Correlation between Mitral Valve Area and Right Ventricle Function based on TAPSE (Tricuspid Annular Plane Systolic Excursion) Parameter in Mitral Stenosis Patient

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ABSTRACT

Background: Mitral stenosis is the most common mitral valve disease found in Indonesia. Mechanical obstruction of blood flow from left atrium to left ventricle is compensated by pressure elevation in the left atrium and pulmonary circulation. It leads to right ventricle dysfunction which can be scored using TAPSE (Tricuspid Annular Plane Systolic Excursion) Parameter.
Aim: The goal of this study is to assess the relationship between mitral valve area and right ventricle function based on TAPSE parameter in mitral stenosis patient.
Methods: This study was conducted in Dr. Sardjito Hospital from May until July 2017. This was a part of mitral stenosis registry study. The parameter used was planimetry mitral valve area and TAPSE from echocardiography. The relationship between mitral valve area and TAPSE score we reanalyzed using Spearman correlation test in SPSS software.
Results: The total sample included in this study was 132 people, consisted of thirty-eight (28.79%) males and ninety-four (71.21%) females. The range of the subjects'age was 18–68 year oldand the mean was 43.31±11.13 year old. The body mass index median was 21.24 (14.24–35.38) kg/m^2. The subjects were dominated by severe degree mitral stenosis patients, those were ninety-three (70.45%) people, followed by moderate degree patients, those were thirty-two (24.24%) people, and mild degree patients, those were seven (5.30%) people. Twenty-eight (21.21%) people had isolated mitral stenosis. The mitral valve area median was 0.8 (0.27–1.90) cm^2. The TAPSE score range was 6–30 mm and the mean was 17.48±4.58 mm. The result from Spearman correlation test showed that the relationship strength between mitral valve area and TAPSE score were very weak (r=0.167) with significant p-value (p=0.028).
Conclusion: There is a statistically significant positive relationship with very weak strength between mitral valve area and TAPSE score as a right ventricle function parameter in mitral stenosis patients (r = 0.167, p = 0.028).

Keywords: mitral stenosis; mitral valve area; right ventricle function; TAPSE.

INTISARI

Latar Belakang: Stenosis mitral merupakan gangguan katup mitral tersering yang di jumpai di Indonesia. Obstruksi mekanik aliran darah dari atrium kiri menuju ventrikel kiri di kompensasi dengan peningkatan tekanan pada atrium kiri dan sirkulasi pulmoner. Hal ini menyebabkan gangguan fungsi ventrikel kanan yang dapat dinilai dengan parameter TAPSE (*Tricuspid Annular Plane Systolic Excursion*).
Tujuan: Penelitian ini bertujuan untuk mengetahui hubungan area katup mitral dengan fungsi ventrikel kanan berdasarkan parameter TAPSE pada pasien stenosis mitral.
Metode: Penelitian dilakukan di RSUP Dr.Sardjito sejak Mei hingga Juli 2017. Penelitian ini merupakan bagian dari registri stenosis mitral. Instrumen penelitian menggunakan data ekokardiografi area katup mitral metode planimetri dan TAPSE. Hubungan area katup mitral

dan nilai TAPSE dianalisis menggunakan perangkat lunak SPSS dengan menggunakan uji analitik korelasi Spearman.
Hasil: Sampel berjumlah 132 orang, diantaranya terdapat 38 (28.79%) orang laki-laki dan 94 (71.21%) orang perempuan. Rentang usia subjek penelitian 18–68 tahun dengan rerata 43.31±11.13 tahun. Median indeks massa tubuh subjek penelitian sebesar 21.24 (14.24–35.38) kg/m^2. Subjek penelitian didominasi oleh stenosis mitral derajat berat yaitu sebanyak 93 (70.45%) orang, diikuti dengan derajat sedang sebanyak 32 (24.24%) orang dan derajat ringan sebanyak 7 (5,30%) orang. Sebanyak 28 (21.21%) orang yang memiliki defek katup jantung berupa stenosis mitral saja. Median area katup mitral sebesar 0.8 (0.27–1.90) cm^2. Rentang nilai TAPSE sebesar 6–30 mm dengan rerata sebesar 17.48±4.58 mm. Hasil uji analitik korelasi Spearman menunjukkan kekuatan hubungan antara area katup mitral dengan nilai TAPSE sangat lemah (r = 0.167) dengan nilai kebermaknaan (p) sebesar 0.028.
Kesimpulan: Terdapat hubungan positif dengan kekuatan sangat lemah dan bermakna secara statistic antara area katup mitral dan TAPSE sebagai parameter fungsi ventrikel kanan pada pasien stenosis mitral (r = 0.167, p = 0.028).

INTRODUCTION

Mitral stenosis constitutes the most frequent mitral valve disease found in developing countries like Indonesia.[1]Mitral stenosis represents a mechanical obstruction of blood flow from the left atrium to the left ventricle. The most common cause of mitral stenosis in adult (more than 90%) is due to the presence of rheumatism in the mitral valve or it is usually called rheumatic heart disease.[2]

Echocardiography is the main modality in evaluating the severity and consequences of mitral stenosis and anatomical lesion involvement.[3]The severity of mitral stenosis depends on the mitral valve area (MVA). EAE/ASE (European Association of Echocardiography/American Society of Echocardiography) recommends planimetry method MVA in measuring MVA.[4]

Valve stiffness in mitral stenosis causes the blood flow from the left atrium needs higher pressure to pass through the mitral valve to go to the left ventricle. This higher pressure can be achieved by raising blood volume of the left atrium that it may result in the dilatation of the left atrium. This pressure is transmitted to its proximal: pulmonary blood vessel that leads to pulmonary hypertension. It will cause the impairment of the right ventricle because the right ventricle definitely needs to raise its pressure so that the blood will be able to go to the lungs. Right ventricle will compensate by undergoinghypertrophy and dilatation. If this process keeps going on until reaching the maximal compensatory capacity of the right ventricle, then it may result in right heart failure.[5]

Right ventricle function plays an important role in evaluating prognosis and clinical symptoms of patients with mitral stenosis. Right ventricle dysfunction is often undetected clinically until the appearance of symptom such as right heart failure-induced systemic vein congestion. Right ventricle dysfunction will lead to higher morbidity and mortality number, as it is influenced by pulmonary hypertension hemodynamic effect. The more severe its degree, the more obvious impact it causes towards the right ventricle. Therefore it is important to understand the right ventricle function of the patients with mitral stenosis in order to prevent the worsening of the patient's condition.[6]

Right ventricle function can be assessed by some parameters. There is a routine right ventricle examination nowadays using TAPSE (Tricuspid Annular Plane Systolic Excursion) parameter. TAPSE is proven as a parameter for evaluating the longitudinal function of the right ventricle (right ventricle systolic function).The advantage of using TAPSE is its easiness and simplicity in measurement, it has good correlation with RVEF (Right Ventricular Ejection Fraction), and has prognostic value in patient with myocardial infarction and pulmonary hypertension as well.[7]

METHODS

This is a cross-sectional study which was conducted in Dr. Sardjito Hospital, Yogyakarta, Indonesia from May 2017 until July 2017. This is a part of mitral stenosis registry study. The data was collected from mitral stenosis patients'

medical records in Dr.Sardjito Hospital from August 2014 until May 2017. The data has been measured by trained echocardiographer and interpreted by cardiologist.

Subjects

The population sample of this study is mitral stenosis inpatient and outpatient in Dr.Sardjito hospital. The subjects were then filtered using inclusion and exclusion criteria and not being randomized. The inclusion criteria of this study were patients diagnosed with mitral stenosis, agreed to participate by signing the informed consent, and having complete data on the medical record (age, body mass index, MVA planimetry, TAPSE, other valvular disease, and history of other disease).

The exclusion criteria of this study were mitral stenosis patient with one or more of these conditions: other significant valve defect (except tricuspid regurgitation secondary to mitral stenosis), pulmonary embolism, congenital heart disease, and chronic obstructive pulmonary disease.

Echocardiography Recording

Patients were examined using 2D transthoracic echocardiography in the left lateral decubitus position. The echocardiography used in this study is Vivid Echo Machine (GE Healthcare). MVA measurement was done by planimetry method with short axis view.[3] TAPSE measurement was done by M-mode with an apical four-chamber view. M-mode cursor was put on the lateral tricuspid valve, then the annular valve excursion distance to the apex was measured at systole.[7]

Statistical analysis

The data obtained will be analyzed using SPSS software for Windows version 23. A correlation test was done to evaluate the relationship between 2 variables, MVA and TAPSE scores. Normally distributed data will be tested using Pearson correlation test and non-normally distributed data will be tested using Spearman correlation test. $P<0.05$ is statistically significant.

RESULT

During August 2014 until May 2017, there are 309 mitral stenosis patients registered in the medical record of the Department of Cardiology and Vascular Medicine, dr. Sardjito Hospital. All of the patients went through anamnesis, physical examination, and echocardiography supporting examination to collect data such as age, BMI, MVA, TAPSE, other valvular disease, and previous disease history.

From 309 patients, there were 94 of them having a moderate-severe degree of mitral regurgitation, 5 of them having moderate-severe degree pulmonary regurgitation, 6 of them having moderate-severe degree tricuspid stenosis, and 55 of them having moderate-severe degree aortic regurgitation. There are 132 people in this study according to inclusion and exclusion criteria.

The youngest patient was at the 18 years old of age and the oldest one was at the 68 years old of age, with the mean of 43.31 ± 11.13 years old. Female subjects were more (94 people (71.21%)) than male subjects (38 people (28.79%)). The body mass index of the subjects had the median of 21.24 kg/m^2 with the lowest value of 14.24 kg/m^2 and the highest value of 35.38 kg/m^2, the mean was 21.66 ± 4.06 kg/m^2.

There were 91 people (68.94%) having normal BMI, and 41 people (31.06%) having BMI above the normal limit. The subject diversity based on the severity of mitral stenosis was dominated by severe degree, 93 people (70.45%), followed by moderate degree, 32 people (24.24%), and mild degree, 7 people (5.30%).

An MVA data as independent variable was having the median of 0.8 cm^2 with the minimum value of 0.27 cm^2 and the maximum value 1.90 cm^2, while the mean was 0.86 ± 0.33 cm^2. TAPSE data as a dependent variable was having the lowest value of 6 mm and the highest value of 30 mm, while the mean was 17.48 ± 4.58 mm.

Table 3 and Figure 1 show the result of analytical correlation by Spearman test about the relation of MVA and TAPSE score $r = 0.167$ and $p = 0.028$. The result indicates a statistically significant positive linear relationship between MVA and TAPSE with very weak strength.

Table 1. Baseline characteristics of the mitral stenosis patients

Variable	Descriptive (n=132)
Age (years)*	18–68 (43.31±11.13)
Gender, n (%)	
Male	38 (28.79%)
Female	94 (71.21%)
Body Mass Index (kg/m^2)**	21.24 (14.24–35.38)
Normal	91 (68.94%)
Higher than Normal	41 (31.06%)
Mitral Stenosis Degree, n(%)	
Severe	93 (70.45%)
Moderate	32 (24.24%)
Mild	7 (5.30%)
Heart Valve Defect, n (%)	
Only mitral stenosis	27 (20.45%)
With other valvular disease (mild degree)	105 9.54%)

***** range (mean ± standard deviation)
****** median (minimum value–maximum value)

Table 2. MVA and TAPSE score in mitral stenosis patients

Variable	Descriptive (n=132)
MVA (cm^2)**	0.8 (0.27–1.90)
TAPSE (mm)*	6–30 (17.48±4.58)

***** range (mean ± standard deviation)
****** median (minimum value–maximum value)

Table 3. Relationship analysis between MVA and TAPSE

Variable	TAPSE		
	Correlation coefficient (*r*)	*P value**	Confidence Interval 95%
MVA	0.167	0.028	-0.017 – 0.347

* statistically significant if p<0.05

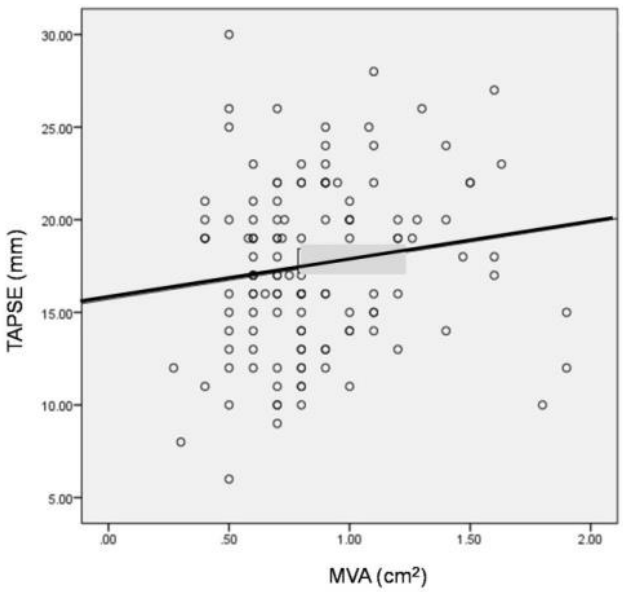

Figure 1. *Scatterplot* data of MVA and TAPSE

DISCUSSION

Positive linear relationship means the wider MVA, the higher TAPSE score will be. This result suits the previous study done by Inciet al.[8]: The rise of TAPSE score after the widening of MVA by Percutaneous Mitral Balloon Valvuloplasty (PMBV) procedure was statistically significant ($p < 0,01$). The other study done by Younan[9]compared TAPSE score between control group and mitral stenosis group. The result showed that the TAPSE score of the control group was higher than the mitral stenosis group. The difference of TAPSE score between both groups were statistically significant (control group: 24±2 mm, mitral stenosis group: 17±5 mm, $p < 0.001$).

This positive linear relationship suits the pathophysiology of mitral stenosis. The narrow value of MVA will disturb the blood flow from the right atrium to the right ventricle. The accumulation of blood flow in left atrium leads to dilatation of left atrium, so that the pressure in the left atrium is getting higher. This increasing pressure is then being transmitted to proximal direction: pulmonary blood vessel. The high pressure in pulmonary blood vessel will increase the right ventricle's afterload that it is eventually going to interfere the systolic function of the right ventricle. The function of right ventricle could be explained through the excursion movement of tricuspid valve that is measured as TAPSE score. The disturbed systolic function can be identified by the decline of excursion movement (decline of TAPSE score).[5]

Correlation strength between MVA and TAPSE is very weak, it is different from the study done by Mittal and Goozar[10] that is used as a reference for sample size measurement. Their study analyzed the correlation between MVA and some right ventricle systolic function parameters: Fractional Shortening (FS) on long and short axis, and Right Ventricular Fractional Area Change (RVFAC). MVA correlation result with long axis FS was counted as moderate and statistically significant ($r = 0.493$, $p < 0.01$), while correlation between MVA and short axis FS and RVFAC was weak and statistically significant (short axis FS $r = 0.392$, $p < 0.05$; RVFAC $r = 0.396$, $p < 0.05$). A different result from those studies may happen because the subjects observed by Mittal and Goozar were patients with mitral valve stenosis only. In this study, the other valvular disease was involved, although it was limited to mild degree only. The presence of valvular heart disease other than mitral stenosis may make the correlation between MVA and TAPSE becomes very weak. There were 71 subjects with mild degree mitral regurgitation and 57 subjects with mild degree pulmonary regurgitation. The other valvular disease, primarily tricuspid regurgitation, in this study was not being excluded because 127 (96.21%) subjects were having tricuspid regurgitation that was induced by mitral stenosis. The impact of those valve defects toward the right ventricle function will be explained in each paragraph below.

A study by Dini et al.[11] showed statistically significant ($p < 0.0001$)different TAPSE score between mitral regurgitation in the vena contracta group < 0.5 cm and ≥ 0.5 cm. The width of vena contracta ≥0.5 cm reflected a significant major hemodynamic problem as it might increase the left ventricle filling pressure and pulmonary capillary pressure, thus would bring bad impact to the right heart.

Eyskens et al.[12] did a study about the impact of pulmonary regurgitation towards right ventricle function in Tetralogy of Fallot post-surgery patient. The result of strain and strain rate measurement showed a regional myocardial systolic function disturbance that was significantly different between each severity group of pulmonary regurgitation. Regional function disturbance became more significant in a patient with severe regurgitation.

A study by Hsiao et al.[13] showed that severe degree tricuspid regurgitation was a significant confounding factor regarding right ventricle function measurement using TAPSE or Doppler tissue method, as it had a crucial impact towards the relationship between annular tricuspid valve movement and RVEF. It was because the severe degree tricuspid regurgitation was frequently coincided with pulmonary hypertension that would affect annular tricuspid ring movement. On the other hand, annular valve systolic excursion measurement had limitation: it was unable to predict all movement of the heart's base and apex during contraction thus would lead to different results of angle proportion between the transducer and annular movement point. Excessive right ventricle

dilatation in severe degree tricuspid regurgitation was going to enlarge the angle between the transducer and annular movement point, so the movement of all tricuspid annular valve could not be measured precisely in consequence. Eventually, severe degree tricuspid regurgitation would affect significantly in increasing both volume and pressure of the right ventricle.

Associated with the above discussion about pulmonary hypertension, there was a study done by Li et al.[13] analyzing the correlation between mPAP (mean Pulmonary Arterial Pressure) and TAPSE in pulmonary hypertension patients. The correlation result was considered as very weak and statistically significant ($r = -0.162$, $p < 0.001$), that it suited this study with MVA that was represented by mPAP. Various right ventricle adaptation towards pulmonary hypertension became the reason for the very weak correlation result, as it could be explained by the statement of Kumar et al.[6] That significant pulmonary artery pressure difference might bring different effect in the right ventricle's segments.

TAPSE parameter limited capability in assessing right ventricle function may become one reason of the very weak correlation between MVA and TAPSE as well. TAPSE limitation is that it assumes single segment, lateral part of the tricuspid valve, as a representation of the entire 3D right ventricle structure function. As it has been discussed in the previous paragraph primarily in tricuspid regurgitation case, TAPSE score is depended on the shooting angle (angle between transducer and tricuspid annular valve).[14]

Besides, inequality of the distribution of the member number in each severity degree in this study needs to be taken into account. The imbalance number of members in each severity degree group brings less balance data that may lead to not statistically significant data.[15] The other limitation of this study is that it could not exclude subject with tricuspid regurgitation. This study also generalizes the heterogeneity of pulmonary hypertension becomes one type only.

CONCLUSION

There is a statistically significant positive relationship with very weak strength between mitral valve area and TAPSE as a right ventricle function parameter in mitral stenosis patients.

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DISCLOSURES AND ETHICS

The study protocol has been approved by the Medical Research Ethics Committee of the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada.

REFERENCES

1. Kuncoro A.S. 2010. Forum ekokardiografi pemeriksaan stenosis mitral akibat proses rheumatik dengan ekokardiografi. J Kardiol Indones, 31:62–65.
2. Omran A.S., Arifi A.A., Mohamed A.A. 2011. Echocardiography in mitral stenosis. J Saudi Hear Assoc, 23:51–58.
3. Vahanian A., Alfieri O., Andreotti F., Antunes M.J., Barón-Esquivias G., Baumgartner H., et al. 2012. Guidelines on the management of valvular heart disease (version 2012). Eur Heart J, 33:2451–2496.
4. Baumgartner H., Hung J., Bermejo J., Chambers J.B., Evangelista A., Griffin B.P., et al. 2009. Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice. Eur J Echocardiogr, 10:1–25.
5. Lilly L.S. 2011. Pathophysiology of Heart Disease. 5th ed. Philadelphia: Lippincott Williams & Wilkins.
6. Kumar V., Jose V.J., Pati P.K., Jose J. 2014. Assessment of right ventricular strain and strain rate in patients with severe mitral stenosis before and after balloon mitral valvuloplasty. Indian Heart J, 66:176–82.
7. Jurcut R., Giusca S., La Gerche A., Vasile S., Ginghina C., Voigt J.U. 2010. The echocardiographic assessment of the right ventricle: What to do in 2010? Eur J Echocardiogr, 11:81–96.
8. İnci S., Erol M.K., Bakırcı E.M., Hamur H., Değirmenci H., Duman H., et al.

2015. Effect of percutaneous mitral balloon valvuloplasty on right ventricular functions in mitral stenosis: Short- and mid-term results. Anadolu Kardiyol Derg, 15:289–296.
9. Younan H. 2015. Detection of subclinical right ventricular systolic dysfunction in patients with mitral stenosis by two dimensional strain and strain rate imaging. Egypt Hear J, 67:47–53.
10. Mittal S.R., Goozar R.S. 2001. Echocardiographic evaluation of right ventricular systolic functions in pure mitral stenosis. Int J Cardiovasc Imaging, 17(1):13–18.
11. Dini F.L., Conti U., Fontanive P., Andreini D., Banti S., Braccini L., et al. 2007. Right ventricular dysfunction is a major predictor of outcome in patients with moderate to severe mitral regurgitation and left ventricular dysfunction. Am Heart J, 154:172–179.
12. Eyskens B., Brown S.C., Claus P., Dymarkowski S., Gewillig M., Bogaert J., et al. The influence of pulmonary regurgitation on regional right ventricular function in children after surgical repair of tetralogy of Fallot. Eur J Echocardiogr, 11:341–345.
13. Hsiao S.H., Lin S.K., Wang W.C., Yang S.H., Gin P.L., Liu C.P. 2006. Severe tricuspid regurgitation shows significant impact in the relationship among peak systolic tricuspid annular velocity, tricuspid annular plane systolic excursion, and right ventricular ejection fraction. J Am Soc Echocardiogr, 19:902–910.
14. Lang R.M., Badano L.P., Mor-Avi V., Afilalo J., Armstrong A., Ernande L., et al. 2015. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr, 28:1–39.
15. Rusticus S.A., Lovato C.Y. 2014. Impact of sample size and variability on the power and type i error rates of equivalence tests: a simulation study. Pract Assessment, Res Eval, 19:1–10.