Conservative Surgical Treatment for Active Infective Tricuspid Valve Endocarditis according to the "Clover Technique"

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ABSTRACT

Aims. This prospective study was undertaken to analyze the outcomes of conservative surgery with the "clover technique" for active infective tricuspid valve endocarditis.

Methods. Five consecutive patients underwent surgery for active infective tricuspid valve endocarditis. The mean age was 36.6 years. Four of the patients were men. In all patients, the tricuspid valve had become mutilated and infected. One patient had associated mitral endocarditis, and one had aortic endocarditis. *Staphylococcus aureus* was the most common bacterial species. Conservative surgery was indicated in all patients with infection limited to the leaflets and/or subvalvular apparatus of the tricuspid valve. Total resection of infected tissues was achieved in all cases. The tricuspid valve was then reconstructed according to the clover technique. A tricuspid annular ring was used in 2 patients.

Results. All 5 patients survived surgery. Intraoperative transesophageal and predischarge transthoracic echocardiographic evaluations showed good results in all patients. The mean follow-up time was 26.4 ± 12.5 months. No recurrent bacterial tricuspid endocarditis occurred during follow-up. All patients were in New York Heart Association functional class I. A transthoracic echocardiography evaluation at the latest control examination showed trivial leakage (3 patients) or no residual regurgitation (2 patients); no transvalvular gradient was found in any of the patients. No tricuspid valve calcification has been detected to date. Cardiac magnetic resonance imaging analyses showed no postoperative void flow and confirmed the preservation of right ventricular function and thus the reliability of this technique.

Conclusions. This novel technique is indicated for tricuspid valve endocarditis and should be considered as an adequate approach in cases of uncontrollable infection involving the tricuspid valve that is responsible for extended valve destruction.

INTRODUCTION

In surgery for tricuspid endocarditis, valve replacement or valvectomy is a common procedure in cases in which medical treatment has failed. The "clover technique" valvular plasty is a new procedure that has allowed us to repair difficult lesions. Prolapse of an entire leaflet or leaflets and/or destruction of the subvalvular apparatus by endocarditis were accessible for conservative surgery with this technique. We report our initial experience with 5 patients in whom we used the clover technique to remedy active infective endocarditis of the tricuspid valve.

PATIENTS AND METHODS

Patients

Between June 2004 and September 2006, 5 patients (4 men, 1 woman; mean age, 36.6 years; range, 29-50 years) underwent tricuspid valve repair with the clover technique. Four patients were intravenous drug addicts, 2 of whom had hepatitis C infection. Four patients had a community-acquired infective endocarditis due to *Staphylococcus aureus* infection, and 1 patient had a nosocomial endocarditis due to *Escherichia coli* infection. Surgery was indicated in all 5 patients because of uncontrollable sepsis, and respiratory failure with massive tricuspid insufficiency was present in 3 of them. Preoperative echocardiography examinations showed limited spread of the infection to the leaflets and the subvalvular apparatus. No annular abscesses were found. The patients' characteristics are summarized in Table 1.

Large vegetations (>2 cm) were found in 4 cases and were associated with destruction of the anterior leaflet in 1 case, of the anterior and septal leaflets in 1 case, and of the anterior and posterior leaflets in 2 cases. One patient presented with a disinsertion of the anterior leaflet (Table 2).

Preoperative echocardiography examinations showed severe tricuspid insufficiency in all of the patients (Table 3).

Two patients underwent preoperative cardiac magnetic resonance imaging (MRI) examinations (Table 4; Figure 1). The associated procedures performed were mitral valve repair in 1 case [Fayad 2005] and aortic valve replacement in another.

Table 1. Preoperative Clinical and Echocardiographic Characteristics of Patients*

	Case 1	Case 2	Case 3	Case 4	Case 5
Age, y	31	50	29	37	36
Sex	Male	Female	Male	Male	Male
NYHA class	IV	III	IV	IV	III
Drug addict	Yes	No	Yes	Yes	Yes
Intravascular catheter/nosocomial infection	–	+	–	–	–
Organism	MRSA	*E coli*	MSSA	MRSA	MSSA
PAP, mm Hg	37	28	30	35	30

*NYHA indicates New York Heart Association; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *S aureus*; PAP, pulmonary artery pressure.

Surgical Procedure

A median sternotomy was performed in all patients. Moderate hypothermia (33°C) and hemodilution cardiopulmonary bypass were established in a usual manner with an aortic cannula and selective cannulation of both vena cava. After aortic cross-clamping, myocardial protection was provided by antegrade cold blood cardioplegia that was repeated every 30 minutes. The tricuspid valve was exposed with retractors positioned through a conventional right atrial surgical access. The anatomy of the lesions was then analyzed and described (Table 2). Intraoperative findings always confirmed the preoperative echocardiographic diagnosis (Table 3). We considered this new clover technique appropriate for patients who present with severe tricuspid regurgitation due to leaflet and chordae destruction and in cases with significant leaflet prolapse.

Once a large resection of the infected and destroyed valvular tissue was achieved, we used this new surgical approach that we have adopted for such difficult situations. This procedure consists of stitching together the middle points of the free edges of the tricuspid leaflets with separate 5/0 Prolene sutures (Ethicon, Somerville, NJ, USA) to produce a clover-shaped valve (Figures 2 and 3). Annuloplasty with a Carpentier tricuspid ring (no. 34 and 36) carried out at the beginning of our experience in 2 patients was based on the stress distribution in

the plicated area and was designed to ensure a stable repair. Following the repair, serum saline was injected into the right ventricle to test the competence of the tricuspid valve. After completing the tricuspid repair and closing the right atrium, we administered warm blood cardioplegia before removing the aortic cross-clamp. After weaning the patient from cardiopulmonary bypass, we evaluated tricuspid valve function with transesophageal echocardiography.

RESULTS

All of the patients survived the operation. Complete control of the acute endocarditis was achieved in all cases by the combination of medical therapy and surgery. The mean (±SD) cardiopulmonary bypass and aortic cross-clamp times were 138 ± 57.3 minutes and 108.4 ± 46.5 minutes, respectively (Table 2). The mean intubation time was 8.4 ± 5.9 hours, and the mean intensive care unit stay was 1.8 ± 0.45 days (Table 2). No postoperative complications or hospital deaths were noted. All of the patients were in sinus rhythm. A complete prospective follow-up was achieved in all patients. The mean follow-up period was 26.4 ± 12.5 months (range, 15-42 months). There was no recurrent endocarditis. No late mortality or need for reoperation was reported during the follow-up period. No recurrence of drug addiction was noted. All of the patients, who had been in New York Heart Association (NYHA) class III to IV preoperatively, were in NYHA functional class I after the operation. No anticoagulation treatment was used in this group of patients during the follow-up period.

Valve Function

Before discharge, all of the patients underwent transthoracic echocardiographic and color Doppler flow control evaluations and showed satisfactory results. At the latest echocardiographic control evaluation during follow-up, tricuspid regurgitation remained trivial or absent in all patients, indicating that the good early result was stable. The mean transvalvular gradients were between 2 and 7 mm Hg across the tricuspid valve (Figure 4). We also noted significant reductions in the right ventricular end-diastolic dimensions. To date, no cases of tricuspid valve calcification have been detected. A cardiac MRI evaluation was carried out in all

Table 2. Operative Tricuspid Valve Characteristics*

	Case 1	Case 2	Case 3	Case 4	Case 5
Regurgitation	IV/IV	III/IV	IV/IV	IV/IV	III/IV
Vegetations	–	1 (26 × 7 mm)	1 (25 mm)	2 (20 × 25 mm, 7 × 5 mm)	1 (20 × 20 mm)
Ruptured chordae	+	+	+	+	+
Perforations	–	+	–	+	+
Prolapse	Anterior leaflet	Anterior and posterior leaflets	Anterior leaflet	Anterior and septal leaflets	Anterior and posterior leaflets
Annuloplasty†	+, 36	+, 32	–	–	–
Associated procedures	Mitral plasty	–	–	–	AVR

*AVR indicates aortic valve replacement (Perimount 25).

†Carpentier tricuspid ring nos. are indicated.

Table 3. Follow-up: Clinical and Echocardiographic Characteristics of Patients*

	Case 1	Case 2	Case 3	Case 4	Case 5
Duration, mo	42	38	19	18	15
Outcome: alive/no reoperation	+	+	+	+	+
Regurgitation in echocardiograph	0	Trivial	0	Trivial	Trivial
Mean transtricuspid echocardiographic gradient, mm Hg	7	2.1	2	6.1	7
PAP, mm Hg	20	19	16	23	21

*PAP indicates pulmonary artery pressure.

Table 4. Cardiac Magnetic Resonance Imaging Characteristics of Patients*

	Case 1	Case 2	Case 3	Case 4	Case 5
Preoperative					
RVEF, %	–	–	–	38	55
TDV, mL/m^2	–	–	–	75	123
Void flow	–	–	–	+++	+++
Postoperative					
RVEF, %	–	44	36	29	53
TDV, mL/m^2	–	53.5	32	53	79
Void flow	–	No	No	No	No

*RVEF indicates right ventricular ejection fraction; TDV, total distribution volume.

patients before discharge (Table 4). Figures 1, 5, and 6 show results for postoperative cardiac MRI control examinations, which confirm the stability and efficacy of the tricuspid clover technique.

COMMENTS

Antibiotic treatment of tricuspid valve endocarditis generally achieves satisfactory results [Mills 1982; Pandis 1984; Hecht 1992]. Medical treatment is preferred because of the poor midterm results obtained with the various surgical options. Although medication is the first treatment choice in right-sided infective endocarditis, even if the endocarditis is inactive, surgery is recommended for patients who are resistant to antibiotics or who exhibit progressive heart failure, repetitive pulmonary embolism, or a giant vegetation.

Infective endocarditis involving the tricuspid valve in intravenous drug users (IDUs) is usually caused by *S aureus* [Miro 2003]. In the past, most *S aureus* strains causing right-sided infective endocarditis in IDUs were susceptible to oxacillin. Today, the role of the oxacillin-resistant strain of *S aureus* must be taken into account. The risk factors for oxacillin resistance in *S aureus*–caused infective endocarditis in IDUs were previous hospitalizations, long-term addiction, and the use of nonprescribed antibiotics [Bassetti 2004]. Enterobacteriaceae, such as *E coli*, rarely cause endocarditis, even when infection is hospital acquired
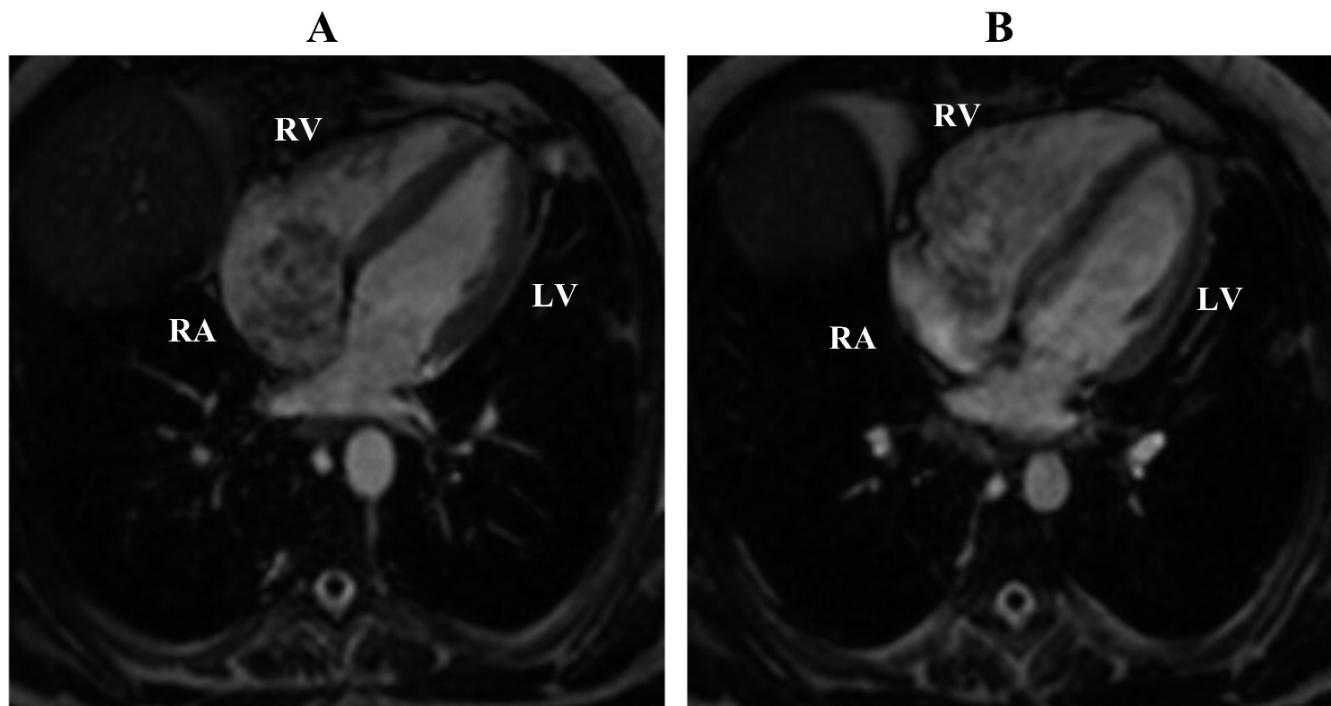
A

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Figure 1. A, Preoperative magnetic resonance imaging (MRI): right and left ventricular end-systolic dimensions. B, Preoperative MRI: right and left ventricular end-diastolic dimensions. RA indicates right atrium; RV, right ventricle; LV, left ventricle.
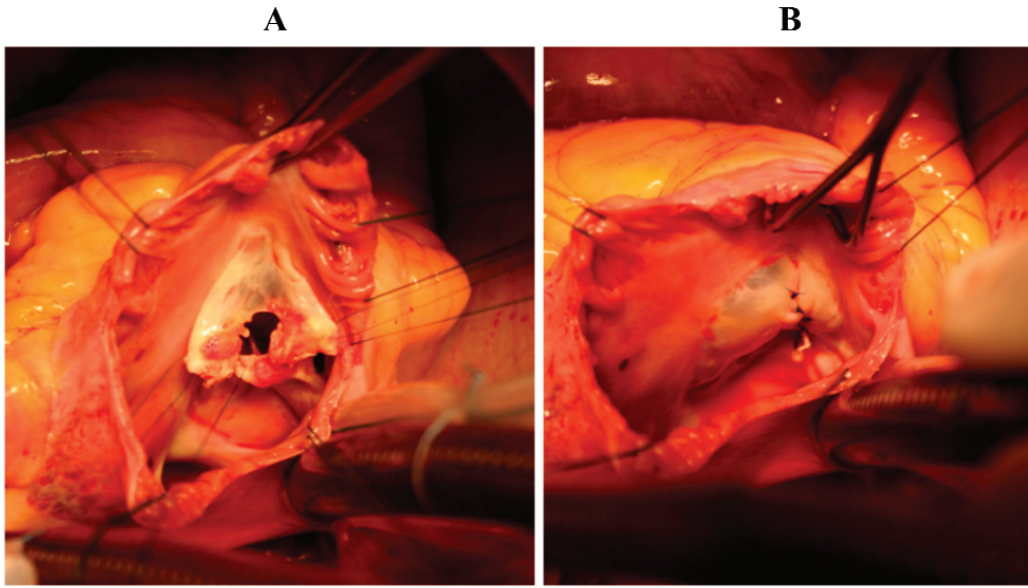
A   **B**

Figure 2. Tricuspid valve view. A, Massive vegetations and destruction of the anterior and septal leaflets. B, Large resection of infected tissue and conservative surgery according to the clover technique without annuloplasty.

[Carruthers 1977; Ben-Ami 2004]. In most IDUs, a short course (2 weeks) of antimicrobial therapy based on a β-lactam/aminoglycoside combination allows the cure of uncomplicated right-sided endocarditis caused by oxacillin-susceptible *S aureus* [Ribera 1996]. Conversely, glycopeptide therapy, with or without gentamicin, does not appear to be rapidly effective for infective endocarditis caused by oxacillin-resistant *S aureus* and consequently often requires more prolonged treatment regimens. For infective endocarditis caused by susceptible strains of *E coli*, a combination of either penicillin or a broad-spectrum cephalosporin with an aminoglycoside is recommended [Baddour 2005].
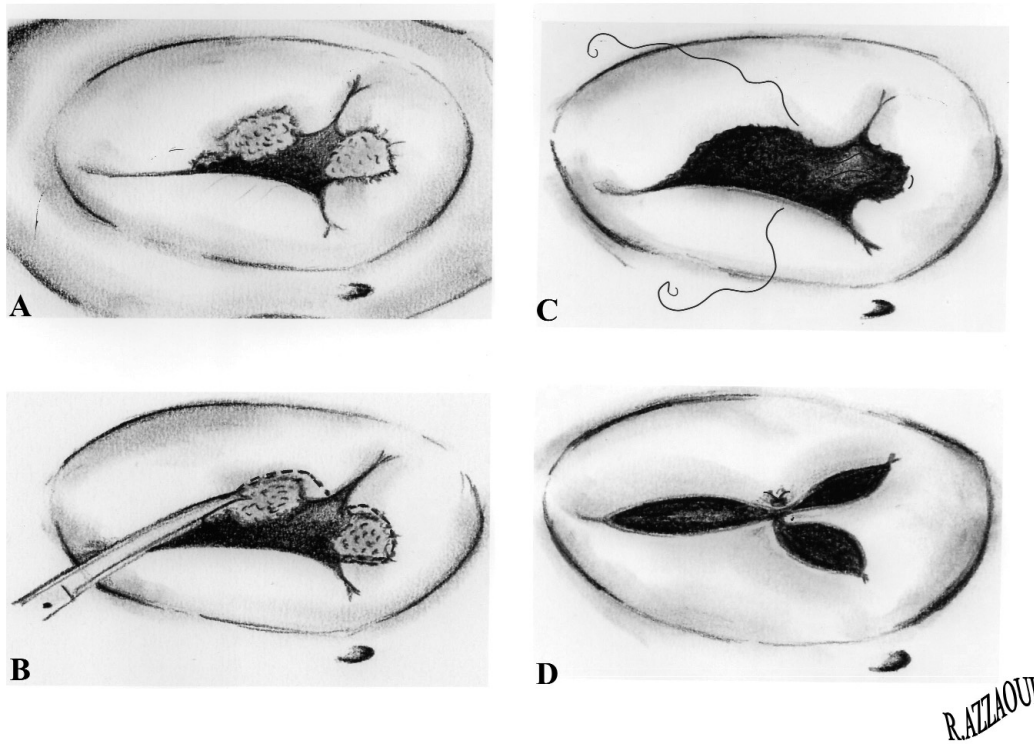

Figure 3. Surgical technique. Schematic drawing of the final shape of the tricuspid valve after the clover technique.
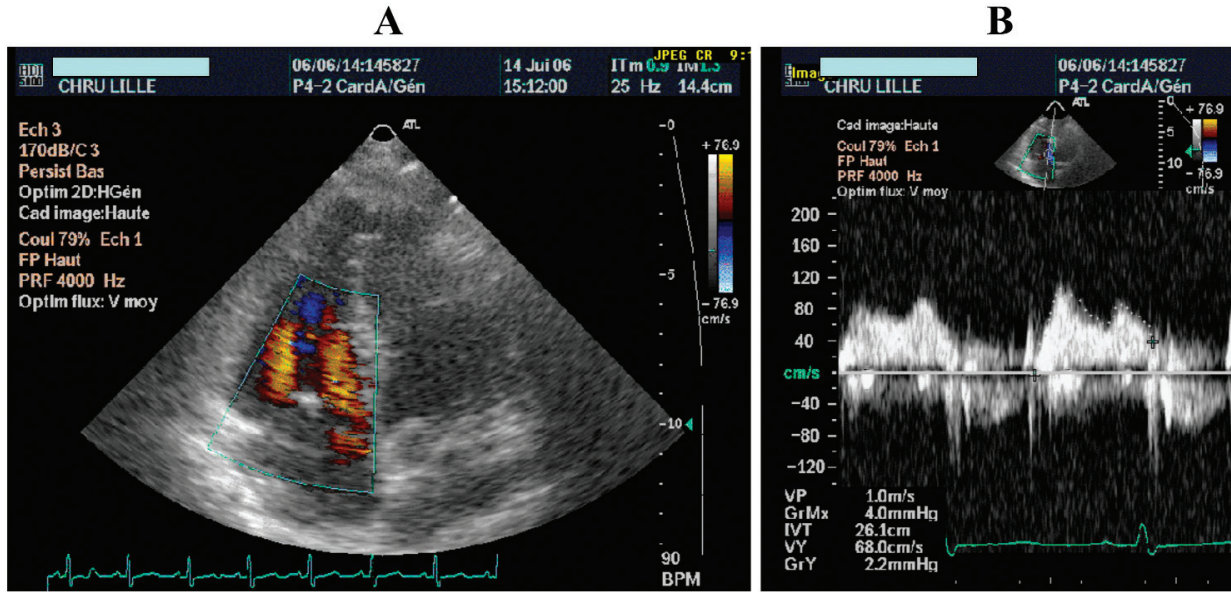
Figure 4. A, Postoperative echocardiographic transthoracic view: aspect of the tricuspid valve after repair. B, Postoperative transvalvular Doppler evaluation of the tricuspid valve.

In our series, medical treatment based on recommendations in the literature was inefficient, and these results prompted a surgery indication.

The surgical options that have been reported in the literature for cases of postendocarditic tricuspid regurgitation due to complex lesions are total tricuspid valve resection and valve replacement using a mechanical or biological prosthesis, or mitral homografts. Arbulu and colleagues [1993] suggested a tricuspid valvulectomy without prosthetic replacement;

however, the late results are consistent with the development of severe failure of the right heart with a frequent need for late reoperation. This technique's benefit is to cure the infection. The second option is tricuspid valve replacement using a mechanical or biological prosthesis. Because of the clinical presentation of this class of patients, the use of such prostheses exposes the patient to serious infectious risk, as well as to dehiscence and thrombosis [McGrath 1990]. The use of mitral homografts has been reported. Partial or total
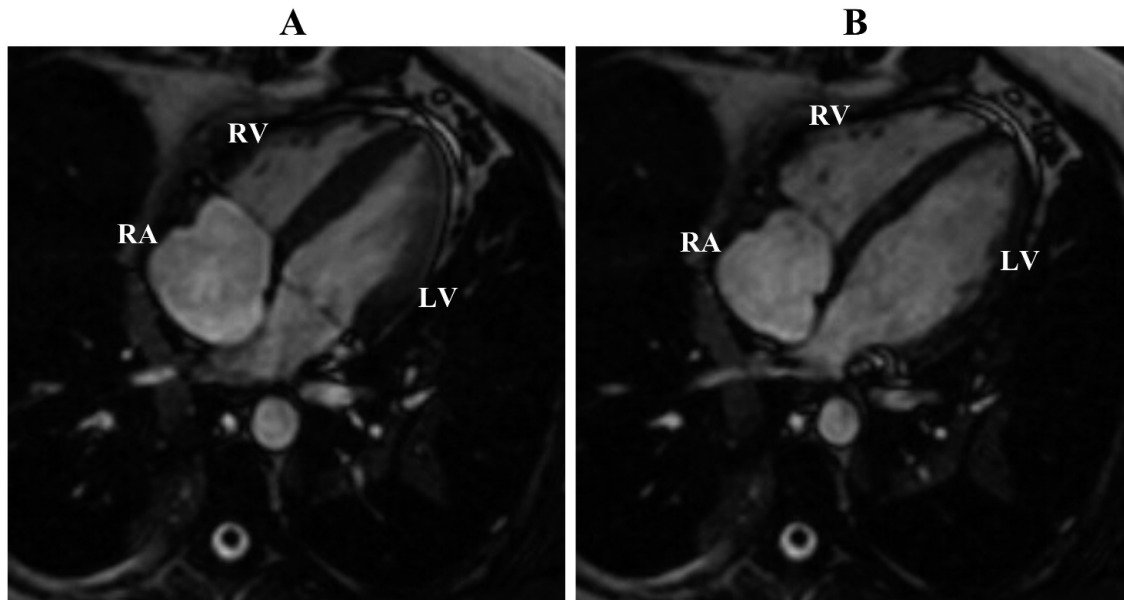

Figure 5. A, Postoperative magnetic resonance imaging (MRI): right and left ventricular end-systolic dimensions. B, Postoperative MRI: right and left ventricular end-diastolic dimensions. RA indicates right atrium; RV, right ventricle; LV, left ventricle.
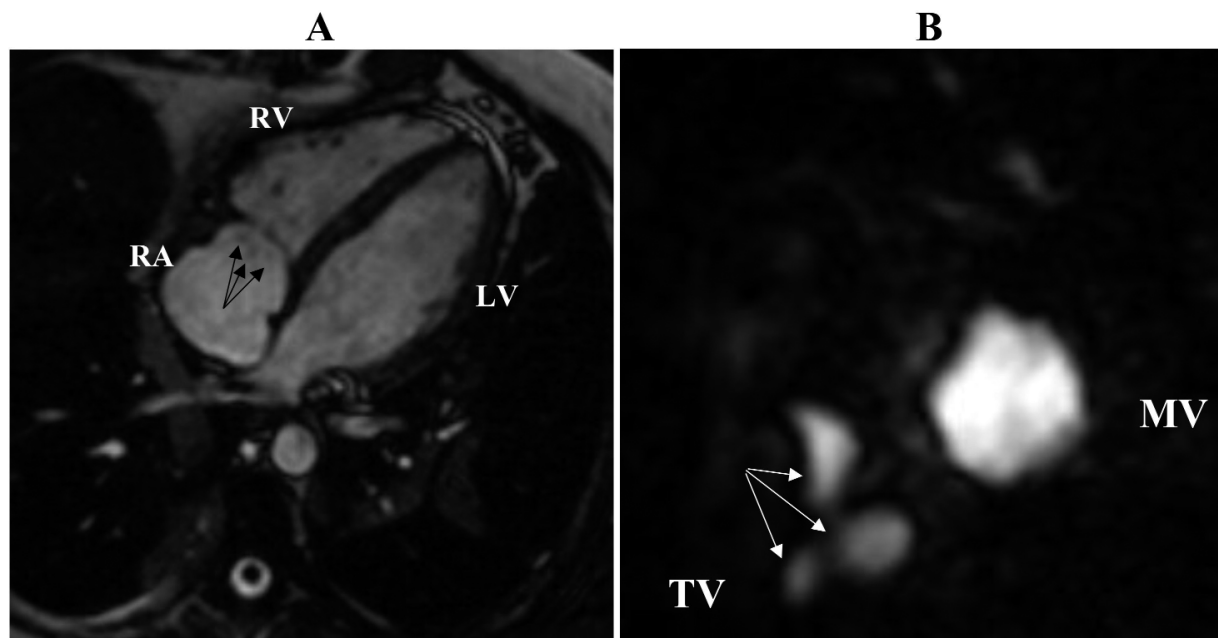
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Figure 6. Magnetic resonance imaging aspect of the tricuspid valve after the clover technique: the 3 functional orifices. RA indicates right atrium; RV, right ventricle; LV, left ventricle; TV, tricuspid valve; MV, mitral valve.

homografts were used as an alternative, with mitigated results [Mestres 1999; Hvass 2001; Couetil 2002]. Procurement difficulties and the requirement of significant surgical expertise make this solution a very difficult and nonreproducible option. In addition, others have suggested the use of aortic or pulmonary homografts or a stentless bioprosthesis. Operative techniques are difficult and nonreproducible, and reports of follow-up have been limited. In addition, tricuspid valve replacement via suturing of the annulus exposes the patient to a higher probability of atrioventricular blocks.

Different conservative techniques have been suggested as alternatives [Walther 1999; Cardarelli 2005; Chiu 2005]. Repair techniques could be achieved via the use of pericardial patch reconstruction and leaflet reinsertion with polytetrafluoroethylene neochordae, if they were suitable. The clover technique adopted for our series of patients was indicated to avoid tricuspid valve replacement because of the difficulties in realizing the techniques mentioned above, and this approach was our preference. The clover technique is reproducible and easy to perform, even in cases of large and extended leaflet destruction. Initially, this technique was described for the treatment of traumatic lesions in the tricuspid valve [Alfieri 2003; De Bonis 2004]. We considered performing this technique for active tricuspid valve endocarditis for different reasons. Indeed, preservation of the native valve offers better resistance to infection and avoids treatment with oral anticoagulants and the associated morbidity, as well as valve thrombosis in cases of mechanical valve replacement [Navia 2005]. Although 2 of our patients at the beginning of our experience received tricuspid annular rings, we believe that annuloplasty is not necessary in patients who present with

acute valve insufficiency. Indeed, enlargement of the right ventricle did not occur during follow-up; however, the fact that the stress exerted on the clover stitch is increased with this technique has to be considered.

In addition, this technique offers the advantage of avoiding the risk of atrioventricular blocks requiring postoperative pacemaker insertion.

One of the major limitations of this technique could be related to its tendency to cause valve stenosis. In our experience, all of the patients benefited from intra- and postoperative echocardiographic control examinations every 6 months; they showed no tricuspid stenosis, with a mean gradient ranging between 2 and 7 mm Hg, despite the extended leaflet resection in patients 4 and 5 (Table 3).

The follow-up confirmed the effectiveness and reliability of this technique, and our option has the advantage of not inserting a prosthesis into an infected zone. Indeed, no infection recurrence was reported in any patient.

All of the patients underwent postoperative cardiac MRI evaluations, which confirmed the efficacy of the repairs. Cardiac MRI has multiple advantages and offers the possibility of reliable pre- and postoperative study of right heart function (Table 4). It allows a fine analysis of valve function and the quality of the repairs. The absence of insufficiency or tricuspid stenosis is analyzed by studying "void flow." In our series, MRI control examinations confirmed the absence of void flow in all analyzed cases. In addition, MRI provides operator-independent analysis and yields a precise analysis and description of leaflet function and aspect, thereby providing a powerful tool for comparing results over time.

In our opinion, tricuspid valve repair is preferable to tricuspid valve replacement when it is feasible. This is the case for all age groups, particularly in young patients, because repair avoids the use of anticoagulants and the rapid deterioration associated with xenografts.

Postendocarditic tricuspid regurgitation is common in young patients who are drug users. Four of the patients in our series were drug users, and 1 patient presented with a nosocomial infection. In addition, *S epidermidis* can cause rapid valve destruction with large vegetations, and the combination of surgery and antibiotic therapy may be necessary. In our preliminary experience, major tricuspid incompetence prompted consideration of the surgical approach. Although several technical possibilities are conceivable when facing such complex lesions in these generally fragile patients, the clover technique seems to be a very good alternative. Nevertheless, long-term follow-up is obviously mandatory.

CONCLUSION

In this preliminary experience, the clover technique proved to be a reproducible and effective approach for conservative surgical treatment of active infective tricuspid valve endocarditis, and the repair was never restrictive.

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