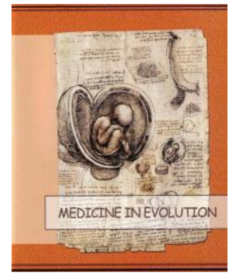
Correlations between left ventricle ejection fraction, global longitudinal strain by two-dimensional speckle tracking and pulse wave velocity in coronary artery disease



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Abstract

Cardiovascular disease (CVD) is one of the main cause responsible for mortality in the world, representing 47% of all deaths in women and 39% of all deaths in men in Europe. Atherosclerosis is the paramount corolary of CVD. There is a close interaction between arterial stiffness and atherosclerosis. The risk scores utilised on a large scale are not entirely predictive for incidence of CVD. Severe coronary artery disease (CAD) is known to lead to left ventricular (LV) dysfunction. Because LV ejection fraction (LVEF) is usually within the normal range in early stages, a more sensitive index for early-stage LV dysfunction is of great importance. Studies proved that global longitudinal strain (GLS) could detect modifications in the earliest stages. Considering their non-invasiveness, a noninvasive assessment of both myocardial and peripheral vessels through GLS and pulse wave velocity (PWV) may become a useful standard tool for early detection of CVD before development of clinical manifestations. This study aimed to establish the link between the severity of CAD, LVEF, GLS and arterial stiffness (PWV). We observed that LVEF is correlated with GLS and that GLS correlates with severity of CAD and also significantly with PWV.

Keywords: coronary artery disease, cardiovascular risk, arterial stiffness, myocardial strain

INTRODUCTION

Cardiovascular disease is associated with increased arterial stiffness and central aortic systolic blood pressure (SBPAo) [1], which is the first sign of vascular dysfunction, arteriosclerosis and atherosclerosis. Arterial stiffness can be quantified through PWV, a simple, noninvasive, and reliable measurement [2]. PWV has the advantage and potential to be utilised in the general population, thus offering an enhancement for identifying and stratifying high-risk patients for more effective CVD prevention [3]. PWV measures the distance travelled by the pulse wave over time. It has the best predictive value for cardiovascular events and the simplicity of its measurement makes it a gold standard for assessing arterial stiffness in daily practise [4]. The association of age with various arterial distensibility parameters has been described exhaustively in the literature. PWV varies with age and gender [5]. Reference values begin at 6.1 (4.6–7.5) m/s for young, healthy individuals and gradually increase with age and presence of hypertension [6]. Evidence suggests that aortic stiffness may contribute initially to the development of hypertension by preceding it [7]. Numerous pharmacological and non-pharmacological solutions can reduce PWV [8] and could offer an alternative for patients at high risk of CVD; thus, we need to assess early and take proper measures for a more favourable outcome in patients with cardiovascular risk. Left ventricular (LV) function can be assessdusing directional components of myocardial deformation or strain. As shown in several studies, global longitudinal strain (GLS) appears to be a sensitive measure of impaired LV systolic function, even better than ejection fraction at predicting cardiovascular disease events and death [9], [10]. There are only a few published studies regarding the association between the severity of coronary artery disease and GLS value [11]. A more sophisticated and noninvasive approach could offer more information about the likeliness and maybe even about the extensiveness of coronary artery disease.

Aim and objectives

The current study aimed to assess the association between the presence and extensiveness of coronary artery disease, echocardiographic and arterial stiffness parameters in coronary patients.

MATERIAL AND METHODS

We performed the current study in the Cardiology Clinic of the Institute of Cardiovascular Diseases between 2018 and 2019. We enrolled 33 consecutive patients with suspected CAD, with a positive history of angina or atypical chest pain. Exclusion criteria were: age<18 years old, lack of cooperation, overt heart failure, haemodynamic instability, atrial fibrillation or frequent ventricular premature complexes, left bundle-branch block, severe valvular disease, cytotoxic treatment, poor sonographic window. Patients underwent transthoracic echocardiography (TTE), 2-D speckle tracking echocardiography (2D-STE) and coronary angiography.

We divided the patients into two groups: group 1 (14 patients) with significant (>50%) CAD, and group 2 (19 patients) with non-significant coronary artery disease. Cardiac ultrasound was performed on a General Electric VIVID 9 equipment with a M4S transducer, with a frequency of 1.5–4.3 MHz and high frame rate (60–90 frames/s). LV volumes were traced manually at end-diastole and end-systole in apical four- and two-chamber views and LVEF was calculated using biplane Simpson's method. We assessed arterial stiffness on an accredited medical device: TensioMed Arteriograph, produced by Medexpert Ltd. Hungary. We created our database in Microsoft Excel. For statistical analysis, we used the Microsoft Excel and SPSSv17 programs. At the beginning of our study, we ran a descriptive analysis of our database by calculating the central tendency and dispersion parameters, for the numerical variables, and a frequency table for the range and qualitative variables. We plotted, by using a histogram, the hospitalisation days and the age variable. We tested the distribution of our data by applying the Shapiro – Wilk test (n<50, n– the sample volume) and we obtained that our data was not normally distributed (p<0.001). Further on, we applied the Mann – Whitney and the Kruskal–Wallis tests, and we performed a regression analysis to study the association between LVEF, GLS LV and PWVao correlated to the severity of coronary artery disease. For the entire study, we set the confidence level at α=0.05.

RESULTS

We included 33 patients admitted to our clinic between 2018 and 2019. For all patients, we introduced information regarding the number of hospitalisation days, age, body mass index (BMI), haemodynamic parameters (systolic and diastolic blood pressure, heart rate, PWVao), blood tests results and echocardiography parameters (LVEDV, LVESV, LVEF, GLS-LV).

For the numerical variables, we calculated the central tendency and distribution parameters and for the range and qualitative variables, we ran frequency tables in SPSS for data distribution and associated percentage. The complete descriptive analysis for the numerical variables is represented in Tables 1 and 2. For the hospitalisation period and the age variable, we plotted a histogram for data distribution (figures 1 and 2).

The frequency tables showed a higher prevalence of male gender (63.3%) compared to females (36.4%). More than half (57.6%) did not have obstructive coronary artery disease, 18.2% had one-vessel CAD, 12.1% had two-vessel CAD, and 12.1% had three-vessel CAD.

Table 1. Distribution parameters calculated for BMI, systolic and diastolic blood pressure and heart rate (n=33)

Statistics	**BMI (kg/m^2)**	**SBP admission**	**DBP admission**	**HR admission**
Mean	27.78	135.76	80.15	78.76
Standard Error	0.77	3.91	2.43	4.32
Median	28	140	80	71
Mode	28	140	70	70
Standard Deviation	4.40	22.47	13.95	24.83

Table 2. Distribution parameters calculated for hospitalisation days, age, LVEDV, LVESV, LVEF, GLSLV variables

Statistics	**Hospital admission (days)**	**Age**	**LVEDV**	**LVESV**	**LVEF**	**GLS LV**
Mean	5.55	56.09	101.61	45.70	0.55	-18.35
Standard Error	0.79	2.65	4.28	3.43	0.01	0.68
Median	4	61	100	40	0.55	-18.7
Mode	3	69	90	40	0.6	-21.3
Standard Deviation	4.56	15.24	24.60	19.71	0.07	3.93

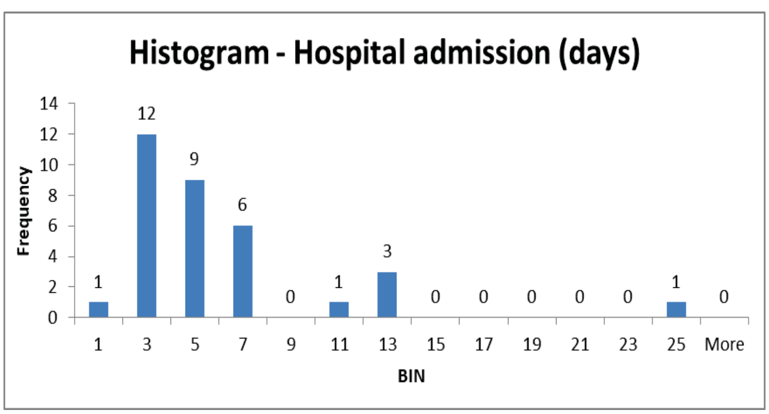

Figure 1. Hospital admission period distribution histogram (n=33)

The mean hospital admission period was 5,55+/-4,56 days. The histogram of the hospital admission period is represented in figure 1.

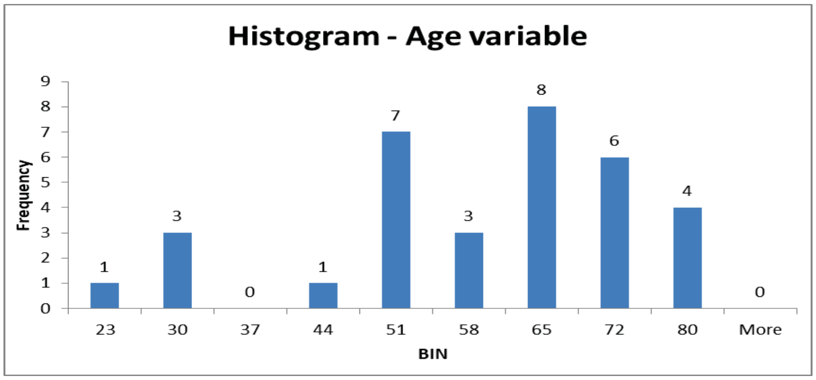

Figure 2. Age distribution histogram (n=33)

The mean age was 56,09+/-15,24. The age distribution histogram is represented in figure 2.

By applying the nonparametric Kruskal Wallis test we observed that GLS in obstructed coronary arteries decreases significantly (p=0.02) with the number of affected vessels (-18.55 for one-vessel, -18.33 for two-vessels and -14.93 for three-vessel disease).

We applied a linear regression model to analyse the association between LVEF values and GLS LV values, we observed a very significant median indirect correlation $(r = -0.52,\ R^2 = 0.27, p = 0.0016 < 0.01)$, represented in figure 3.

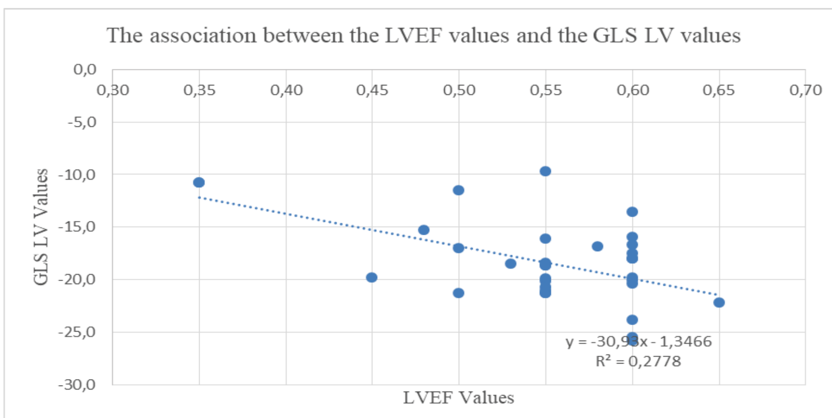

Figure 3. Correlation between LVEF and GLS LV values. Linear regression model

By applying the same regression model, we also obtained a significant strong positive correlation (p<0.001, r=0.93, R2=0.87) between arterial stiffness values and global longitudinal strain values. (figure 4)

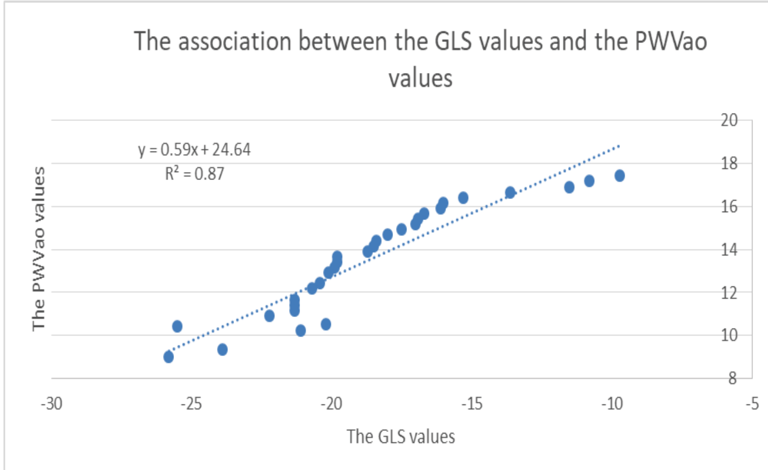

Figure 4. Correlation between PWVao and GLS values. Linear regression model

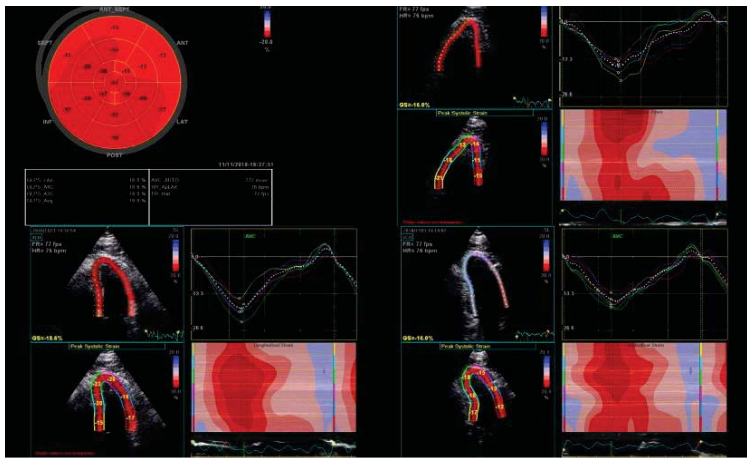

Figure 5. Example of speckle-tracking echocardiography for calculation of longitudinal strain values

An example of speckle-tracking echocardiography to calculate longitudinal strain values is represented in figure 5.

DISCUSSIONS

Coronary artery disease (CAD) is one of the leading causes of morbidity and mortality in the world [12].

More than 50% of patients currently referred for coronary angiography assessment have normal coronary arteries or nonobstructive CAD [13]. Noninvasive assessment of patients with coronary artery disease (CAD) remains a clinical challenge despite the widespread use of imaging and provocative testing.

Left ventricular (LV) ejection fraction (LVEF) assesses global systolic function and is useful in risk evaluation and management of numerous cardiovascular diseases. Nonetheless, this parameter has limitations in conditions where the ratio of stroke volume to LV cavity size is maintained [14]. Global longitudinal strain appears to be a sensitive measure of impaired LV systolic function in early stages of ventricular dysfunction, when LVEF is still normal [15].

Studies proved that measurement of global longitudinal strain using 2D speckle tracking echocardiography is also a sensitive and accurate tool in prediction of severe CAD [16]. Gaibazzi et al. proved that rest GLS had a comparable accuracy with stress-echo data for prediction of angiographically obstructive CAD, which increased furthermore when combined with clinical data, similar to stress echocardiography wall motion [17]. Interactions between the left ventricular and the arterial systems are critical determinants of cardiovascular function [18]. Pulse wave velocity is a parameter of arterial function and an early sign of atherosclerosis. We noticed that GLS and PWV are associated, but we need larger cohorts to study ventricular-arterial coupling furthermore. This noninvasive approach could be clinically useful in the early assessment of all patients with cardiovascular risk before developing symptoms.

CONCLUSIONS

Left ventricular ejection fraction and global longitudinal strain were significantly correlated in this small study. Both left ventricular ejection fraction and global longitudinal strain by two-dimensional speckle tracking echocardiography proved useful in correlating to severity of coronary artery disease. We noticed that pulse wave velocity, as a marker of arterial stiffness, and global longitudinal strain, as a marker of left ventricular performance, were significantly correlated. Further research on larger cohorts is necessary to establish if all patients with or without symptoms of angina could benefit from speckle tracking echocardiography and arterial stiffness assessment in the early stages of atherosclerosis before significant obstruction in the arteries occurs.

Conflict of interests: The authors declare that they have no conflict of interests. Compliance with ethical standards: We undersign and certificate that the procedures and the experiments we have done respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2000 [19], as well as the national law.

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