

Tricuspid valve surgery

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ABSTRACT

Introduction: The tricuspid valve has been taken as a non-critical valve in terms of acute or late mortality in a number of conditions. Tricuspid functional regurgitation is a cause of late operations with an increased morbidity. A number of techniques have been described and used in clinical practice in the past forty years and include simple suture techniques and the use of support for annuloplasty with the use of different types of prosthetic rings. The experience accumulated over the years indicates that tricuspid annuloplasty is mandatory to improve late results, which are superior, in general, to replacement of the valve.

Methods: The role of echocardiography in defining surgical planning, intraoperative results and follow-up is reviewed as echocardiography is a fundamental tool in cardiac surgery. Surgery for isolated lesions of the tricuspid valve has not received much attention and herein we report the results of the follow-up of a limited series of patients undergoing isolated tricuspid surgery.

Results: The correlation between echocardiographic measurements and surgical measurements was confirmed and was helpful at the time of the confirmation of repair ($r = 0.53$). Forty-seven patients (18 repair, 29 replacement) underwent isolated surgery. Results of isolated tricuspid repair seemed to be superior when compared to those of tricuspid replacement. Survival was 20.7% for tricuspid valve replacement ($N = 18$) and 50% for tricuspid valve repair ($N = 29$) ($p = 0.04$). Freedom from reoperation was $94.4 \pm 5.4\%$ for repair and $67.3 \pm 12.1\%$ for replacement ($p = 0.0011$).

Conclusions: The tricuspid valve continues to be a surgical challenge.

Keywords: tricuspid valve, tricuspid regurgitation, valve repair, echocardiography.

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INTRODUCTION

The tricuspid valve (TV) is usually considered a forgotten valve. This is because the other cardiac valves are more frequently addressed in the scientific literature (1, 2).

The aortic and mitral valves are involved in rheumatic disease showing gross changes after an acute or chronic inflammatory reaction. The diseases of the TV frequently present in the form of regurgitation, which is functional as a consequence of pulmonary congestion. The gross anatomy of the TV is seldom seriously affected as to require replacement regardless of the disease (3). Replacement of the TV is, in fact, an uncommon clinical operation in current times (4) as repair conveys good long-term results

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(5-8). In the specific case of rheumatic valve disease it is clear that survival is better and reoperation less frequently required when the valve is repaired (9, 10).

On the other hand, the mechanisms of TV normal and abnormal function are well known for decades (11) and what is clear is that right ventricular contractility is a key component of TV function and that left-sided lesions do influence on TV function as well. Considering all of the above, it might be of interest to briefly review current concepts and therapeutic attitudes towards a diseased TV.

Dealing with the tricuspid valve. The TV has been approached from different perspectives but the underlying accepted philosophy of repair. It is known that functional TV regurgitation is more amenable for repair than organic involvement and it can be said that a myriad of possibilities have already been tested in clinical practice with success.

Non-prosthetic repair. Bicuspidization of the TV can be considered a very early type of repair without the use of prosthetic material. Their results sustained the test of time as reported by Kay et al. (12); however, there were always concerns on residual tricuspid regurgitation that were addressed at a later stage when comparisons were made with prosthetically-supported repairs (13). For TV repair, de De Vega selective and adjustable suture-based repair is credited as one of the most popular valve operations in the past four decades since it was first reported in 1972 (14). Technical tips are simple and this operation is a truly reproducible one as it has been shown in the literature. Some concerns exist about somewhat unpredictable results (13). But forty years later this technique continues to be widely used. There are a number of factors that might influence on its results that have recently been addressed by Yilmaz et al. (15) and on which De Vega has briefly summarized for practical purposes (16).

A number of modifications of the De Vega procedure have also been described and clinically tested (17-19). Some focused on the segmental nature of the repair (19, 20) on top of the semicircular extension including the anteroseptal and posteroseptal commissures. The concept of vanishing annuloplasty was introduced trying to eliminate foreign materials; after such a vanishing annuloplasty, the benefit of semicircular repair will remain (21, 22). The truth with regards actual effectiveness might be related, like in the setting of the mitral valve, on which of the multiple components of the tricuspid valve complex bears the responsibility of the substrate for regurgitant lesions. This is well described by Navia et al. in a retrospective analysis of multiple types of supported and non-supported repairs of the TV (23). The essence of non-prosthetic repair is based on preservation of valvular mechanism while maintaining the physiological flexibility of the annulus; prosthetic material is not required; there are less chances of damage to the conduction tissue and also important that these techniques are easy, fast to perform and cheap.

Prosthetic repair. Since the early independent work by Carpentier et al. (24) and Duran et al. (11, 25) the concept of supported TV repair using different types of prosthetic rings has developed rapidly. There are currently more than 20 different ring designs in the market for mitral and tricuspid repair. Ring repair follows the same basic statements accumulated in the literature and that are contemplated in guidelines, namely that here is evidence that TV regurgitation associated with dilatation of the tricuspid annulus should be repaired, that tricuspid dilatation is an ongoing process that may progress to severe TR if untreated and that annuloplasty of the TV based on tricuspid dilatation improves functional status independent of the degree of regurgitation (26, 27).

Correction of annular dilatation, remodeling the shape of the annulus, improvement of coaptation between leaflets during systole and stabilization of repair over time are the main goals of ring repair. The controversy about which type and shape is still active. If a ring has to be opened or closed, flexible or rigid, permanent or degradable is still a matter of controversy that is likely to be active for years. The contribution by Navia et al. on the comparisons of techniques that include any type of support or the lack of it is of importance as defines success as related to the valve component influencing on the lesion (23).

What seems clear is that TV ring annuloplasty tends to confer stability to the repair that positively influences long-term outcomes (10, 28). Furthermore, there is a trend towards a reduced number or reoperations. This is serious information and may favour the use of rings in clinical conditions in which annular dilatation plays a major role. Other than the discussion on the type and shape of the ring, materials could play a role in future decisions in specific groups of patients.

As with vanishing sutures (22), the recently introduced concept of a biodegradable ring addresses important issues like the preservation of the potential for growth of the mitral annulus, which is of particular impact in pediatric population, the avoidance of synthetic material with a speculated lesser risk of endocarditis, the lack of anticoagulation during the first three postoperative months and an associated easy implantation technique (29). On the questions: is the fibrous tissue induced by the ring capable of allowing for the natural growth of the valve orifice in children, hence preventing valves stenosis over time? and is the fibrous tissue capable of resisting against the tensile stretch of the dilated annulus?, recent experience confirms that the biodegradable ring does not restrict annulus growth

without impact on valve function (30). *No action.* The lack of action is another way to deal with the TV. As stressed by De Vega in his recent editorial (16), the TV has been approached in different ways for more than forty years and there still are some doubts on specific issues. Perhaps one of the most important questions still under debate is if clinically silent TV regurgitation must be address when surgery is performed on the mitral valve. As stated in the guidelines (26,27) this is a problem in which decisions are usually not easy. However, the contribution by Yilmaz et al. in which 699 patients were retrospectively analyzed (15), has been instrumental in defining that, perhaps, those cases with non-significant TV regurgitation should not need repair when left-sided surgery is performed. In the words of the authors this actually means that a selective approach is preferred.

METHODS

Echocardiography is likely to be the most important tool in cardiology in modern times. It is an almost non-invasive technique giving an enormous amount of information on morphology and function of the cardiac valves and the myocardium. This is of particular importance at the time of surgery where transesophageal echocardiography (TEE) helps in three important issues:

- 1) confirming lesions immediately before the procedure;
- 2) in assessing the quality of a given repair or the myocardial function at the end of the operation;
- 3) during the postoperative period before discharge to disclose the presence of pericardial effusion and to evaluate eventual failures or dysfunctions of any cardiac structure. This applies to all types of cardiac defects and its surgical correction regardless of the etiology (31).

In the case of the TV, intraoperative TEE introduces a quality factor as accurate measurements may help in determining the type of an eventual repair. Up to what extent the right ventricular function or the annulus diameter will be instrumental in a successful outcome could be a matter of discussion but it seems that the more accurate measurements the higher the success of the repair.

In recent times we have conducted a preliminary study in which the degree of tricuspid regurgitation, right ventricular contractility, the dimensions of the right heart cavities, diameter of the tricuspid annulus in mm in mid-systole have been measured. As TEE is a routine, choosing specific views addressing the TV is summarized in the following: mid-esophageal four-chamber view with colour-Doppler mapping, mid-esophageal right ventricular inflow and outflow tracts and short-axis transgastric tricuspid valve view.

Using this methodology, the aim was to evaluate if the preoperative estimates of the tricuspid ring in mm using TEE were confirmed with the measurements at surgery with the right atrium opened. For this measurement study and the analysis of the long-term follow-up of patients who underwent isolated tricuspid surgery, ethical approval was waived given the observational and retrospective design. The observers performed three measurements on TEE with the patient hemodynamically stable. Measurements at operation were taken between the antero-posterior and the antero-septal commissures.

RESULTS

In this early series of 59 patients with a mean age of 63.9 years, the correlation between echocardiographic measurements and surgical measurements was confirmed

and was helpful at the time of the confirmation of repair ($r = 0.53$).

Isolated tricuspid valve surgery with normal functioning left side. The end-stage rheumatic heart valve disease. It is clear today that rheumatic valve disease is a well known heart condition which is anecdotal in the so-called developed countries but is still the most common cause of heart disease in the world.

When the tricuspid valve is involved the prognosis of the disease is worse (32-34). Isolated tricuspid rheumatic valve disease is infrequent; due to this, clinical results of isolated tricuspid valve disease when appears with normal functioning left side valves are not known in detail (35).

This is due to the scarce information available opposite to tricuspid regurgitation later after left side valve repair or replacement, which entails a high risk and very bad prognosis (36).

This lack of information prompted us to review a series of patients over a long period of time that underwent surgery for isolated TV disease. Between 1977 and 2010, 47 patients with a mean age of 59 years (19% male, 81% in atrial fibrillation) underwent repair (18/38.3%) or replacement (29/61.7%). Preoperative characteristics are shown in *Table 1*. Tricuspid repair consisted in a De Vega annuloplasty (N=8), Duran flexible ring annuloplasty (N=10) with associated commissurotomy in 2. Tricuspid valve replacement was performed with a mechanical valve in 14 and with a tissue valve in 15 patients. Follow-up was complete in 97.8% of the patients with a mean follow-up of 16 years (3 months - 33 years).

Survival at the abovementioned follow-up is 20.7% for TV replacement (N=18) and 50% for TV repair (N=29) ($p = 0.04$) (*Table 2*). Freedom from reoperation is $94.4 \pm 5.4\%$ for repair and $67.3 \pm 12.1\%$ for replacement ($p = 0.0011$).

Table 1 - Preoperative characteristics of patients with isolated tricuspid surgery.

	TV Replacement	TV Repair	p value
	N = 29	N = 18	
Age	59.9 ± 13.6	62.3 ± 5.5	n.s.
Range	21-76	53-76	
Female	23 (79.3 %)	15 (83.3 %)	n.s.
Weight	59.6 ± 11.5	66.5 ± 10.3	n.s.
Height	157.3 ± 6.5	160.9 ± 7.4	n.s.
Body surface area	24.1 ± 4.4	25.7 ± 3.5	n.s.
Atrial fibrillation	27 (93.1 %)	14 (77.8 %)	n.s.
Cardiac index	2.0 ± 0.7	2.1 ± 0.3	n.s.
PA Systolic pressure	43.3 ± 13.7	42.7 ± 11.3	n.s.
Pulmonary capillary pressure	26.5 ± 2.4	21.7 ± 4.2	< 0.0011
Left ventricular EF	57.8 ± 10.1	54.3 ± 11.7	n.s.
Mean TV regurgitation	3.57	3.55	n.s.
Previous TV surgery			0.04
Repair	7 (24.1 %)	2 (11.1 %)	
Replacement	4 (13.8 %)	-	
Previous CPB operations			n.s.
One	11 (37.9 %)	6 (33.3 %)	
Two	9 (31.0 %)	2 (11.1 %)	
Three	2 (6.9 %)	-	
NYHA class III	7 (24.1 %)	12 (66.7 %)	0.002
NYHA class IV	19 (65.5 %)	4 (22.2 %)	

PA = pulmonary artery; TV = tricuspid valve; EF = ejection fraction; CPB = Cardiopulmonary Bypass; NYHA = New York Heart Association.

Table 2 - Intra-, postoperative and follow-up data.

	TV Replacement	TV Repair	p value
CPB time	79.9 ± 42.8	75.7 ± 45.7	
Ischemic time	21.8 ± 23.1	64.5 ± 48.8	n.s.
Mortality	8 (27.6 %)	-	0.0002
Cardiac	6	-	0.01
Bleeding	1	-	
Neurologic	1	-	
Late mortality	15 (51.7 %)	9 (50.0 %)	n.s.
Cardiac	2	3	
Valvular	1	1	
Unknown	7	1	
Reoperation	1	2	
Thromboembolism	1	-	
Hemorrhage	-	1	
Malignancy	1	-	
Others non cardiac	2	1	

TV = tricuspid valve; CPB = Cardiopulmonary Bypass

DISCUSSION

In these case series we noted that the correlation between echocardiographic measurements and surgical measurements was confirmed and was helpful at the time of the confirmation of repair ($r = 0.53$). Furthermore, results of isolated tricuspid repair seemed to be superior when compared to those of tricuspid replacement. Survival was 20.7% for TV replacement and 50% for TV repair. Freedom from reoperation was $94.4 \pm 5.4\%$ for repair and $67.3 \pm 12.1\%$ for replacement.

It is clear that this was a small series accumulated over a long period of time and this may be a cause of controversy when analyzing results in an uncommon situation. However, we understand that isolated tricuspid valve surgery with normal functioning left side valve occurs after mitral and/or aortic valve surgery, isolated tricuspid valve surgery has a high early and late mortality due to cardiac causes and that tricuspid valve replacement entails a worse result comparing with tricuspid valve repair.

Other than classical repair or replacement of the TV and exception made of the old approach of simple valvectomy without valve replacement in specific cases for salvage as advocated by Arbulu three decades ago (37), valve transplantation using cryopreserved homografts has been an alternative to TV replacement in specific subgroups of patients (38). This has been used by us mostly in cases of TV infection that required surgical treatment as has been reported before (39). Some technical modifications have been introduced over time (40) but one of the most interesting experiences during the follow-up has been to learn about the eventual possibility of repairing a transplanted mitral valve into the TV position (41). Of course that should be taken as a surgical anecdote but it may be useful in isolated cases.

CONCLUSION

The tricuspid valve is still a challenging surgical problem. There is variability in approach and techniques. Echocardiography is fundamental in planning and execution. Specific subsets of patients are at high risk of morbidity and mortality.

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