Cardiovasc Surg Int 2024;11(2):95-101
http://dx.doi.org/DOI: 10.5606/e-cvsi.2024.1649
www.e-cvsi.org

Cardiovascular Surgery and Interventions

Original Article Open Access

Assessing in-hospital mortality in tricuspid valve surgery: A focus on the tricuspid annular plane systolic excursion/pulmonary artery systolic pressure ratio

Mehmet Altunova, Tuğba Aktemur

Department of Cardiology, University of Health Sciences, Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital, İstanbul, Türkiye

Received: March 07, 2024 ***Accepted:*** March 29, 2024 ***Published online:*** May 09, 2024

ABSTRACT

Objectives: This study aimed to investigate the association between the tricuspid annular plane systolic excursion (TAPSE)/pulmonary artery systolic pressure (PASP) ratio and in-hospital mortality in patients undergoing tricuspid valve replacement or repair.

Patients and methods: A retrospective evaluation was conducted with 302 consecutive patients (182 females, 120 males; mean age: 59.5±11.7 years) who underwent surgical intervention on the tricuspid valve at our tertiary center between January 2019 and January 2022. The final endpoint of the study was determined as in-hospital mortality. Patients were divided into two groups: those who developed in-hospital mortality and those who did not. Regression analyses were conducted to identify the independent variables.

Results: Forty-eight patients died in the hospital. Multivariate logistic regression analysis aimed at determining the predictors of in-hospital mortality identified age (p=0.023), TAPSE/PASP (p=0.024), and hospital stay duration (p<0.001) as independent determinants of in-hospital mortality. A receiver operating characteristic curve was plotted, and a cutoff value of 0.30 was determined using the Youden index (area under the curve=0.692, 95% confidence interval 0.609-0.774, p<0.001). This cutoff value could detect in-hospital mortality with a sensitivity of 66.8% and specificity of 68.7%.

Conclusion: The TAPSE/PASP ratio, a simple echocardiographic score, is associated with in-hospital mortality in patients undergoing tricuspid valve replacement or repair.

Keywords: Mortality, TAPSE/PASP, tricuspid valve surgery.

Tricuspid valve (TV) disease, either organic or secondary to other cardiac conditions, namely mitral valve disease or atrial fibrillation, is relatively common. The incidence of tricuspid regurgitation is observed in 0.55% of the general population and 4% of patients aged above 75 years.[1] Although the main background of severe tricuspid disease is mostly mitral stenosis or regurgitation,[2] atrial fibrillation,[3] or an implanted cardiac device,[4] 8.1% of patients with TV regurgitation do not have other valve diseases.[5] Surgery is indicated in symptomatic patients with severe tricuspid regurgitation and stenosis, irrespective of the cause.[2]

Surgical treatment of TV disease, either TV replacement or repair, has an increased mortality rate.[6] Several studies have shown the superiority of TV repair to TV replacement. Patients with valve replacement have increased all caused mortality rates and increased in-hospital stay.[7,8] Right ventricular mid-cavity length and TV tenting area were shown to be long-term predictors of one-year mortality after TV annuloplasty.[9] Regarding the short-term prognosis of TV surgery, TRI-SCORE, which is based on clinical and laboratory variables, was shown to be a predictor of in-hospital mortality.[10] Sarcopenia was demonstrated as an independent risk factor of increased in-hospital stay in this patient group.[11]

The tricuspid annular plane systolic excursion (TAPSE)/pulmonary artery systolic pressure (PASP) ratio is a simple echocardiographic score and is found to be related to increased mortality in various

Corresponding author: Mehmet Altunova, MD. SBÜ, Mehmet Akif Ersoy Göğüs Kalp ve Damar Cerrahisi Eğitim ve Araştırma Hastanesi, Kardiyoloji Kliniği, 34303 Küçükçekmece, İstanbul, Türkiye
E-mail: dr.mehmetaltunova@gmail.com

Citation:
Altunova M, Aktemur T. Assessing in-hospital mortality in tricuspid valve surgery: A focus on the tricuspid annular plane systolic excursion/pulmonary artery systolic pressure ratio. Cardiovasc Surg Int 2024;11(2):95-101. doi: 10.5606/e-cvsi.2024.1649.

diseases. Initially, it was reported that a lower TAPSE/PASP ratio is related to increased mortality in patients with pulmonary embolism.[12] Recently, this ratio was found to be a beneficial marker of mortality in patients with cardiac amyloidosis.[13] A lower TAPSE/PASP ratio was represented as a marker of development of pulmonary arterial hypertension.[14] This study aimed to investigate the relationship between in-hospital stay and the TAPSE/PASP ratio in patients who underwent TV replacement or repair.

PATIENTS AND METHODS

This retrospective study included 450 consecutive symptomatic patients with severe TV disease who underwent TV surgery at the Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital, Department of Cardiology between January 2019 and January 2022. Patients with severe and symptomatic TV disease were discussed by the heart team, and surgical decisions were made by this team. Exclusion criteria were as follows: patients with systemic inflammatory diseases, those with chronic autoimmune disease, patients with active systemic infections, urgent operation due to any cause, and patients with a prior history of type 1-3 pulmonary arterial hypertension. After exclusion criteria were applied, 302 patients (182 females, 120 males; mean age: 59.5±11.7 years) were enrolled in this study.

The demographic information, clinical features, laboratory values, and echocardiography variables were obtained from patient files and hospital records. Routine blood tests were performed to assess complete blood count, lipid profile, complete blood count, serum C-reactive protein, and albumin levels. Blood samples were obtained from a forearm vein after a 12-h fast before performing the endovascular intervention. A Cobas 8000 c502 (Roche Holding AG, Basel, Switzerland) analyzer was used to evaluate serum C-reactive protein and albumin levels. Hospital stay time and the duration of mechanical intubation requirement were recorded. For each patient, the EuroSCORE II was calculated (https://www.euroscore.org).

Preprocedural transthoracic echocardiography was performed in each participant. An experienced echocardiographer performed all the echocardiographic evaluations using an echocardiography device with a 3.2-mHz adult probe (GE Vingmed Ultrasound AS, Horten, Norway).

Tricuspid annular plane systolic excursion is a parameter of longitudinal systolic performance of the right ventricle. Apical four-chamber view was used to obtain TAPSE values.[15] The M-mode precursor was aligned along the right ventricular free wall perpendicular to the lateral tricuspid annulus. The distance moved by the leading edge of the annulus from end-diastole toward the apex at end-systole was measured.[16]

Maximum tricuspid regurgitation was obtained either in four-chamber view or a right ventricle-focused four-chamber view. The Bernoulli equation was used to calculate the systolic pulmonary artery pressure.[16]

Statistical analysis

Data were analyzed using IBM SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). To assess the normal distribution of variables, visual methods such as histograms and probability plots were employed alongside the Kolmogorov-Smirnov test. Numerical variables with a normal distribution were presented as mean ± standard deviation (SD), while numerical variables without a normal distribution were presented as median (interquartile range). Categorical variables were expressed as frequency (%). To determine the predictive value of the TAPSE/PASP value for the development of in-hospital mortality, receiver operating characteristic (ROC) curve and the Youden index [max (sensitivity + specificity -1)] were used. Numerical variables were compared between the two groups using the unpaired Student's t-test and the Mann-Whitney U test, depending on the distribution. Categorical variables were compared using the chi-square test or Fisher exact test. Univariate and multivariate logistic regression analyses were performed to determine the independent determinants of in-hospital mortality. The level of statistical significance was set at $p<0.05$, and an area under the ROC curve (AUC) >0.5 was considered statistically significant.

RESULTS

During the follow-up period, 48 patients died in the hospital. Patients were divided into two groups: patients with in-hospital mortality (non-survivors) and patients without in-hospital mortality (survivors). The baseline demographic, laboratory, and procedural data of the study group are presented

Table 1
Demographic, clinical, and procedural characteristics of the study group

	All patient (n=302)					Survivor group (n=254)					Non-survivor group (n=48)					
	n	%	Mean±SD	Median	IQR	n	%	Mean±SD	Median	IQR	n	%	Mean±SD	Median	IQR	*p*
Age (year)			59.5±11.7					58.5±11.9					64.6±8.6			**0.001**
Sex																
Female	182	60.3				155	61				27	56.3				0.535
Body surface area (cm^2)			1.8±0.18					1.81±0.18					1.79±0.16			0.440
Diabetes mellitus	108	35.8				85	33.5				23	47.9				0.055
Hypertension	158	52.3				136	53.5				22	45.8				0.327
COPD	56	18.5				44	17.3				12	25				0.209
Coronary artery disease	120	39.7				103	40.6				17	35.4				0.505
Smoking	35	11.6				25	9.8				10	20.8				**0.029**
Atrial fibrillation	222	73.5				191	75.2				31	64.6				0.126
Pacemaker	15	5				10	3.9				5	10.4				0.058
Congestive heart failure	69	22.8				53	20.9				16	33.3				0.059
Pulmonary hypertension	273	91				227	90.1				46	95.8				0.202
Albumin (g/dL)			3.98±0.62					4±0.6					3.9±0.6			0.506
Creatinine (mg/dL)				0.89	0.71-1.1				0.89	0.72-1.08				0.91	0.68-1.14	0.689
Leukocyte (10^3/uL)			7.76±2.36					7.8±2.3					7.7±2.6			0.910
Hemoglobin (g/dL)			12.5±2.1					12.5±2					12.3±2.4			0.577
Alanine transaminase (U/L)				16	12-24				16	12-23				19	12.3-28.5	0.135
Platelets (10^3/uL)				238	186-294.5				243	189-299.5				219	174.8-265	0.082
Hemoglobin A1c (%)			6.3±0.87					6.3±0.86					6.3±0.93			0.931
LVEF (%)			53.4±9					53.8±9					51±9.1			**0.044**
RVs			10.5±1.6					10.6±1.7					9.8±1.4			**0.004**
TAPSE			17.3±3.7					17.7±3.6					15.5±3.5			**<0.001**
PASP			51.8±14.9					50.8±14.5					57.1±15.8			**0.007**
TAPSE/ PASP			0.37±0.15					0.38±0.16					0.30±0.12			**<0.001**
Mitral valve replacement	281	93				238	93.7				43	89.6				0.304
Aortic valve replacement	79	26.2				61	24				18	37.5				0.051
CABG	56	18.5				45	17.7				11	37.5				0.395
Tricuspid surgery																0.612
Tricuspid valve replacement	104	34.4				89	85.6				15	14.4				
Tricuspid valve plasty	198	65.6				165	83.3				33	16.7				
Left atrium ligation	33	10.9				29	11.4				4	8.3				0.530
Ablation	8	2.6				8	3.1				0	0				0.213
Cardiopulmonary bypass time				126	105-154				122	103.5-154				137	115.3-159.8	0.056
Cross clamp time			89.9±33.3					88.8±32					96.2±39.8			0.163
Hospital stay (days)				11.5	8-17				11	8-16				18	9-41	**<0.001**
ICU stay (days)				3	2-6				3	2-5.3				12	4-26.8	**<0.001**
Intubation duration (days)				1	1-2				1	1-2				2	1-9	**<0.001**
EuroSCORE II			2.72±2.1							2.40±1.88			4.22±2.88			0.056

IQR: Interquartile range; SD: Standard deviation; COPD: Chronic obstructive pulmonary disease; LVEF: Left ventricular ejection fraction; RVs: Right ventricle free wall tissue doppler systolic wave; TAPSE: Tricuspid annular plane systolic excursion; PASP: Pulmonary arterial systolic pressure; CABG: Coronary artery bypass graft; ICU: Intensive care unit.

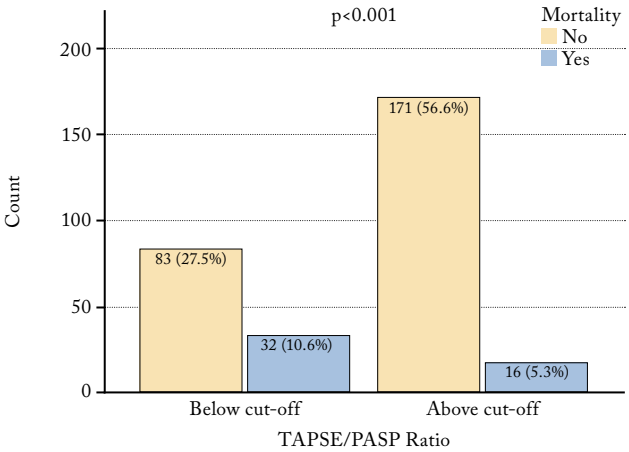

Figure 1. Distribution of TAPSE/PASP cutoff values among groups with in-hospital mortality.

TAPSE: Tricuspid annular plane systolic excursion; PASP: Pulmonary arterial systolic pressure.

in Table 1. The two groups were comparable in terms of demographic characteristics, except for age (p=0.001) and smoking (p=0.029). These parameters were higher in the nonsurvivors group. No significant differences were found between the two groups in terms of laboratory parameters. Regarding echocardiographic parameters, PASP (p=0.007) was higher in the nonsurvivors group, whereas in the survivors group, LVEF (53.8±9% *vs.* 51±9.1%, p=0.044), tissue Doppler imaging of right ventricular free walls (10.6±1.7 *vs.* 9.8±1.4, p=0.004), TAPSE (17.7±3.6 *vs.* 15.5±3.5, p<0.001), and TAPSE/PASP (0.38±0.16 *vs.* 0.30±0.12, p<0.001) were higher compared to the nonsurvivors group. In terms of postoperative follow-up, hospital stay (18 [9-41] *vs.* 11 [8-16], p<0.001), the duration of intensive care unit stay (18 [9-41] *vs.* 11 [8-16], p<0.001), and intubation duration (12 [4-26.8] *vs.* 3 [2-5.3], p<0.001) were significantly higher in the nonsurvivors group compared to the survivors. Figure 1 illustrates the relationship between patients' TAPSE/PASP value and in-hospital mortality. According to these results, two-thirds of patients who experienced mortality had a TAPSE/PASP value below the cutoff point.

In Table 2, the surgical procedures performed on the patients were as follows: six (2%) patients underwent TV replacement and coronary artery bypass grafting, 46 (15.2%) patients underwent double valve replacement and coronary artery bypass grafting, 62 (20.5%) patients underwent triple valve replacement, 182 (60.3%) patients underwent double valve replacement, and six (2%) patients underwent isolated TV replacement or repair. There was no clear association between surgery subtypes and in-hospital mortality.

Univariate logistic regression analyses were conducted with all parameters to determine the predictors of in-hospital mortality in patients. Among the parameters significantly associated with in-hospital mortality, age, smoking, LVEF, tissue Doppler imaging of right ventricular free walls, TAPSE/PASP, and duration of in-hospital stay are presented in Table 3. In the multivariate logistic regression analysis conducted using these variables, age (p=0.023), TAPSE/PASP (p=0.024), and hospital stay duration (p<0.001) emerged as

Table 2
Distribution of operation types

	All patient (n=302)		Survivor group (n=254)		Non-survivor group (n=48)		
Surgery type	n	%	n	%	n	%	*p*
Isolated tricuspid valve surgery	6	2	5	2	1	2.1	
Combined mitral and tricuspid valve surgery	172	57	152	59.8	20	41.7	
Combined aortic and tricuspid valve surgery	10	3.3	7	2.8	3	6.3	
Combined aortic, mitral and tricuspid valve surgery	62	20.5	49	19.3	13	27.1	0.230
Combined mitral and tricuspid valve and CABG surgery	42	13.9	33	13	9	18.8	
Combined aortic and tricuspid valve and CABG surgery	4	1.3	4	1.6	0	0	
Combined aortic, mitral and tricuspid valve and CABG surgery	6	2	4	1.6	2	4.2	

CABG: Coronary artery bypass graft.

Table 3
Independent predictors for in-hospital mortality with univariate and multivariate logistic regression analysis

	Univariate analysis			Multivariate analysis		
	OR	95% CI	*p*	OR	95% CI	*p*
Age	1.057	1.023-1.093	**0.001**	1.046	1.006-1.087	**0.023**
Smoking	2.411	1.073-5.417	**0.033**	2.215	0.843-5.819	0.107
LVEF	0.968	0.938-0.999	**0.046**	0.985	0.757-1.282	0.910
RVS	0.754	0.620-0.916	**0.004**	0.955	0.751-1.215	0.708
TAPSE/PASP	0.281	0.148-0.533	**0.001**	0.369	0.155-0.876	**0.024**
Hospital stay	1.056	1.034-1.079	**<0.001**	1.045	1.022-1.069	**<0.001**

OR: Odds ratio; CI: Confidence interval; LVEF: Left ventricular ejection fraction; RSV: Systolic annular tissue velocity of the lateral tricuspid annulus; TAPSE: Tricuspid annular plane systolic excursion; PASP: Pulmonary arterial systolic pressure.

independent determinants of in-hospital mortality. A ROC curve was plotted to determine the optimal cut-off value for TAPSE/PASP that best detects in-hospital mortality (Figure 2), and a cutoff value of 0.30 was determined using the Youden index (AUC=0.692, 95% confidence interval 0.609-0.774, p<0.001). This cutoff value could detect in-hospital mortality with a sensitivity of 66.8% and specificity of 68.7%.

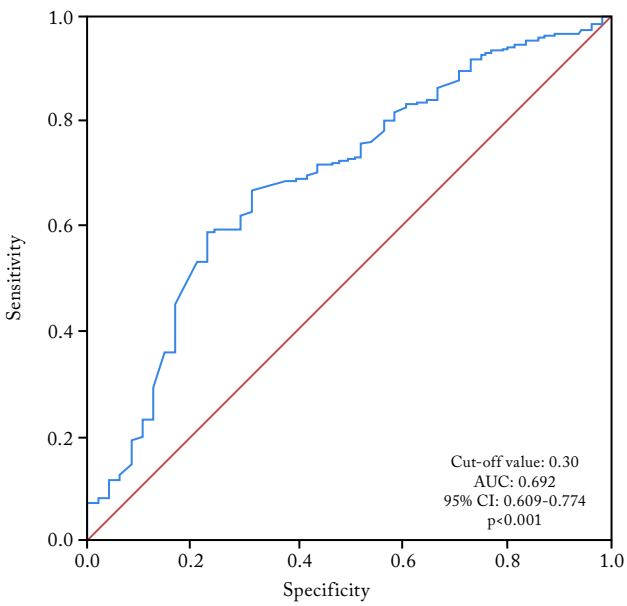

Figure 2. The ROC curve for TAPSE/PASP as a predictor of in-hospital mortality.

TAPSE: Tricuspid annular plane systolic excursion; PASP: Pulmonary arterial systolic pressure.

DISCUSSION

Through this study, we investigated the relationship between the TAPSE/PASP ratio and in-hospital mortality of surgically treated TV disease. Noteworthy this research highlights:

- TAPSE/PASP ratio is an independent predictor of in-hospital mortality in patients, who underwent TV surgery.

- Advanced age is an independent rick factor of in-hospital mortality in such patient group. With regard to the current knowledge, this present study is the first data, which represents the relationship with lower TAPSE/PASP ratio and in-hospital mortality in this patient group in literature.

Open repair or replacement of the TV is a high-risk operation. Kawsara et al.[6] have recently represented that 8.7% of surgically treated patients have in-hospital mortality. In the same data, acute heart failure signs and symptoms, nonelective surgery, and liver dysfunction were shown to be the independent predictors of in-hospital mortality. However, this study was performed in patients with isolated TV disease. The majority of our patients underwent surgery due to concomitant valve diseases or coronary artery.

With regard to long-term mortality, Wong et al.[7] illustrated that only 12.6% of patients underwent isolated TV surgery among 2,644 patients. In this data, it is clearly shown that TV replacement is an independent predictor of all-cause long-term mortality. With respect to our findings, there is no

clear difference between TV replacement and repair in term of in-hospital mortality. Long-term findings are required in our patient group.

The TRI-SCORE is a relatively new score, which is shown to be an independent predictor of in-hospital mortality in patients who underwent surgery due to isolated TV disease. This score consists of clinical, echocardiographic, and laboratory parameters, namely advanced age, clinical status evaluated by the New York Heart Association system, right-sided heart failure signs and symptoms, requirement of high-dose loop diuretics, deterioration of renal status, elevated total bilirubin, worsening of ejection fraction, and moderate to severe right ventricular systolic function.[10] Dreyfus et al.[10] showed that an advanced TRI-SCORE predicts not only in-hospital but also one-year mortality in 466 patients who were surgically treated due to isolated TV disease. Similarly, advanced age is also an independent risk factor for our patients. The main difference of our study is that the vast majority of our patients were operated on due to concomitant valve and coronary diseases. Yiu et al.[9] illustrated that right ventricular mid-cavitary dimensions and increased TV tenting area predict one-year mortality in 74 patients who underwent TV surgery due to concomitant valve disease. According to this study, the right ventricle diameter and tenting area should be measured before concomitant valve surgeries.

The TAPSE/PASP ratio is a simple scoring system based on the echocardiograhic calculations of TAPSE and PASP. This scoring system has been shown to be beneficial in various patient groups. Çolak et al.[12] demonstrated that a TAPSE/PASP ratio <0.20, combined with worse clinical status, is related to poor prognosis in patients with chronic thromboembolic pulmonary hypertension.

In a study with a median follow-up period of 680 days, Maccallini et al.[13] illustrated that an increased TAPSE/PASP ratio is associated with increased long-term survival and hospitalization-free survival rates in 233 patients with cardiac amyloidosis. Moreover, among 2,555 patients with systemic sclerosis, a TAPSE/PASP ratio <0.55 was an independent risk factor of development for the pulmonary arterial hypertension.[14] The TAPSE/PASP could be considered a risk factor of all-cause mortality.[14]

In our data, we aimed to identify the risk factors of in-hospital mortality in this patient group. Similar to previous studies, advanced age was shown to be the independent predictor of in-hospital mortality.[15,16] This simple, cost-effective, and time-saving method was shown to be functional in predicting short-term prognosis in patients who underwent TV surgery. To the best of our knowledge, this is the first study that represents such a relationship.

There are several limitations to this study. First, it was a retrospective study conducted with a relatively limited number of patients. Second, this study was performed in a heterogeneous patient group. The vast majority of studies have been performed in patients who have been operated on due to isolated TV disease. Third, long-term findings of the patients were required. Finally, there is no clear cutoff value of the TAPSE/PASP ratio in various patient groups. Further studies are needed to identify this value.

In conclusion, a decreased TAPSE/PASP ratio is related to a deterioration in short-term outcomes and in-hospital mortality in patients who underwent TV surgery. It is a valid and time-saving scoring system that can be used daily in clinical practice. The scoring system can be used to identify high-risk patients, allowing for more meticulous preoperative and postoperative evaluations, thereby reducing mortality rates.

Ethics Committee Approval: The study protocol was approved by the Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee (date: 27.02.2024, no: 2024.01.13). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Study design, statistics, overwiew: A.A.; Writing and references: T.A.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Cardoso JL, Ferraz Costa GN, Neves F, Gonçalves L, Teixeira R. Tricuspid repair in mitral regurgitation surgery: A systematic review and meta-analysis. J Cardiothorac Surg 2023;18:76. doi: 10.1186/s13019-023-02158-9.
2. Vahanian A, Beyersdorf F, Praz F, Milojevic M, Baldus S, Bauersachs J, et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease: Developed by the Task Force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). Rev Esp Cardiol (Engl Ed) 2022;75:524. doi: 10.1016/j.rec.2022.05.006.
3. Volpato V, Mor-Avi V, Veronesi F, Addetia K, Yamat M, Weinert L, et al. Three-dimensional echocardiography investigation of the mechanisms of tricuspid annular dilatation. Int J Cardiovasc Imaging 2020;36:33-43. doi: 10.1007/s10554-019-01686-7.
4. Anvardeen K, Rao R, Hazra S, Hay K, Dai H, Stoyanov N, et al. Prevalence and significance of tricuspid regurgitation post-endocardial lead placement. JACC Cardiovasc Imaging 2019;12:562-4. doi: 10.1016/j.jcmg.2018.07.009.
5. Topilsky Y, Maltais S, Medina Inojosa J, Oguz D, Michelena H, Maalouf J, et al. Burden of tricuspid regurgitation in patients diagnosed in the community setting. JACC Cardiovasc Imaging 2019;12:433-42. doi: 10.1016/j.jcmg.2018.06.014.
6. Kawsara A, Alqahtani F, Nkomo VT, Eleid MF, Pislaru SV, Rihal CS, et al. Determinants of morbidity and mortality associated with isolated tricuspid valve surgery. J Am Heart Assoc 2021;10:e018417. doi: 10.1161/JAHA.120.018417.
7. Wong WK, Chen SW, Chou AH, Lee HA, Cheng YT, Tsai FC, et al. Late outcomes of valve repair versus replacement in isolated and concomitant tricuspid valve surgery: A nationwide cohort study. J Am Heart Assoc 2020;9:e015637. doi: 10.1161/JAHA.119.015637.
8. Dhoble A, Zhao Y, Vejpongsa P, Loghin C, Smalling RW, Estrera A, et al. National 10-year trends and outcomes of isolated and concomitant tricuspid valve surgery. J Cardiovasc Surg (Torino) 2019;60:119-27. doi: 10.23736/S0021-9509.18.10468-X.
9. Yiu KH, Wong A, Pu L, Chiang MF, Sit KY, Chan D, et al. Prognostic value of preoperative right ventricular geometry and tricuspid valve tethering area in patients undergoing tricuspid annuloplasty. Circulation 2014;129:87-92. doi: 10.1161/CIRCULATIONAHA.113.003811.
10. Dreyfus J, Bohbot Y, Coisne A, Lavie-Badie Y, Flagiello M, Bazire B, et al. Predictive value of the TRI-SCORE for in-hospital mortality after redo isolated tricuspid valve surgery. Heart 2023;109:951-8. doi: 10.1136/heartjnl-2022-322167.
11. Oh J, Song IK, Nam JS, Lee SW, Lee EH, Choi IC. Sarcopenia as a prognostic factor for outcomes after isolated tricuspid valve surgery. J Cardiol 2020;76:585-92. doi: 10.1016/j.jjcc.2020.07.010.
12. Çolak A, Kumral Z, Kış M, Şentürk B, Sezgin D, Ömeroğlu Şimşek G, et al. The usefulness of the TAPSE/sPAP ratio for predicting survival in medically treated chronic thromboembolic pulmonary hypertension. Turk Kardiyol Dern Ars 2023;51:470-7. doi: 10.5543/tkda.2023.78074.
13. Maccallini M, Barge-Caballero G, Barge-Caballero E, López-Pérez M, Bilbao-Quesada R, González-Babarro E, et al. Prognostic value of the tricuspid annular plane systolic excursion/systolic pulmonary artery pressure ratio in cardiac amyloidosis. Rev Esp Cardiol (Engl Ed) 2024:S1885-5857(24)00036-7. doi: 10.1016/j.rec.2024.01.001.
14. Colalillo A, Hoffmann-Vold AM, Pellicano C, Romaniello A, Gabrielli A, Hachulla E, et al. The role of TAPSE/sPAP ratio in predicting pulmonary hypertension and mortality in the systemic sclerosis EUSTAR cohort. Autoimmun Rev 2023;22:103290. doi: 10.1016/j.autrev.2023.103290.
15. Aloia E, Cameli M, D'Ascenzi F, Sciaccaluga C, Mondillo S. TAPSE: An old but useful tool in different diseases. Int J Cardiol 2016;225:177-83. doi: 10.1016/j.ijcard.2016.10.009.
16. Mitchell C, Rahko PS, Blauwet LA, Canaday B, Finstuen JA, Foster MC, et al. Guidelines for performing a comprehensive transthoracic echocardiographic examination in adults: Recommendations from the American Society of Echocardiography. J Am Soc Echocardiogr 2019;32:1-64. doi: 10.1016/j.echo.2018.06.004.