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REVIEW ARTICLE

Surgical management of severe damage of the aortic annulus

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Mini abstract Aortic annular erosion and abscess are serious complications of prosthetic aortic valve endocarditis and can be treated with aortic valve translocation and left ventricle outflow tract reconstruction. These two surgical techniques seem to have similar early postoperative outcomes, and their use can be considered an option after the failure of conventional surgical methods.

1. Introduction

Aortic annular erosion and abscess are serious complications of native and prosthetic aortic valve endocarditis.[1] Although antibiotics alone may occasionally sterilize the abscess cavity, most patients require surgical treatment. The management of these lesions is difficult due to extensive tissue destruction, the lack of supportive tissue concerning where to implant the prosthesis, and eventual left ventricular aortic discontinuity.[2]

Surgical treatment consists of radical debridement of the infected area and reconstruction of the annular defect.

Several techniques have been described to treat this condition.[3–7] The exclusion of the abscess cavity is usually achieved using a patch to reconstruct the left ventricle outflow tract, with subsequent valve or root replacement. However, in cases of severe circumferential destruction of the aortic annulus, the reconstruction of the left ventricle outflow tract and translocation of the aortic valve into the ascending aorta have been suggested as alternative techniques to implant the new valve prosthesis away from the infected area.

In this article, we systematically reviewed the literature on this subject. Furthermore, we analyzed the outcomes of patients with severe aortic annular destruction treated by

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left ventricular outflow tract reconstruction or aortic valve translocation.

2. Materials and methods

2.1. Search strategy

A computerized search of the published English literature was conducted using the Medline database from 1946 to April 2014 with the use of the OVID interface.

(aortic valve endocarditis.mp. OR prosthetic aortic valve endocarditis.mp. OR outflow tract reconstruction.mp. OR aortic valve translocation.mp.)

Articles were considered relevant for this review if their subject was related to the issue. The selected articles were reviewed by the authors and were judged on their relevant contribution to the subject of this study. The "related article" function was used to broaden the search: all abstracts, studies, and citations were reviewed. Furthermore, all references listed were hand-searched for other relevant articles, and a citation tracker was used to identify any relevant literature.

2.2. Search outcome

Nine hundred sixty-three reports were found in the Medline database, among which 32 were included in this review. The results of the most relevant reports are presented in Table 1.

2.3. Inclusion and exclusion criteria

Studies concerning the transposition of the aortic valve and reconstruction of the left ventricle outflow tract were selected for analysis. The inclusion criteria were full-text papers that reported the presence of a severely destroyed annulus, postoperative mortality, and long-term follow up, as well as discussed the need for reoperation due to reinfection and valve dehiscence. Studies that did not meet these criteria were excluded from the analysis.

2.4. Data extraction

The following data were extracted from the reviewed papers: year of publication, patients' demographics, article type, postoperative mortality, reinfection rate, postoperative valve dehiscence, demography, and morbidity.

2.5. Data synthesis and statistical analysis

The data concerning the patient characteristics (age and mean follow-up) were summarized as weighted means. Common cumulative values were used to summarize preoperative characteristics (gender, presence of abscess, and patients with aortic prosthetic valve endocarditis) and postoperative results of the patients (hospital mortality, late mortality, reoperation rate due to reinfection, and valve dehiscence).

3. Results

3.1. Study population

One hundred twenty-one (121) patients were treated with aortic valve translocation or left ventricle outflow tract reconstruction, among which 113 (93%) patients had aortic prosthetic valve endocarditis. The age of the study group population ranged from 15 to 81 years. Fifteen patients (12%) died during the hospital stay, while late mortality occurred in 26 patients (21%). Eight patients (7%) had an episode of recurrent infective endocarditis requiring surgery. The presence of abscess or annular destruction was reported in all of the patients, and postoperative echocardiography revealed the presence of valvular or perivalvular leakage in five patients (4%) (Table 2).

3.1.1. Patients with aortic valve translocation

Thirty-nine (39) patients were treated with aortic valve translocation, among whom 34 (87%) had aortic prosthetic valve endocarditis. The age of the study population ranged from 15 to 81 years. Five patients (13%) died during the hospital stay, while late mortality occurred in 15 patients (38%). Two patients (5%) had an episode of recurrent infective endocarditis requiring surgery. The presence of abscess or annular destruction was reported in all of the patients, and postoperative echocardiography did not reveal any valvular or perivalvular leakage in any of the patients.

3.1.2. Patients with reconstruction of the left ventricle outflow

Eight-two (82) patients were treated with left ventricle outflow tract reconstruction, among whom 79 (96%) had aortic prosthetic valve endocarditis. The age of the study population ranged from 22 to 73 years. Ten patients (12%) died during the hospital stay, while late mortality occurred in 11 patients (13%). Six patients (7%) had an episode of recurrent infective endocarditis requiring surgery. The presence of abscess or annular destruction was reported in all of the patients, and postoperative echocardiography revealed the presence of valvular or perivalvular leakage in five patients (6%).

3.2. Surgical techniques

3.2.1. Aortic valve translocation

Danielson[8,9] and Reitz[10] treated the patients by translocation of the aortic valve, debridement of the abscess cavity, closure of the native coronary artery ostia, and coronary artery bypass grafting to the coronary arteries. Danielson inserted the valve in a supra-annular position in the native ascending aorta, tying the sutures externally, and suturing a Y anastomosis between the two venous grafts used to bypass the coronary arteries. Reitz located the aortic valve in a Dacron tube graft, which was then sutured into the ascending aorta, and suggested to bypass all three main cardiac vessels distally with single vein grafts. Nottin[11] reported the use of the same surgical procedure previously described by Reitz, but he modified the surgical

Table 1 Patient characteristics

Author	Number of patients	Age (years)	Gender	Destroyed annulus	Patients with APVE	Hospital mortality	Late mortality	Recurrent endocarditis	Follow-up (months)	Valve dehiscence	Type of surgery	Etiology
Danielson[8] 1973	1	15	1 M	1 (100%)	1 (100%)	1 (100%)	0	0	4	0	AVT	*Staphylococcus epidermidis*
Reitz[10] 1980	4	44 to 74 (mean 63)	4 M	4 (100%)	4 (100%)	1 (25%)	1 (25%)	0	4 to 18	0	AVT	*Enterococcus* = 3 Unknown
Nottin[11] 2005	21	18 to 81 (mean 44)	15 M 6 F	21 (100%)	21 (100%)	3 (14%)	7 (33%) Survival at 5, 10, 15-years: 38%, 38%, 35%	0	3 to 186	0	AVT	*Staphylococcus epidermidis* = 3 *Streptococcus* = 6 *Staphylococcus Aureus* = 4 Unknown = 6 Listeria = 1 Brucella = 1
Saxena[12] 2009	1	50	1 M	1 (100%)	1 (100%)	0	0	0	12	0	AVT	*Streptococcus mitis*
Dreyfus[15] 1989	1	17	1 M	1 (100%)	1 (100%)	0	0	0	6	0	AVT	*Enterococcus*
Endo[14] 1995	11	27 to 57 (mean 46)	9 M 2 F	11 (100%)	6 (54%)	0	7 (64%)	2 (18%)	6 to 62	0	AVT	Unknown
Frantz[16] 1980	2	22 and 67	2 M	2 (100%)	1 (50%)	1 (50%)	0	0	6	0	LVOTR	*Staphylococcus epidermidis* *Citrobacter freundii*
Jault[17] 1993	59	Mean 42 ± 16	NA	59 (100%)	59 (100%)	8 (14%)	6 (10%) Survival at 5-years: 51%	6 (10%)	72	5 (8%)	LVOTR	*Hemolytic Streptococcus* = 16 Enterococci = 7 Staphylococci = 13 Gram negative = 10 Other
Aoyagi[18] 2001	3	68 to 73 (mean 71)	2 M 1 F	3 (100%)	3 (100%)	1 (33%)	0	0	9 and 51	0	LVOTR	*Streptococcus* spp. = 2 *Staphylococcus aureus*
Masetti[19] 2008	6	25 to 57	NA	6 (100%)	5 (83%)	0	2 (33%)	0	10 to 63	0	LVOTR	Unknown
Stamou[20] 2011	12	29 to 61 (mean 49)	6 M 6 F	12 (100%)	11 (92%)	0	3 (25%) Survival at 5-years: 75%	0	3 to 132	0	LVOTR	Unknown

APVE: aortic prosthetic valve endocarditis; M: male; F: female; AVT: aortic valve translocation; LVOTR: left ventricle outflow tract reconstruction.

Table 2 Postoperative outcomes of patients undergoing AVT and LVOTR

	AVT	LVOTR	All population
Patients	39	82	121
APVE	34 (87%)	79 (96%)	113 (93%)
Hospital mortality	5 (13%)	10 (12%)	15 (12%)
Late mortality	15 (38%)	11 (13%)	26 (21%)
Recurrent endocarditis	2 (5%)	6 (7%)	8 (7%)
Valve dehiscence	0	5 (6%)	5 (4%)
Destroyed annulus	39	82	121
Age (years)	Range 15 to 81	Range 22 to 73	Range 15 to 81

APVE: aortic prosthetic valve endocarditis; AVT: aortic valve translocation; LVOTR: left ventricle outflow tract reconstruction.

technique by direct revascularization of the left coronary main trunk through a transverse sinus approach and then inserted the prosthetic valve inside a short Dacron tube implanted into the ascending aorta above the coronary ostia. Saxena[12] applied the surgical technique described by Danielson, implanting the aortic valve extra-anatomically at the level of the sinotubular junction.

Some authors have suggested the use of a modified Danielson technique to overcome the pitfalls of this technique. Endo[13,14] made a new aortic composite valve prosthesis using a translocation method. A single-ring prosthesis was separated from a ringed graft and then was sutured directly to a prosthetic valve. This composite ringed valve was fixed to the aortic wall at three points using U-shaped sutures, and the aorta was ligated circumferentially with a Dacron tape against the groove in the ring. However, Dreyfus[15] used a modified Danielson's technique by reimplanting the left main coronary artery directly into the conduit instead of using a venous graft.

3.2.2. Left ventricle outflow tract reconstruction

In the case of circumferential abscess, an extra-annular implantation of the aortic valve is required. Frantz[16] repaired the left ventricular-aortic discontinuity using a composite valve-woven Dacron tube graft sutured to the base of the heart with pledgeted horizontal mattress sutures through the ventricular septum, ventricular wall muscle, and mitral valve. The distal end of the graft was sutured into the lumen of the aorta, the aortotomy was closed over the graft, and the coronary ostia were sutured into the side of the graft. A different surgical approach was proposed by Jault[17], who suggested to treat the ventricular-aortic discontinuity by inserting a subcoronary valve conduit made of autologous pericardium. The graft was sutured on the left ventricular endocardium and on the anterior leaflet of the mitral valve, below the abscess, whereas its upper end was sutured to the aortic wall below the coronary ostia. Conversely, Aoyagi[18] suggested the use of a xenopericardial conduit to reconstruct the left ventricle outflow tract. A bovine or porcine pericardium was tailored to be a conduit that matched the left ventricle outflow tract in size. The distal end of the conduit was secured to the mitral valve annulus and healthy left ventricle wall, below the abscess, whereas the proximal end was sutured to the aortic wall below the coronary artery ostia. Next, the new prosthetic valve was fixed into the bovine pericardial conduit. Masetti[19] and Stamou[20] have suggested the use of a polyester graft for the reconstruction of the left outflow tract, and they applied a new surgical technique that combines the reconstruction of the left ventricular outflow tract and translocation of the aortic valve in patients with an annular abscess. After debridement of the infected tissue, a tubular graft is placed into the left ventricle outflow tract and is sutured to the mitral valve below the eroded area and adjacent myocardium. The graft is then everted from the left ventricle outflow tract, and a composite graft containing the valve attached to the graft is sutured to the rim of the tubular graft. The distal end of the composite graft is then sutured to the distal ascending aorta, and myocardial revascularization is performed.

4. Discussion

Prosthetic aortic valve endocarditis is the principal cause of annular erosion, and it can be successfully treated in most patients through combined medical and surgical therapies. Although medical therapy alone may result in a cure, most patients are best treated by valve replacement. The goals of the operation are to remove the infected tissue, restore the hemodynamic function, and correct any additional mechanical defects, such as septal perforation, aneurysm, or fistulas. Adherence to these principles usually allows the insertion of a new prosthesis in the normal anatomic annulus using conventional surgical techniques.[21–24]

When erosive abscesses occur in the aortic annulus, they can usually be debrided, and the annular defects can be reconstructed using different techniques. Small abscess cavities can be repaired with a direct closure, while large abscess cavities can be repaired using autologous pericardium or Dacron patches; if necessary, fibrin glue saturated with antibiotics can be injected into the cavity, and fistulae can be closed using patches in pericardium.[25]

In rare instances, the annulus can be destroyed to such an extent that satisfactory orthotropic placement of a new prosthesis is impossible. In this particular setting, whereas the aortic homograft is considered the treatment of choice for patients with extensive annular destruction and subannular abscesses,[26] radical debridement of the infected area and translocation of the aortic valve or reconstruction of the left ventricle outflow tract seem to be a surgical option because they allow implantation of the prosthesis and distancing from the focus of the infection.

The concept of the insertion of an aortic valve prosthesis into the ascending aorta is not new because this was suggested during the early years of cardiovascular surgery on the aortic valve. Roe,[27] in 1958, in an animal model, implanted the aortic valve in the ascending aorta. The main difficulty with this location is that the pressure in the coronary arteries is low during diastole when most of the coronary blood flow normally occurs.

Physiologically, the perfusion of the myocardium occurs during the diastolic phase of the cardiac cycle. Placing an aortic valve in the ascending aorta, above the coronary ostia, significantly reduces the amount of blood that reaches the myocardium in diastole, resulting in myocardium ischemia. Myocardial revascularization using vein grafts or the mammary artery is usually performed to overcome this pitfall.

In the case of prosthetic aortic valve endocarditis, the decision for aortic valve translocation should be based on the following criteria: extensive root infection with major disruption of the aortic annulus, dehiscence greater than 50% of the valve prosthesis with perivalvular necrosis extending to greater than 50% of the annular circumference, and the presence of one or more periannular abscesses.[11]

Although a major indication for using the described technique is endocarditis causing annular erosion, other indications include significant non-infective erosion and calcification of the annulus, particularly in the reoperative setting. A severely calcified and small annulus may preclude the correct and safe insertion of a prosthetic valve, resulting in a potential outflow tract obstruction.

Danielson[8,9] and Reitz[10] reported the first cases of the translocation of the aortic valve as an alternative technical solution to aortic a homograft, but the techniques used were slightly different. Danielson inserted the valve in a supra-annular position in the ascending aorta, and the coronary arteries were bypassed proximally. Reitz located the aortic valve in a Dacron tube graft, and the coronary arteries were bypassed distally, but this technique obliges the surgeon to dissect the left side of the heart to reach the circumflex artery, making the procedure more complex. However, these initial experiences were disappointing in terms of short- and long-term success. Nottin[11] reported the results of 21 patients with prosthetic aortic valve endocarditis and massive destruction of the aortic annulus and root. The hospital mortality was 14%. The 5-, 10-, and 15-year actuarial survival rates were 38%, 38%, and 35%, respectively. At follow-up, seven patients had died; none had recurrent infective endocarditis or paravalvular leakage, and none of the survivors developed aortic root dilatation. Saxena[12] applied, with success, the surgical technique described by Danielson[8] in a patient with prosthetic aortic valve endocarditis and a destroyed annulus who had previously undergone coronary artery bypass grafting.

The techniques described above[8–12] have the advantages of avoiding reimplantation of a prosthetic valve into an infected annulus and the promotion of healing of the aortic root abscess. The down sides are that the aortic root wall and subannular structures are unprotected from systemic pressure; the production of sutures at the circumference of the ascending aorta is not an easy way to fix the valve prosthesis to the aortic wall. A thread tied loosely causes leakage, and a tightened one damages the aortic wall, leading to hemorrhage during the early stage and pseudoaneurysm formation during the late stage. The presence of vein grafts puts the patients at risk for graft closure and myocardial infarction, and the implantation of an additional foreign body (Dacron graft) in proximity to the infected area might theoretically increase the possibility of reinfection.

Some authors have suggested the use of a modified Danielson technique to overcome the pitfalls of this technique. Endo[13,14] applied his threadless method technique in seven patients and compared the outcomes in this group of patients with a group of four patients treated with the original Danielson technique.[14] He reported no perioperative or hospital deaths in either group. At follow-up, the late mortality, vein graft failure, reinfection rate, and presence of aortic pseudoaneurysm were 100%, 25%, 25%, and 75% and 43%, 28%, 14%, and 0%, respectively, in patients operated using the Danielson's method and Endo's threadless method. The patients treated with the threadless technique seem to have had a better outcome. Conversely, Dreyfus reimplanted the left main coronary artery directly into the conduit instead of using a venous graft to reduce the risk of graft failure.[15]

Some authors[16–20] have suggested the reconstruction of the left ventricle outflow in the context of a severely damaged aortic root believing that this technique has particular value when severe destruction of the aortic annulus precludes the safe placement of a prosthetic valve into the aortic annulus and when insertion of a prosthesis would result in significant left ventricle outflow tract obstruction affecting the coronary ostia.

A technique that excludes the aortic root disease from the systemic pressure and avoids bypass grafting using a composite graft was first reported by Frantz.[16] A few years later, Jault[17] reported on 59 patients with prosthetic aortic valve endocarditis, 22 of whom had extensive circumferential abscesses. The ventricular-aortic discontinuity was treated in 11 cases by insertion of a subcoronary valve conduit. In 10 cases, a supracoronary valve conduit was used as previously described.[8] In one case, the author implanted an apicoaortic valve conduit. He reported a survival at 5 years of 51%. The reconstruction of the left ventricle outflow tract with a xenopericardial conduit was suggested by Aoyagi.[18] This technique was applied only in three patients with circumferential annular destruction. At follow-up, two patients survived, and none had recurrent infection, pericardial patch aneurysm, or prosthetic valve dehiscence. More recently, Masetti[19] and Stamou[20] have suggested the use of a polyester graft for the reconstruction of the left outflow tract. In 2008, Masetti,[19] in a series of six patients, among whom two had prosthetic aortic valve endocarditis and annulus destruction, did not report any hospital mortality. At follow-up, four patients were still alive (67%), and none had obstruction of the left ventricle outflow tract. A few years later, Stamou,[20] in a series of 12 patients, among whom four had prosthetic aortic valve endocarditis, reported a 75% 5-year survival. No recurrence of endocarditis was reported, and computed tomography of the chest at 1 year demonstrated patency of the coronary interposition grafts in nine patients.

The reconstruction of the outflow tract with a composite graft for the repair of extensive aortic root abscess has several advantages not offered by other techniques. Debridement of the abscess can be performed without the concern of leaving sufficient tissue for direct suture approximation of the aorta. The valve can be implanted in the reconstructed area. The remaining abscess wall is protected from systemic pressure by the Dacron graft, preventing gradual expansion and rupture of the aneurysm.

The coronary ostia and remaining rim of the healthy aorta can be sutured to the graft in a fashion that prevents tension on the sutures and possible distortion of the coronary arteries. Hemostasis is assisted by suturing the composite graft within the lumen of the aorta and closure of the aorta over the graft. Coronary bypass is not required in this repair, avoiding potential late morbidity associated with the use of saphenous veins.

The two techniques have been used mainly in the context of aortic prosthetic valve endocarditis for which the patients had a damaged annulus or an infectious abscess cavity or previous surgeries. Both techniques reported an acceptable rate of hospital mortality and recurrent endocarditis, with only a higher incidence of valve dehiscence in the group of patients who had undergone reconstruction of the outflow tract. The most common etiology identified was *Staphylococcus* and *Streptococcus* bacteria, but it was not possible to identify the causative agent in all cases of infective endocarditis. This limit makes it difficult to make an analysis focused on the causative agent as one of the primary determinants of the outcome.

Only a few articles are included in this review, and the number of patients treated with these two techniques is low. These factors made it impossible to perform a statistical analysis.

The aortic homograft is still considered the first-choice material in patients with severe annular destruction because of their greater resistance to infections than prosthetic valves; however, recurrent infection has been reported.[28] The disadvantages of homografts are their limited availability and tendency to calcify, placing the patient at risk for reoperation; furthermore, homografts may not be adapted to reconstruct a severely damaged aortic root. Several authors have reported favorable results of endocarditis treated with prosthetic material[28,29] in terms of the reinfection rate and long-term mortality, questioning the necessity of using biological material and advocating the use of prosthetic material with comparable results.[30,31]

The use of stentless prostheses in the treatment of aortic valve endocarditis has been advocated.

Stentless prostheses offer low reinfection rates ranging from 3.7% to 8.6%. The low reinfection rate and good hemodynamic values are comparable to cryopreserved homografts, and stentless prostheses are available at any time. The design of certain prostheses allows the application of various surgical techniques. In patients with less extensive aortic root abscess, a stentless prosthesis can be implanted in a subcoronary position. For patients with a more extensive infection, where the abscess is localized at and above the level of the annulus, the bioprosthesis can be inserted as a total root replacement.[32]

5. Conclusion

The aortic valve translocation and the left ventricle outflow tract reconstruction surgical techniques seem to have similar early postoperative outcomes. Their use should be limited to patients with aortic valve prosthetic endocarditis associated with extensive annular destruction and subannular abscesses, after failure of conventional surgical methods.

Conflict of interest

None declared.

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