

# Surgical Treatment of Complete Transposition of the Great Arteries in Newborn

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**Key words:** Newborn; Switch Operation; Transposition of the Great Arteries

## INTRODUCTION

Complete transposition of the great arteries (TGAs) is a common cyanotic congenital heart defect, with an incidence rate of 0.02%, accounting for 5–7% of congenital heart diseases.<sup>[1]</sup> After birth, infants with TGA largely rely on ventricular septal defect (VSD), atrial septal defect (ASD), and patent ductus arteriosus (PDA) to sustain life. Without systemic-pulmonary shunt and surgical correction, these infants will probably die on the day after birth.

Because of the favorable outcome brought by its anatomical correction, arterial switch operation (ASO) has become the preferred option for treating TGA. Once ASO could not be implemented for newborns as early as possible, the application of balloon atrial septostomy (BAS) allowed the infants with TGA to undergo surgery one month after birth. However, BAS may also induce vascular injury, arrhythmia, atrial perforation, and pericardial tamponade and increase the risks of stroke and cerebral embolism.<sup>[1]</sup> Therefore, it is generally believed that infants with TGA should undergo ASO in two weeks after birth. Nevvazhay *et al.*<sup>[2]</sup> proposed that ASO should be carried out as early as possible on infants with TGA, without performing BAS. Anderson *et al.*<sup>[3]</sup> suggested that ASO performed on the 3<sup>rd</sup> day after birth could avoid the deterioration of left ventricular function, reduce postoperative complications and mortality, and thus effectively reduce hospital stay and costs. At present, the specific timing of surgery remains controversial. In this study, by analyzing and summarizing the surgical data of ASO for newborns, the proper timing of surgery, surgical indications, and surgical outcomes were explored.

## METHODS

### General information

From June 2000 to April 2015, ASO was performed on 23 infants (19 males and 4 females), aged 2 h to 30 days ( $12.0 \pm 9.4$  days), weighed 2.5–4.5 kg ( $3.5 \pm 0.6$  kg). Five infants accompanied with VSD and 18 infants with intact ventricular septum (IVS). Moreover, 21 infants were accompanied with ASD, 22 with PDA, and one with neonatal intestinal malformation. In 20 cases, coronary artery started, respectively, from the left and right posterior sinus of the pulmonary artery; in three cases, the origin of coronary artery was abnormally distributed. One of them, the right coronary artery started from the left posterior sinus, with the circumflex artery starting from the right posterior sinus; in one case, the circumflex artery started from the right coronary artery; and one case was single ostium, starting from the left posterior sinus of the pulmonary artery. The partial pressure of oxygen ( $\text{PaO}_2$ ) preoperation was  $41.9 \pm 16.9$  mmHg, the arterial oxygen saturation ( $\text{SaO}_2\%$ ) was  $68.2 \pm 20.0\%$ , and the transcutaneous oxygen saturation ( $\text{SpO}_2\%$ ) was  $69.4 \pm 11.9\%$ . In addition, five infants had undergone mechanical ventilation due to hypoxemia, and 12 infants had been administered with prostaglandin E1 to maintain PDA open before surgical.

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## Surgical approach

All infants underwent surgical correction of ASO. For one case with left ventricular dysplasia and functional degradation, systemic-pulmonary shunt (anastomosis of innominate artery and pulmonary artery) and pulmonary artery banding had been carried out, and Stage II ASO was performed one week later. All ASOs were performed under general anesthesia through cardiopulmonary bypass at low temperature (18–22°C) and low flow (50 ml·kg<sup>-1</sup>·min<sup>-1</sup>). Median sternotomy and removal of the thymus tissue were performed intraoperatively. The ascending aorta, pulmonary artery, and arterial duct were fully dissociated. After the establishment of cardiopulmonary bypass, the arterial duct was cut, the ascending aorta was cross-clamped, and cardioplegia was infused through the aortic root to protect the myocardial tissue. The right atrium was opened and explored, and autologous pericardium or polyester fabric was used to repair the ASD and VSD. Then, the aorta and pulmonary artery were, respectively, transected above the aortic valve and pulmonary valve. Both left and right coronary arteries were excised from the aorta with “coronary button” ostia. The incisions on the proximal end of pulmonary artery were made appropriately and were then anastomosed to the ostia of bilateral coronary arteries with 7-0 Prolene. The continuous suture was performed with 6-0 Prolene beneath the bifurcation of the pulmonary artery to connect the distal end of the ascending aorta and the proximal end of the pulmonary artery to form a new aorta. Autologous pericardium was used to repair the proximal end of the aorta, which connected with the distal end of the pulmonary artery by continuous suture with 6-0 Prolene to form a new pulmonary artery. De-air was fully completed, the occlusion clamp on the ascending aorta was released, and cardiac resuscitation was carried out. After careful confirmation that there was no bleeding at all anastomoses, the cardiopulmonary bypass was stopped and removed. Pacing leads were installed at the epicardium before hemostasis and sternal closure.

## Postoperative care

All postoperative infants were sent into Intensive Care Unit after surgery with continuous mechanical ventilation and enhanced airway care to prevent infections of the respiratory tract. Vital signs were continuously monitored, sedation, analgesia, cardiac, and diuretic therapies were conducted to maintain a stable circulation. The systemic blood capacity was controlled, the left atrial pressure was maintained at 7–10 mmHg, and blood gas was monitored so as to maintain electrolyte balance. Moreover, vasodilators were given to reduce the left ventricular afterload. Antibiotics were routinely employed to prevent infection, and warm-keeping measures were taken to prevent the occurrence of neonatal scleredema. In addition, the urine was monitored, and peritoneal dialysis should be timely applied once renal insufficiency was detected.

## Outcomes

Twenty-two infants were cured and discharged, while one infant died 23 days after surgery due to congenital volvulus

and resulting necrosis, with a mortality rate of 4.3% (1/23). Comparing with the conditions before surgery, hypoxia and pulmonary arterial pressure were significantly improved in all cases. Low cardiac output syndrome was postoperatively found in three infants, who then underwent delayed sternal closure; acute renal insufficiency was found in 1 infant, and the renal function was recovered 12 days after receiving peritoneal dialysis; delayed incision healing was found in five infants, and three of them were debrided and resutured.

## DISCUSSION

### Timing of surgery

In this study, four infants had been clearly diagnosed during prenatal examinations and underwent surgical treatment of ASO in 2, 5, 11, and 26 h after birth, respectively, and all of them were cured and discharged; among the remaining 19 infants who underwent surgery within one month after birth, 18 were cured and discharged while one died of intestinal malformations. Early ASO can reduce postoperative complications and mortality, as well as treatment costs.<sup>[3]</sup> However, a delayed operation may increase not only the use of mechanical ventilation and the incidence of respiratory tract infections, but also the medical costs and hospital stays.<sup>[4]</sup> Even in TGA infants with PDA and normal peripheral oxygen saturation, the average cerebral blood oxygen partial pressure is often only 50% or lower. Especially, the newborns may show evident hypoxemia, increasing damages to the central nerve system, especially the brain white matter. Early surgical treatment of ASO can also eliminate hypoxemia and help improve the prognosis and brain development of infants with TGA.<sup>[5]</sup> For this reason, once clearly diagnosed with TGA, all infants should undergo the surgery as soon as possible to effectively reduce pulmonary vascular resistance and timely improve hypoxia in infants. Meanwhile, the other possibly associated congenital malformations could be diagnosed and treated, contributing to the postoperative recovery and growth of the infants.

### Selection of surgical methods

In this study, 22 infants underwent surgical correction of Stage I ASO. One infant aged 28 days underwent rapid Stage II ASO, because preoperative ultrasound examination showed a left ventricular end-diastolic diameter of 15 mm and the pulmonary arterial pressure was intraoperatively measured (27 mmHg) as less than 50% of the aortic pressure (95 mmHg). ASO should be performed as early as possible for newborns with TGA, especially those with IVS, as it might lead to death from Hypoxemia. Meanwhile, a low pressure might occur in the pulmonary circulation, degenerating the left ventricular myocardium, and thus making it unable to bear the high load of systemic circulation. Comprehensive assessment of left ventricular function should be carried out preoperatively and intraoperatively. If the left ventricular contractility is decreased as the best treatment period is missed, the infant should undergo a rapid Stage II ASO. That is, a pulmonary artery banding should be carried out first to train the left ventricular function, and

ASO will be performed 1 week later when the left ventricular function is sufficiently improved to bear the afterload of systemic circulation.

### Proactive prevention and treatment of complications Coronary ischemia

Coronary arterial stenosis occurred after ASO is a life-threatening surgical complication, with an incidence of 3–18%.<sup>[6]</sup> The major reasons for coronary arterial stenosis include anastomotic stenosis, mechanical distortion and high tension of coronary artery, or operative injury, especially in the patients with intramural coronary artery in ascending aorta and single coronary artery. An appropriate anastomotic position should be accurately determined during the surgery, to avoid mechanical twisting and stretching that may cause coronary arterial stenosis. For the coronary artery that is abnormally distributed, the anatomy should be clear to avoid injury. For the single coronary, an anastomosis using the autologous pulmonary arterial vessel wall to enlarge coronary ostium can be employed to avoid ostial stenosis of the coronary artery. In this study, one case was found with the single coronary, originating from the left posterior sinus of the pulmonary artery. A “button” coronary ostium was excised, and its lower edge was sutured by the 7-0 Prolene to the proximal end of the aorta, while its upper edge was broadened with autologous pulmonary arterial patch graft and sutured to the proximal end of the new aorta with 5-0 Prolene, in order to avoid distortion and stenosis.

Vital signs and hemodynamic stability of the infants were closely monitored after surgery. In the early postoperative period, when the infants were observed with unexplained ventricular dysfunction, low cardiac output syndrome, and refractory arrhythmia, early arterial insufficiency should be highly suspected,<sup>[1]</sup> and reoperation should be performed immediately.

### Left ventricular dysfunction

In the early postoperative period, the observed left ventricular dysfunction might be related to the myocardial ischemia caused by postoperative coronary arterial stenosis, insufficient intraoperative myocardial protection, and the left ventricular atrophy induced by late timing of surgery. With the widespread use of prenatal care, as well as early ASO, preoperative left ventricular function assessment and training, intraoperative-enhanced myocardial protection, and the improvements in coronary arterial anastomosis, the incidence of postoperative left ventricular dysfunction has been drastically reduced. In this study, three cases were found with low cardiac output, with an incidence of 13.0% (3/23), and delayed sternal closure was adopted; 1 case with TGA/IVS underwent rapid Stage II ASO, and the postoperative left ventricular function was recovered well. The incidence of postoperative low cardiac output is not associated with the differences in age and weight of the infant. Intraoperative precise operation, enhanced myocardial protection, and shortened period of myocardial ischemia, combined with a preoperative comprehensive assessment of left ventricular function to identify the surgical

indications, as well as proactive treatment of left ventricular dysfunction, can effectively prevent the occurrence of low cardiac output.

### Other surgical complications

In this study, acute renal insufficiency was found in one case. Peritoneal dialysis was immediately performed, and the renal function of the infant was recovered 12 days later. Because of the young age, light weight, complex lesions, and poor operation endurance of the infants, five cases (21.7%, 5/23) were found with delayed incision healing after surgery. Three of them were debrided and resutured. Therefore, early feeding should be adopted after surgery to provide adequate nutrition, thereby preventing the poor wound healing.

In conclusion, TGA is a life-threatening complex congenital heart disease commonly found in infants. The defect can be early diagnosed through screening during pregnancy and postnatal examination. For infants clearly diagnosed of TGA, surgical correlation of ASO should be performed as soon as possible. However, for infants who have already missed the best treatment period, the left ventricular function should be comprehensively assessed, and the Stage II ASO should be adopted. By strengthening the intraoperative precise operation and myocardial protection, and enhancing the prevention of postoperative complications, satisfactory therapeutic effects can be achieved in improving the symptoms of ischemia and hypoxia and promoting the growth and development of the infants.

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### Conflicts of interest

There are no conflicts of interest.

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