Chapter

Contemporary Approach with Mitral Valve Allograft in the Treatment of Tricuspid Valve Pathology

Mikhail D. Nuzhdin, Roman N. Komarov and Vladimir A. Bolsunovsky

Abstract

Symptomatic tricuspid valve diseases are associated with a high risk of heart failure and poor prognosis. The current valve substitutes still carry the risk of associated complications. Allografts have been considered a valuable surgical option for decades since the first reports were introduced. The challenging surgical technique along with controversial results and homograft shortage discourage surgical society from wider use of allografts in tricuspid surgery. The largest world surgical experience with mitral allograft in the treatment of tricuspid valve disease is described in the study. A total of 20 patients underwent tricuspid valve replacement by mitral homograft in two clinics from October 2021 to February 2023. Surgical technique and initial results are presented in the chapter. There was no early mortality, postoperative bleeding, myocardium infarction, stroke, or sternal wound infection. Two patients needed permanent pacemaker implantation after redoing surgery before discharge. In the follow-up period, two patients suffered from a relapse of infective endocarditis in 3 and 6 months postoperatively with moderate homograft dysfunction, none of them underwent reintervention. There was no late mortality or permanent pacemaker implantation in the follow-up period. Satisfactory clinical and hemodynamic results, reproduceable technique and accessibility make homografts plausible valve substitutes in tricuspid surgery.

Keywords: allograft, mitral valve, tricuspid valve, endocarditis, valve prosthesis

1. Introduction

The prevalence of moderate-to-severe tricuspid regurgitation (TR) increases with age, affecting about 4% of the patients aged 75 years and is observed in up to 0.6% of the general population [1].

Primary TR usually appears as a result of infective endocarditis, rheumatic heart disease, carcinoid syndrome, myxomatous disease, endomyocardial fibrosis,

congenital heart disease, and other less frequent causes, such as thoracic trauma and iatrogenic damage [2].

Severe TR is associated with poor survival and worsening heart failure symptoms. [1, 3–5].

The choice between a biological valve and a mechanical valve for the tricuspid position is still controversial [6].

The use of allograft substitutes or autografts is not uniform across European and American units and is greatly dependent on surgeons' individual experience and training [7].

Technical challenge and the lack of training in these techniques over the last 10 years, coupled with the absence of readily available homograft valves at many centers, has restricted the widespread use of this substitute, confining the "art" of homograft surgery to the hands of a small group of surgeons [8].

It is undeniable that when such factors as the severity of the destructive process or its extension to the valves are involved, the balance in the choice of the most suitable substitute is critically weighted toward homografts over conventional stented or mechanical prostheses [7].

Replacement of the tricuspid valve (TVR) using a homograft could provide favorable in-hospital and mid- to long-term clinical outcomes for patients with a variety of causes and age groups, despite slightly complex surgical technique compared with prosthetic valve replacement. This procedure might be useful, particularly in treating active bacterial endocarditis or young patients, in centers at which homograft tissue is available [9].

2. Current clinical guidelines on the management of tricuspid valve diseases

In spite of clinical significance of early surgery, TV interventions are often initiated too late [10, 11]. Appropriate timing of tricuspid surgery is essential to avoid irreversible right ventricle (RV) dysfunction with subsequent increased surgical risk [12, 13]. Not only have clinical and diagnostic thresholds been defined but also there is inconclusive data for prognostic value of tricuspid annular pulmonary systolic excursion in patients with primary TR undergoing surgical intervention. Clinical importance of tricuspid annulus plane systolic excursion (TAPSE) and RV reverse remodeling have been highlighted predominantly in secondary tricuspid valve regurgitation studies [14, 15].

2.1 Indication for tricuspid valve intervention and prosthesis choice

Regarding severe primary TR, recent guidelines recommend surgical intervention in symptomatic patients. In selected asymptomatic or mildly symptomatic patients who are appropriate for surgery, an intervention should also be considered when RV dilatation or declining RV function is observed.

Whenever possible, annuloplasty with prosthetic rings is preferable to valve replacement, which should only be considered when the tricuspid valve leaflets are tethered and the annulus severely dilated [14, 16]. In the presence of a cardiac implantable electronic device lead, the technique used should be adapted to the patient's condition and the surgeon's experience [17].

TVR procedure accounts for less than 10% of all interventions on the tricuspid valve [18, 19].

Replacement of the tricuspid valve is a necessary measure in cases where annuloplasty is not possible (infective endocarditis, Ebstein's anomaly, reoperation after unsuccessful plastic surgery, prosthetic endocarditis) [19].

Mechanical valves are considered better durability, but higher risk of thrombosis, bleeding complication due to anticoagulation and decreased turbulence [19–21].

Biological prostheses do not require long-term anticoagulants and have a lower risk of hemorrhagic events, but at the same time durability is limited as a result of structural valve deterioration [16].

There are no specific guidelines devoted to a type of prosthetic valve that would be the best choice in the tricuspid position [22].

One meta-analysis strongly indicates the risk of thrombosis in mechanical valves is higher, while other end-points are not significantly different between the two types of valves [6].

Transcatheter tricuspid valve interventions may be considered by the Heart Team at experienced Heart Valve Centers in symptomatic, inoperable, and anatomically eligible patients in whom symptomatic or prognostic improvement can be expected. For detailed anatomical evaluation, transesophageal (TOE) echocardiography (ECHO) and cardiac computed tomography may be preferred owing to higher spatial resolution [23, 24].

3. Historical insight on allograft valve substitutes for tricuspid valve surgery

The first mitral homograft in humans was performed in 1965 by Senning. Since that time, there has been a limited number of implants mainly because of technical difficulties related to the insertion of the papillary muscles. Homologous transplantation of the mitral valve was also applied for TVR in the case of infective endocarditis or for the replacement of a degenerated bioprosthesis. Satisfactory results have been reported. However, due to the lack of anatomical landmarks, the implantation procedure has remained technically challenging. Thus until further progress demonstrated a clear superiority of the mitral homograft, bioprosthesis has remained the gold standard for replacing the mitral or the tricuspid valve with a biological substitute [25].

The most significant surgical experience with allografts in tricuspid surgery was reported by Hvass U., et al., 2002–9 patients, Couetil J.-P.A., 2002–7 patients, Kalangos A., 2004–8 patients [26–28].

The largest world experience with tricuspid homografts in the tricuspid position was depicted by Shrestha B.M.S. in 2010 and included 14 patients [9].

It should be mentioned that the overall allografts data regarding both mitral and tricuspid valve surgery is confined to small case series with a lack of initial and long-term results. Surgical techniques have not been described properly as well.

3.1 Indication for surgery and types of allografts used in tricuspid position

According to world surgical experience of allografts for tricuspid valve disease, the most relevant indications for interventions were: infective endocarditis, rheumatic heart disease, degenerative and congenital heart diseases including Ebshtein anomaly,

bioprosthetic dysfunction (**Table 1**.) [9, 29, 30]. Allografts had been utilized both in primary and redo cases [9, 29].

3.2 Surgical techniques

Historically, mitral and tricuspid homografts in the tricuspid position were used either for total (complete) valve replacement or for partial TVR, usually anterior tricuspid leaflet. Positioning of the mitral homograft in the tricuspid annulus also varied throughout the studies. Anti-anatomical orientation of the mitral homograft (anterior homograft leaflet to the septal portion of tricuspid annulus) was first introduced by J.L.Pomar, C.A.Mesters and many other authors followed such technique (**Table 2**) [30]. Conversely, anatomical orientation (anterior homograft leaflet to anterior portion of tricuspid annulus) was proposed only by Couetil J.-P.A., 2002 and Kalangos A., 2004 [27, 28].

The most challenging issue has always been securing homograft's papillary muscles in the right ventricle cavity. Right ventricle papillary muscles, along with the free wall and interventricular septum had been proposed for papillary muscle fixation (**Table 2**). Annuloplasty as a bail-out procedure was described in some studies, by the way, the data is inconclusive.

3.3 Outcomes

Initial and long-term results of allografts in tricuspid surgery are summarized in **Table 3**. Early and 30-day mortality was not reported in any study. Postoperative complications included a complete atrioventricular block in one study from Ostrovsky Y., 2015 and – postoperative bleeding that required resternotomy in another study from Luciani G.B., 2021 [32, 33]. Overall survival at the end of the follow-up period was 100 [90,7–100] %, freedom from graft dysfunction — 100%, and freedom from reoperation — 100 [79–100] %. All authors confirmed complete recovery from infection in patients who had undergone surgery due to infective endocarditis.

	Author, year	N	Etiology	Allograft type
1	Di Summa et al., [29]	1	Infective endocarditis	Tricuspid
2	Pomar and Mesters [30]	3	Infective endocarditis	Mitral
3	Miyagishima [31]	5	Infective endocarditis	Mitral
4	Hvass [26]	9	Infective endocarditis, congenital	Mitral
5	Couetil [27]	7	Infective endocarditis	Mitral
6	Kalangos [28]	8	Failed tricuspid repair in children	Mitral
7	Shrestha [9]	14	Infective endocarditis, congenital and rheumatic heart disease, redo surgery	Tricuspid (n = 13)
8	Ostrovsky [32]	2	Infective endocarditis	Mitral
9	Luciani [33]	1	Infective endocarditis	Pulmonary

Table 1.
Indication for surgery and allograft type for tricuspid valve (world data).

	Author, year	N	Graft orientation	Completeness of repair	Papillary muscle fixation	Annuloplasty
1	Di Summa et al., [29]	1	N/d	Total	RV papillary muscles	—
2	Pomar and Mesters [30]	3	Anti-anatomical	Total	RV free wall	N/d
3	Miyagishima et al. [31]	5	Anti-anatomical	Total	RV free wall	Rigid mitral ring
4	Hvass et al. [26]	9	Anti-anatomical	Total	RV free wall	Flexible annuloplasty ring
5	Couetil [27]	7	Anatomical	Partial	RV free wall	Ring
6	Kalangos [28]	8	Anatomical	Total	IVS RV free wall	Ring
7	Shrestha [9]	14	Anatomical	Partial	RV papillary muscles IVS RV free wall	Ring (n = 5), Suture annuloplasty (n = 2)
8	Ostrovsky [32]	2	Anti-anatomical	Total	IVS RV free wall	—
9	Luciani [33]	1	N/a	Total	RV papillary muscles	—

N – number of patients; N/d – no data available; RV – right ventricle; IVS – Interventricular septum.

Table 2.
Surgical aspects for homograft tricuspid valve replacement (world experience).

4. Contemporary approach for mitral allograft as a feasible prosthetic substitute in tricuspid valve surgery. Two-center experience

4.1 Patients and methods

4.1.1 Patient's population

Between October 2021 and February 2023, a total of 20 patients underwent TVR by means of mitral homograft at the two institutions ("Chelyabinsk Regional Clinical Hospital" and the "Sechenov University"). This study was approved by the Regional Ethics Committee of the 2 hospitals, and all patients signed their informed consent. The Institutional Review Board approved this study (# 19_2021) on 18 October 2021. The baseline clinical characteristic is depicted in **Table 4**.

4.1.2 Preoperative assessment and indication for surgery

Preoperative assessment included calculating EuroScore II risk, Tri-Score band, and MELD Score regarding the patient's age, clinical symptoms of right heart failure, ejection fraction, daily Furosemide intake, and major laboratory findings. Estimated and predicted in-hospital mortality and morbidity along with 3-month predicted mortality were taken into consideration [34–36].

	Author, year	N	Follow-up, month	Early and 30-day mortality	Survival	Freedom from graft dysfunction	Reoperation freedom
1	Di Summa et al. [29]	1	6	0	100%		100%
2	Pomar and Mesters [30]	3	252	0	33%		33%
3	Miyagishima et al. [31]	5	12	0	80%	N/d	N/d
4	Hvass et al. [26]	9	3	0	100%	100%	100%
5	Couetil [27]	7	46	0	85,8%	N/d	100%
6	Kalangos [28]	8	68	0	100%	100%	100%
7	Shrestha [9], 2010	14	126	0	100%	100%	78,6%
8	Ostrovsky [32], 2015	2	3	0	100%	100%	100%
9	Luciani [33], 2021	1	18	0	100%	100%	100%

N – number of patients; N/d – no data available.

Table 3.
Early and long-term outcomes for homograft tricuspid valve replacement (world experience).

4.1.3 Surgical intervention

TVR was performed using conventional cardiopulmonary bypass with bicaval cannulation and either cold blood or crystalloid cardioplegia infusion under the full-sternotomy.

4.2 Surgical technique for tricuspid valve replacement by means of mitral homograft

Homograft delivery was carried out by means of express airlines as soon as the decision to use homograft as a valve substitute had been made. All homografts were ordered from Saint-Petersburg Homograft Bank. Homografts implanted in patients were produced according to the specifications TU 9398-001-80,966,705. The starting material for the manufacture of homografts is the tissue components of the cardiovascular system of a deceased person. Unlike other similar methods of preservation, a sparing technique of osmolar decellularization and preservation of the native structure of the connective tissue matrix has been used. The manufacturing technology of this medical product ensures maximum preservation of the native properties of the connective tissue matrix and high hemocompatibility.

Important features of these products are their elasticity and plasticity, which makes it easy to model products during their implantation, taking into account the

Baseline characteristics.	**n (n = 20)**
Age (years), mean ± SD	38,8 ± 10,7
Height (см), mean ± SD	170,6 ± 7,43
Body mass index (kg/m^2), mean ± SD	23,6 ± 3,26
Body surface area (m^2), mean ± SD	1,81 ± 0,14
Weight (kg), mean ± SD	69,3 ± 10,1
EuroScore II, %, Me [Q1-Q3]	2 [1,3-2,5]
MELD Score, Me [Q1-Q3]	8 [7–9]
Estimated_3d_mortality, Me [Q1-Q3]	1,9 [1,9-1,9]
Tri-Score, Me [Q1-Q3]	4 [4–6]
Predicted in-hospital mortality(%), Me [Q1-Q3]	8[8–22]
Total bilirubin, Me [Q1-Q3]	14,8 [7,35-23,1]
Total protein, M ± SD	76,7 ± 8,69
Albumin, M ± SD	40,1 ± 6,63
Creatinin (mcmol/l), Me [Q1-Q3]	83 [74,8-95,5]
Daily dose furosemide (mg/day), Me [Q1-Q3]	40 [40–80]
Clinical signs	
Dyspnea, n (%)	20 (100%)
Leg oedema, n (%)	8 (40%)
Ascites, n (%)	5 (25%)
Uncontrolled infection, n (%)	5 (25%)
NYHA class, n (%)	II - 3 (15%) III - 12 (60%) IV - 5 (25%)
Pneumonia, n (%)	5 (25%)
Positive blood culture, n (%)	3 (15%)
Hepatitis C, n (%)	11 (55%)
HIV, n (%)	5 (25%)
ARVT, n (%)	5 (25%)
Under antibiotic therapy, n (%)	6 (30%)

M ± SD – mean and standard deviation; Me [Q1-Q3] – median and interquartile range. NYHA – New York Heart Association; HIV – human immune virus; ARVT – anti-retrovirus therapy.

Table 4.
Patient characteristics.

characteristics of the patient's individual anatomy. Homografts are stored at a temperature of 0 to 4 degrees Celsius or be cryopreserved and stored at a temperature of minus 150 degrees Celsius.

A homograft for mitral valve replacement is represented by a mitral valve with a muscular layer in the area of the annulus fibrosus, a 5 mm rim of the left atrial endocardium, a chordal apparatus of the mitral valve, and a section of papillary (papillary) muscles with a sutured platform.

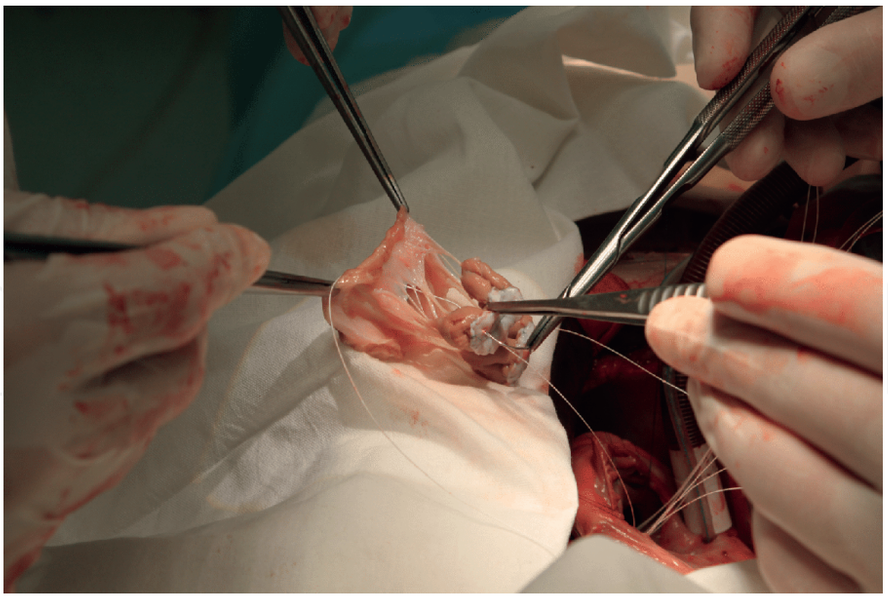

Figure 1.
Mitral homograft with papillary muscles reinforced with pericardial flap.

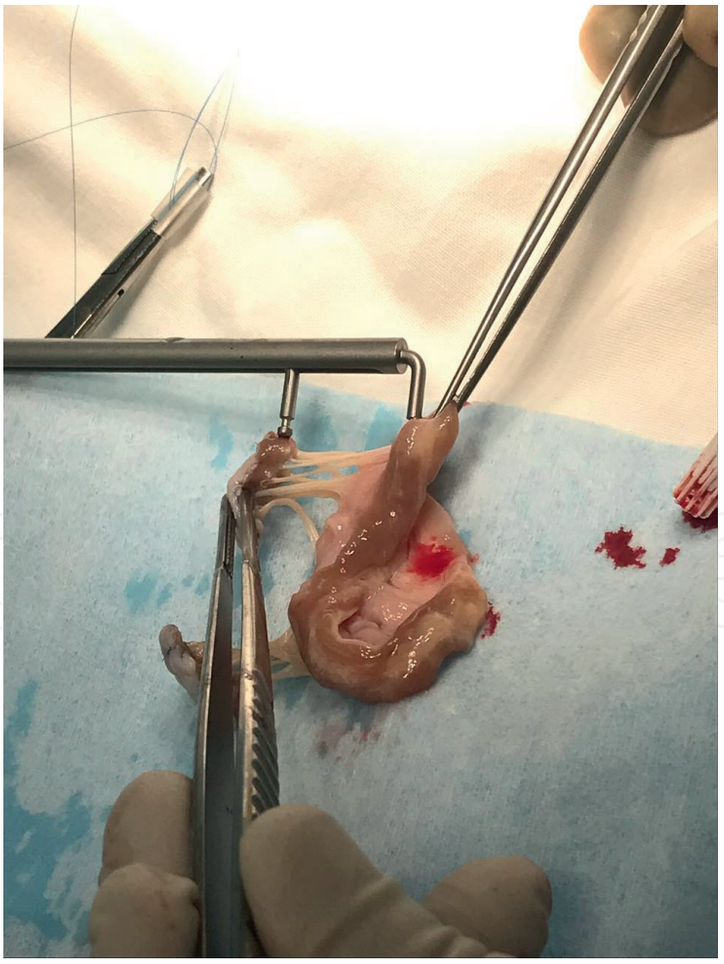

Figure 2.
Measurement of the distance between homograft annulus to the papillary muscle head.

In the manufacture of a medical product, the distance of the marginal chords to the papillary area is estimated and taken into account during its formation.

Freshly prepared products are stored in solution for 3 months. During this period should be implanted.

The sterility of each product is confirmed by negative microbiological and virological tests. It should be mentioned that the base of each homograft papillary muscle is reinforced with a pericardial flap for reliable suturing (**Figure 1**).

Assuming there is no guideline for sizing homografts preoperatively, our choice was based on measured tricuspid annulus diameter and surgical experience. The patient's body size, right ventricle dimensions, and pulmonary artery pressure were taken into account as well.

The original technique for TVR with mitral homograft that was proposed and utilized in our clinical had been described previously [37]. Further steps were partially modified in order to simplify the procedure and make results more predictable and stable. Those were: 1. keeping mitral homograft posterior leaflet totally oriented to septal portion of tricuspid annulus and anterior mitral homograft leaflet oriented straight opposite to the septal part, which is believed to preserve natural orientation of all homograft structures as a functional unit; 2. Harvesting and taking away any residual muscular tissue of homograft annulus; 3. Systematic use of rigid ring, either synthetic or biological (bovine pericardium); 4. Correction of any residual leaflet prolapse by suturing polytetrafluoroethylene (PTFE) chords. We did not take into account the complex anatomy of papillary muscle and diverse papillary head distribution, whereas the number of main muscles (generally 2), and their size was given full respect. Homograft papillary muscles were pre-implanted first in order to reduce the risk of tear of interventricular myocardium when the annulus was in place. The proper point for papillaries was chosen in accordance with measurements made on homograft (**Figures 2** and **3**).

In all cases, homograft papillary muscles were reimplanted to the interventricular septum just above the reflection of the supraventricular crest of the RV (for anterolateral homograft papillary muscle) and left to the anterior papillary muscle of the RV (for posteromedial homograft muscle) (**Figure 3**). Interpapillary distance was measured in all cases as well in order not to distort homograft anatomy (**Figure 4**). For papillary muscle, fixation were routinely used PTFE chords. Not only did it provide firm fixation, but also allowed further leaflet repair in case of residual prolapse (**Figure 5**).

Based on these principles, mitral homograft was oriented as a functional unit in the inlet part of the right ventricle cavity, given full respect to mitral valve apparatus and RV hemodynamic. Never have we ever considered the RV-free wall for papillary muscle fixation.

4.2.1 Echocardiographic assessment

Transthoracic ECHO was routinely performed by experienced medical technologists, before surgery, at 1 week, 6 months, and 1 year postoperatively. Preoperative and postoperative assessments, including grading of valve regurgitation, ventricles volumes, and function, were obtained according to guidelines [38]. All patients underwent intrapreoperative TOE ECHO to determine the degree of severity and location of tricuspid regurgitation and the final repair result.

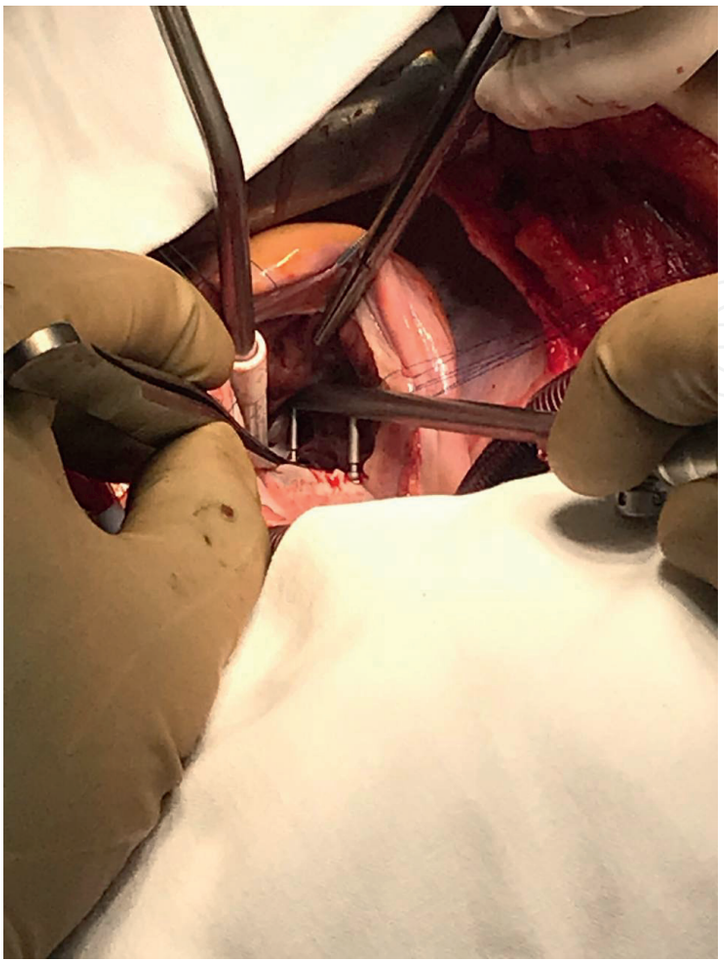

Figure 3.
Measurement of the distance between tricuspid annulus to the septum (just above the supraventricular crest).

4.2.2 Follow-up

Follow-up data after the operation were obtained through a review of patient medical records during follow-up visits and telephone interviews.

4.2.3 Definitions and data collection

Early and mid-term complications, as well as morbidity and mortality data, were summarized according to recommendations for reporting outcomes after cardiac valve interventions [39]. Early mortality was defined as in-hospital and 30-day mortality; late mortality was defined as death occurring beyond this period. Early graft dysfunction was defined as any homograft regurgitation with a vena contracta more than 0,7 cm due to central jet or periannular leak.

4.3 Statistical analysis

Descriptive statistics included continuous variables as the mean ± standard deviation or as the median and interquartile range; categorical variables are summarized as frequencies and percentages. Statistical analyses were performed using IBM SPSS Statistics Software for Windows, version 26.0 (IBM Corporation, Armonk, NY, USA).

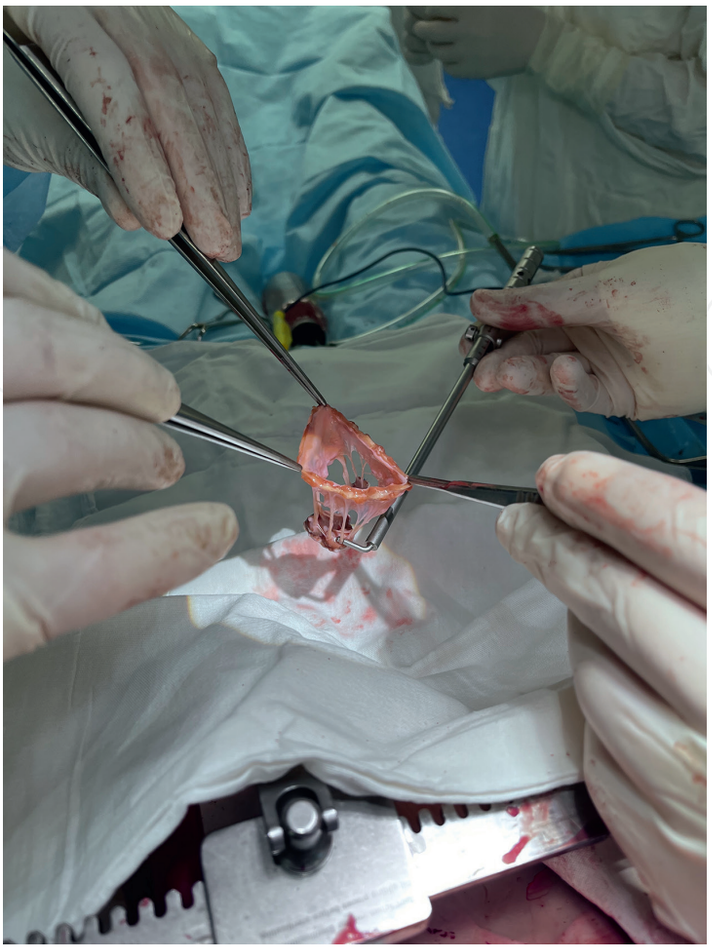

Figure 4.
Measurement of interpapillary muscle distance on the mitral homograft.

5. Results

5.1 Patient characteristics

Baseline characteristics are detailed in **Table 4**. The mean age was 38,8 ± 10,7 years, and 30% of the patients were female. All patients were operated on with acceptable predicted operative risk, in-hospital and 3-month mortality. Mean EuroScore II was 2 [1,3-2,5], while estimated 3-month mortality and predicted in-hospital mortality calculated by MELD Score and more specific Tri-Score were 1,9 [1,9-1,9] % and 8 [8–22] %, respectively. In our clinic, we persuaded the policy of early intervention rather than "watchful waiting" in terms of multiorgan failure in patients with severe tricuspid regurgitation, which is why there were no significant changes in major laboratory parameters before surgery. The mean daily dose of furosemide intake (mg/day) was 40 [40–80]. The majority of patients were highly symptomatic with III-IV NYHA class - 17 (85%). Surgical indications were based on the symptoms of heart failure in 15 (75%) patients, while the rest 5 (25%) had signs of uncontrolled infection despite appropriate antibiotic therapy. Due to prolong preoperative antibiotic medication, only 3 (15%) patients showed positive blood culture samples.

Figure 5.
PTFE chords are passed through the homograft leaflet.

5.2 Etiology of tricuspid valve disease and type of procedure

The etiology of tricuspid valve disease and types of procedures are depicted in **Table 5**. Among patients who underwent surgery, tricuspid regurgitation appeared due to infective endocarditis in 15 (75%) patients, as part of congenital disease in 4 (20%) patients, and degenerative lesions in 3 (15%) patients. Bioprosthetic failure accounted for 3 (15%) patients and mechanical prosthesis thrombosis in 1 patient. Most of the patients underwent intervention under either elective or urgent settings—8 (40%) and 10 (50%) patients respectively. Emergent tricuspid valve replacement was performed in two patients. There were 15 (75%) primary cases and 5 (25%) redo cases with a median interval from the first surgery 26 [3.5–78] months.

5.3 Early complications, mortality, and outcomes

Early postoperative complications and outcomes are highlighted in **Table 6**. There was no in-hospital mortality, postoperative myocardial infarction, stroke, renal failure, wound complications, and bleeding required resternotomy. Two patients who underwent redo surgery required permanent pacemaker implantation due to severe tricuspid annulus damage. In one patient with fungal prosthetic endocarditis, a parahomograft leak was diagnosed but did not require reoperation. This

Etiology of tricuspid valve disease	
Infective endocarditis, n (%)	15 (75%)
Degenerative, n (%)	3 (15%)
Congenital, n (%)	4 (20%)
Other, n (%)	2 (10%)
Bioprosthetic disfunction, n (%)	3 (15%)
Mechanical prosthesis thrombosis, n (%)	1 (5%)
Type of procedure	
Urgent, n (%)	10 (50%)
Emergent, n (%)	2 (10%)
Elective, n (%)	8 (40%)
Primary operation, n (%)	15 (75%)
Redo, n (%)	5 (25%)
Time from primary operation (months), Me [Q1-Q3]	26 [3,5–78]

Me [Q1-Q3] – median and interquartile range.

Table 5.
Etiology of tricuspid valve disease and type of procedure.

complication was considered as an early homograft dysfunction, nevertheless, it did not prevent a patient from complete endocarditis recovery and successful discharge from the hospital. In the follow-up period, two patients experienced a relapse of infective endocarditis in 3 and 6 months postoperatively with moderate homograft dysfunction, nevertheless, such dysfunction was tolerated well and patients recovered from infection. Patients have not been scheduled for redo operation yet. One patient had the second episode of endocarditis 1 year postoperatively and the affected valve was the aortic valve, whereas the mitral homograft was competent. There was no late mortality, or permanent pacemaker implantation in the follow-up period.

6. Discussion

Tricuspid valve operations continue to be among the most infrequently performed cardiac surgical procedures. An analysis of the Society of Thoracic Surgeons database reported only approximately 5000 tricuspid valve procedures performed per year, and most of these procedures were repairs [11].

TVR is therefore even less common, especially when it is performed in isolation [40].

It is not surprising that institutional analyses often evaluate multiple decades of operative practice to analyze fewer than 100 TVR [41]. Despite the fact that TVR has not seemed to be complicated in terms of surgical technique, operative mortality is still reported to be high, moreover, there are quite variable outcomes among studies. Leviner and colleagues reported 5.7% 30-days mortality and 14.3% 1-year mortality for the whole cohort, with a slightly higher, but not statistically significant, mortality risk for those patients who underwent isolated TVR [41]. According to Cheng Z., **e**arly mortality after TVR was 0–23.46% for biological valves and 3.03–40% for

Postoperative complications	N = 20
Myocardial infarction, n (%)	0 (0%)
Stroke, n (%)	0 (0%)
Pulmonary embolism, n (%)	0 (0%)
Pneumonia, n (%)	3 (15%)
Major bleeding, n (%)	0 (0%)
Resternotomy, n (%)	0 (0%)
Renal failure, n (%)	0 (0%)
Permanent pacemaker implantation, n (%)	2 (10%)
Other complications, n (%)	2 (10%)
Operative mortality, n (%)	0 (0%)
30-day mortality, n (%)	0 (0%)
Early graft dysfunction, n (%)	1 (5%)
PASP (mmHg), Me [Q1-Q3]	30 [30–35]
VC, Me [Q1-Q3]	0,1 [0,1-0,3]
Peak PG, Me [Q1-Q3]	5,1 [5–8]
Mean PG, M ± SD	3,16 ± 1,39

Me [Q1-Q3] – median and interquartile range; M ± SD – mean and standard deviation; PASP – pulmonary artery systolic pressure; VC – vena contracta on mitral homograft; Peak PG – peak transhomograft diastolic pressure gradient; Mean PG – mean transhomograft diastolic pressure gradient.

Table 6.
Early complications, mortality, and outcomes.

mechanical valves respectively, while the reoperation rate of biological valves was 1.94–22% while mechanical prostheses were 0.83–19.57% [6].

Regarding other significant postoperative complications, bleeding required resternotomy, and permanent pacemaker implantation remain to be unacceptably high—25.81 and 18.18% respectively, even in current reports devoted to isolated TVR with either biological or mechanical prosthesis [41]. In our study, zero mortality, and low postoperative complication rates were achieved. Having been proposed for TVR, mechanical and biological valves did not prove their complication-free profile, nevertheless, these valve substitutes are still recommended.

Among those studies that gave insight into feasibility of allografts in tricuspid surgery, there were a lot of inconclusive results in terms of surgical technique, and early- and long-term results. This fact could be explained by limited experience, homograft shortage, and low accessibility, as well as more complex surgical techniques. By the way, available data represent excellent initial results with allograft valves in the treatment of tricuspid valve disease [9, 31, 34]. Comparative studies with commonly used biological and mechanical prosthesis have not been conducted which increase the importance of our study by providing the relevant experience with mitral homografts in the tricuspid position. Obvious beneficial effects, derived from using homografts, could be a low reinfection rate, better hemodynamic performance, and no need for anticoagulation therapy, further valve repair options in case of endocarditis relapse or annular dilatation [42]. Not only does the homograft valve in tricuspid position allow further open valve repair, but also provides some opportunities for transcatheter TVR [43].

When it comes to possible drawbacks of using homografts in tricuspid surgery, such possible disadvantages are brought to mind—unpredictable long-term durability and variety of preserving methods for homograft tissue which therefore might rise or sustain existing reluctance to homograft surgery. Banking on the long-term durability of homograft tissue, relevant scientific data will be available provided a larger surgical experience appears. In accordance with Campelos P., long-term durability could generally be achieved for mitral homograft, but the data is confined to one report [30]. Recent advances in decellularized allografts for aortic valve surgery only encourage wider utilizing homograft valves in cardiac surgery [44]. The type of conduit is considered to be one of the most important factors in long-term durability, for example, the survival rate of the pulmonary conduit is higher than that of aortic conduit [45, 46]. Baltivala et al. found that the graft survival rate of patients with a history of transplantation was worse than that of other patients [47]. The relationship between bioactivity and durability of homograft valved conduit is still controversial. Fibroblasts living in the graft can reshape and reconstruct collagen structure and extracellular matrix, thus enhancing durability [48]. However, these unevenly distributed fibroblasts may have phenotypic changes and abnormal biological behavior due to immune responses or environmental changes. Decellularized valved conduits demonstrate almost complete removal of cells and cellular components by histological and immunocytochemical analysis without corresponding changes in biomechanics *in vitro* [49]. Studies compared rejection rate, immune response, and cellular activity in atrioventricular homografts vs. aortic and pulmonary homografts have not been published yet due to the complexity of comparison and different hemodynamic patterns, though it should be one of the future directions in homograft tissue science, implicated to cardio-vascular surgery.

7. Conclusion

Tricuspid valve used to be a "forgotten" valve in terms of hemodynamic consequences and appropriate time of surgery. Still, there is no ideal valve substitute for tricuspid valve replacement in cases of severe leaflet damage when valve repair is not feasible. A variety of challenging circumstances and unresolved issues exist in the treatment of tricuspid valve disease, which encourages us to find alternative solution in such clinical scenarios like active infective endocarditis, prosthetic endocarditis, and dysfunction where commonly used prosthetic material does not seem to be perfect. Assuming our initial experience with mitral homograft for tricuspid valve replacement, allograft tissue valves might take place as a plausible valve substitute, especially in patients with endocarditis, either native or prosthetic. Excellent hemodynamic performance along with highly acceptable clinical results could be achieved with mitral homografts in tricuspid surgery according to the results of our study. Low risk of perioperative complications, zero early and mid-term mortality, as well as no need for redo surgery in one postoperative year allow us to consider mitral homograft as an alternative substitute to the biological and mechanical prosthesis in tricuspid valve surgery.

Conflict of interest

The authors declare no conflict of interest.

Author details

Mikhail D. Nuzhdin[1*], Roman N. Komarov[2] and Vladimir A. Bolsunovsky[3]

1 State Budgetary Healthcare Institution Chelyabinsk Regional Clinical Hospital, Chelyabinsk, Russian Federation

2 Federal State Autonomous Educational Institution of Higher Education First Moscow State Medical University Named After I.M. Sechenova of the Ministry of Health of the Russian Federation (Sechenov University), Moscow, Russian Federation

3 Sain-Petersburg Homograft Bank, St. Petersburg, Russian Federation

*Address all correspondence to: austesla2022@gmail.com

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