Tricuspid annulus diameter does not predict the development of tricuspid regurgitation after mitral valve repair for mitral regurgitation due to degenerative diseases

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ABSTRACT

Background: Heart valve surgery guidelines suggest that tricuspid valve annuloplasty may be beneficial in patients with a tricuspid annulus (TA) ≥ 40 mm even in the absence of functional tricuspid regurgitation (TR) at the time of surgery for left-sided valve lesions (class 2a). Given the broad spectrum of degenerative diseases that affect the atrioventricular valves, we hypothesize that this measurement might not be predictive of TR after mitral valve (MV) repair.

Methods: The diameter of the TA was measured preoperatively in a cohort of 312 consecutive patients who had isolated MV repair for degenerative diseases. The mean TA diameter was 36 mm (95% confidence interval [CI], 35-37 mm). TA ≥ 40 mm was present in 80 patients. The median duration of echocardiographic follow-up was 6.7 years (interquartile range, 5.4-8.4 years), and was 100% complete. The main study endpoint was postoperative TR of moderate or greater degree.

Results: Thirty patients had new or persistent TR at some point during follow-up. The probability of postoperative TR at 7 years was 6.6% (95% CI, 4.6%-9.4%) for all patients, 6.8% (95% CI, 4.6%-10.4%) for TA < 40 mm, and 6.0% (95% CI, 2.9%-12.2%) for TA ≥ 40 mm. Preoperative TA diameter was not associated with the odds of postoperative TR in either the univariable or multivariable regression models. In these analyses, preoperative TR was the strongest predictor of postoperative TR.

Conclusions: TA ≥ 40 mm is not predictive of the development of postoperative TR after MV repair for degenerative diseases. (J Thorac Cardiovasc Surg 2018;155:2429-36)

Probability of postoperative tricuspid regurgitation after mitral valve repair for degenerative disease in patients with a tricuspid annulus diameter ≥ 40 mm.

Central Message

A preoperative tricuspid annulus diameter ≥ 40 mm was not associated with the development of postoperative functional tricuspid regurgitation after mitral valve repair for degenerative diseases.

Perspective

Heart valve guidelines suggest that tricuspid valve annuloplasty should be performed during left side valve operations in the absence of tricuspid regurgitation if the tricuspid annulus diameter is ≥ 40 mm. In this observational study, preoperative tricuspid annulus diameter was not associated with odds of postoperative tricuspid regurgitation in either univariable or multivariable regression models.

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Functional tricuspid regurgitation (TR) results from leaflet tethering secondary to right ventricular and annular dilatation.¹ Right ventricular dilatation is often caused

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Abbreviations and Acronyms

MA	= mitral annulus
MV	= mitral valve
MR	= mitral regurgitation
TA	= tricuspid annulus
TR	= tricuspid regurgitation
TV	= tricuspid valve
TVA	= tricuspid valve annuloplasty

by increased right ventricular pressure and/or volume overload, but can also be caused by right ventricular infarction or idiopathic cardiomyopathy.

Functional TR is common in patients with advanced left-sided heart valve diseases. Current guidelines on the management of heart valve diseases^{2,3} suggest that tricuspid valve annuloplasty (TVA) may be beneficial in patients with trace or mild functional TR and a tricuspid annulus (TA) diameter ≥ 40 mm as measured by echocardiography or 70 mm as measured by direct inspection of the tricuspid valve (TV) during surgery for left-sided valve lesions (class 2a, meaning that it should be considered, but the evidence is conflicting).

The concept of performing TVA based on TA dilatation rather than on TR grade was introduced by Dreyfus and colleagues,⁴ who hypothesized that a dilated TA is a permanent and even progressive lesion that if left unattended at the time of mitral valve (MV) repair, may progress and cause severe TR postoperatively. There is evidence that the TA dilates and changes its shape from elliptical to spherical in patients with severe TR.^{1,5} Whether TVA should be performed when the TA diameter measures ≥ 40 mm remains controversial, however.

Degenerative diseases of the MV, the most common causes of mitral regurgitation (MR) in North America, include a broad spectrum of lesions in the leaflets and annuli of the atrioventricular valves. We hypothesize that a TA diameter ≥ 40 mm in patients with MR due to degenerative diseases is not predictive of postoperative TR after MV repair for degenerative diseases. In this study, we examined the effect of TA diameter in the development of TR after MV repair for MR due to degenerative diseases.

PATIENTS AND METHODS

This study was approved by the Review Ethics Board of University Health Network, and individual patient consent was required. All patients ($n = 1247$) who underwent MV repair for MR due to degenerative disease between January 1985 and December 2010 performed by a single surgeon (Dr David) have been followed prospectively. Patients who underwent surgery after October 2005 had preoperative TA diameters measured during both systole and diastole. This new entry was prompted by the report by Dreyfus and colleagues supporting the importance of preoperative TA size in predicting postoperative TR after MV repair.⁴ Of the 335 patients

who underwent surgery between October 2005 and December 2010, 25 had concomitant TVA and were excluded from this study.

The patients were followed by the referring cardiologists and seen by the surgeon at 2 to 3 months and then contacted by his research personnel every 2 to 3 years thereafter. Echocardiography was performed preoperatively, during surgery, at 1 week postsurgery, and at each follow-up contact unless there was a reason to image the heart more often. A total of 984 postoperative echocardiograms were available for analysis; 303 patients (97%) had more than 1 study, and 87% had more than 2 studies. The majority of postoperative studies were performed at a certified echocardiography laboratory and read by an experienced echocardiographer. MR and TR were recorded as none (0), trace (1+), mild (2+), moderate (3+), or severe (4+), according to the guidelines of the American Society of Echocardiography.⁶ If the echocardiographer reported the MR or TR as "mild to moderate" or "moderate to severe," which occurred in 27 studies, the recorded images were reviewed by blinded echocardiographers from our institution and entered into the database according to their interpretation as mild ($n = 6$), moderate ($n = 19$), or severe ($n = 2$).

The TA and mitral annulus (MA) diameters were measured preoperatively by transesophageal echocardiography at end of diastole in a 4-chamber view at 0° for the TA and at 0° and 90° for the MA.

Adverse events were recorded according to guidelines set by cardiac surgical societies.⁷ The cause of death was determined by hospital chart review, death certificate, or information from the physician who was caring for the patient at that time. Clinical and echocardiographic follow-up was 100% complete; the median duration of clinical follow-up was 7.1 years (interquartile range [IQR], 5.8-8.8 years), and the median duration of echocardiographic follow-up was 6.7 years (IQR, 5.4-8.4 years). There were no substantial differences in the number of patients reaching landmark follow-up durations between clinical and imaging follow-up.

Statistical Analysis

Data are presented as median with IQR (ie, 25th and 75th percentiles) and frequencies as appropriate. Pearson correlation was used to determine the association between preoperative TA and MA size along with linear regression models. Nonlinearity of the association between preoperative TA and MA size was assessed through various mathematical transformations of MA size; the Akaike information criterion was used to compare the different models. Linear regression was used to determine the associations between preoperative TA and preoperative TR and degree of myxomatous degeneration (separately, both modeled as categorical variables). The Kaplan-Meier method was used to estimate survival over time. The cumulative incidences of stroke and reoperation were calculated with death as a competing risk. Given the low number of patients experiencing any of these 3 outcomes, no attempt was made to identify risk factors.

The progression of moderate or severe TR over time was modeled using logistic regression models adjusted for repeated measures through an autoregressive covariance structure (mixed longitudinal regression models). The autoregressive covariance structure was chosen specifically because this structure assumes homogenous variance over time and correlations between the different observations in the same patient that decline exponentially over time. Both assumptions are true in this type of data (repeated echocardiograms over time). Univariable risk factor analysis was performed using this approach.

Given the limited number of outcomes available for analysis, we elected to perform multivariable risk factor analysis using a priori selection of variables based on clinical relevance. Variables selected as potential risk factors were sex, age at the time of surgery, preoperative atrial fibrillation/concomitant maze procedure, preoperative hypertension, preoperative TA ≥ 40 mm, preoperative TR grade, and time since the index procedure.

The association between TA ≥ 40 mm and progression of moderate or severe TR over time was assessed for various subgroups of patients to determine whether there was any interaction between clinical characteristics and the effect of preoperative TA size on postoperative TR.

TABLE 1. Patient profile stratified by preoperative TA diameter

Variable	Entire cohort (n = 312)	TA <40 mm (n = 232)	TA ≥40 mm (n = 80)	P value
Age, y, median (IQR)	58 (50-67)	59 (49-67)	57 (50-66)	.89
Male sex, n (%)	221 (70.8)	151 (65.1)	70 (87.5)	<.001
Body surface area, m ² (IQR)	1.91 (1.75-2.08)	1.90 (1.72-2.06)	2.00 (1.85-2.11)	<.001
Body mass index, kg/m ² , median (IQR)	25.9 (23.6-28.4)	25.8 (23.2-28.4)	26.3 (24.2-28.6)	.42
Preoperative heart rhythm, n (%)				
Atrial fibrillation or flutter	44 (14.1)	25 (10.8)	19 (23.8)	.008
History of atrial fibrillation	10 (3.2)	7 (3.0)	3 (3.8)	.75
Complete heart block/pacemaker	1 (0.3)	0 (0.0)	1 (1.3)	.26
Previous heart operations, n (%)				
Coronary artery bypass	2 (0.6)	2 (0.9)	0 (0.0)	1.00
Percutaneous coronary interventions	2 (0.6)	2 (0.9)	0 (0.0)	1.00
Atrial septal defect closure	2 (0.6)	2 (0.9)	0 (0.0)	1.00
NYHA functional classification, n (%)				.24
Class I	93 (29.8)	72 (31.0)	21 (26.3)	
Class II	124 (39.7)	96 (41.4)	28 (35.0)	
Class III	91 (29.2)	62 (26.7)	29 (36.3)	
Class IV	4 (1.3)	2 (0.9)	2 (2.5)	
Left ventricular ejection fraction, n (%)				.08
≥60	258 (82.7)	198 (85.3)	60 (75.0)	
40-59	46 (14.7)	28 (12.1)	18 (22.5)	
20-39	8 (2.6)	6 (2.6)	2 (2.5)	
Symptomatology, n (%)				
Congestive heart failure	108 (34.6)	76 (32.8)	32 (40.0)	.028
Angina pectoris	13 (4.2)	13 (5.6)	0 (0.0)	.03
Syncope episodes	4 (1.3)	4 (1.7)	0 (0.0)	.58
Associated conditions, n (%)				
Hyperlipidemia	111 (35.6)	88 (37.9)	23 (28.8)	.18
Family history of CAD	135 (43.3)	106 (45.7)	29 (36.3)	.15
Diabetes mellitus	15 (4.8)	12 (5.2)	3 (3.8)	.77
Hypertension	115 (36.9)	87 (37.5)	28 (35.0)	.79
Smoking history	124 (39.7)	90 (38.8)	34 (42.5)	.60
Severe COPD	5 (1.6)	4 (1.7)	1 (1.3)	1.00
Previous stroke or TIA	9 (2.9)	9 (3.9)	0 (0.0)	.12
Infective endocarditis	14 (4.5)	12 (5.2)	2 (2.5)	.53
Coronary artery disease	43 (13.8)	31 (13.4)	12 (15.0)	.71

TA, Tricuspid annulus; IQR, interquartile range; NYHA, New York Heart Association; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; TIA, transient ischemic attack.

Missing data were rare (2.0%) and distributed randomly; consequently, mean imputation was used to handle the few missing data elements. There were no missing outcomes data. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Patient profile and operative data for the entire cohort and stratified by preoperative TA size are shown in [Tables 1](#) and [2](#), respectively.

Clinical Outcomes

There were 2 operative and 11 late deaths, including 2 due to stroke, 1 due to endocarditis, and 10 due to noncardiac causes. There was 1 MV re-repair for recurrent MR at 5 years after surgery and 1 MV re-repair for mitral

stenosis caused by pannus at 7 years after surgery. Six patients sustained a stroke, 2 of whom died. [Table 3](#) presents data on the freedom from morbid events over time.

Tricuspid and Mitral Valves

There were modest positive linear associations between preoperative TA and MA diameters ([Figure 1](#)) and between TA diameter and TR grade ([Figure 2](#)), but no association between TA diameter and the degree of MV degeneration ([Figure 3](#)). Eighty patients (26%) had a TA diameter ≥40 mm before surgery. Thirty patients had new or persistent TR ≥3+ at some point during follow-up. [Figure 4](#) shows the probability of postoperative TR ≥3+ during follow-up in all patients, in patients with TA diameter ≥40 mm, and in patients with TA diameter

TABLE 2. Operative data stratified by preoperative TA diameter

Variable	Entire cohort (n = 312)	TA <40 mm (n = 232)	TA ≥40 mm (n = 80)	P value
MV prolapse, n (%)				.46
None (annular dilatation)	12 (3.9)	11 (4.7)	1 (1.3)	
Anterior leaflet	21 (6.7)	14 (6.0)	7 (8.8)	
Posterior leaflet	112 (35.9)	84 (36.2)	28 (35.0)	
Both leaflets	167 (53.5)	123 (53.0)	44 (55.0)	
Echocardiographic measurements, mm, median (IQR)				
MA at 0°	40 (37-45)	40 (36-43)	43 (39-47)	<.001
MA at 90°	40 (37-45)	40 (36-44)	42 (39-47)	.02
TA at 0°	35 (32-40)	34 (32-36)	41 (40-42)	<.001
TR grade, n (%)				.06
None or trace (0 – 1+)	150 (48.1)	120 (51.8)	30 (37.5)	
Mild (2+)	144 (46.2)	101 (43.5)	43 (53.8)	
Moderate (3+)	18 (5.8)	11 (4.7)	7 (8.8)	
Degree of MV myxomatous degeneration, n (%)*				.94
Mild	105 (33.7)	79 (34.1)	26 (32.5)	
Moderate	135 (43.3)	99 (42.7)	36 (45.0)	
Advanced	72 (23.1)	54 (23.3)	19 (22.5)	
Dystrophic calcification of the annulus, n (%)	12 (3.9)	10 (4.3)	2 (2.5)	.74
Operation performed, n (%)				
MV repair with Simplici-T band	312 (100)	232 (100)	80 (100)	1.00
Chordal replacement	252 (80.8)	184 (79.3)	68 (85.0)	.32
Reconstruction of the MA	12 (3.9)	10 (4.3)	2 (2.5)	.74
Maze for atrial fibrillation	54 (17.3)	32 (13.8)	22 (27.5)	.01
Repair of atrial septal defect	15 (4.8)	9 (3.9)	6 (7.5)	.23
Replacement of the ascending aorta	7 (2.2)	6 (2.6)	1 (1.3)	.68
Coronary artery bypass	43 (13.8)	31 (13.4)	12 (15.0)	.71
Resection of atrial myxoma	1 (0.3)	1 (0.4)	0 (0.0)	1.00
Septal myectomy	2 (0.6)	1 (0.4)	1 (1.3)	.45
Aortic clamping time, min, median (IQR)	66 (47-81)	63 (46-100)	72 (53-84)	.06
Cardiopulmonary bypass time, min, median (IQR)	82 (64-101)	81 (62-100)	92 (71-106)	.04

TA, Tricuspid annulus; MV, mitral valve; IQR, interquartile range; MA, mitral annulus; TR, tricuspid regurgitation. *Degree of myxomatous degeneration.⁸

<40 mm separately. Table 4 present the results of univariable analyses of variables associated with postoperative TR ≥3+, and Table 5 presents the results of multivariable analysis. Preoperative TA diameter was not associated with the odds of postoperative TR in either the univariable or multivariable regression models. This remained true regardless of whether TA size was modeled as a continuous variable, as an ordinal variable, or using the threshold of ≥40 mm. There was a significant association between TA diameter indexed to body surface area

and odds of postoperative TR in univariable analysis (Table 4); however, this association did not remain significant in the multivariable regression model (Table 5). In subgroup analysis, preoperative TA diameter ≥40 mm was not associated with increased risk of postoperative TR in any subgroup of patients except patients with a preoperative left ventricular ejection fraction <60% (Table 6).

Twelve patients developed MR ≥3, and 1 patient developed mitral stenosis due to pannus during follow-up.

TABLE 3. Clinical outcomes: freedom from mortality from Kaplan-Meier estimates, cumulative incidences of reoperation and stroke over time with death as a competing risk, and number of patients with data available at different follow-up landmarks

Outcome	1 y	3 y	5 y	10 y
Survival, % (95% CI)	99.4 (97.5-99.8)	98.4 (96.1-99.3)	97.7 (95.2-98.9)	90.8 (74.2-96.9)
Reoperation, CuI (95% CI)	0.0	0.7 (0.2-2.6)	0.7 (0.2-2.6)	0.7 (0.2-2.6)
Stroke, CuI (95% CI)	0.3 (0.1-2.3)	0.5 (0.2-2.5)	1.3 (0.5-3.5)	2.9 (1.1-7.3)
No. of patients, clinical	310	297	277	16
No. of patients, imaging	301	289	255	10

CI, Confidence interval; CuI, cumulative incidence.

FIGURE 1. Correlation of preoperative tricuspid annulus size and preoperative mitral annulus size.

DISCUSSION

The concept of performing TVA based on the diameter of the TA rather than on the severity of TR was introduced by Dreyfus and colleagues⁴ in 2005. These investigators systematically explored the TV at the time of MV repair for MR due to various pathologies in 311 patients, and performed TVA whenever the distance from the anteroposterior commissure to the anteroposterior commissure was ≥ 70 mm.⁴ They found that this approach greatly reduced the risk of developing TR after MV repair.⁴ We are not aware of any study that has correlated this surgical measurement in the arrested heart with preoperative TA diameter, but 40 mm appears in the guidelines.^{2,3}

Although we do not dispute that a dilated TA is often associated with functional TR, the value of 40 mm as a cutoff to recommend TVA without TR at the time of MV repair for degenerative MR needs further evaluation. The TV leaflets, like the MV leaflets, vary in size in patients with degenerative diseases. Patients with fibroelastic deficiency frequently have small MV leaflets, so small that at one time we were reluctant to use an annuloplasty ring or band for fear of creating mitral stenosis.⁸ The TV leaflets are also small in these patients, and a TA of 40 mm is likely too large, and this TVA is probably

FIGURE 2. Tricuspid annulus size versus preoperative tricuspid regurgitation grade.

FIGURE 3. Tricuspid annulus size versus degree of degeneration of the mitral valve.

necessary to prevent late TR. On the other hand, patients with myxomatous degeneration of the MV frequently have large leaflets with large MAs and also large TV leaflets with larger TAs. This type of degenerative disease is present in most of our patients, and a TA of 40 mm is likely normal and is only rarely associated with severe TR (at least in our experience), and when this association is present, it is often a result of leaflet prolapse rather than annular dilatation. In this study, TA diameter was moderately correlated with MA diameter (Figure 1), as well as with the severity of preoperative TR (Figure 2), but was not correlated with the degree of myxomatous degeneration. This finding was surprising, because we expected to find large TV leaflets and consequently larger TAs in patients with more advanced degrees of myxomatous degeneration.

TA ≥ 40 mm or TA ≥ 21 mm/m² did not predict the development of postoperative TR. Preoperative TA diameter was not associated with postoperative TR in either the univariable or multivariable regression models. This remained true regardless of whether TA diameter was modeled as a continuous variable, as an ordinal variable, or using the threshold of ≥ 40 mm. There was a significant association between TA size indexed to body surface area and the odds of postoperative TR in univariable analysis; however, this association did not remain significant in the multivariable regression model. Preoperative TA diameter ≥ 40 mm was not associated with an increased risk of postoperative TR in any subgroup of patients except patients with a preoperative left ventricular ejection fraction $< 60\%$. In a recent study, we examined a much larger sample of patients and found that impaired left ventricular function was associated with the development of postoperative TR.⁹ The most powerful predictor of postoperative TR was the presence of untreated moderate TR before surgery.

We are not the first group to challenge the concept that TA ≥ 40 mm is predictive of postoperative functional TR after MV repair for degenerative diseases. Sordelli and colleagues,¹⁰ from Milan, Italy, prospectively evaluated

FIGURE 4. Estimated punctual probability of postoperative tricuspid regurgitation of moderate degree or greater over time (*figure*) and at specific follow-up landmarks (*embedded table*). Data are provided for in all patients (*upper panel*) and in patients with TA <40 mm and TA ≥40 mm.

the predictive value of TA diameter assessed by 3D transesophageal echocardiography in the development of TR in 706 patients who had undergone isolated MV repair for MR due to degenerative diseases (77% with

TABLE 4. Univariable risk factor analysis for postoperative TR ≥3+ over time

Variable	OR	95% CI	P value
Age (5-y increment)	1.61	1.34-1.93	<.001
Time since operation (y)	1.05	0.96-1.14	.27
Preoperative MA size (mm)	0.99	0.92-1.06	.72
Preoperative MV area in 0°	0.99	0.93-1.06	.85
Preoperative MV area in 90°	0.96	0.89-1.03	.22
Female sex	4.08	1.84-9.05	<.001
Atrial fibrillation/maze procedure	4.63	2.10-10.24	<.001
Hypertension	2.90	1.29-6.55	.01
Preoperative TA size (mm)	1.06	0.99-1.15	.10
<35	Reference		
35-39	2.33	0.88-6.17	.09
40-42	1.74	0.57-5.31	.33
42-45	1.68	0.20-14.02	.63
>45	3.71	0.44-31.18	.23
Preoperative TA size ≥40 mm	1.13	0.48-2.68	.77
TA size/BSA >21 mm/m ²	2.416	1.279-4.565	.007
Preoperative TR ≥3+	13.6	5.71-32.59	<.001
Preoperative degeneration of MV (reference: mild)			
Moderate	0.86	0.36-2.06	.74
Severe	0.39	0.14-1.07	.07
Preoperative LV grade (per grade)	1.03	0.49-2.17	.94

OR, Odds ratio; CI, confidence interval; MA, mitral annulus; MV, mitral valve; TA, tricuspid annulus; BSA, body surface area; TR, tricuspid regurgitation; LV, left ventricular.

myxomatous diseases, with a broad spectrum of lesions, and 23% with fibroelastic deficiency). They performed a detailed analysis of the diastolic and systolic TA diameters (anteroposterior and septolateral) and the outcomes of

TABLE 5. Multivariable risk factor analysis for postoperative TR ≥3+ over time for preoperative TA size ≥40 mm and preoperative TA size indexed to body surface area

Variable	OR (95% CI)	P value
Preoperative TA size ≥40 mm		
Time since operation (per year)	1.094 (0.986-1.213)	.09
Age (5-y increment)	1.312 (1.054-1.633)	.02
Female sex	4.244 (1.748-10.307)	.001
Atrial fibrillation/maze procedure	1.744 (0.666-4.567)	.26
Hypertension	2.485 (0.958-6.449)	.06
Preoperative TR ≥3+	7.629 (2.105-27.658)	.002
Preoperative TA size ≥40 mm	1.405 (0.492-4.014)	.53
Preoperative TA indexed to BSA		
Time since operation (per year)	1.094 (0.986-1.213)	.09
Age (5-y increment)	1.294 (1.050-1.594)	.02
Female sex	3.735 (1.445-9.652)	.007
Atrial fibrillation/maze procedure	1.849 (0.680-5.024)	.23
Hypertension	2.513 (0.965-6.546)	.06
Preoperative TR ≥3+	7.537 (2.141-26.528)	.002
Preoperative TA indexed to BSA	1.024 (0.905-1.160)	.70

OR, Odds ratio; CI, confidence interval; TA, tricuspid annulus; TR, tricuspid regurgitation; BSA, body surface area.

TABLE 6. Association between preoperative TA size ≥ 40 mm and postoperative TR $\geq 3+$ over time for various subgroups of patients

Patient subgroup	OR (95% CI)	P value
Age (y)		
<50	3.376 (0.214-53.372)	.39
50-59	0.908 (0.750-10.930)	.94
60-69	0.626 (0.130-3.011)	.56
≥ 70	2.013 (0.605-6.701)	.25
Sex		
Male	1.191 (0.366-3.876)	.77
Female	3.210 (0.883-11.666)	.08
Atrial fibrillation/maze procedure*		
Yes	1.472 (0.474-4.573)	.50
No	0.474 (0.102-2.207)	.34
BSA (m^2)		
≤ 1.75	1.993 (0.399-9.599)	.40
1.76-1.90	1.052 (0.238-4.663)	.95
1.91-2.05	1.246 (0.114-13.591)	.86
> 2.05	2.158 (0.403-11.547)	.37
Preoperative grade of TR		
1-2	1.855 (0.310-11.115)	.50
2	1.518 (0.449-5.135)	.50
$\geq 3+$	0.229 (0.045-1.167)	.08
Preoperative degeneration of MV		
Mild	1.540 (0.406-5.847)	.53
Moderate	0.777 (0.200-3.017)	.72
Severe	1.642 (0.310-8.695)	.56
Ejection fraction (%)		
≥ 60	0.672 (0.242-1.860)	.44
< 60	7.112 (1.205-41.980)	.03
Preoperative MA size (mm)		
≤ 37	1.713 (0.410-7.151)	.46
38-40	2.536 (0.257-25.013)	.43
41-45	0.264 (0.029-2.390)	.24
≥ 46	1.626 (0.262-10.091)	.60

OR, Odds ratio; CI, confidence interval; BSA, body surface area; TR, tricuspid regurgitation; MV, mitral valve; MA, mitral annulus. *Given the small number of patients, the 41 patients with atrial fibrillation and the maze procedure, 13 patients with a history of atrial fibrillation and the maze procedure, and 3 patients with atrial fibrillation but no maze procedure were combined in a single category.

surgery after a mean follow-up of 2 years (range, 0.5-5 years). TR decreased by 1 grade in 32% of the patients, remained unchanged in 62%, and increased by 1 grade in 5.5%, but only 3 patients developed moderate or severe TR. The authors concluded that “newly developed significant TR is a rare event after successful repair of degenerative MR,” and that “analysis of TA does not predict early to midterm subsequent TR progression.”¹⁰ The MV pathology (myxomatous vs fibroelastic deficiency) was not entered into the multivariable models in that study. Of note, the TA and MA in our study are very similar to those reported by Sordelli and colleagues.¹⁰

A recent report based on the Society of Thoracic Surgeons database on TVA at the time of MV surgery indicated that concomitant TVA was performed in 14.3%

of all MV operations, but in centers that performed more than 10 MV operations per year, this percentage ranged from 75% in 2 centers to <10% in more than 300 centers.¹¹ In addition, TVA was performed in only 3.5% when the grade of TR was mild or less, 30.6% when it was moderate, and 75.6% when it was severe.¹¹ However, as documented in this study and a previous study,⁹ preoperative moderate TR is associated with postoperative TR of moderate or severe degree after MV repair for degenerative diseases, and we now believe that TVA is appropriate in these patients. In addition, TVA should be considered in patients with longstanding atrial fibrillation, dilated right atrium, impaired left ventricular systolic function, and female, even in the absence of moderate or severe TR.^{9,12}

Study Limitations

In this retrospective study, the TA and MA diameters were obtained intraoperatively, and the values may have been affected by the anesthetic, assisted ventilation, and loading conditions, which were not controlled for at the time of measurement. The sizes and areas of the TV leaflets were not measured to correlate with the diameter of TA and development of TR. In addition, TR after MV repair for degenerative diseases is uncommon, and the sample size of this study was too small and the duration of follow-up too short to enable a more detailed analysis of the variables associated with postoperative TR. Finally, given the limited sample size and the close to significant association between preoperative TA diameter as a continuous variable and increased odds of postoperative TR over time, we cannot exclude the possibility that the lack of association is in fact a type II error resulting from an underpowered comparison.

CONCLUSIONS

TA ≥ 40 mm was not associated with the development of TR after MV repair for degenerative diseases, likely because of the variable size of the TV leaflets in patients with degenerative diseases. Preoperative moderate TR was the most powerful predictor of postoperative TR in multivariable analysis.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://aats.blob.core.windows.net/media/17AM/2017-05-01/BallroomABC/05-01-17_BallroomABC_1450_David.mp4.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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