Spiral arterial switch operation in transposition of the great arteries

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The spiral arterial switch operation (ASO) is seldom performed, because the functional implications of the spiral relationship of the great arteries (SROGA) are not well known.

Clinical Summary
A 10-day-old baby boy underwent spiral ASO (Figure 1) and repair of septal defects and coarctation. The aorta was right anterior 30° to the pulmonary trunk. A single coronary artery pierced into aortic sinus 2 closer to the facing commissure with a retro-pulmonary left main and anteaortic Vieuxussen artery. We cut back into noncoronary sinus 1 to augment the pulmonary pathway by anterior wall of the neoaortic root.

Besides augmenting the facing sinus wall, the recent modification (Figure 1) that differs from the previous technique1 (similar to Figure 2) includes the following three points, which can also be applied to cases with usual coronary pattern: (1) The aorta is amputated obliquely (Figure 1, A) so that a larger left lip (Figure 1, C) can be used as the floor of the pulmonary pathway (Figure 1, E). (2) The right posterior part of the pulmonary trunk is divided (Figure 1, A and B) to make a larger flap to be evverted to the left and a more leftward pulmonary pathway after neoaortic anastomosis and posterior attachment (suturing the caudal edge of the right pulmonary artery to the posterior neoaorta) accordingly. (3) The posterior attachment site is ascertained after release of the aortic crossclamp, as in the previous technique. However, to facilitate exposure, the aorta is crossclamped again distal to the deepest site of attachment and then stitched from the right (Figure 1, D).

The postoperative course was smooth. Follow-up echocardiography showed smooth flow without a pressure gradient across the pulmonary or aortic pathway.

Discussion
An article in The Lancet2 and its figure prompted us to review distal suprapulmonary stenosis complicated after an ASO. The main reasons for this stenosis were claimed to be technical, and its incidence dropped after generous patching of the pulmonary sinus and extensive hilar dissection. However, such distal stenosis inherent with the procedure itself still existed, as noted by de Leval3 in a comment on that article. We point out that this morbidity was closely related to the so-called Lecompte maneuver, mobilization of the pulmonary bifurcation anterior to the ascending aorta. This viewpoint is well illustrated in the Figure 1 of that article.2 The transposed great arteries were switched in such a fashion (Figure 3, B) that the normal SROGA was not restored. The naturally created great arteries are normally in a spiral fashion (Figure 3, C); thus the pulmonary arteries are prevented from being compressed by the ascending aorta. After the Lecompte maneuver, however, not only is the anterior pulmonary trunk (low pressure) flattened,4 resulting in branch pulmonary arterial stenosis with increased peak velocity during systole,5 but also the posterior left bronchus may be compressed (airway pressure with cartilage).6,7 All occurs because the high-pressure ascending aorta may suppress itself (high pressure). That is to say, the acute angulation of the aortic arch after the Lecompte maneuver (Figure 3, B) may cause hypoplastic arch and neocoarctation that was not present at the time of ASO.8 We therefore advocate modified ASO by spiral reconstruction.1

We have even proved the functional implications of the SROGA by computational fluid dynamics.9 The flow inside the spiral model is more streamlined than is the Lecompte model. The recognition of the transposed great arteries as an anteroposterior reversal of the great arteries without appreciation of nonexistence of the normal SROGA is too simpleminded. If one looks back into the history of surgical treatment for transposition, once the functional implication of normal ventricles was well known, nobody selected the right ventricle as the systemic pumping chamber.
Figure 1. Techniques of spiral arterial switch operation for single coronary artery. Semilunar valves are all omitted for clear illustration. A, Aorta is amputated obliquely. Left posterior wall of pulmonary trunk is not divided. Two J-shaped incisions are made on facing parts of great arteries. Anterior wall of pulmonary trunk is cut back along dashed line to accommodate ascending aorta. B, Anulus of facing commissure in old aorta is fixed to anterior wall of pulmonary trunk (depicted by Y stitches). Lateral edges of two J-shaped incisions facing each other are sutured together (depicted by X stitches) to form aortopulmonary window. Then semiflap of pulmonary trunk is placed into opposite aortic sinus and sutured so that it acts as posterior wall of neopulmonary trunk and as anterior wall of neoaorta. C, Suture for pulmonary trunk semiflap in sinus 2 (depicted by l stitches) is finished. Anterior lip of cut back pulmonary trunk is everted to left. Distal aorta is sutured to posterior wall of pulmonary trunk along dotted line. Aortic sinus 1 is cut back along dashed line. D, Neoaortic anastomosis is finished. Cut back edge of aortic sinus 1 is attached to anterior neoaortic root to augment pulmonary pathway. Cut edge of pulmonary trunk and caudal edge of right pulmonary artery are attached to posterior aorta from right. E, Cephalic cut edge of right pulmonary artery is attached to posterior outer wall of aorta from left. Caudal edge of anterior pulmonary trunk flap is attached to amputated edge of aortic sinus 1 to form floor of pulmonary pathway. F, Finally, attaching anterior pulmonary trunk flap to ascending aorta completes roofing of anterior pulmonary pathway.

Figure 2. Techniques of modified arterial switch operation with neopulmonary trunk in left anterior portion. Main difference from previously published figure is in part C. Cephalic edge of pulmonary semiflap is sutured to amputated edge of sinus 1 (depicted by heavy l stitches) instead of inner wall of sinus 1 just to cover coronary sinus, thus less suture line is needed. Parts are as in Figure 1.
child grows may cause pressure gradient at the simple procedure in the text only. Namely, for those with higher demanding operation, in part because we depicted the details of the sonography either became smaller or did not develop on follow-up. grafts, the suprapulmonary gradient estimated by Doppler ultrasound. In all other 11 patients, who received autologous tissue developed 3.5 years after reoperation but dropped after balloon stenosis, the suprapulmonary gradient as great as 65 mm Hg whom an equine pericardium was used to repair the supra-aortic arteries may be wrong, or at least may provide suboptimal correction. Lecompte maneuver merely to reverse the anteroposterior great angulation of arch that is present after nonspiral Lecompte maneuver (B) is absent in other three illustrations. Modified from Prêtre R, Tamisier D, Bonhoeffer P, Mauriat P, Pouard P, Sisi D, et al. Results of the arterial switch operation in neonates with transposed great arteries. Reprinted with permission from Elsevier Science (The Lancet, 2001;357:1826-30).

Likewise, we think that people adopted the nonspiral Lecompte maneuver just because the functional implication of the SROGA was not well known. Now that we know the functional implications of SROGA, spiral ASO to restore the natural SROGA should be recommended for transposition. Therefore, ASO with the Lecompte maneuver merely to reverse the anteroposterior great arteries may be wrong, or at least may provide suboptimal correction.

One may be concerned that the gradual “untwisting” as the child grows may cause pressure gradient at the “common wall” site in our technique.1 We report the follow-up data on our original 12 patients 3.20 ± 0.54 years after the operation. In patient 3, in whom an equine pericardium was used to repair the supra-aortic stenosis, the suprapulmonary gradient as great as 65 mm Hg developed 3.5 years after reoperation but dropped after balloon dilatation. In all other 11 patients, who received autologous tissue grafts, the suprapulmonary gradient estimated by Doppler ultrasonography either became smaller or did not develop on follow-up. Some may argue that our technique adds difficulty to an already demanding operation, in part because we depicted the details of the complicated procedure in our previous article but described the simple procedure in the text only.1 Namely, for those with higher takeoff of the coronary artery (inadequate tissue to suture inside the sinus wall), the cephalic edge of pulmonary semilunar was sutured to the cephalic edge of sinus 1 (Figure 2). We believe that this simple technique, which was used in most cases, made life easier.

The recent modification (Figure 1) is even simpler. One can cut back into noncoronary facing sinus 1 to augment the pulmonary pathway by anterior wall of the neoaoartic root. This autologous viable tissue is of course superior to the previous technique of cutting back into nonfacing anterior sinus and using a pericardial patch for augmentation (Figure 2, C). We showed that not using pericardial patch to roof the anterior pulmonary pathway is possible (Figure 1, F), like not using a patch in a Senning operation. In addition to augmenting the facing sinus 1, the first two modifications mentioned previously that can be applied to usual coronary patterns contributed to the ability to dispense with a patch. We recommend spiral reconstruction of the great arteries at least for transposition if people are used to conventional method of coronary transfer.

Addendum
After this paper was submitted, 3 babies with complete transposition and usual coronary pattern successfully underwent modified spiral ASO as above.

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References