Original Article

Cryopreserved Aortic Homograft for Aortic Valve Replacement. Immediate Results

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Objective

To assess immediate clinical and echocardiographic results of the use of cryopreserved aortic homografts for aortic valve replacement.

Material

Eighteen patients with aortic valve disease underwent aortic valve replacement, receiving a cryopreserved aortic homograft, 15 were male, 10 had aortic regurgitation, and 8 had aortic stenosis. Age ranged from 18 to 65 years (mean, 44.5 ± 18.14 years). Four patients had infective endocarditis, 12 patients were in functional class II, and 6 patients were in functional class III (NYHA). Left ventricular function was normal in 15 patients.

Results

Hospital mortality was 5.5% (1 patient) due to respiratory distress; the other patients were discharged from the hospital between the fifth and eighth postoperative days in functional class I. Maximal aortic transvalvular gradient, on echocardiography, ranged from 0 to 30 mmHg, with a mean of 10.9 ± 9.2 mmHg. Five patients did not have any degree of regurgitation through the aortic homograft, 11 patients (61.1%) had minimal regurgitation, and 2 had mild regurgitation. Duration of extracorporeal circulation ranged from 130 to 220 minutes (mean, 183.9 ± 36.7 minutes). Duration of aortic clamping ranged from 102 to 168 minutes (mean, 139.14 ± 25.10 minutes). Bleeding in the postoperative period ranged from 210 to 1220 mL, with a mean of 511.4 ± 335.1 mL. Reoperations were not necessary. Duration of orotracheal intubation ranged from 2 hours 50 minutes to 17 hours with a mean of 9.14 ± 3.6 hours.

Conclusion

Cryopreserved aortic homografts may be routinely used with low hospital morbidity and mortality.

Key words

aortic homograft, valve replacement, aortic valve disease

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The idea of using an aortic homograft (grafts derived from humans) for the treatment of aortic valve disease is not new and is often mixed with the history of aortic valve replacement. Actually, homografts were the first biological prostheses successfully used in the orthostatic position by Ross [1] and Barrat-Boyes [2] in 1962. These authors, working independently, used the subcoronary technique proposed by Duram and Gunning [3] and used "fresh" homografts, sterilized in antibiotic solutions and maintained in a nutritional solution, enabling storage for up to a month.

The limitations on the use of homografts included the difficulties in obtaining them, inefficient sterilization techniques, and the greater risk of valve regurgitation due to distorted or unaligned commissures, observed in the subcoronary technique, used in the first series [4-10]. On the other hand, the development of mechanical prostheses and biological prostheses, which were easier to obtain and maneuver, led to the replacement of the homograft.

Subsequently, the development of cryopreservation [11] enabling storage for long periods (up to 10 years) and obtaining valves from donors, with the heart still beating, and greater cell viability, aroused interest in homografts again, because of their excellent hemodynamic profile, low transvalvular gradients, and minimal incidence of thromboembolism and endocarditis [6,12-14]. Additionally, they are considered the ideal replacement prostheses in patients with active endocarditis [15].

The objective of this study was to present immediate results, up to 30 days after replacement, with the use of cryopreserved aortic homografts, in the aortic position, for the treatment of aortic valve disease.

Methods

Eighteen patients with aortic valve disease and an indication for replacement were selected to receive cryopreserved aortic homografts. The use of cryopreserved aortic homografts was approved in accordance with the guidelines of the Medical Ethics Committee.

Fifteen patients were male, 10 had aortic regurgitation, and 8 had aortic stenosis. Age ranged from 18 to 65, (mean, 44.5±18.14 years). Four patients had infective endocarditis, and in 1 patient endocarditis was complicated by 2 valve ring abscesses. Twelve patients were in functional class II, and 6 patients were in functional class III (NYHA).

Left ventricular function was normal in 15 patients, 2 had mild dysfunction, and 1 had severe left ventricular dysfunction.

Exclusion criteria were: valvular reoperations, associated co-

ronary disease, chronic renal disease, chronic obstructive pulmonary disease, peripheral artery diseases with severe clinical involvement, associated carotid lesions, associated multiple severe valvular diseases.

Patients underwent a midline sternotomy. Extracorporeal circulation was installed, with aortic and right atrial cannulation. Surgery was performed with mild hypothermia at 28°C.

Myocardial protection was performed through continuous retrograde cardioplegia through the coronary sinus in 10 patients and, in 8 patients, it was anterograde, through the coronary ostia, intermittent, every 20 minutes. Cold blood cardioplegia was used with potassium added (15mEq/L), only during induction, in the dosages. Perfusate blood was used without adding any potassium or other substances.

We used in all patients, tranexamic acid, albumin, corticosteroids, and we performed perfusate ultrafiltration, during the entire period of extracorporeal circulation.

The replacement technique used was the aortic root replacement with reimplantation of coronary arteries (*root replacement*).

We started with total aortic section, approximately 2cm above the sinus tubular junction. We performed aortic valve leaflet resection, valvular annulus decalcification when necessary, and measured the aortic annulus.

With the measurement of the aortic annulus, the cryopreserved aortic homograft was chosen, usually being 1- to 2-mm smaller than the aortic annulus. Next, thawing was performed in the operating room in 15 minutes (fast defrost).

While thawing was taking place, left and right coronary ostia were isolated. Simple 3-0 polyester stitches were passed over the aortic valvular annulus and in the valvular annulus of the aortic homograft. The homograft was lowered until the annulus and all the stitches were tied, leaving a Teflon tape fixed within each tied stitch, aiming at reinforcing hemostasia, and avoiding future dilations of the aortic annulus. Next, reimplantation of the coronary arteries was performed, with continuous sutures, using a 6/0 polypropylene. End-to-end anastomosis was performed of the distal end of the homograft and of the patient's aorta with a continuous suture 4/0 polypropylene.

During the procedure, left chambers were decompressed through a vacuum positioned in the left ventricle through the right superior pulmonary vein or through the tip of the left ventricle. This suction is also used to withdraw air and help in the restoration of left ventricular function, after aortic declamping.

In the intraoperative period, duration of extracorporeal circulation and myocardial anoxia (duration of aortic clamping) were assessed, obtained right from the perfusion chart. The need for performing associated procedures was also assessed.

In the postoperative period, the main clinical morbidities, such as the presence of myocardial infarction, stroke, acute renal failure, bleeding, need for reoperation, duration of orotracheal intubation, and respiratory complications, were assessed. Additionally, all patients underwent transthoracic echocardiography before hospital discharge, between the fifth and eighth postoperative days.

Results

Aortic homograft number 20 was used in 6 patients, number 22 in 10 patients, and number 24 in 2 patients.

Five patients underwent associated procedures, such as posterior enlargement of aortic annulus (Managuan) in 2 patients with congenital aortic stenosis, mitral valve plastia in 2 patients, and replacement in 1 patient who had infective endocarditis with ring abscess. Those abscesses were resected using bovine pericardium, and later placement of the aortic homograft.

Duration of extracorporeal circulation ranged from 130 to 220 minutes (mean, 183.9 ± 36.7). Duration of aortic clamping ranged from 102 (mean, 139.14 ± 25.10) minutes.

Hospital mortality was 5.5% (1 patient). This patient experienced bleeding in the aortic annulus at the end of the procedure, and it was necessary to resort to extracorporeal circulation. Because of that, total duration of extracorporeal circulation was prolonged, and the patient developed, in the postoperative period, respiratory failure from noncardiogenic pulmonary edema, leading to death on the seventh postoperative day.

None of the patients had electrocardiographic alterations that suggested ischemia or myocardial infarction due to coronary ostia mobilization; likewise, neither of the patients had low cardiac output syndrome.

Bleeding in the postoperative period ranged from 210 to 1220 mL (mean, 511.4 ± 335.1). No reoperations were necessary because of bleeding or coagulopathy.

None of the patients experienced neurological complications.

The orotracheal intubation period ranged from 2 hours and 50 minutes to 17 hours (mean, 9.14 ± 3.6). No respiratory complications occurred that required orotracheal reintubation.

All patients were discharged from the hospital between the fifth and eighth postoperative days in functional class I (NHYA).

All patients underwent bidimensional echocardiography before hospital discharge on the fifth postoperative day.

The maximal aortic transvalvular gradient ranged from zero to 30 mm Hg, with a mean of 10.9 ± 9.2 mmHg. In 2 patients, the echocardiogram revealed a normal aortic valve.

Five patients did not have any level of regurgitation by the homograft, 11 patients (61.1%) had minimal regurgitation, and 2 patients had mild regurgitation.

None of the patients experienced homograft dysfunction that required reoperation to exchange the homograft.

Discussion

In this study, it was found that implantation of cryopreserved aortic homografts by using the root replacement technique may be performed with low morbidity and mortality. Additionally, cryopreserved aortic homografts have excellent hemodynamic performance with a low transvalvular gradient, minimal regurgitation, and none of the patients experienced homograft dysfunction requiring intervention in the immediate postoperative period.

The following 2 variables influenced the clinical outcome in the development of the homografts: the preservation and the replacement technique. For these reasons, heterogeneous results are observed in the literature [4,5].

Efficiency of the preservation technique is assessed by the ability to preserve cellular viability, and this is assessed by the percentage of viable fibroblasts after valve implantation [16,17].

Homografts are classified according to the level of cell viability into homovital, viable, and nonviable [17]. The difference is in the

level of cellular viability, which varies depending on the preservation technique used.

"*Homovital" (fresh)* grafts are withdrawn from donors with the heart still beating, preserved in nutrient solutions, and implanted within 48 hours. *Viable homografts* are those that contain at least 50% of the live fibroblasts, achieved with cryopreservation [11]. The nonviable homografts are those that do not contain live cell elements, lost during a warm ischemia period or during the sterilization and the preservation process. This preservation takes place in media nutrients at 4°C temperature [17,18].

It is important to point out that this kind of preservation allows for a short period of storage, and this homograft must be used within 4 to 6 weeks at the most, whereas cryopreservation allows for long storage periods (up to 10 years).

Because of the cellular viability and the longer storage period available, cryopreservation has become the most common method currently used. In addition, several studies have demonstrated more favorable clinical results, reduced valvular regurgitation index, and need for reoperation, with cryopreserved homografts (viable) when compared with homografts preserved in nutrient solution (nonviable) [19-22].

Just as the valvular preservation methods influence the clinical results, the replacement technique is another extremely important factor in the immediate and late clinical outcomes.

Three types of replacement techniques are available for implantation of the aortic valve homograft. The first technique used was the subcoronary technique also known as *free-hand,* with 2 suture lines; the lower suture line is initiated in the lower part of the aortic valve annulus continuously, and the other suture line is subcoronary and by-passing the coronary ostia.

The second technique is the root replacement technique, more elaborated, where all of the aortic root is replaced and requires reimplantation of coronary arteries.

The third is the mini-root technique where the patient's aorta is maintained and covers the homograft, which is placed within it. Coronary artery reimplantation is also necessary.

Although several studies have reported satisfactory results using the subcoronary technique[19,21], this technique has a greater risk of aortic regurgitation. Recently, a high incidence of aortic valvular regurgitation has been described, ranging from 46 to 80% [8,23,24]. Rotating and turning the valve upside down, using continuous sutures, and especially-dilating the sinus tubular junction, hindering proper alignment of the commissures, are considered the main reasons for valvular regurgitation in the postoperative period [25,26].

On the other hand, comparative analyses have demonstrated more satisfactory clinical results with homografts using the root replacement technique, with a lower occurrence of valvular regurgitation, lower gradients, and a decreased need for reoperations [23,27].

In the present study, all homografts were cryopreserved, and the root replacement technique was used in all patients. Only 1 patient had mild aortic regurgitation in the postoperative period in the hospital, and the remaining patients had minimal or no aortic failure. Additionally, transvalvular gradients were low (mean, 10.9 mmHg). Only 1 patient had an increased maximal gradient (30 mmHg); 1 case was congenital stenosis, requiring enlargement of the aortic annulus, which may not have been ideal.

The occurrence of these low gradients and the absence of regurgitation confirm the excellent hemodynamic performance of cryopreserved aortic homografts used with the root replacement technique.

The absence of valvular support and the preservation of sinus tubular junction integrity determine proper blood flow throughout the aortic root, in the Valsalva sinus, and coronary ostia. Then, there will be a lower incidence of valvular regurgitation and a lower transvalvular gradient when compared with conventional prostheses (mechanical or biological) placed with support [28,29].

These low transvalvular gradients will reflect in the complete remission of ventricular hypertrophy [28], with improved left ventricular function [30], which may result in an increase in late survival [31].

Thus, it is possible to infer that the use of aortic homografts leads to an improvement in the clinical condition of the patients, and a ventricular reshaping with a possible impact on their late survival.

Another issue that has always been discussed is that surgery for replacement with homografts is longer, because of the more difficult operative technique, thus requiring a longer duration of extracorporeal circulation and aortic clamping (myocardial anoxia). This fact is often used to indicate that homograft surgery is a riskier procedure and may cause complications in the postoperative period.

Although the duration of extracorporeal circulation and anoxia is a real complicating factor, the literature has demonstrated that a longer duration of extracorporeal circulation is well tolerated, and it is not the main morbidity factor in the postoperative period.

A technical complication occurred in our material in the intraoperative period, leading to a prolonged duration of extracorporeal circulation and mortality. In the 17 patients without operative technique problems, the mean 183.9-minute duration of extracorporeal circulation was well tolerated, and no bleeding, low cardiac output, myocardial infarction, or other morbidities occurred related to extracorporeal circulation or to myocardial anoxia.

Hospital mortality with the use of homografts varies from 1.7 to 17% [27,32,33]. This great variability is given to the heterogenous population receiving the homografts. Because they are resistant to the development of endocarditis, aortic homografts have been used in patients with infective endocarditis, with annulus abscess, in addition to diseases with aortic root dilations.

Dossche and cols.[32], using the root replacement technique, reported a hospital mortality of 9.1%, explaining that this mortality was due to the complexity of the lesions associated with the aortic valve treatment, such as aortic dilations, endocarditis, and annulus abscess. They report only 1 death in the beginning of the study from replacement technique failure.

Likewise, Prager and cols. [27] had a 17% mortality due to morbidities associated with aortic dissection and extensive infections in the aortic root.

On the other hand, O´Brien and cols. [33] reported a 1.7% mortality using the root replacement technique, and Yacoub and cols.[34], reporting similar mortality rates, did not observe differences between the subcoronary technique free-hand, or the root replacement technique.

In our study, 1 patient had complicated endocarditis and annulus abscess; 2 patients underwent associated procedures, such as posterior aortic annulus enlargement, and 1 patient had severe ventricular preoperative dysfunction. Despite these morbidities, our only death (5.5%) occurred in the third patient undergoing replacement, without morbidities who had aortic bleeding at the

aortic annulus, because of a technical failure that may be attributed to the learning curve of the procedure. In the next 15 patients undergoing replacement, no mortality or hospital morbidity occurred. Therefore, for patients with isolated aortic valve disease, cryopreserved homograft will not increase hospital morbidity and mortality, and the possible complications are more commonly associated with preoperative conditions, such as ventricular function, infective endocarditis, and other related morbidities, rather than with the replacement technique itself.

From the results obtained, considering the excellent hemodynamic performance of cryopreserved homografts, with low transvalvular gradients, and minimal regurgitation, we believe that cryopreserved aortic homografts may be routinely used in patients with aortic valve disease and preserved left ventricular function.

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