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Right ventricle to pulmonary artery conduit

Abstract

Right ventricle outflow tract reconstruction is required in various congenital cardiac disorders where there is discontinuity between right ventricle and pulmonary arteries, there is irreparable pulmonary valve stenosis or insufficiency or severe hypoplasia of Right ventricular outflow tract. The extracardiac Right Ventricle-to-Pulmonary Artery conduit has allowed routine repair of congenital anomalies with such defects. Right ventricular outflow tract (RVOT) reconstruction is one of the most challenging surgical procedure in neonates, infants and children as it depends on multiple factors like pulmonary valve or RVOT pathology, patient size and growth requirement.

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Introduction

The pulmonary valve replacement is the most common valvular procedure in patients with congenital cardiac disorder. Reconstruction of right ventricular outflow tract is one of the most challenging tasks in congenital cardiac surgery especially in neonates and infants. It is performed in patients with loss of continuity between RV and central pulmonary arteries or in whom there is significant pulmonary valve stenosis/atresia or regurgitation or hypoplasia of RVOT. Such conditions include Tetralogy of Fallot (with or without pulmonary atresia), truncus arteriosus, transposition of great arteries with pulmonary stenosis (whether congenitally corrected or not), pulmonary atresia with intact ventricular septum, certain complex forms of double outlet right ventricle or Ross procedure. Use of extracardiac conduit has permitted repair of these complex forms of congenital cardiac disorders.

Evolution

Journey began with use of non-valved pericardial conduit by Rastelli and coworkers in 1964[1] followed by Ross and Somerville using valved aortic allograft in 1966.[2] In 1970s and early 1980s the porcine valve Dacron conduit was most commonly used conduit, but it was associated with frequent development of neointimal peel within the Dacron tube causing late obstructive complications, hence was abandoned.[3] During late 1980s till late 1990s, cryopreserved aortic and pulmonary allografts became the first choice conduits. In 1999, bovine jugular vein graft was introduced and is widely used internationally.[4] Several other stentless heterografts such as the Lab-Cor, Tissue Med, Bio-Cor, and Shelhigh stentless heterograft conduits were developed, but not used on a wide scale.[5–8] Due to limited availability of extracardiac conduits, their high cost, increased rate of re-intervention and technical challenges in their implantation, many surgeons tried to devise new techniques so as to obviate the need of the conduits. These so called non-conduit options were based on the principle of creating direct continuity between RVOT and native pulmonary arteries so as to allow growth with age. These options included Reparation a l'Etage Ventriculaire or REV procedure introduced by Lecompte in 1982,[9] Nikaidoh procedure in 1984,[10] Barbero-Marcial procedure in 1990[11] with subsequent modifications in these procedures. However, these non-conduit options resulted in free pulmonary regurgitation causing right ventricular failure in short and long terms necessitating the use of pulmonary valve insertion. This issue was addressed by using monocusp RVOT patch constructed of autologous or bovine pericardium,[12] allograft pulmonary valve cusp[13] or PTFE membrane.[14] Others introduced bicuspid or folded PTFE membrane for this purpose.[15,16] To address the availability limitations of valved conduits and technical shortcomings of some of the non-valved conduits, another surgical option is the construction of a valved conduit from the patient's own pericardium or PTFE tube and using either PTFE membrane or autologous pericardium for construction of valve, especially in areas of limited resources.[17–20]

Ideal conduit

An ideal conduit should possess following characteristics: Long-term patency, Availability in a range of sizes, Good handling characteristics, Long-term valve function, Growth potential, Low cost, Low infectious potential and No need for anticoagulation. However, all these requirements may not be met by a single option. One of the major criteria that should be delivered by the conduit is its long term patency so as to decrease rate of re-intervention and associated complications. Durability of the conduit depends on multiple factors like age at the time of insertion, conduit size, underlying diagnosis, position of the conduit, residual pulmonary artery hypertension/stenosis and type of the conduit.[3,21–23] Type of the conduit used is one of the major factors for durability of the graft.

Recent work

Homografts have shown good short-term results[24–26] but the long term results have been disappointing[27–29] and are comparable with those of heterografts.[30] Obstruction in homografts most commonly occurs at the valvular level, which then requires stent implanatation and/or transcatheter balloon dilation, which is associated with unavoidable consequence of pulmonary regurgitation.[31] On the other hand, heterografts have the early disadvantage of bleeding; they cause coronary compression by the valve ring and their use is inadequate in neonates and infants with thin and friable pulmonary arteries.[32] Valve degeneration/calcification, peel tissue ingrowth and obstruction are the main causes of their late failure.[33,34] Several studies have been undertaken to compare the different conduits.[35–37] Freedom from explantation was significantly better for Contegra patients at 5 and 10 years as compared to allografts conduits (Contegra, 85% and 67% versus AC, 75% and 45%) in the study conducted by Fiore, Brown, and colleagues.[35,36] Vitanova and coworkers[31] evaluated durability of homografts, Contegra and Hancock conduits less than 15mm in size and concluded that 5years freedom from conduit explantation for the homografts, Contegra and polyester conduits were 69.4%, 59.4%, and 53.8%, respectively.

Therefore, to address the limited availability in small sizes, high cost and increased re-intervention rates associated with homograft conduits, surgeons have developed various alternative techniques to overcome these shortcomings by using patient's own pericardium or PTFE to construct the valved conduit with good results. Schlichter and coworkers[20] evaluated long term outcome of autologous pericardial valved conduit with bicuspid valve over 10 years. At 5 and 10years, freedom from re-intervention was 92% and 76% and was 100% at 10 years for conduits larger than 16mm at time of implantation. Lacour-Gayet and colleagues[38] and Kreutzer[39] reported 100% freedom from reintervention at 7years using pericardial valved conduits in patients with truncus arteriosus. Yamashita et al.[19] used ePTFE valved conduits with sinuses of size less than 16mm in 303 patients and followed them over a median period of 1.7years. Freedom from conduit replacement and freedom from conduit re-intervention were 90.1%±4.8% and 77.2%±5.6%, respectively. In ten year experience of Ando and Takahashi[40] using handmade trileaflet PTFE valved conduit in 139 patients, freedom from conduit explantation was 88.0%±6.8%, and mild pulmonary regurgitation was seen in 75.0% at 10years. However, these techniques are sophisticated and technically more demanding as they require specific instruments especially for construction of sinuses in the conduit. To overcome these shortcomings, Chang and Chang[41] developed a technique to make trileaflet PTFE conduit which is technically easier, less time consuming and has minimum suture length. All of their 15 conduits at 2years were functioning normally without any obstruction or regurgitation.

Conclusion

No conduit has been developed till today that has all the attributes of an ideal conduit. Further research and creativity is required to provide a conduit that will possess features which will increase longevity of the conduit by decreasing early structural deterioration, facilitate conduit implantation, improved flow characteristics so as to decrease valve stress, would have no antigenicity and may be able to grow with the patient.

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None.

Conflicts of interest

The authors declare that there is no conflict of interest.

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