Review article

Right ventricle to pulmonary artery connection: Evolution and current alternatives

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Abstract

Despite the introduction of different right ventricle to pulmonary artery reconstructive techniques and conduits, the ideal option is yet to be developed. Valved conduits mimicking the natural right ventricular outflow, however, they do not grow and re-operation for conduit replacement is inevitable. So, surgeons have constantly tried to evolve surgical techniques that would obviate their use and allow age-related growth. We tried to review the evolution of these techniques and the current status of these alternatives focusing on their suitability for variable age groups and different pathological entities.

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Keywords: Congenital heart disease; Allograft; Homograft; Pulmonary arteries; Rastelli procedure

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1. Introduction

A sizeable proportion of congenital heart defects have a component of RVOT abnormality. This may be in the form of a simple stenosis, severe pulmonary regurgitation (PR) or a more complicated right ventricle — pulmonary artery (RV-PA) discontinuity [1].

Absence of continuity between the RV and PA calls for a more complicated intervention. In these cases, a conduit must be implanted, or the pulmonary arteries must be approximated to the pulmonary ventricle directly, using a variety of well-known techniques [1−3]. Those lesions could be collected and categorized into three major groups (Table 1).

Despite the introduction of different RV—PA reconstructive techniques and conduits, the ideal options are yet to be developed [3]. We tried to review the evolution and current status of these options, focusing on value and limitations of each option and its suitability for variable age groups, anatomical and clinical situation. The different types of RV-PA conduits and reconstructive options were collected [1−4] and suggestively classified based mainly on the valvular element (Table 2).

2. Evolution

The journey started in 1964 when Rastelli and coworkers inserted a non valved pericardial tube as the first right ventricle to pulmonary artery (RV-PA) conduit in a child with pulmonary atresia [5]. Valved conduits were first used by Ross [6] and soon after by Rastelli [7] and since then have remained the mainstay of the treatment of RV — PA discontinuity. Irradiated cryopreserved homografts were used but were found to calcify and degenerate rapidly, resulting in severe conduit stenosis [8]. So the initial difficulties were homograft conduit patency besides limited availability [3].

Stented glutaraldehyde treated porcine aortic valve mounted in Dacron tubes (Hancock conduits) were developed to address these problems. Despite suboptimal handling characteristics, the relatively wide commercial availability in a range of sizes down to 12 mm made the value of these conduits [9].

Table 1
Types of RVOT discontinuity.

<table>
<thead>
<tr>
<th>Absent RVOT</th>
<th>Pulmonary atresia</th>
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<tbody>
<tr>
<td>Unsuitable RVOT</td>
<td>Truncus arteriosus</td>
</tr>
<tr>
<td>Iatrogenic</td>
<td>D-TGA + VSD + PS</td>
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<tr>
<td></td>
<td>L-TGA + PS</td>
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<tr>
<td></td>
<td>Complicated DORV</td>
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<td>Ross procedure</td>
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Table 2
RV-PA conduits and reconstructive options.

<table>
<thead>
<tr>
<th>Valved conduits</th>
<th>Homografts</th>
<th>Aortic homograft</th>
</tr>
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<tbody>
<tr>
<td>Xenografts</td>
<td>Stentless (native)</td>
<td>Stented (synthetic)</td>
</tr>
<tr>
<td>Manually constructed</td>
<td>Composite</td>
<td>Hancock valve</td>
</tr>
<tr>
<td></td>
<td>Autologous</td>
<td>Bovine jugular vein (Contegra)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Porcine aortic root (Free Style)</td>
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<tr>
<td>Valve less options</td>
<td>Non valved conduits</td>
<td>Prosthetic valve in a synthetic tube</td>
</tr>
<tr>
<td></td>
<td>Native</td>
<td>Valved pericardial tubes</td>
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<tr>
<td></td>
<td>Synthetic</td>
<td>Hancock valve</td>
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<tr>
<td>Non conduit repair</td>
<td>REV procedure</td>
<td>Hancock valve</td>
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<td></td>
<td>Nikaido operation</td>
<td>Hancock valve</td>
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<td></td>
<td>Half turned truncal switch</td>
<td>Hancock valve</td>
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<td></td>
<td>Barbero Marcieio technique</td>
<td>Hancock valve</td>
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<tr>
<td>Pulmonary valve replacement</td>
<td>Surgical</td>
<td>Tissue valves</td>
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<tr>
<td></td>
<td>Synthetic</td>
<td>Mechanical valves</td>
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<td></td>
<td>Interventional</td>
<td>Trans catheter pulmonary valve implantation</td>
</tr>
</tbody>
</table>
Fresh antibiotic sterilized homografts performed quite well in the pulmonary position for a limited number of centers [10,11]. The limited shelf-life of such products, however, prohibited this from becoming a commercially viable option despite clinical performance that was superior to heterografts [3].

Cryopreservation processes became further refined and cryopreserved homografts came into wide use in the mid-1980s. These homografts offered clear technical advantages over Dacron tube-mounted stented heterografts with regard to ease of implantation [1-4].

Because of homografts limited availability especially in small sizes, efforts persist (again) to arrive at a more readily available heterograft alternative. Freestyle considered as a good alternative [4,12]. In 1999, Contegra came in use and it is now commercially available and more widely used internationally [4,13]. Also, several other stent less heterograft options have been developed but not used on a wide scale, this group includes the Lab-Cor, Tissue Med, Bio-Cor, and Shelhigh stentless heterograft conduits [14-17].

Given the problems with the use of conduits, surgeons have constantly tried to evolve surgical techniques that would obviate their use. The common surgical principle in all these so called non conduit options is the direct continuity of right ventricular muscle with native PA and this would allow age-related growth. Additionally, some attempt is made at containing severe pulmonary regurgitation by incorporating a monocusp [1].

Lecompte in 1982 initiated this type of repair for correction of TGA with VSD and PS and he named his operation: Réparation à l’Etage Ventriculaire or REV procedure in short [18]. In 1984, Nikaidoh further extended this principle into a more radical repair [19]. A variation on this theme termed a “half-turned truncal switch” operation has recently been proposed by Yamagishi et al. [20].

Early attempts at conduit less RV-PA connection were confined to conditions with decreased pulmonary blood flow, because it was feared that postoperative pulmonary incompetence in the face of pulmonary hypertension would not be well tolerated and lead to adverse outcomes. The first successful attempt at non-conduit repair for TA was reported by Reid in 1986 [21]. Subsequently a series of cases were reported by Barbero-Marcial who modified the technique by using the left atrial appendage in the posterior wall [22]. Subsequent modifications by others have attempted to avoid the use of the left atrial appendage [3].

Another surgical option that addresses the availability limitations of valved conduits, and the technical shortcomings of some of the non-conduit options discussed previously, is the construction of a valved conduit from the patient's own pericardium [3,23]. This conduit is clearly attractive for surgeons practicing in areas of limited resources.

3. Ideal option

Favorable characteristics should the planned connection possess could be concluded in the following [1,3,4]:

✓ Long-term patency,
✓ Availability in a range of sizes,
✓ Good handling characteristics,
✓ Long-term valve function,
✓ Growth potential,
✓ Low cost,
✓ Low infectious potential,
✓ No need for anticoagulation.

These ideal criteria may never be delivered by a single option [1]. Also, these criteria are varied in importance and cannot be applied universally to the surgeon implanting, or patient receiving, such a conduit. For example, an adult patient should have no need for growth potential in a conduit. Also, the importance placed on conduit cost will depend on the medical economic milieu of the surgeon and patient. The first three ideals, however, must be largely met to offer viable surgical options for the patient. That is to say, the conduit must (1) be available in a size that can be placed in the patient's chest, (2) handle well enough for the surgeon to achieve a hemostatic, geometrically adequate repair, and finally, (3) offer some time period of patency so that reoperations are not required with prohibitive frequency. These three ideals, then, form the core needs for all right ventricle to pulmonary artery connections [3].
4. Conduit survival

Conduit survival is defined as the time to first conduit change [3] which determines the reoperation rate for each conduit that can be prohibitive or non-prohibitive for its use. It depends on two major factors:

- Durability of conduit function which is affected by [3,4,24,25]:
  - Conduit size/body weight mismatch: due to the non-growing nature of these conduits.
  - Loss of conduit diameter: Possible mechanical causes for this include longitudinal stretching, compression, or kinking of the conduit. Similarly; pseudo intima formation progressively reduces Dacron-mounted heterografts conduit diameter. Also, anastomotic stricture or calcific degeneration of the conduit valve are adding factors.
  - Age at conduit insertion: when used in neonates and young children, conduit longevity is markedly shortened because of a combination of progressive body-weight/conduit size mismatch and a poorly understood accelerated degeneration of the conduit valve. In addition, the physiologic tolerance for loss of conduit diameter will naturally be lower in a smaller conduit.
  - Position: In most studies, the major risk factor for conduit failure is the heterotopic position of the conduit mostly because anterior placement predispose to compression from the sternum and create more hemodynamic stress and orthotopic position of the conduit in Ross patients is associated with lower rate of reoperation.
  - Immunity: Recipient humoral and cellular immune response elicited after the implant of a cryopreserved homograft were proofed by some investigators. However, the clinical impact of this immune response to the development of conduit stenosis or the need for re-intervention is unclear. Similarly, though some studies have shown that ABO-compatible and HLA- matched homografts are more durable than unmatched homografts; this observation has not been consistently demonstrated.
  - Hemodynamic stress: residual branch pulmonary artery stenosis or high pulmonary artery pressure may have some influence explained by the burden created on the wall and valve but less consistently been shown to increase the risk of failure.
  - Type of the conduit: either valved or non valved, native or synthetic, homografts, xenografts, or autologous alternatives.

Criteria for conduit exchange:

The criteria for conduit change are not standardized, and are likely to change over time at even a single institution. The indications for conduit replacement in asymptomatic patients with conduit stenosis is ranging between near systemic (80%) or systemic pressure of the RV and a peak instantaneous Doppler systolic gradient greater than 65–70 mmHg in some centers and 40–50 mmHg in others with comparable late results; supporting using higher gradient as an indication for reoperation. Furthermore, trans-catheter interventions such as balloon dilatation or stent implantation when indicated may prolong the RV–PA conduit span and delay the first reoperation for conduit obstruction [25].

5. RV-PA conduits and reconstructive options (Table 2)

- Homografts

Cryopreserved pulmonary allografts were the gold standard in the United States from the mid-1980s through the late 1990s [26] and till 2004 Homografts were the most widely used conduits to restore or create continuity between the pulmonary ventricle and pulmonary arteries [3]. Homografts are classified as aortic or pulmonary and as irradiated, fresh antibiotic sterilized and cryopreserved. Cryopreserved homografts offered a clear improvement over antibiotic-tissue culture media storage with regard to shelf-life. Consequently, larger numbers of homografts became available in a wider range of sizes.

Cryopreserved aortic homografts show increased tendency toward calcification, but remain as durable as pulmonary homografts in growing children with normal pulmonary artery pressure [4] with several centers reporting superior durability for pulmonary homografts versus aortic homografts in adults. However, pseudo-aneurysm and fusiform conduit dilation are more common with pulmonary homografts when implanted into patients with elevated pulmonary artery pressures [27].
Forbes et al. [3] preferred evaluating each conduit by reviewing its characteristics in comparison to the ideal conduit characteristics mentioned before; especially: patency, availability and handling characteristics which are considered by some as the core three ideal attributes.

Favorable handling characteristics during implantation considered as the clearest advantages of homografts over other available conduit options including; suturing, compressibility. The bifurcating pulmonary grafts can be directly anastomosed to branch pulmonary arteries in the absence of adequate central pulmonary arteries [1,3,4].

Cost and availability of homografts are variable between countries and age groups. Homografts are generally limited in the smaller sizes (below 16 mm). So, homograft availability is an issue for the infant and neonates. Downsizing of adult homografts, to solve this problem, was introduced by some surgeons by removing one semilunar valve leaflet with a corresponding strip of the conduit. This converts the valve to a bicuspid arrangement, but this appears to function well in vitro tests and in patients [28].

Once a patient receives a conduit, re-operation for conduit replacement is inevitable. So, long term patency rate is one of the most important conduit attributes. Freedom from re-intervention rates reported in the literature for homografts ranges widely, from 30% to over 80% at 10 years [2] while non- Ross operation and Smaller conduit size (or younger age at operation) have been consistently shown in multiple series to be the main risk factors for homograft conduit failure [4,23]. The data comparing heterografts and homografts are more conflicted in adult-sized patients, with some centers finding stented heterograft conduits possessing superior durability to that of homografts, while others have found the opposite to be true [29,30]. These disparate inter-institutional findings might be explained by technical variables [3].

- **Xenografts**

Unlike homografts, xenografts are more heterogenous group of conduits. Xenografts can be stented or non-stented, totally native or composite native valve in synthetic tube and the animal of origin varied but mostly are bovine or porcine. Generally, advantages of xenografts conduits include abundant supply, availability of small conduits for neonatal applications, good handling characteristics (except those with Dacron tubes), and relatively low cost (in comparison to homografts) [2].

Hancock conduits were the first heterograft to develop. The main advantage was the availability in a range of sizes, down to 12 mm needed for repair in small age [3]. However, the Dacron tube was relatively stiff and difficult to sew onto pulmonary arteries and right ventricle of infants and small children. Also, the fixed diameter of the stented valve annulus, although protective from mechanical compression, contributed to difficulty positioning these conduits in the small chest [31]. Despite these suboptimal handling characteristics, their relatively wide commercial availability made the chance of primary repair in many centers for specific lesions especially truncus arteriosus which is difficult to palliate [9].

The longevity of these conduits was found to be of limited duration by a number of centers [32] and comparable to homografts in others even in patients below 1 year of age independent of their size [23].

Stent less heterografts have been developed and included several options; The Freestyle, Contegra and others. Freestyle is a glutaraldehyde-fixed porcine aortic valve and root has the potential for longer valve competence when compared with homografts in many series. The main disadvantages are un-availability below 19 mm in diameter and inadequate length to reach from the right ventricular free wall to the pulmonary arteries in most adult patients and usually extended by polytetrafluoroethylene or woven Dacron tube graft [12–33].

Contegra is a bovine jugular vein with its smooth valve and main advantages are; availability in multiple sizes ranging from 12 mm to 22 mm, reasonable cost, excellent handling characteristics with the smaller sizes are suitable for neonates and considered as good alternative to homograft conduits especially in small age [2]. Young age at implantation is a risk factor for re-intervention and distal conduit stenosis with significant early fibrotic ring formation at the distal anastomosis [33]. Also, dramatic conduit dilation and regurgitation in the setting of pulmonary hypertension or distal obstruction were reported [34] long term data reported in the literature regarding durability of the bovine jugular vein graft varies significantly, with freedom from re-intervention ranging between 66% at 3 years to 90% at 7 years [35,36].

Many other stentless heterograft conduits have been developed including mainly; Shellhigh (stent less porcine pulmonary valve mounted in a bovine pericardial tube) and Bio-Core (stent less porcine aortic valve mounted in a bovine pericardial tube) and less commonly; Lab-Core and Tissue-Med. In spite of some variations; the results of this
group of conduits considered suboptimal and did not gain wide acceptance or considered as good alternative to homografts [3].

○ Valveless options:

Because of the lack of growth potential for all types of valved conduits and consequently high rate of reoperations, as well as the relative expense of homografts and xenografts, the non-conduit repair which includes a number of technical options have been developed for RVOT reconstruction that avoid a valved conduit and call for direct anastomosis of the pulmonary arteries to the RVOT. These techniques include: REV procedure, Nikaidoh operation, half turned truncal switch operation produced by yamagishi, Barbero-Marcial technique for truncus arteriosus. The assumption is that, as in correction of tetralogy of Fallot with trans-annular outflow patch, there is a direct continuity of right ventricular muscle with native PA for at least part of the circumference of the reconstructed outflow and this would allow age-related growth [1]. Non valved tubes (will be mentioned in a separate section) either synthetic or pericardial are considered as another valve less option used mainly when valved conduits are not available and non-conduit repair is technically not feasible.

Severe pulmonary regurgitation would be a natural consequent for which incorporating a monocusp is always attempted. The monocusp RVOT patch can be constructed with autologous or bovine pericardium, allograft pulmonary valve cusp, or a 0.1 mm polytetrafluoroethylene (PTFE) membrane [4]. Each of these materials have demonstrated good immediate postoperative valve competency and reduced early PI but long term results varied. The major advantage of the 0.1 mm PTFE is that it does not allow tissue ingrowth and remains functional for a much longer period. In a study of 192 patients divided into three groups with variable RVOT anatomy; Freedom from increased PI greater than moderate was 86% at 1 year, 68% at 5 years, and 48% at 10 years and freedom from reoperation was 96% at 1 year, 89% at 5 years, and 82% at 10 years following surgery using PTFE monocusp patch [37].

The detrimental effects of chronic PR on RV function are now becoming more evident [38]. So, even for patients with previously protected pulmonary circulation, chronic PR is more deleterious in comparison to patients post tetralogy of Fallot repair as they have a larger ventricular incision which tends to be more in the body of the RV rather than in the infundibulum [1] and pulmonary valve implantation usually required. So, re-intervention for RVOT obstruction is reduced but re-intervention for RVOT in general is not significantly reduced [39,40].

For patients with decreased pulmonary blood flow; early survival is comparable to valved conduit repair [41]. In addition; non conduit repair provide a more direct route from the left ventricle to the aorta and offer improved long-term freedom from LVOTO obstruction which considered by Lecompte as the main advantage of the REV operation over the conventional Rastelli repair [42].

In truncus arteriosus the concern about long-term RV dysfunction remains but the more significant is the greater early mortality possibly because of the higher incidence of postoperative pulmonary hypertensive crises and some authors stated that; at least for repair of truncus arteriosus, early postoperative pulmonary valve competence contributes to favorable short-term outcomes [43]. However, tissue friability and limited space in neonates make conventional conduit repair difficult, and therefore non-conduit options hold greater appeal [1] and favorable results have been demonstrated because pulmonary vascular resistance is still low [44,45].

○ Surgical techniques

The common surgical principle in all these non-conduit options is: 1) direct autologous tissue approximation of the opened out main PA or PA bifurcation to the superior margin of the right ventriculotomy, thus creating the posterior wall of the RV outflow, and 2) roofing this with a generous patch of autologous pericardium to create the anterior wall of the outflow [1]. The detailed technical aspects of these techniques are described elsewhere but general description and main differences will be focused upon here.

REV:

Réparation à l’Etage Ventriculaire or REV procedure is the name given by Lecompte in 1982 to his description for the first of these types of repair for transposition with VSD and PS. Classic intra-cardiac repair requires generous resection of the infundibular septum to provide a straight path from the left ventricle to aorta with tunnel VSD closure.
to reduce the possibility of late LVOT obstruction. Extra-cardiac repair should include translocation of the PA bifurcation anterior to the aorta (Lecompte maneuver) and a mono cusp is sutured to the right ventriculotomy. Extensive mobilization of PA into the lung hilum on either side should be carried out with or without excision of wedge shaped area of the aorta to reduce stretch on the anteriorly trans-located PA and to allow a comfortable lie in front of the ascending aorta [17] but generally patients who have had prior systemic to pulmonary shunts tend to have fibrosis and thickening of the PAs that makes the Lecompte maneuver difficult or unsafe [1].

Nikaidoh operation:

In 1984, Nikaidoh described the aortic translocation; a more challenging but more anatomic repair for transposition with VSD and PS [18] that also can be further adapted with increasing experience to the treatment of other lesions like DORV with malposed great vessels and PS [41]. In his technique aortic root excised from the RVOT and sutured to the LVOT after excision of the pulmonary root, so, the LVOT is further straightened by this posterior translocation of the aortic root which often necessitates explantation and relocation of one or both coronary arteries as well. The VSD is closed with a patch to complete the left ventricular outflow following which the RV outflow is then reconstructed in much the same way as in the REV procedure, after performing the Lecompte maneuver [18]. The Nikaidoh procedure is also not feasible in all patients as in case of important coronary artery crossing the RVOT, pulmonary atresia and remote location of the VSD. However, even when anatomic variations preclude the use of the REV procedure or the Nikaidoh procedure in their original form surgeons can use modifications and combinations of these two procedures to achieve a conduit less repair [1].

Half-turned truncal switch operation:

Yamagishi et al. [20] described a more attractive variation for reconstructing the pulmonary outflow termed a “half-turned truncal switch” operation in which both semilunar valves are harvested as a single unit and, after coronary button removal, rotated 180°. The aortic valve comes to lie over the LVOT, as in the Nikaidoh and Ross- Konno operations, but the usually more diminutive pulmonary annulus is over the RVOT, where it can be split anteriorly and augmented with a flat patch, with or without a monocusp valve.

Reid and Barbero- Marcial techniques:

In 1986, Reid et al. [21] have proposed a non- conduit repair for Type I and Type II truncus arteriosus in which the pulmonary arterial confluence can be separated and drawn down directly to the right ventriculotomy. Barbero-Marcial et al. [22] connected the pulmonary confluence to the right ventriculotomy using a flap of the left atrial appendage. The anterior wall was then completed using autologous pericardium after mono cusp incorporation.

Manually constructed conduits:

Autologous Pericardial Conduits

Either valved or non valved, autologous pericardial conduit could be reconstructed at time of surgery. In 1964; Rastelli inserted a non valved pericardial tube, it was the first RV-PA conduit [5]. In the current era; only few centers consider valved pericardial conduits as a surgical alternative that addresses the availability limitations of other valved conduits, and the technical and physiological shortcomings of the non-conduit options discussed previously. In one series of 58 patients, although progression from mild to severe valve regurgitation over several months was reported by some but only 15% required surgical intervention on the conduit during follow-up period of 7.5 years [23]. The limitations of the technique are the requirement for a second surgeon to construct the conduit, and the likely inadequate amount of pericardium available in many re-operative sternotomy cases [3]. This conduit is clearly attractive for surgeons practicing in areas of limited resources.

Composite conduits:

Composite valve graft made of bio prosthetic or mechanical valves in Dacron or Polytetrafluoroethylene (PTFE) tube can be constructed manually at the time of the operation. Valveless synthetic tubes are less commonly used in the
modern era. Advantages of composite conduits include availability and long shelf life. Limitations include; non-suitability for neonates and small children, not amenable to catheter-based dilation or stenting if the child were to outgrow the conduit. Thus, an “adult” size is often implanted even in older children [2] introduction of recent modifications to Dacron processing have reduced the incidence of development of thick fibrous peels within the lumen of Dacron conduits [46] and recent studies have challenged the results of the previous studies suggested inferior durability of these conduits compared with homografts [29].

- Pulmonary valve replacement:
  - Mechanical valves
    Pulmonary valve implantation within native RVOT commonly performed following trans-annular repair of tetralogy of Fallot. The need for anticoagulation and the high risk of thrombosis is the well-known disadvantages of mechanical valves that limit their extensive use despite long-term durability of these valves [47]. Requiring anticoagulation for other reasons may justify use of mechanical valves in the pulmonary position [2].

- Bio prosthetic valves
  Stented bioprosthetic valves made of porcine and bovine pericardium have been implanted extensively in the pulmonary position. Calcification is the mode of failure of bio prosthetic valves, and several manufacturers have developed anti-calcification treatment processes to limit this complication. In a retrospective review of 229 pulmonary valve implantations at Children's Hospital Boston, no differences in freedom from structural valve deterioration could be found between several bio prosthetic valve types at short-term follow-up, with freedom from re-intervention of approximately 94% at 5 years [2].

- Trans-catheter valves
  Several types of trans-catheter valves have developed for application in the pulmonary position. The discussion of types and outcome of this category is beyond the scope of this work and can be reviewed elsewhere but what could be mentioned here is that trans-catheter PVI showed rapid evolution and has shown excellent short and mid-term outcome [48,49].

6. Summary

RV – PA connection: the way to the best choice:
Because we are dealing with a heterogenous group of patients and multiple non-ideal options, we tried to consider a reasonable way of thinking when choosing the way to connect the pulmonary ventricle to the pulmonary circulation making it optimum for a given patient rather than ideal for all patients through answering the following three questions:

- What are the available options?
  - The non-conduit repair is usually attending option if technically feasible and physiologically tolerated. Valveless tubes are usually available. Xenografts are available in countries with supported financial resources and to a lesser extent in developing countries. Homografts are the most unavailable option mainly because of limited donors especially in small sizes other than cost that is higher than other conduits.

- Which of the available options are suitable?
  - Suitability depends on three major factors:
    - Age: homografts, Contegra and pericardial tubes are suitable for neonate and small infants rather than synthetic materials and stented conduits.
    - Physiological considerations: valve less options carry very high risk in case of high pulmonary vascular resistance, small scarred pulmonary arteries and poor ventricular function.
Anatomical considerations: in case of big loss of the pulmonary arteries, pulmonary homograft is preferred for bifurcation reconstruction.
- Others: type of previously placed conduits, limited space in chest cavity and relation of great vessels

Which of the suitable options gives the best outcome?

… Which affected by surgeons and centers experience. Examples of these variations are:

✓ In neonates and infants with normal pulmonary artery pressures, several studies have shown superior durability of pulmonary homografts compared with aortic homografts and Contegra [13,50]. Yet other studies have demonstrated similar freedom from re-intervention between Contegra and homografts [23]. In the presence of elevated pulmonary artery pressures, aortic homografts are preferred [27,51].
✓ For adults, durability of stented heterograft conduit found by some centers to be superior to that of homografts while others found the opposite [29,30].
✓ … Simple algorithm for conduit choice could be conducted from the approach of Brown et al.; (1) For non Ross RVOT reconstruction: they favor the Contegra in infants, children, and young adults < 18 years old {either with or without support rings which resulted in a lower freedom from graft failure in one report but no positive impact was seen in reducing conduit dysfunction [52]} and the stentless porcine aortic root (Freestyle) or a stented biologic valve of at least 25 mm in diameter in patients >18 years old who require a pulmonary valve replacement to achieve an adequate effective orifice area. (2) For Ross procedure: the pulmonary homograft is their current conduit of choice for replacement of the pulmonary autograft in patients >5 years of age and in the younger Ross patients <5 years old, they favor the Contegra conduit [4].

7. Conclusion

A sizeable proportion of congenital heart defects have a component of right ventricular outflow tract abnormality. The conduit that possesses all of the favorable attributes has not yet been developed. Risk factors for early structural deterioration include young age at operation and non-Ross operation for most prostheses. Methods to improve the longevity of RV-to-PA conduits will focus on the production of materials that provide an optimal tissue match between the conduit and patient, which should facilitate conduit implantation, provide flow characteristics that minimize valve stress and reduce the risk of immune response to foreign antigens present within the conduit. Future research may provide a conduit with these characteristics, which most importantly will be capable of growing with the patient.

Options for RVOT reconstruction vary by age group. The use of RV-to-PA conduits in neonates and small infants allows an early biventricular repair, which ensures normal pulmonary blood flow and minimizes volume and pressure loading on the developing RV and eliminate the risks of palliation.

Cryopreserved homografts were the most widely used conduits to restore or create continuity between the pulmonary ventricle and pulmonary arteries. Alternatively, because of clear limitations, a number of the widely available heterografts have and are being implanted in the pulmonary position. Contegra is extensively used in the current practice especially in small sizes (TA). The non- conduit and autologous strategies for primary repair appear to contribute to higher early mortality rates especially in lesions with pulmonary hypertension, though outflow tract re-intervention rates are lower and they allow early primary repair when valved conduits are not available.

Value and limitations of all alternatives should be considered and surgical strategy should be tailored for each patient according to availability, suitability and experience of the surgical team.

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