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RESEARCH ARTICLE

Tricuspid regurgitation: Frequency, clinical presentation, management and outcome among patients with severe left-sided valvular heart disease in Europe. Insights from the ESC-EORP Valvular Heart Disease II survey

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Aims Tricuspid regurgitation (TR) is commonly observed in patients with severe left-sided valvular heart disease (VHD). This study sought to assess TR frequency, management and outcome in this population.

Methods and results Among 6883 patients with severe native left-sided VHD or previous left-sided valvular intervention enrolled in the EURObservational Research Programme prospective VHD II survey, moderate or severe TR was very frequent in patients with severe mitral VHD (30% when mitral stenosis, 36% when mitral regurgitation [MR]), especially in patients with secondary MR (46%), and rare in patients with severe aortic VHD (4% when aortic stenosis, 3% when aortic regurgitation). An increase in TR grade was associated with a more severe clinical presentation and a poorer 6-month survival ($p < 0.0001$). Rates of concomitant tricuspid valve (TV) intervention at the time of left-sided heart valve surgery were high at the time of mitral valve surgery (50% when mitral stenosis, 41% when MR). Concordance between class I indications (patients with severe TR) for concomitant TV surgery at the time of left-sided valvular heart surgery according to guidelines and real-practice decision-making was very good (88% overall, 95% in patients operated on for MR).

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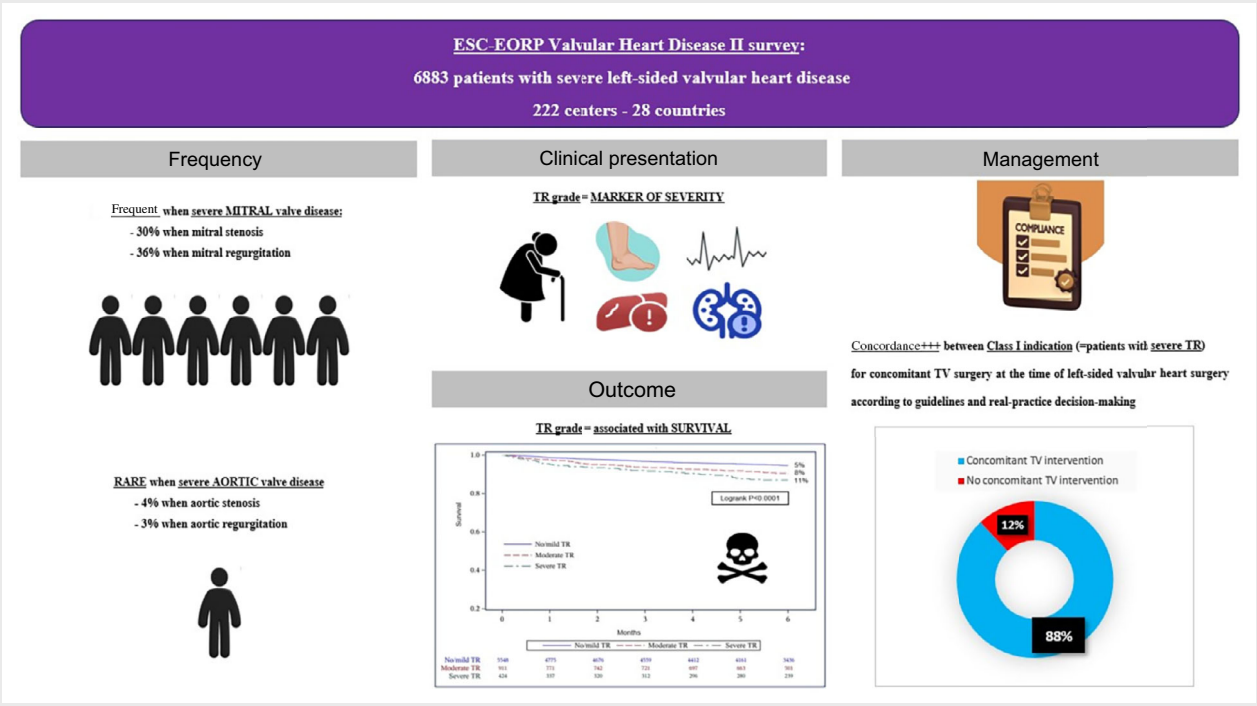
†Listed in in online supplementary *Appendix S1*.

Conclusion In this large international prospective survey among patients with severe left-sided VHD, moderate/severe TR was frequent in patients with mitral valve disease and was associated with a poorer outcome as TR grade increased. In patients with severe TR, compliance to guidelines for class I indications for concomitant TV surgery at the time of left-sided heart valve surgery was very good.

Graphical Abstract



Tricuspid regurgitation (TR): frequency, clinical presentation, management and outcome among patients with severe left-sided valvular heart disease in Europe. ESC-EORP, European Society of Cardiology-EURObservational Research Programme; TV, tricuspid valve.

Keywords Guidelines • Left-sided heart valve disease • Management • Outcome • Tricuspid regurgitation

Introduction

Moderate or severe tricuspid regurgitation (TR) is a frequent condition, affecting over 1.6 million individuals in the US.[1] In approximately half of those patients, TR is secondary to left-sided valvular heart disease (VHD)[2] but prevalence and grade of TR according to each left-sided VHD have not been well described.

Tricuspid regurgitation is an independent prognostic factor associated with significant morbidity and mortality, and its risk increases with its severity, regardless of its mechanism or aetiology.[3–8] TR often persists or even progresses after successful correction of mitral or aortic valve disease, including surgical or transcatheter interventions, when the tricuspid valve (TV) is left untreated at the time of left-sided valvular intervention,[9,10] with an adverse prognosis for those patients.[11] Recommendations from European Society of Cardiology (ESC)/European Association for Cardiothoracic Surgery (EACTS) and American College of Cardiology (ACC)/American Heart Association (AHA) for concomitant TV intervention at the time of left-sided heart valve surgery are well codified for patients with severe TR (class IB regardless of the TR mechanism in ACC/AHA guidelines; class IC for primary TR and class IB for secondary TR in ESC/EACTS guidelines) but less categorical for patients with less than severe TR (class IIaB when the tricuspid annulus is dilated in ACC/AHA and ESC/EACTS guidelines, class IIaB for prior signs and symptoms of right-sided heart failure in ACC/AHA guidelines and class IIaC for moderate primary TR in ESC/EACTS guidelines).[12,13]

This study aimed to use data from the international VHD II survey, designed by the ESC EURObservational Research Programme (EORP)[14] to assess TR frequency, management and outcome among patients with severe left-sided VHD in a large multicentre cohort in Europe.

Methods

Study population

The VHD II survey was prospectively designed to assess adherence to guidelines and was conducted between January and August 2017 in 222 centres across 28 countries. Patients were included in this registry if they fulfilled the following criteria: signed informed consent, age ≥18 years, severe native VHD or previous valvular intervention. Exclusion criteria were acute infective endocarditis, enrolment in a valve intervention study impacting on management, and VHD related to complex congenital heart disease.[14]

In the current study, we included patients from the VHD II Survey if they had at least one severe left-sided native VHD or if they had previously undergone a valvular intervention, and excluded patients with isolated right-sided VHD or previous right-sided valvular intervention.

Severe aortic or mitral VHD and grades of TR, divided into no/mild, moderate and severe, were defined at each local centRE by echocardiography using an integrative approach but without specifying the results for each of the different assessable parameters.

The VHD II Survey was approved for the ESC by the Comité Consultatif sur le Traitement de l'Information en matière de Recherche dans le domaine de la Santé (CCTRS) (5 October 2016) and the Commission Nationale de l'Informatique et des Libertés (CNIL) (14 April 2017). National coordinators, in conjunction with local centres, (or) participating centres (depending on whether they are country/centre based) managed the approvals of national or regional ethics committees or Institutional Review Boards, according to local regulations. The study was performed according to the ethical principles of the Declaration of Helsinki on investigation in humans, and informed consent was obtained from all patients for inclusion in the study.

Tricuspid regurgitation and severe left-sided valvular heart disease

Among patients with severe left-sided VHD or previous left-sided valvular intervention, we specifically studied frequency and grade of TR according to left-sided VHD as well as characteristics and 6-month overall survival of patients according to TR grade.

Concomitant tricuspid valve intervention at the time of left-sided heart valve intervention

Among patients who underwent an intervention for severe left-sided VHD during the study period, we analysed the rates of surgical and transcatheter intervention on left heart valve disease and the frequency of concomitant TV intervention. More specifically, we studied the concordance between class I indications for concomitant TV intervention (patients with severe TR) from the 2012 ESC/EACTS and 2014 AHA/ACC guidelines which were applicable at the time of the survey[15,16] and therapeutic decision-making. We also assessed the rates of concomitant TV intervention at the time of left-sided heart valve surgery in patients with moderate TR.

Statistical analysis

Variables were expressed as median (interquartile range) for continuous variables and number of patients (percentage) for categorical variables. Comparisons between groups of patients with severe left-sided VHD according to TR grade were performed with a χ^2 or Fisher exact test for categorical variables and a Kruskal–Wallis test for continuous variables.

Concordance with class I recommendations for concomitant TV intervention according to the 2012 ESC/EACTS and 2014 AHA/ACC guidelines[15,16] and therapeutic decision-making was assessed by the frequency of concomitant TV interventions which were performed in patients who underwent interventions for severe left-sided VHD and had severe TR.

Six-month survival rates according to TR grade in the overall population were assessed using the Kaplan–Meier method and compared with a log-rank test. The relationship between 6-month survival and TR grade was analysed using an unadjusted Cox proportional hazard model and two different Cox models, adjusted according to EuroSCORE II or Charlson comorbidity index.

Missing data were not imputed. Analyses were performed at the two-tailed $p < 0.05$ level, using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Frequency and grade of tricuspid regurgitation in patients with severe left-sided valvular heart disease

In the VHD II survey, 7247 adult patients were recruited. After exclusion of patients with isolated right-sided VHD or previous right-sided valvular intervention, 6883 patients with severe left-sided VHD or previous left-sided valvular intervention represented our study population. Among them, 5548 (81%) had no or mild TR, 911 (13%) had moderate TR and 424 (6%) had severe TR, with no difference between patients with native left-sided valve disease or previous left-sided valvular intervention ($p = 0.472$). Moderate or severe TR was rare in patients with severe aortic valve disease (4% in patients with severe aortic stenosis and 3% in patients with severe aortic regurgitation) but common in patients with severe mitral valve disease (30% in patients with severe mitral stenosis and 36% in patients with severe mitral regurgitation [MR]), especially in patients with secondary MR (46%). Similarly, moderate or severe TR was frequent in patients with severe multiple left-sided valve disease (32%) (*Figure 1* and online supplementary *Table S1*).

Characteristics of patients with severe left-sided valvular heart disease according to tricuspid regurgitation grade

Overall, as described in *Table 1*, the severity of the clinical, biological and echocardiographic presentation progressively increased alongside the TR grade. Thus, an increase in TR grade was observed in patients with a more severe cardiac and non-cardiac

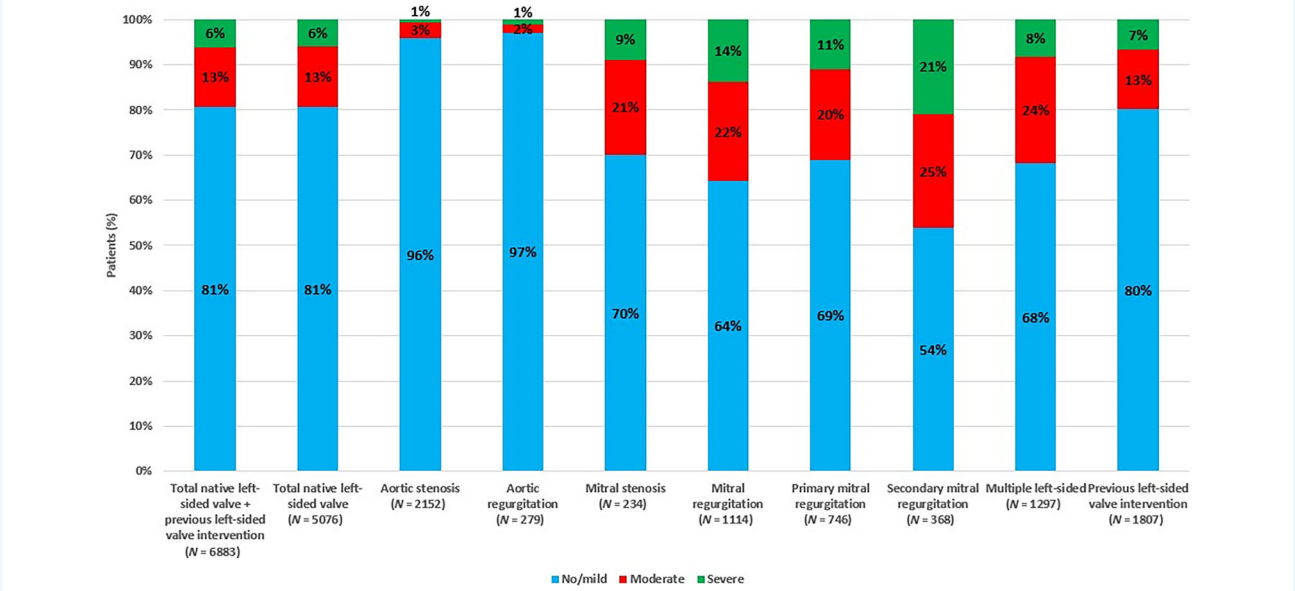


Figure 1 Frequency and grade of tricuspid regurgitation in patients with severe left-sided valvular heart disease (native or previous left-sided valvular intervention) according to left-sided valve disease.

presentation, as patients had more previous hospitalization for heart failure during the last year, diuretics, New York Heart Association (NYHA) functional class III/IV, congestive heart failure signs at the time of examination, limited mobility, atrial fibrillation, liver dysfunction, higher systolic pulmonary artery pressure, Charlson index and EuroSCORE II, as well as reduced creatinine clearance and left ventricular ejection fraction ($p < 0.0001$ for all).

Outcome of patients with severe left-sided valvular heart disease according to tricuspid regurgitation grade

Tricuspid regurgitation severity was associated with all-cause mortality at 6 months that significantly increased with TR grade (5% for patients with no or mild TR, 8% for moderate TR and 11% for severe TR, $p < 0.0001$) (*Figure 2*), even after adjustment for EuroSCORE II (adjusted hazard ratio [HR] 1.62 [95% confidence interval 1.16–2.26], $p = 0.004$ for moderate TR versus no/mild TR, and adjusted HR 2.53 [1.74–3.69], $p < 0.0001$ for severe TR vs. no/mild TR) or Charlson comorbidity index (adjusted HR 1.67 [1.21–2.32], $p = 0.002$ for moderate TR vs. no/mild TR, and adjusted HR 2.69 [1.86–3.89], $p < 0.0001$ for severe TR vs. no/mild TR) (*Table 2*).

Management of patients with severe left-sided valvular heart disease

A TV intervention was performed in 4% ($n = 262$) of the 8883 patients ($n = 73$ with no/mild TR, $n = 119$ with moderate TR and $n = 70$ with severe TR), always at the time of left-sided valve surgery. TV surgery was mostly a repair (96% of all TV procedures) while biological and mechanical prostheses were rarely implanted in the tricuspid position (3% and 1%, respectively).

Rates of tricuspid valve intervention in the subset of patients who underwent an intervention for severe left-sided valvular heart disease

A concomitant TV intervention at the time of left-sided heart valve intervention was performed in 13% ($n = 262$) of the 2081 patients who underwent a (surgical or transcatheter) left-sided valvular heart intervention during the survey period.

All 262 concomitant TV interventions were carried out at the time of left-sided heart valve surgery, accounting for 19% of the 1391 patients who underwent a left-sided heart valve surgery (*Figure 3*). Rates of concomitant TV intervention at the time of left-sided heart valve surgery were very low for aortic valve surgery (1% for aortic stenosis and 2% for aortic regurgitation) but high for mitral valve surgery, as it was performed in more than 40% in case of surgery for MR and up to 50% for mitral stenosis (*Figure 3*).

Transcatheter interventions represented overall one third of all left-sided heart valve interventions (online supplementary *Figure S1*). Conversely, no transcatheter intervention was performed for the TV. Thus, among the 690 patients who underwent a transcatheter intervention at the left-sided heart valve level, none of them had a concomitant transcatheter TV intervention.

Rates of tricuspid valve intervention according to tricuspid regurgitation grade in the subset of patients who underwent a left-sided heart valve surgery

Among the 2081 patients who underwent (surgical or transcatheter) left-sided valvular heart intervention during the study

Table 1 Characteristics of patients with severe left-sided valvular heart disease according to tricuspid regurgitation grade

	No/mild TR ($n = 5548$)	Moderate TR ($N = 911$)	Severe TR ($n = 424$)	*p*-value between the three groups	*p*-value moderate vs. no/mild TR	*p*-value Severe vs. no/mild TR	*p*-value severe vs. moderate TR
Patient characteristics							
Age, years	71.0 (61.0–80.0)	74.0 (64.0–81.0)	71.0 (61.0–79.0)	**<0.001**	**<0.001**	0.957	**0.019**
Female sex	2441 (44)	499 (55)	248 (59)	**<0.001**	**<0.001**	**<0.001**	0.203
Body mass index, kg/m^2	27.0 (24.1–30.3)	26.5 (23.6–29.8)	26.0 (23.4–29.7)	**<0.001**	**0.003**	**0.001**	0.365
Previous coronary intervention	905/5526 (16)	182/904 (20)	62/419 (15)	**0.011**	**0.005**	0.398	**0.020**
Permanent pacemaker	285/5026 (6)	89/801 (11)	52/366 (14)	**<0.001**	**<0.001**	**<0.001**	0.132
Hospitalization for heart failure during the last year	912/5547 (16)	261 (29)	159 (38)	**<0.001**	**<0.001**	**<0.001**	**0.001**
NYHA class				**<0.001**	**<0.001**	**<0.001**	**<0.001**
I	1494 (27)	106 (12)	35 (8)				
II	2200 (40)	319 (35)	125 (30)				
III	1662 (30)	418 (46)	207 (49)				
IV	192 (4)	68 (8)	57 (13				
Congestive heart failure	941 (17)	341 (37)	205 (48)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Atrial fibrillation/flutter	1049/5531 (19)	440/910 (48)	242/422 (57)	**<0.001**	**<0.001**	**<0.001**	**0.002**
Creatinine clearance, ml/min	69.9 (49.6–94.0)	59.5 (42.0–80.2)	57.2 (40.8–79.2)	**<0.001**	**<0.001**	**<0.001**	0.177
Cardiovascular risk factors							
Hypertension	3733 (67)	662 (73)	254 (60)	**<0.001**	**0.001**	**0.002**	**<0.001**
Diabetes	1201/5547 (22)	201 (22)	90 (21)	0.936	0.780	0.838	0.730
Comorbidities							
Chronic dialysis	59 (1)	10 (1)	6 (1)	0.797	0.926	0.463	0.620
Chronic pulmonary disease	591/5511 (11)	125/900 (14)	56/421 (13)	**0.009**	**0.005**	0.102	0.772
Liver dysfunction	92/5459 (2)	30/876 (3)	36/418 (9)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Previous myocardial infarction	514/5510 (9)	120/895 (13)	45/417 (11)	**<0.001**	**<0.001**	0.324	0.183
Previous stroke/TIA	417 (8)	69 (8)	42 (10)	0.203	0.951	0.075	0.151
Lower limb atherosclerosis	249/5103 (5)	46/797 (6)	17/376 (5)	0.514	0.282	0.755	0.375
Limited mobility	325 (6)	87 (10)	53 (13)	**<0.001**	**<0.001**	**<0.001**	0.101
Charlson comorbidity index	3.0 (2.0–5.0)	4.0 (3.0–6.0)	4.0 (3.0–6.0)	**<0.001**	**<0.001**	**<0.001**	0.929
EuroSCORE II	1.9 (1.0–3.7)	3.0 (1.6–6.5)	3.8 (2.0–7.3)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Left-sided valvular heart disease							
Aortic valve disease	2335 (42)	77 (9)	19 (5)	**<0.001**	**<0.001**	**<0.001**	**0.009**
Mitral valve disease	879 (16)	293 (32)	176 (42)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Multiple valve disease	885 (16)	305 (34)	107 (25)	**<0.001**	**<0.001**	**<0.001**	**0.002**
Previous intervention	1449 (26)	236 (26)	122 (29)	**0.472**	0.893	0.231	0.271
Drug therapy at admission							
Diuretics	2808/4867 (58)	662/842 (79)	339/392 (87)	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Transthoracic echocardiography							
LV ejection fraction <60%	2825/5447 (52)	579/894 (65)	299/417 (72)	**<0.001**	**<0.001**	**<0.001**	**0.013**
Systolic pulmonary artery pressure >55 mmHg	499/5041 (10)	289/880 (33)	226/405 (56)	**<0.001**	**<0.00**	**<0.001**	**<0.001**

Values are given as *n* (%) or median (interquartile range); bolded results are statistically significant at the $p < 0.05$ level.
LV, left ventricular; NYHA, New York Heart Association; TIA, transient ischaemic attack; TR, tricuspid regurgitation.

period, 5% ($n = 107$) had severe TR and 13% ($n = 261$) had moderate TR.

In patients with severe TR, a concomitant TV intervention was performed at the time of left-sided heart valve surgery in 88% of patients (class I ESC/EACTS and AHA/ACC recommendation).[15,16] This rate rose to 95% at the time of mitral valve surgery for MR (*Figure 4A*).

In patients with moderate TR, a concomitant TV intervention was performed at the time of left-sided heart valve surgery in 76% of patients overall and in the subset of patients operated on for MR (*Figure 4B*).

Discussion

In this large international prospective survey of patients with severe left-sided VHD in Europe, the main results can be summarized as follows (*Graphical Abstract*): (i) moderate and severe TR were frequent among patients with severe mitral valve disease and rare among patients with aortic valve disease; (ii) an increase in TR grade was associated with a more severe clinical presentation and a poorer overall survival at 6 months; (iii) rates of concomitant TV intervention at the time of left-sided heart valve surgery were high at the time of mitral valve surgery but very low at the time of aortic valve surgery; (iv) concordance between class I indications (patients with severe TR) for concomitant TV surgery at the time of left-sided valvular heart surgery according to guidelines and real-practice decision-making was very good (88% overall), especially for patients undergoing surgery for MR (95%); (v) a concomitant TV surgery at the time of left-sided valvular heart surgery was also performed in most patients with moderate TR (76% overall).

Prevalence of moderate or greater TR in the general population has recently been described in the Oxfordshire (United Kingdom),

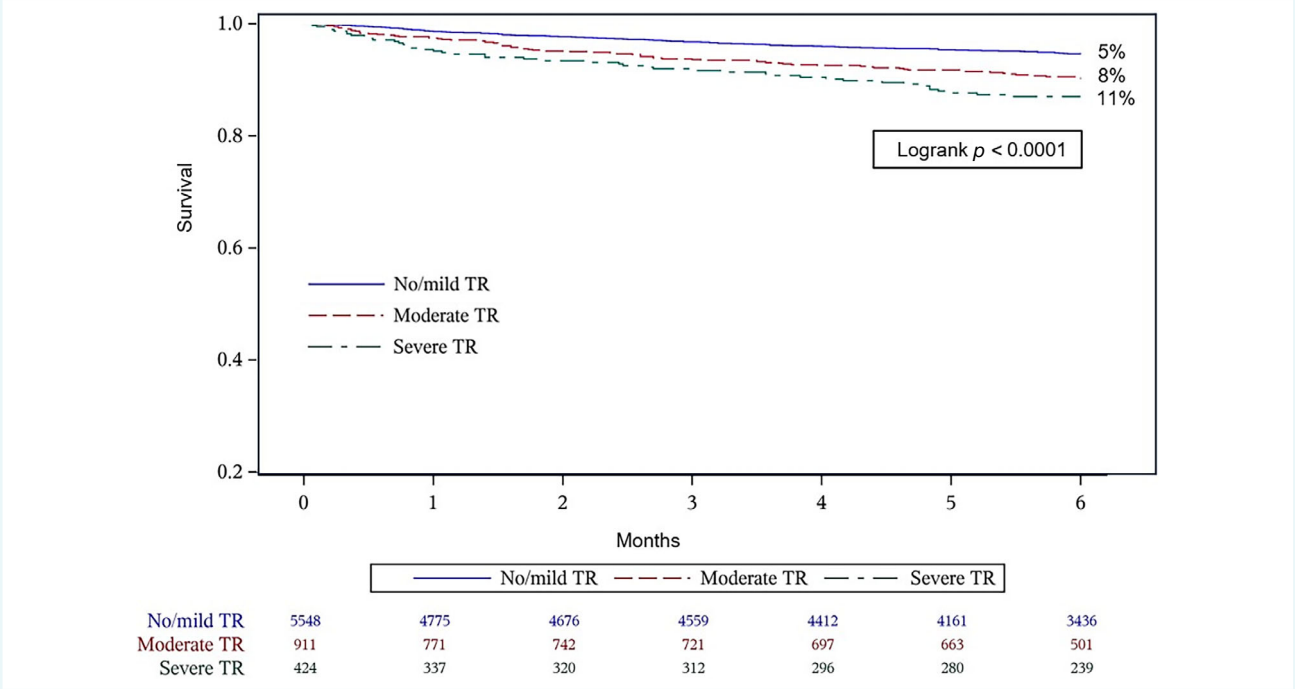


Figure 2 Kaplan–Meier 6-month overall survival in patients with severe left-sided valvular heart disease (native or previous left-sided valvular intervention) according to tricuspid regurgitation (TR) grade.

Table 2 Hazard ratios for overall all-cause death at 6 months in patients with severe left-sided valvular heart disease (native or previous left-sided valvular intervention) according to tricuspid regurgitation grade

	Hazard ratio	95% confidence interval	*p*-value
Unadjusted			
Moderate TR vs. no/mild TR	1.75	1.28–2.41	<0.001
Severe TR vs. no/mild TR	2.94	2.05–4.21	<0.001
Adjusted on EuroSCORE II			
Moderate TR vs. no/mild TR	1.62	1.16–2.26	0.004
Severe TR vs. no/mild TR	2.53	1.74–3.69	<0.001
EuroSCORE II (per 1% increase)	1.04	1.03–1.05	<0.001
Adjusted on Charlson comorbidity index			
Moderate TR vs. no/mild TR	1.67	1.21–2.32	0.002
Severe TR vs. no/mild TR	2.69	1.86–3.89	<0.001
Charlson comorbidity index (per 1-point increase)	1.12	1.10–1.14	<0.001

TR, tricuspid regurgitation.

being strongly age-related (1.1% in subjects aged 65–74 years and 6.6% in those aged ≥75 years).[17] This study is the first to depict frequency and grade of TR associated with severe left-sided VHD, not only overall, but also according to specific settings such as previous valvular intervention, multiple left-sided VHD or primary/secondary MR. In a recent study, Chancellor *et al.*[4] have shown that among 17 483 patients undergoing aortic valve replacement, 6% had moderate and 1% had severe TR, which is concordant with our results showing that severe TR is rare among patients with severe aortic stenosis (3% had moderate and 1% had severe TR in our study). Conversely, rates of moderate or severe TR were particularly high in patients with severe mitral VHD, especially secondary MR, probably stressed by both older age and atrial fibrillation, which is consistent with a recent series of 606 patients treated with transcatheter repair for MR in whom 57% had moderate or severe TR at baseline.[18]

Tricuspid regurgitation is a serious condition and a predictive factor of outcome with a poorer outcome related to its grade.[6–8] Previous studies had shown that presence of severe TR before treatment of left-sided VHD was a predictor of poor outcome for both patients with aortic stenosis[3] and MR,[11,18,19] regardless of the treatment strategy (surgery or transcatheter) for left-sided VHD. This study is the first to show a parallel between the severity of the TR grade and overall mortality in the setting of all severe left-sided VHD, which is a very common situation as it represents approximately half of patients with TR.[2] However, in our population, it was also striking to see that severity of the TR grade was associated with a poorer clinical, biological and echocardiographic presentation, with notably more congestive heart failure, atrial fibrillation, renal and liver failure, which are also confounding factors associated with poor outcome as recently shown in TRIGISTRY.[20]

The vast majority of TV surgery is currently performed at the time of left-sided valve surgery (86% of overall TV surgery in the Society of Thoracic Surgeons database in the USA[21] and 92% in France[22]), especially at the time of mitral valve surgery,[23] as mitral

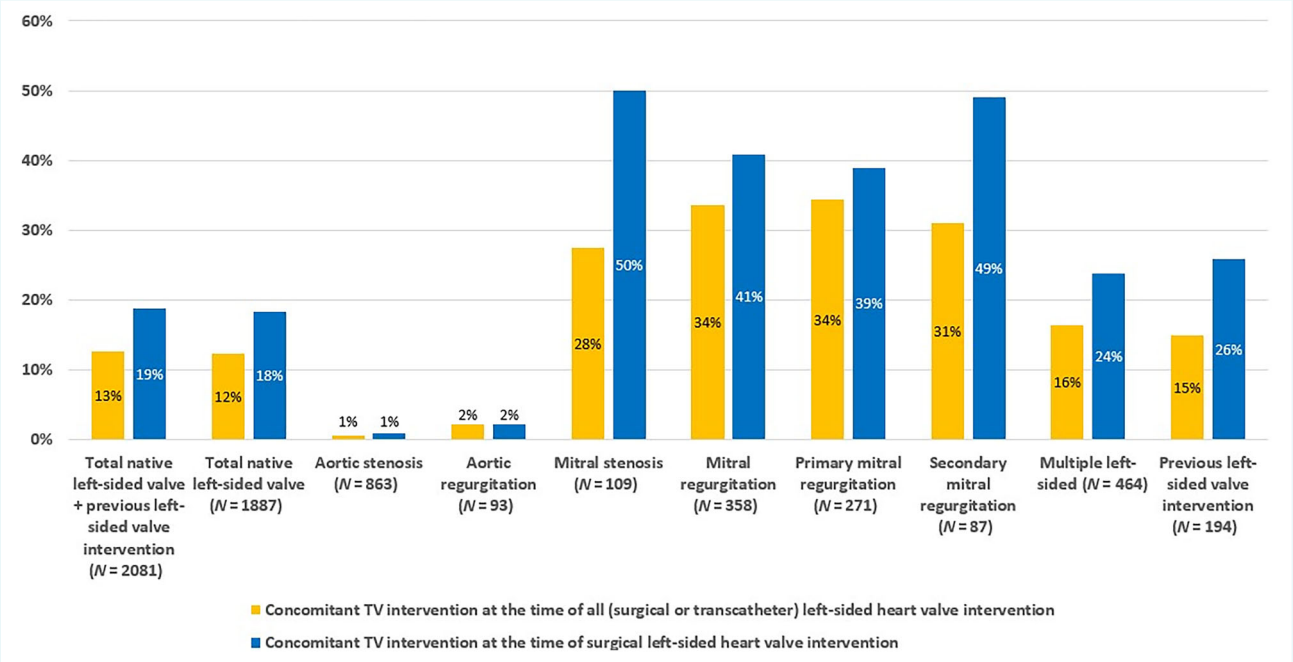


Figure 3 Rates of concomitant tricuspid valve (TV) intervention at the time of all (surgical or transcatheter) or only surgical left-sided heart valve intervention according to left-sided heart valve disease.

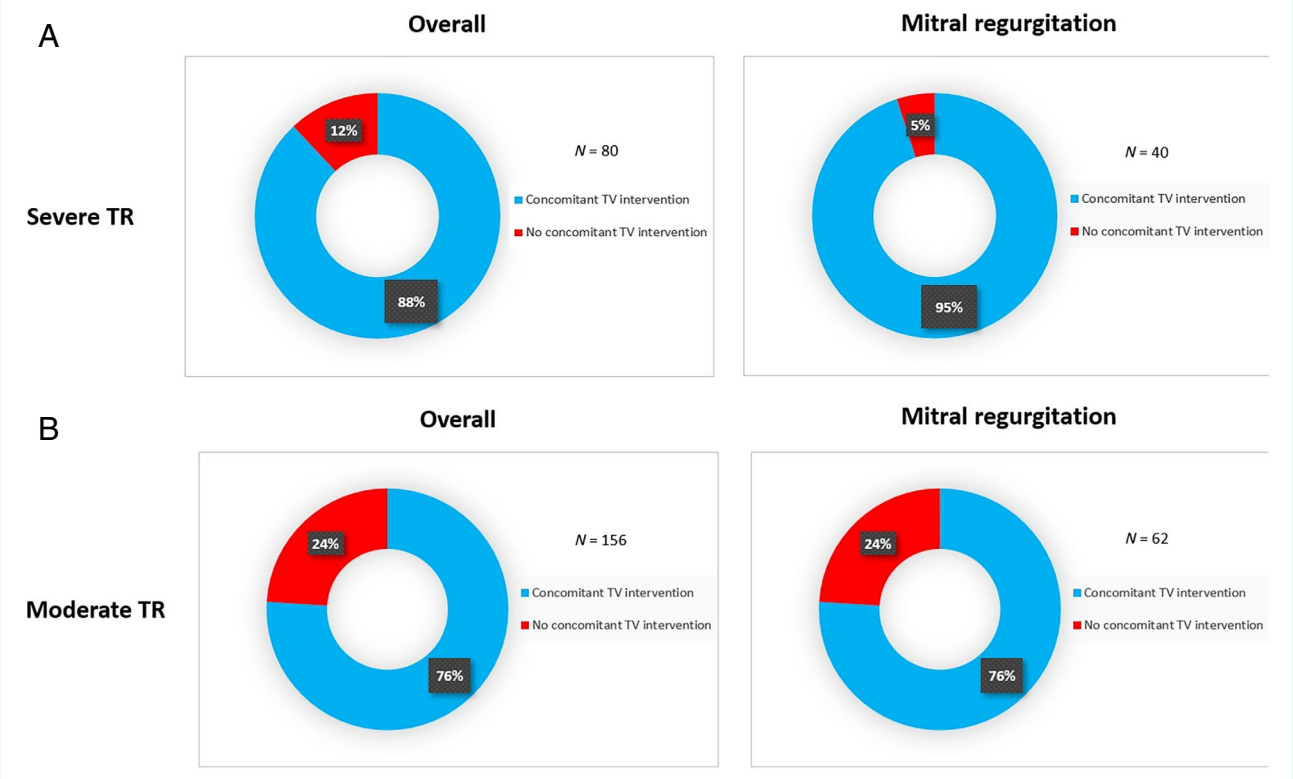


Figure 4 Rates of concomitant tricuspid valve (TV) intervention at the time of left-sided heart valve surgery according to tricuspid regurgitation (TR) grade in the overall population and in the subset of patients operated on for mitral regurgitation. (*A*) Patients with severe TR (class I indications for concomitant TV intervention in both ESC/EACTS and AHA/ACC guidelines. (*B*) Patients with moderate TR.

VHD is frequently associated with TV disease. Likewise, in our study, a TV surgical correction was frequently performed at the time of mitral valve surgical interventions (50% in patients operated on for mitral stenosis, 39% for primary MR and 49% for secondary MR) but only in 1% of surgical interventions for aortic stenosis. Our results are consistent with the literature. Indeed, among 17 483 patients who underwent surgical aortic valve replacement in a regional Society of Thoracic Surgeons database between 2001 and 2017, only 0.6% underwent a concomitant TV intervention.[4] On the contrary, among all mitral valve surgeries performed for MR in France between 2014 and 2016, a concomitant TV intervention was performed in 20% of the 7593 patients with primary MR and 27% of the 2935 patients with secondary MR.[24]

When assessing rates of concomitant TV intervention at the time of left-sided heart valve surgery according to TR grade, this survey highlighted first, a very good adherence to ESC/EACTS and AHA/ACC guidelines, as a concomitant TV intervention was performed at the time of left-sided heart valve surgery in 88% of all patients with severe TR as a class I indication according to 2012 ESC/EACTS and 2014 AHA/ACC guidelines,[15,16] indication that has been maintained in the most recent American and European guidelines.[12,13] This rate was particularly high (95%) at the time of mitral valve surgery for MR. Second, we observed that most patients (76%) with moderate TR also benefited from a concomitant TV surgery at the time of left-sided heart valve surgery. This is an interesting finding as it has recently been pointed out by the Cardiothoracic Surgical Trials Network that pre-operative ≥ moderate TR was associated with clinical events, including heart failure hospitalization, and should be taken into account in addition to other parameters that should be systematically assessed, such as tricuspid annulus diameter or atrial fibrillation, to decide whether a concomitant TV intervention should be performed at the time of left-sided heart valve surgery.[25] Real practices described in this VHD II survey were thus consistent with the observed steady increase over time in the number of combined TV surgery at the time of left-sided heart valve surgery.[22,26]

When the survey was conducted, transcatheter treatment represented one third of all curative interventions for severe left-sided VHD, with a higher proportion for patients with aortic stenosis, mitral stenosis or previous left-sided intervention. The number of transcatheter interventions for severe left-sided VHD is currently significantly growing with the advent of transcatheter aortic valve replacement for aortic stenosis and the development of transcatheter mitral valve repair, especially transcatheter edge-to-edge repair, and replacement. Population ageing, previous valve surgery (26% of our population), addition of indications for transcatheter treatment of MR in selected patients and extension of indications for transcatheter treatment of aortic stenosis toward low-risk patients in the last guidelines will intensify this trend.[12,13]

Transcatheter treatment for TR, that can be a repair or a replacement for patients with high surgical risk,[27] is currently under development and available only within the scope of trials in expert centres.[28] Randomized controlled trials (TRILUMINATE Pivotal trial recently published,[29] TRI-FR, CLASP II TR, TRISCEND II Pivotal trial) will try to demonstrate the safety and effectiveness of transcatheter treatments in improving clinical outcomes in comparison to medical therapy. In a recent observational study, Mehr *et al.*[30] have shown that concurrent correction of mitral and tricuspid regurgitation with transcatheter edge-to-edge valve repair was associated with a higher 1-year survival rate compared with isolated transcatheter edge-to-edge mitral valve repair in patients with severe MR and severe TR. Further studies are mandatory to carefully evaluate the benefit of combined mitral and tricuspid valve transcatheter interventions as well as the best strategy (one or two procedures) if combined interventions appear to be useful. In our survey, which was performed in 2017, no patient received a transcatheter treatment for TR. While waiting for the widespread use in routine practice of validated, safe and effective, transcatheter treatment to correct TR, the presence of severe TR associated with severe left-sided VHD should be taken into consideration, especially for mitral valve diseases, in the choice of the best therapeutic option between concomitant mitral and tricuspid surgical correction versus isolated mitral transcatheter intervention when a transcatheter TV intervention cannot be performed.

Study limitations

The present study deserves several comments. First, this voluntary survey was not population-based and there may be legitimate concerns regarding its ability to represent wider practice due to potential selection, referral and treatment bias. However, the design of the present survey allows for a detailed analysis of the relationship between patient characteristics and therapeutic decision-making in the light of ESC guidelines in a wide spectrum of healthcare structures and countries. Thus, we could not affirm the exact prevalence and grade of TR in patients with severe left-sided VHD but we can assume that the frequency found in this registry should be close to its prevalence in the population, thanks to a very large number of patients ($n = 6883$) in many centres ($n = 222$) across many countries.[28] Second, there was no centralized echocardiographic analysis. Right ventricular function was not collected as well as mechanism of TR but we assume that most patients had functional TR related to severe left-sided heart valve disease. Moreover, we were not able to assess adherence to class IIa recommendations based on tricuspid annulus dilatation in patients with less than severe TR as the tricuspid annulus diameter in transthoracic echocardiography was not collected in this registry. Third, hospitalization for heart failure and TR progression during follow-up were not included in the data collection, and although the follow-up period was relatively short (6 months), it did not hinder our ability to observe differences in survival according to TR grade, thanks to the substantial number of patients in the study.

Conclusion

In this large international prospective survey among patients with severe left-sided VHD, we have shown that moderate or severe TR was frequent in patients with mitral VHD and that TR grade increase was associated with a more severe clinical presentation and a poorer survival. Concordance between guidelines and

real-practice decision-making for class I indications (patients with severe TR) for concomitant TV surgery at the time of left-sided heart valve surgery was very good.

Supplementary Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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