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Correlation between mitral annular plane systolic excursion (MAPSE) at different degrees of ejection fraction in patients with diabetes mellitus

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ABSTRACT

Background and aim. Diabetic cardiomyopathy is characterized by myocardial structure and function abnormality in the absence of other cardiovascular risk factors. Early detection of cardiac dysfunction is crucial for timely intervention and improved patient outcomes. The purpose of this study is to determine how mitral annular plane systolic excursion (MAPSE) is a sensitive marker of early cardiac dysfunction in patients with diabetes mellitus by examining the relationship between MAPSE values and different levels of ejection fraction.

Methods and material. An analytical cross-sectional study was carried out at Dr. Wahidin Sudirohusodo Hospital in Indonesia's Integrated Heart Center. The sample included 79 patients with ages from 18 to 65 years old and a type 2 diabetes diagnosis. Data collected included age, gender, ejection fraction, and MAPSE. Statistical methods included descriptive analysis and Spearman correlation tests.

Results. The study population was predominantly male (71%), with a mean age of 55.5 years for those without EF impairment and 59.5 years for those with impairment. The average impaired EF was 37.69%. MAPSE examination in septal, lateral, and average segments showed significant differences. There is a strong positive association between MAPSE and EF in all study samples. In patients with preserved EF (average EF 58%), MAPSE was 14.4 mm, and in those with reduced EF (average EF 29%), MAPSE was 6.31mm, with significant positive correlations. No significant results were observed in subjects with mid-range EF.

Conclusions. This research revealed that mitral annular plane systolic excursion (MAPSE) is significantly associated with ejection fraction (EF) in individuals with diabetes mellitus (DM), mainly when EF is either well-maintained or diminished.

Keywords: ejection fraction, diabetes mellitus, systolic excursion of the mitral annular plane

INTRODUCTION

Diabetes mellitus (DM) is characterized by altered insulin production or utilization, resulting in elevated blood sugar levels [1]. Based on data from the International Diabetes Federation (IDF), in 2015, there were around 415 million adults with diabetes. This number is expected to increase in 2040 to 642 million sufferers [2]. Complications due to DM disease can be in the form of blood vessel disorders, both macrovascular and microvascular. The macrovascular complications of diabetes are mainly coronary artery, peripheral artery, and cerebrovascular diseases and microvascular such as retinopathy, nephropathy, and neuropathy [3].

Diabetes has a profound impact on every organ in the body, and an overwhelming two-thirds of deaths within the diabetic population are attributed

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to cardiovascular disease. Diabetes-related heart disease manifests as coronary artery disease, cardiac autonomic neuropathy, or diabetic cardiomyopathy. The prevalence of heart failure is high in the diabetic population, and diabetic cardiomyopathy is the most frequent cause of heart failure despite its lack of attention in people with diabetes [4].

Diabetic cardiomyopathy refers to myocardial structure and function abnormality in individuals with diabetes without other cardiovascular risk factors like coronary artery disease, hypertension, or significant valvular disease. Hyperglycemia, systemic insulin resistance, and impaired cardiac insulin metabolism are the major clinical abnormalities in diabetes mellitus, and all are involved in the pathogenesis of diabetic cardiomyopathy [5].

Early in the course of diabetic cardiomyopathy's development, symptoms are typically absent. Left ventricular hypertrophy and decreased left ventricular compliance, which are characterized by delayed early diastolic filling, rapid atrial filling, and prolonged isovolumetric relaxation, are among the initial symptoms. Systolic dysfunction precedes left ventricular dilatation and clinical heart failure [6].

An effective metric for evaluating the longitudinal function of the left ventricle (LV) is the mitral annular plane systolic excursion (MAPSE) value. It has been a standard practice to assess ejection fraction (EF) with this extra metric. MAPSE is a highly sensitive marker of longitudinal systolic function that can identify early signs of systolic malfunction [7]. The mitral annulus can frequently be observed and viewed even with poor left ventricular imaging quality and insufficient visibility of the heart muscle. MAPSE is simple to perform because it does not depend on knowing ideal heart muscle dimensions [8].

Measuring MAPSE can reveal problems in left ventricular longitudinal function, a sensitive measure indicating cardiac function. MAPSE is correlated with left ventricular global systolic function and has been utilized as an echocardiographic metric to assess left ventricular longitudinal function. Prior clinical research has demonstrated that MAPSE is a sensitive parameter for characterizing abnormalities in patients with early-stage cardiovascular disease, where longitudinal function is impaired prior to the onset of more severe cardiac disorders. It can also be used to determine global cardiac longitudinal function and describe the movement of the mitral annulus during the systolic phase [7]. The researcher is interested in the correlation between mitral annular plane systolic excursion (MAPSE) values at various degrees of ejection fraction of patients with diabetes mellitus.

MATERIAL AND METHODS

This research is analytical research using the cross-sectional method. This research will be conducted at the Integrated Heart Center, Wahidin Sudirohusodo Hospital, Makassar. Sampling was conducted for six months, from January 2023 until the minimum sample size (79 patients) was met. The study population was formed by all patients who underwent treatment, either inpatient or outpatient at Wahidin Hospital Polyclinic, and were diagnosed with type 2 DM. The study sample included the entire affordable population meeting the inclusion criteria: individuals aged 18-65 diagnosed with type 2 diabetes and willing to sign an informed consent form. The sampling method was consecutive sampling, where research subjects were obtained based on the order of admission in the hospital until the minimum sample size was met.

Data extracted were hyperglycemia, diabetes, age, gender, nutritional status, hypertension, dyslipidemia, ejection fraction, and MAPSE. Hyperglycemia was considered when blood sugar levels were elevated (≥200 mg/dl) upon hospital admission. High blood sugar, or diabetes, is usually diagnosed by a HbA1c test result that is greater than 6.5% using National Glycohaemoglobin Standardization Program (NGSP) standardized methods. Considered age was the chronological age calculated by subtracting the date, month, and year of sampling from the date, month, and year of birth. Gender was male or female as determined by the Identity Card and confirmation of physical examination. Body mass index measurement results were obtained based on the formula BB (Body Weight)/TB (Height)2 expressed in units (kg/m^2). Hypertension was a condition marked by ≥140 mmHg in systolic blood pressure and/or diastolic ≥90 mmHg at a clinic or health care facility. A condition known as dyslipidemia impairs lipid metabolism and causes either increased or decreased levels of plasma lipids. The primary anomalies in the lipid fraction are a decrease in HDL cholesterol and an increase in total cholesterol, LDL cholesterol, and/or triglycerides. The term “ejection fraction” (EF) describes the percentage of blood that is pumped out of the ventricle with each heartbeat as determined by echocardiography. The formula EF = (EDV-ESV)/EDV, which is derived from combining apical 2 (biplane) with apical 4 (single plane), was used to estimate EDV and ESV. MAPSE is a parameter taken from M-mode measurements that can assess abnormalities in the myocardium region to evaluate left ventricular function using echocardiography equipment in an apical 4-chamber view.

The research data form was used to record all of the data, which were then categorized according to their nature and purpose. The best statistical method was then determined to explain the frequency distri-

bution, mean value, standard deviation, and range of essential data characteristics. Kolmogorov-Smirnov was the test used for normalcy. Pearson correlation test to correlate Numeric scaled variables between two groups. In this case, the significance of the relationship between MAPSE with M-Mode to ejection fraction in patients with type 2 diabetes mellitus should be determined. Meanwhile, the Spearman correlation test is an alternative analysis of the Pearson correlation test if the data is not normally distributed.

This study was approved by Hasanuddin University's Ethics Committee for Biomedical Research on Humans at the Faculty of Medicine in Makassar, South Sulawesi, Indonesia. Drawing from the recommendation letter with reference number 55/UN4.6.4. 5.31/PP36/2024, January 19th, 2024, regarding length of the study's authorization from January 2023 to July 31th, 2023, with protocol number: UH23120925.

TABLE 1. Subjects characteristics

Parameter	Normal EF (n=21)	Impaired EF (n=58)	p-value*
Sex •Male •Female	 12 (57.1) 9 (42.9)	 44 (75.9) 14 (24.1)	0.106
Age	55.5+12.01	59.55 + 11.74	0.307
EF	58.00 + 4.74	37.69 + 9.40	0.000
HbA1C	9.252 + 2.19	9.709 + 2.14	0.159
FPG	170.62 + 58.95	191.60 + 44.59	0.386
RPG	235.86 + 61.02	233.60 + 72.40	0.479
Septal MAPSE	13.19 + 2.92	6.638+ 1.32	<0.000
Lateral MAPSE	14.9 + 3.36	7.91 + 1.97	<0.000
Mean MAPSE	14.04 + 3.23	7.27 + 1.79	<0.000

**Chi-Square p <0.05*
HbA1C: Hemoglobin A1C test; EF: Ejection Fraction: FPG: Fasting plasma glucose; RPG: Random plasma glucose; MAPSE: Mitral Annulus Plane Systolic Excursion

RESULTS

In this study, 79 samples were obtained who suffered from type 2 DM consisting of 21 (27%) research subjects without impaired ejection fraction (EF) and 58 (73%) subjects with impaired EF. Male gender was found to be more, namely 56 (71%) subjects compared to 23 (29%) female subjects. The mean age of subjects without EF impairment was 55.5 years, and subjects with EF impairment were 59.5 years. The average impaired EF value was 37.69%, where a significant p-value was obtained. The MAPSE examination in both septal, lateral, and average segments had a significant p-value. The study characteristics are presented in Table 1.

TABLE 2. The correlation between MAPSE and ejection fraction

Variable	n	Mean (SD)	Correlation	p*
EF MAPSE	79	43 + 12.3 9.07 + 3.65	0.861	**0.000**

**Pearson correlation; MAPSE: Mitral Annulus Plane Systolic Excursion; EF: Ejection Fraction:*

This study analyzed the correlation between MAPSE and ejection fraction of DM patients in all study samples. Significant results were obtained (p <0.05) with a positive correlation.

TABLE 3. The correlation between MAPSE and ejection fraction at various degrees of ejection fraction

Variable	n (%)	Mean (SD)	Correlation	p*
Preserved EF MAPSE	21 (26.6)	 58 + 4.74 14.04 + 3.06	0.877	**0.000**
Mid-range EF MAPSE	31 (39.2)	 45 + 2.28 8.09 + 1.22	0.41	0.822
Reduced EF MAPSE	27 (34.2)	 29 + 6.69 6.31+ 1.41	0.923	**0.000**

**Pearson correlation; MAPSE: Mitral Annulus Plane Systolic Excursion; EF: Ejection Fraction: Preserved EF>50%, Mid-range EF 40-49%, Reduced EF <40%*

This study analyzed the correlation between MAPSE and ejection fraction at various degrees of ejection fraction. In 21 research subjects with Preserved EF, the average EF was 58%, and MAPSE 14.4 mm, where significant results were obtained (p <0.05) with the form of correlation is a positive correlation; the same thing was also obtained in 27 research subjects with reduced EF where the average EF was 29% and MAPSE 6.31 mm. In this study, there were no significant results in subjects with mid-range EF.

DISCUSSION

In this study, significant results were obtained (p <0.05) with the form correlation being a positive correlation between MAPSE and ejection fraction of DM patients in all study samples (Table 2). The same results were also put forward by Adel et al. who conducted a study on the prospective analysis of 170 patients with systolic dysfunction found that there was a significant positive correlation between mean MAPSE and EF measured by M-mode (r = 0.554, P <0.001) [9]. Qinet et al. also proved that there was a significant correlation between MAPSE measurements and left ventricular function assessed by three-dimensional echocardiography and cardiac magnetic resonance imaging (MRI) [10].

Several studies have found that a decreased MAPSE is associated with factors including atrial fibrillation, myocardial infarction, dilated cardiomyopathy, and age, all impacting left ventricular function [11]. The main benefit of using MAPSE for the assessment of left ventricular function is its simplicity. It is a simple and effortless, one-dimensional measurement that can be conducted even by novice practitioners with minimal training in echocardiog-

raphy [12]. Zaky et al. showed a "curve contour" with M-mode echocardiography through the mitral ring, which measures 1.6 - 6.4 cm. They found "deviations" from normal limits of the mitral ring activity in patients with heart disease. Based on these findings, MAPSE was later recommended as another measurement option for left ventricular function [13].

Table 3 presents the correlation of MAPSE in various degrees of ejection fraction in patients with DM. Patients with preserved EF and reduced EF showed a significant positive correlation, but not in patients with mid-range EF. Patients with preserved EF had an average EF of 58% and MAPSE of 14.4 mm, reduced EF had an average EF of 29% and MAPSE of 6.31 mm, and mid-range EF had an average EF of 45% and MAPSE of 8.09 mm. Hu et al. suggested that MAPSE ≥10 mm indicates preserved EF, <8 mm indicates mid-range EF, and <7 mm indicates reduced EF.7 Salah et al. conducted a study involving 100 asymptomatic patients with type 2 DM, finding that MAPSE was significantly lower in the DM group (12 mm) compared to the control group (14mm) ($p < 0.001$). MAPSE had a linearly significant positive correlation with EF.

CONCLUSION

This study found that mitral annulus plane systolic excursion (MAPSE) is positively correlated with EF in patients with DM, especially in preserved EF and reduced EF. Mitral annulus plane systolic excursion (MAPSE) can be used as a parameter to assess EF in impaired left ventricular function.

Ethics Committee approval

The Ethics Committee for Biomedical Research on Humans at Hasanuddin University's Faculty of Medicine in Makassar, South Sulawesi, Indonesia, gave its approval for this study. Predicated on letter of recommendation 55/UN4.6.4.5.31/PP36/2024, January 19th, 2024, regarding the length of the study's authorization from January 2023 to July 31, 2023, with protocol number: UH23120925

Authors' contributions:

Concept, design, materials, resources, processing and gathering of data, analysis and interpretation, literature search, and manuscript writing are all included in MR. KS stands for idea, design, oversight, analysis, and interpretation, as well as literature search. AMA stands for idea, design, oversight, analysis, and interpretation, as well as literature search. SB (idea, plan, and evaluation). HR (idea, blueprint, assessment). Idea, Architecture, Interpretation, and Critical Evaluation, or AAZ. The manuscript was written by all authors, who also contributed to its revisions and content assessment. They have all read and given their approval to the paper, attesting to the accuracy and validity of the study findings. The final manuscript was read and approved by all authors.

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Conflict of interest:

Each author attests that they have no financial ties (stock ownership, equity holdings, consultancies, patent/licensing agreements, etc.) that would put their submitted work in jeopardy.

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