without damaging the tricuspid valve or the conduction system.

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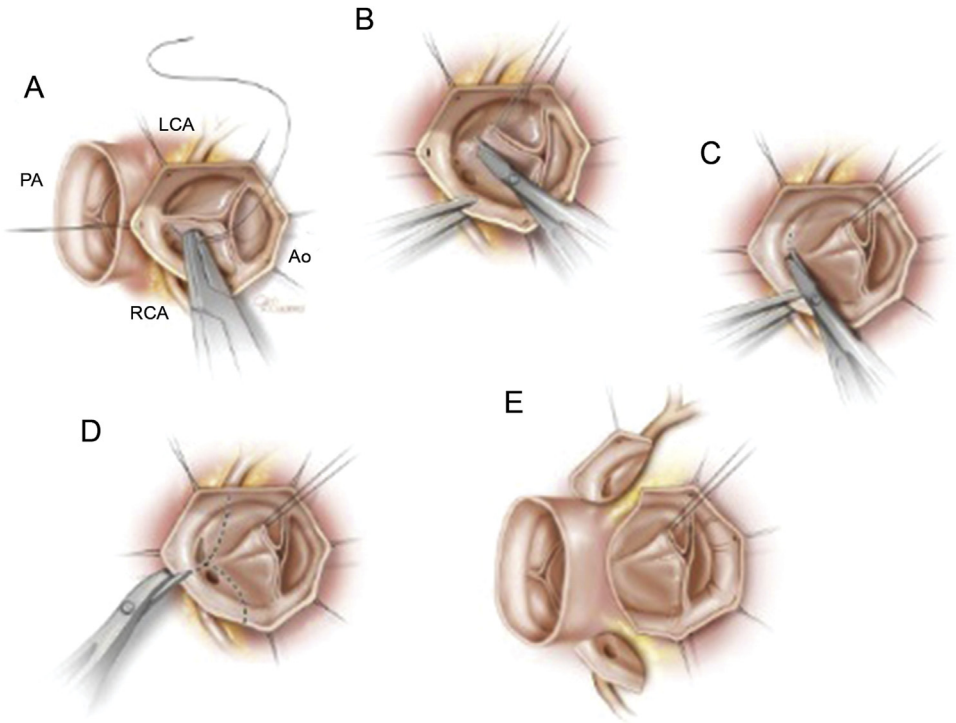

Fig 1. Coronary ostial translocation. (A) Site of left and right coronary arteries to be used in translocation above the sinotubular junction. (B) Small transverse aortotomy. (C) Clear and careful visualization of the coronary ostia. (D) Generous resection of the coronary ostial buttons down to the reflection point of the aortic valve. (E) Coronary buttons will be placed where they are not subject to axial torsion. (Ao = aorta; LCA = left coronary artery; PA = pulmonary artery; RCA = right coronary artery.) (Printed with permission from Texas Children's Hospital.)

The most technically demanding element in the ASO is the coronary ostial translocation. The initial evaluation of the anatomic relationship of the great vessels should be performed before cannulation and cardiopulmonary bypass are initiated. We typically instruct trainees to dissect the epicardial reflection between the great vessels and then place small marking stitches where one sees the most optimal location for the subsequent coronary ostial translocation. This can be very helpful in the subsequent successful coronary ostial transfer. However, this may not be possible, particularly in the setting of patients with intramural coronary arteries or a single posteriorly located coronary or in conditions of a side-by-side great vessel relationship.

We favor direct aortic cannulation in the distal ascending aorta, except in circumstances where aortic arch repair is anticipated. In that setting, we will often sew a graft on the innominate artery for arterial inflow and to facilitate antegrade cerebral perfusion during the aortic arch reconstruction. Except in the very smallest babies (typically <2.0 kg), we favor separate venacaval cannulation such that the operation can be performed on full-flow cardiopulmonary bypass with mild or moderate hypothermia. After an initial dose of aortic root cardioplegia, we typically administer intermittent cardioplegia directly into the coronary ostia for the duration of the aortic cross clamp. The first decision, the site of transection of the ascending aorta, is typically done just above the aortic sinotubular junction with extreme care. A small transverse aortotomy is performed, and then the coronary ostia is carefully visualized such that the remainder of the aortic transection can be accomplished without compromising a future coronary ostial button. Furthermore, we favor generous coronary ostial buttons and will typically resect these buttons right down to the reflexion point of the aortic valve. This facilitates a more reproducible and forgiving coronary translocation. A minimum amount of dissections to the coronary artery should be performed, which will allow coronary ostial translocation. After the coronary button mobilization, the pulmonary artery is transected in a strategic fashion. To create the neo-ostia in coronary translocation, we favor creating medially based trapdoor flap incisions in almost all cases. Furthermore, the initial marking stitches can be very helpful.

The coronary buttons will go where they will not be subject to axial torsion or distortion. In some settings this means placing them in the same anterior aortic sinuses of Valsalva, particularly in cases where there is not semilunar valve commissural alignment. The coronary ostial anastomoses are then performed with continuous running nonabsorbable suture, either running 7-0 or 8-0 Prolene (Ethicon, Somerville, NJ). We do not do this in a double-layered fashion. After the LeCompte maneuver is performed, aortic continuity is reestablished.

Once the intracardiac portion of the operation is completed before the actual arterial switch procedure (which is recommended), we then proceed with closure of the atrial septal defect during rewarming and then will remove the aortic cross clamp, allowing the heart to be resuscitated while we accomplish the pulmonary artery reconstruction. The neopulmonary sinuses of Valsalva are reconstructed with liberal patches of fresh autologous pericardium, and then pulmonary arterial continuity is