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Embolization of Aortopulmonary Collateral Artery Cooperate with Valved Conduit Attached to the Right Ventricular Outflow Tract for Patient After Tetralogy of Fallot Repair: A One-Stop Procedure

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ABSTRACT

We describe a one-stop procedure for aortopulmonary collateral artery (APCA) and postoperative complications of Tetralogy of Fallot (TOF). Postoperative complications of TOF include right ventricular outflow tract stenosis, pulmonary valvular annular stenosis, pulmonary regurgitation, and aortopulmonary artery stenosis. The one-stop procedure was defined as after APCA embolization. The heart continued to function under cardiopulmonary bypass during median sternotomy to reconstruct the right ventricular outflow tract with a valved conduit and replace the aortopulmonary artery. A biological valved was sewed within the valved conduit in an artificial blood vessel in vitro and subsequently was used in the procedure and achieved significant results.

INTRODUCTION

Long-term survival and overall prognosis after surgical repair of the Tetralogy of Fallot (TOF) remain favorable despite the risk of reoperation [Nollert 1997]. Although surgical treatment may provide anatomical and physiological corrections, it appears to be an important risk factor for reoperation among survivors with advanced disease. In particular, pulmonary valve reconstruction of the right ventricular outflow tract (RVOT) often distorts pulmonary valve function, leading to long-term pulmonary valve regurgitation (PR) [Giannopoulos 2004]. PR is the most common and important clinical complication that usually occurs approximately 10 years after TOF repair. PR causes right ventricle enlargement and other complications, such as left ventricular insufficiency, arrhythmias, heart failure, and death [Mizuno 2014]. Currently, pulmonary valve replacement, percutaneous pulmonary valve stent implantation, percutaneous aortopulmonary stent implantation, and other surgical methods achieve good results; however, they have some drawbacks. However, these treatments seemed to be ineffective for patients with APCA, PR, pulmonary valvular annulus stenosis (PVAS), and pulmonary artery stenosis (PAS). Therefore, we implemented a one-stop procedure for patients with APCA, PR, PVAS, and PAS after TOF repair surgery and demonstrated the feasibility of the technique to achieve significant results.

METHODS

The patient successfully was anesthetized. The Seldinger method was used to puncture the right common femoral artery and insert a 5-F sheath. The catheter guidewire technique to conduct the "Pig" catheter to the proximal ascending aorta for angiography (ascending aorta, aortic arch, descending aorta, celiac trunk, superior mesenteric artery, and bilateral renal artery) was well-visualized. The descending part of the aortic arch showed two large lateral branches connected

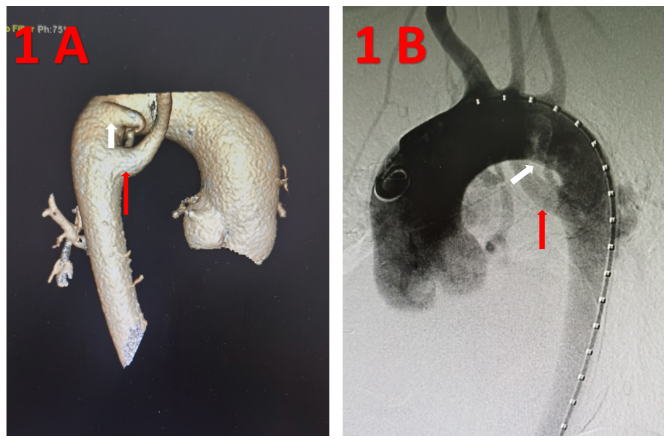

Figure 1. A) The computed tomography angiography reconstruction image of the aortopulmonary collateral artery. The red arrow showed the right aortopulmonary collateral artery, and the white arrow showed the left aortopulmonary collateral artery. B) The digital substraction angiography image of the aortopulmonary collateral artery.

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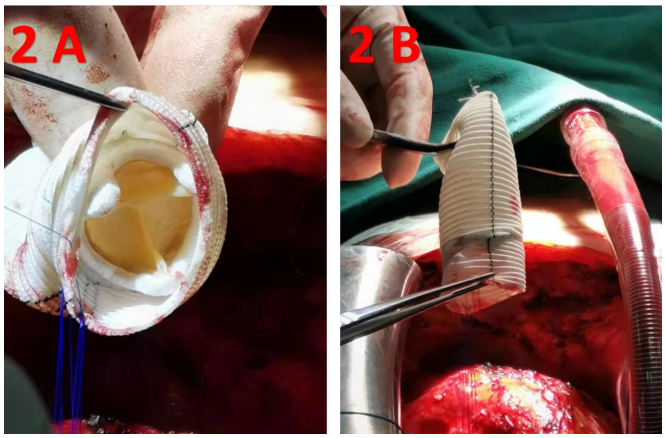

Figure 2. A) A biological valve was pre-sutured to an artificial straight blood vessel in vitro to form a valved conduit. B) The appearance of the valved conduit.

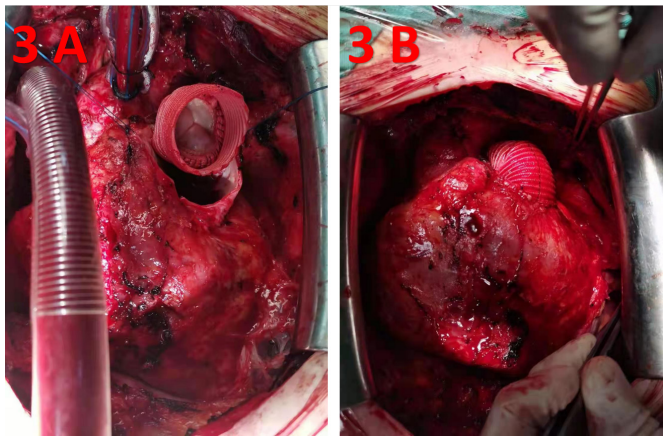

Figure 3. A) The distal end of the valved conduit was anastomosed with the distal end of the pulmonary artery. B) The proximal end of the valved conduit was sutured to the right ventricle.

to the left and right pulmonary arteries, which were approximately 20 mm apart, with diameters of 10 mm and 9 mm, respectively. One (the red arrow) was ascending from the descending aorta to the right pulmonary artery, and the other (the white arrow) was descending from the aortic arch to the left pulmonary artery (Figure 1A and 1B). The 2.7-F microcatheter (Boston Scientific, DirexionTM, Marlborough, MA) was guided into the collateral of the right pulmonary artery via the vascular sheath with an M001465 wire (Boston Scientific, Marlborough, MA), and two 8 × 40 mm spring coils (Boston Scientific, InterlockTM, Marlborough, MA) were placed through the catheter to embolize the right APCA. Similarly, three spring coils were placed to embolize the left APCA with the following type specifications: 12 × 40 mm, 10 × 40 mm, and 6 × 20 mm. No contrast agent was found in the lateral branches of the two pulmonary arteries. Next, the catheter guidewire and vascular sheath were removed, and the right common femoral artery was closed and wrapped with external pressure. Oozing blood was not detected, and the right dorsalis pedis artery pulsated well. The patient recovered well from the operation.

Following that, median sternotomy was performed, the sternum distractor was opened while stopping bleeding, and adhesive pericardium carefully was dissociated to expose the heart. Extracardiac examination showed right ventricular enlargement and 3 mg/kg heparinization of the whole body. Cardiopulmonary bypass (CPB) routinely was performed under thermal insulation without heart arrest. The pulmonary artery and right ventricular outflow tract were cut open, and no muscle bundle thickening was observed in the right ventricular outflow tract. The original pericardial patch was severely thickened and calcified, resulting in severe stenosis of the pulmonary valve ring and main pulmonary artery. The junction of the pulmonary valve annular to the aortopulmonary artery was cut, and a biological valve (type specification: 23#, Medtronic, Inc.) and an artificial straight blood vessel (type specification: 28#, InterVascular SAS), which was pre-sutured to an artificial straight blood vessel in vitro to form a valved conduit, were used (Figure 2A and 2B). The distal end of the valved conduit was anastomosed with the distal end of the open pulmonary artery using a 5-0 Prolene line, and the proximal end was sutured to the right ventricle. Finally, surgery was performed (Figure 3A and 3B).

DISCUSSION

Long-term survival and overall prognosis after surgical repair of TOF were satisfactory, which initially was performed with large right ventriculotomy and usually with the placement of a pulmonary annular patch to relieve right ventricular outflow tract obstruction. However, Kaemmerer et al revealed that significant anatomical residues and sequelae persisted or developed in many cases [Hickey 2009; Kaemmerer 2012]. First, TOF with severe PAS often led to APCA formation. When surgical repair is neither ligation nor incomplete ligation, the APCA expands with age and disease progression, and large amounts of aortic blood flow pass through these collateral arteries into the pulmonary circulation. If a patient undergoes reoperation, a large amount of pulmonary arterial blood will appear during the operation, affecting the surgical field exposure, increasing the difficulty of the operation, and prolonging the operation time. Additionally, this can lead to postoperative pulmonary perfusion, respiratory distress syndrome, low cardiac output, or even heart failure owing to ventricular overload postoperatively. APCA greatly varies and frequently is associated with APCA participating in the pulmonary blood supply. In addition to the limitations of anatomical location and reoperation field, as well as the effect of adhesive pericardial tissue, identifying or completely isolating the APCA during surgery results in a low surgical ligation rate, significant trauma, and poorer prognosis of patients. Therefore, before surgical pulmonary valve and aortopulmonary artery replacement, we performed embolization of the large APCA under intervention to establish a good foundation for subsequent surgical treatment.

PR, right ventricular outflow tract stenosis, pulmonary annulus stenosis, and PAS were reported as common complications after TOF repair during 20 years of follow up. Although the first radical surgical treatment can achieve anatomical and physiological corrections, a significant risk of reoperation remained in advanced survivors [Bacha 2001]. Furthermore, pulmonary valve replacement for patients with TOF can affect right ventricular volume, which subsequently affects right ventricular function [Latus 2021]. Therefore, most researchers have approved percutaneous pulmonary valve implantation to solve this problem and achieve good results. However, percutaneous pulmonary valve implantation cannot provide a complete therapeutic effect in patients with PAS. This problem can be resolved perfectly using our procedure at the same time. The proximal end of the prefabricated valved conduit was sutured to the right ventricle, which solved the problem affecting the right ventricle volume and relieved severe PR to achieve physiological and anatomical corrections. The distal artificial vessels were anastomosed with the distal left and right pulmonary artery bifurcations, and the PAS was relieved. It is worth mentioning that this procedure only needs to be performed with CPB without cardiac arrest and that the early interventional embolization of APCA provides good surgical conditions.

Our patient had a satisfactory surgical outcome that could be due to the selected one-stop procedure. First, interventional embolization of APCA was performed, which not only created a good surgical environment for the subsequent surgery but also reduced problems in the following aspects: 1) resulting in high return blood volume, poor surgical field exposure, and unstable perfusion pressure; 2) large intraoperative blood flow shunt may lead to hypoxia damage due to insufficient perfusion of the brain, kidney, and other important organs; 3) increased circulating blood temperature during operation, which was not conducive to myocardial protection; and 4) postoperative hyperperfusion of pulmonary vessels leading to "perfusion lung." Complete removal of the sequelae via surgery was critical. Valved conduits can simultaneously relieve PVAS, PR, and PAS without cardiac arrest in a timely manner in sewing the biovalve into the artificial vessel. This resulted in good postoperative outcomes for patients.

In conclusion, our one-stop procedure, in which embolization of APCA cooperated with a valved conduit attached to the right ventricular outflow tract for patients after TOF repair, was successful. This is a good option for patients, who are unsuitable for percutaneous pulmonary valve implantation or percutaneous aortopulmonary artery stent implantation. However, rigorous, long-term follow up and further extensive clinical use are necessary to allow complete evaluation of its effectiveness.

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