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SUCCESSFUL REOPERATION USING HOMOGRAFTS FOR TRICUSPID AND PULMONARY VALVE REGURGITATION AFTER RADICAL DOUBLE OUTLET RIGHT VENTRICLE CORRECTION

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Currently, there is a growing number of repeat cardiac interventions in children who have previously undergone surgery for congenital heart defects. This has renewed interest in identifying reconstructive materials that are resistant to the host's defense mechanisms. Among such materials, cryopreserved homografts in various modifications are of particular relevance. Numerous studies have reported on the use of these prostheses in different anatomical positions; however, cases involving simultaneous implantation of multiple homografts in a single patient for correction of congenital heart defects remain rare. To our knowledge, there are no published reports describing the use of a mitral homograft as a tricuspid valve substitute in combination with prosthetic pulmonary valve replacement using an allograft conduit. This report presents the first successful case of double valve replacement in a pediatric patient who had previously undergone radical correction of a double outlet right ventricle.

Keywords: mitral homograft, pulmonary homograft, repeat interventions.

INTRODUCTION

Currently, there has been a noticeable increase in the number of repeat interventions in congenital heart disease (CHD) surgery. This trend is primarily associated with the growing complexity of the defects being operated on, and the improved survival rates of patients following CHD correction. Whereas the early stages of pediatric cardiac surgery were dominated by the search for effective methods of defect correction, one of the main challenges today lies in identifying the ideal reconstructive material – particularly for heart valve replacement – that maintains long-term functionality without degeneration.

The use of homografts in complex CHD surgery dates back nearly 60 years, beginning in 1966 when Donald Ross performed the first aortic valve replacement with a homograft in an 8-year-old child [1]. Today, pulmonary homografts are predominantly employed in pediatric cardiac surgery, while aortic and mitral homografts are more commonly used in adults [2]. Despite the technical difficulties associated with their implantation, homografts generally provide satisfactory long-term clinical outcomes. However, their broader application in children remains limited by the scarcity of small-sized grafts and the tendency of the tissue to calcify as the child grows.

This report presents the first documented case of double valve replacement – of both the pulmonary and tricuspid valves – using homografts in a patient who had previously undergone radical correction of a double outlet right ventricle (DORV).

CASE DESCRIPTION

A 15-year-old female patient weighing 77 kg was admitted to the pediatric cardiovascular surgery ward at Bakulev National Medical Research Center for Cardiovascular Surgery. She had previously undergone radical correction of DORV in 2009, which included reconstruction of the right ventricular outflow tract (RVOT) using a single-leaflet xenopericardial patch.

At the time of admission, the patient presented with signs of heart failure on physical exertion, including shortness of breath and fatigue. She had a history of frequent infections of the ear, nose, and throat (ENT) organs.

Transthoracic echocardiography revealed severe regurgitation of both the pulmonary and tricuspid valves, with marked dilation of the right ventricle (end-diastolic dimension – 5.7 cm) and right atrium (6.5 × 8.5 cm). The tricuspid annulus was enlarged to 42 mm (Fig. 1).

Based on preoperative diagnostic findings, a decision was made to perform RVOT reconstruction using a cryopreserved allogeneic conduit, with possible replacement of the tricuspid valve (TV).

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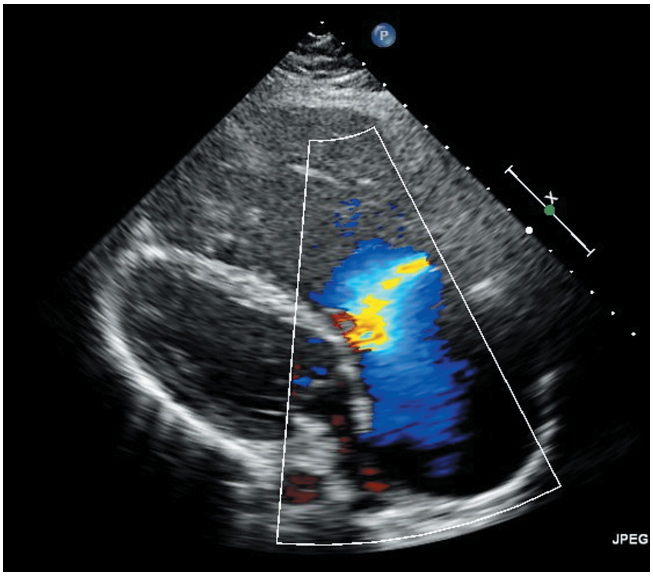

Fig. 1. Transthoracic echocardiography showing grade IV tricuspid valve regurgitation

The operation was carried out under standard cardiopulmonary bypass, hypothermia, and pharmacological cold cardioplegia using Custodiol solution.

Intraoperative examination revealed deformation and severe hypoplasia of all TV leaflets, rendering reconstructive surgery impossible; therefore, valve replacement was indicated.

At the pulmonary trunk level, marked calcification was observed in the previously implanted patch and the preserved native pulmonary valve (PV) leaflets. Complete excision of the calcified patch, native PV leaflets, and altered TV leaflets was performed. Subsequently, prosthetic replacement of the pulmonary trunk was carried out using pulmonary homograft No. 28 (Fig. 2a, Fig. 3a), and the TV was replaced with mitral homograft No. 32 (Fig. 2b, Fig. 3b).

During implantation of mitral homograft, the medial and lateral papillary "legs" were sutured to the interventricular septum, after which the prosthetic annular

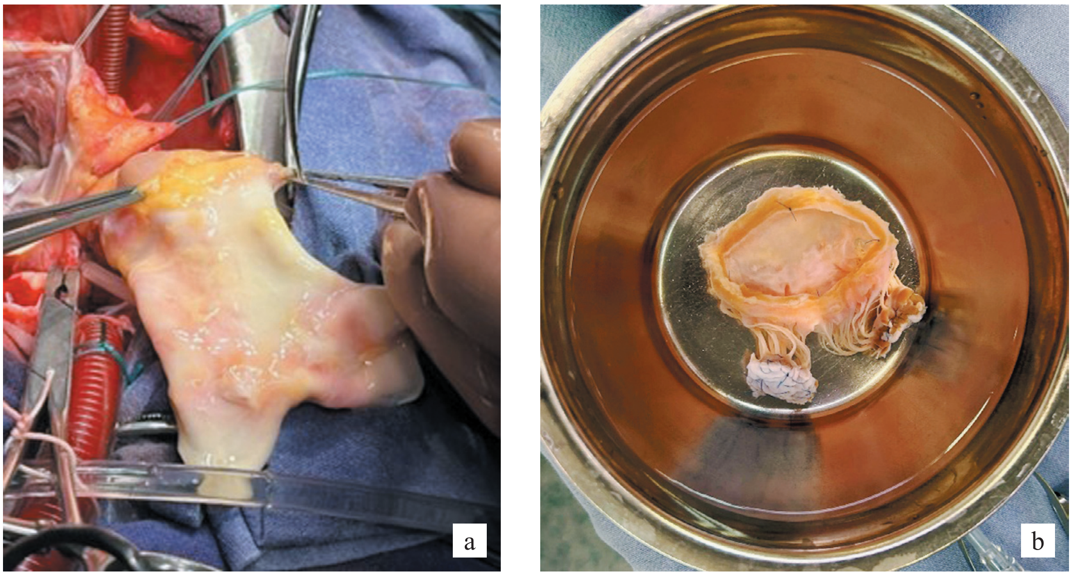

Fig. 2. General view of the homografts used for implantation: a, pulmonary homograft; b, mitral homograft

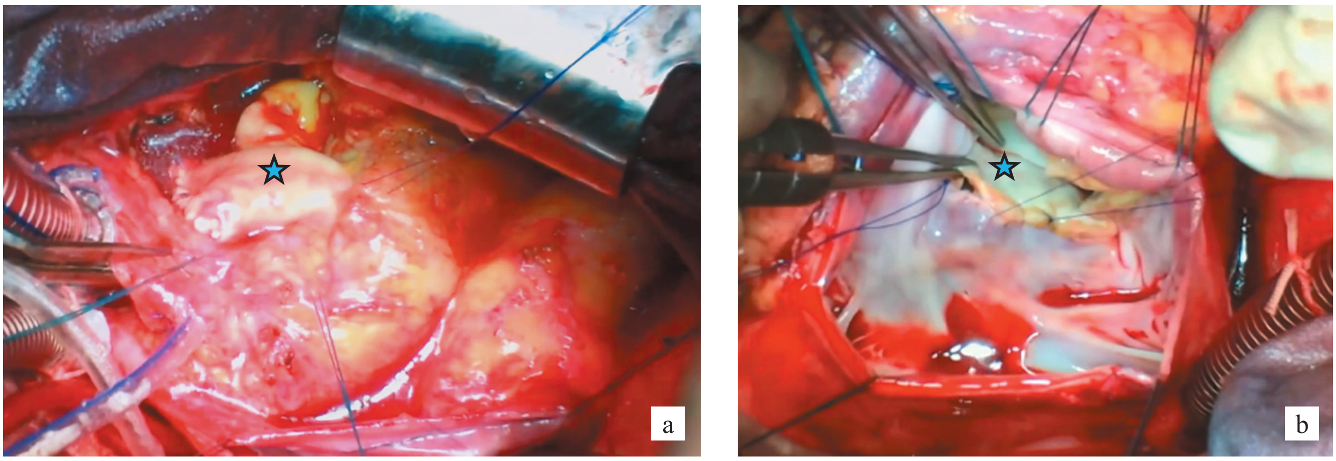

Fig. 3. Intraoperative photographs (patient's head positioned to the left): a, implanted pulmonary homograft (indicated by an asterisk); b, mitral homograft implanted in the tricuspid position (indicated by an asterisk)

rim was secured to the native fibrous ring. The total cardiopulmonary bypass time was 200 minutes, and the aortic cross-clamp time was 130 minutes.

The onset of cardiac activity after cardioplegia was accompanied by complete transverse heart block followed by restoration of sinus rhythm. The immediate postoperative period was uneventful, and the patient was discharged on postoperative day 11.

At the time of discharge, transthoracic echocardiography showed satisfactory function of both prosthetic valves without significant transvalvular gradients (PV prosthesis: systolic gradient 15 mm Hg, grade I regurgitation; TV prosthesis: peak diastolic gradient 4 mm Hg, grade I regurgitation).

At the 8-month follow-up, echocardiographic evaluation revealed no increase in transvalvular gradients or regurgitation.

DISCUSSION

Between 1966 and 1969, Huber and Senning were the first to use mitral homografts for TV replacement in two patients with organic valve disease; however, the outcomes were unsatisfactory [3]. The first series of successful implantations was later reported by Pomar and Mestres in 1993 [4]. In 1996, Hvass et al. described the first successful application of this technique in a six-year-old girl with infective endocarditis [5]. These encouraging results stimulated further development and refinement of surgical techniques for homograft implantation, including improved fixation of papillary muscles and reinforcement of the subvalvular apparatus.

In Russia, the first such operations were performed by Ivan Skopin at Bakulev National Medical Research Center for Cardiovascular Surgery in 1998. Four patients underwent surgery with good immediate and long-term outcomes [6].

The feasibility of using homografts for RVOT reconstruction was first demonstrated by Ross in 1966, when he implanted an aortic homograft into the pulmonary position in an eight-year-old child with pulmonary artery atresia [1]. Subsequently, advances in donor selection, sterilization, cryopreservation, along with increased availability, have firmly established homografts as an essential component of modern cardiac surgery [7–9].

Since the 2000s, alongside homografts, a new generation of biological conduits made from bovine jugular veins has been actively used, demonstrating favorable short-term [10] and long-term outcomes [11, 12]. However, as clinical experience with these conduits accumulated, multiple studies reported a high incidence of infective endocarditis (IE), which remains the principal limitation to their widespread adoption. In a comparative study by Ugaki et al., IE developed in 9.4% of patients with bovine jugular vein conduits, compared with only 0.7% in those with homografts [13]. Moreover, homografts are less prone to stenosis than other biological conduits, thereby significantly reducing the need for repeat interventions [13, 14].

Anticoagulant therapy is mandatory for all synthetic and mechanical prostheses, but it is generally unnecessary when using biological prostheses, including jugular vein and homograft-based conduits [15].

To date, a review of the scientific literature has revealed no published cases describing simultaneous double-valve (tricuspid and pulmonary) replacement using pulmonary and mitral homografts in a single patient. According to a meta-analysis by Van den Eynde et al., pulmonary artery replacement without concomitant correction of tricuspid insufficiency is associated with a higher incidence of significant residual regurgitation compared with simultaneous tricuspid valve repair or replacement [16]. In our case, plastic surgery was limited due to the structural pathology of the tricuspid valve.

Currently, there is a growing trend toward the use of endovascular approaches for reintervention on heart valves after CHD correction [17]. However, this technique remains limited by strict patient selection criteria and the relatively small number of studies confirming its long-term benefits and safety.

CONCLUSION

The presented clinical case demonstrates the feasibility of successful simultaneous implantation of a mitral homograft in the tricuspid position and a pulmonary homograft. Double-valve biological replacement of the pulmonary and tricuspid valves offers several key advantages: the implanted conduits can adapt to somatic growth, unlike frame-based biological or mechanical prostheses, and it eliminates the need for lifelong anticoagulant therapy.

Conflict of interest. *During the procedure, a pulmonary homograft manufactured by the laboratory of allogeneic materials for cardiovascular surgery at Bakulev National Medical Research Center for Cardiovascular Surgery (Moscow), headed by co-author K.M. Dzhidzhikhiya, and a mitral homograft produced by CardioStar (St. Petersburg), whose CEO is co-author V.A. Bolsunovsky, were used.*

REFERENCES

1. *Ross DN, Somerville J.* Correction of pulmonary atresia with a homograft aortic valve. *Lancet*. 1966 Dec 31; 2 (7479): 1446–1447. doi: 10.1016/s0140-6736(66)90600-3.
2. *Rajashekar P, Gupta A, Velayoudam D.* Choice of valve substitutes. *Indian J Thorac Cardiovasc Surg*. 2024 May; 40 (Suppl 1): 78–82. doi: 10.1007/s12055-024-01733-6.
3. *Huber R, Rothlin M, Senning A.* Spätresultate nach Atrioventrikulärklappenersatz mit Mitralallotransplantat.

Thorac Cardiovasc Surg. 1975 Feb; 23 (1): 33–38. doi: 10.1055/s-0028-1096923.
4. *Pomar JL, Mestres CA.* Tricuspid valve replacement using a mitral homograft. Surgical technique and initial results. *J Heart Valve Dis*. 1993 Mar; 2 (2): 125–128. PMID: 8261148.
5. *Hvass U, Lansac E, Chatel D, Henri I.* Mitral homograft for tricuspid valve endocarditis complicating a congenital fistula between the right coronary artery and right ventricle. *J Heart Valve Dis.* 1996 Sep; 5 (5): 564–566. PMID: 8895001.
6. *Shamsiev GA, Muratov RM, Amiragov RI, Babenko SI.* Long-term result of surgical treatment of tricuspid valve infective endocarditis with cryopreserved mitral homograft. *Russian Journal of Thoracic and Cardiovascular Surgery.* 2014; 56 (4): 52–55. (in Russ.).
7. *Shatalov KV, Bolsunovsky VA, Gamisoniya AM, Arnautova IV, Akhtyamov RR.* The first experience of implantation of a mitral homograft in the tricuspid position in children. *Russian Journal of Thoracic and Cardiovascular Surgery.* 2023; 65 (5): 589–594. (in Russ.). doi: 10.24022/0236-2791-2023-65-5-589-594.
8. *Jashari R.* Transplantation of cryopreserved human heart valves in Europe: 30 years of banking in Brussels and future perspectives. *Cell Tissue Bank.* 2021 Dec; 22 (4): 519–537. doi: 10.1007/s10561-021-09902-2.
9. *Brodskiy AG, Bolsunovskiy VA, Kosovskikh EA, Urvantseva IA, Tverdokhlib YaV, Tiltaeva LA, Belyaeva EE.* Correction of truncal insufficiency using a pulmonary homograph in a patient with a common arterial trunk and interrupted aortic arch. *Children's Heart and Vascular Diseases.* 2024; 21 (2): 158–162. (in Russ.). doi: 10.24022/1810-0686-2024-21-2-158-162.
10. *Bové T, Demanet H, Wauthy P, Goldstein JP, Dessy H, Viart P et al.* Early results of valved bovine jugular vein conduit versus bicuspid homograft for right ventricular outflow tract reconstruction. *Ann Thorac Surg.* 2002 Aug; 74 (2): 536–541; discussion 541. doi: 10.1016/s0003-4975(02)03728-1.
11. *Gist KM, Mitchell MB, Jaggers J, Campbell DN, Yu JA, Landeck BF 2nd.* Assessment of the relationship between Contegra conduit size and early valvar insufficiency. *Ann Thorac Surg.* 2012 Mar; 93 (3): 856–861. doi: 10.1016/j.athoracsur.2011.10.057.
12. *Boudjemline Y, Bonnet D, Massih TA, Agnoletti G, Iserin F, Jaubert F et al.* Use of bovine jugular vein to reconstruct the right ventricular outflow tract: early results. *J Thorac Cardiovasc Surg.* 2003 Aug; 126 (2): 490–497. doi: 10.1016/s0022-5223(03)00232-0.
13. *Ugaki S, Rutledge J, Al Aklabi M, Ross DB, Adatia I, Rebeyka IM.* An increased incidence of conduit endocarditis in patients receiving bovine jugular vein grafts compared to cryopreserved homograft for right ventricular outflow reconstruction. *Ann Thorac Surg.* 2015 Jan; 99 (1): 140–146. doi: 10.1016/j.athoracsur.2014.08.034.
14. *Vitanova K, Cleuziou J, Hörer J, Kasnar-Samprec J, Vogt M, Schreiber C, Lange R.* Which type of conduit to choose for right ventricular outflow tract reconstruction in patients below 1 year of age? *Eur J Cardiothorac Surg.* 2014 Dec; 46 (6): 961–966; discussion 966. doi: 10.1093/ejcts/ezu080.
15. *Boethig D, Schreiber C, Hazekamp M, Blanz U, Prêtre R, Asfour B et al.* Risk factors for distal Contegra stenosis: results of a prospective European multicentre study. *Thorac Cardiovasc Surg.* 2012 Apr; 60 (3): 195–204. doi: 10.1055/s-0031-1298062.
16. *Van den Eynde J, Callahan CP, Lo Rito M, Hussein N, Carvajal H, Guariento A et al.* Tricuspid Valve Intervention at the Time of Pulmonary Valve Replacement in Adults With Congenital Heart Disease: A Systematic Review and Meta-Analysis. *J Am Heart Assoc.* 2021 Dec 21; 10 (24): e022909. doi: 10.1161/JAHA.121.022909.
17. *Small AJ, Aksoy O, Levi DS, Salem MM, Yang EH, Aboulhosn JA.* Combined Transcatheter Tricuspid and Pulmonary Valve Replacement. *World J Pediatr Congenit Heart Surg.* 2020 Jul; 11 (4): 432–437. doi: 10.1177/2150135120918777.

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