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Cardio-ankle Velocity Index (CAVI) as a Marker of Multivessel Coronary Artery Disease in Diabetic Patient

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Abstract--- Aim: *To investigate the ability of the arterial stiffness parameter cardio-ankle velocity index (CAVI) to predict coronary disease in diabetic patient.*

Method: *155 consecutive patients underwent CAVI prior for coronary angiography for different indications between March 2018 until March 2019 at Al Hussein teaching hospital-Samawah city-Iraq. Patients with atrial fibrillation, aortic valve regurgitation and low Ankle Brachial Index (ABI<0.9) were excluded. After coronary angiography, patients were categorized as those with no vessel disease (group 1), those with single vessel disease (1VD) (group 2), those with two vessels disease (2VDs) (group 3) and those with three vessels disease (3VDs) (group4). In relation to diabetes they were categorized into four groups: Those has no DM and No demonstrable CAD (Non DM. Non CAD) (group 1), those with no DM but CAD (Non DM. CAD) (group2), Those with DM and no CAD (DM. NonCAD) (group 3) and those DM and CAD (DM.CAD) (group 4).*

Results: *CAVI was significantly higher in those with 1VD than normal (mean±SD) (9.35±1.05 Vs 8.138±6.73) (P<0.05), Those with 2VD has significantly higher CAVI than those with no vessel disease (mean±SD) (9.8±0.84 Vs 8.13±6.73) (P<0.05), Those with 3VD has significantly higher CAVI than those with No vessel disease (mean±SD) (11.48±1.1 Vs 8.138±6.73), (P<0.001) Those with 3VDS has significantly higher CAVI than those with 2VD (mean±SD) (11.48±1.1 Vs 9.8±0.84) (P<0.05). As for Diabetics, Those with DM and CAD (group 4) has the highest CAVI among other groups (mean±SD) (10.73 ±1.323 Vs 9.865±1.346) (p<0.05).*

Conclusion: *CAVI can be a simple non-invasive test to predict multivessel disease in diabetic patients.*

Keywords--- *CAVI, Multivessel, Coronary Artery Disease.*

I. INTRODUCTION

The progression of atherosclerosis is usually silent and diagnosed when an arterial flow-limiting stenosis of the affected organ (i.e. Stable angina in critical coronary artery disease) or sudden rupture of atherosclerotic plaque causing acute infarct of the supplied organ. Arterial stiffness is the hallmark of diffuse atherosclerosis. Early non-invasive recognition of severe and diffuse coronary artery diseases is for paramount importance. Unlike the Pulse wave Velocity (PWV), which is well-established parameter of arterial stiffness (1), CAVI (Carotid-Ankle vascular index) doesn't affected by the blood pressure at the time of study making it reliable and reproducible at any Blood pressure level (2), (3). CAVI is a parameter of adjusted PWV for blood pressure, based on a stiffness parameter β (4) using Bramwell-Hill's formula (5). CAVI is calculated as follows:

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$$\mathrm{CAVI} = a\left(\frac{2\rho}{\Delta P}\right) \times \ln\left(\frac{\mathrm{Ps}}{\mathrm{Pd}}\right) \times \mathrm{PWV}^2 + b, \quad (1)$$

where Ps indicates systolic pressure in brachial artery; Pd, diastolic pressure in brachial artery; ρ, density of blood; a,b, correction coefficient. CAVI has been correlated with the risk factors for atherosclerosis: Diabetes Mellitus, Dyslipidemia, Hypertension, Obesity & chronic kidney disease (6-11) and Coronary artery diseases (12), we hypothesize that CAVI can discriminate patients with severe diffuse Coronary artery disease (three vessel disease) (3VDs) specially in high risk patient thus anticipating this group with high morbidity and mortality.

II. SUBJECT AND METHOD

2.1. Study Population

The current study is a prospective observational study at A Hussein teaching hospital in Samawah city from march 2018 until march 2019. 155 Adult patients in whom coronary angiography was scheduled were recruited to the study. These patients had diverse risk factors: DM, smoking, Hypertension and dyslipidemia.

We excluded patients with any of the following characteristics: (1) severe aortic insufficiency, (2) PAD, (3) atrial fibrillation (AF), (4) informed consent was not given. We excluded patients with severe aortic insufficiency, PAD, and AF because it was difficult to accurately measure CAVI in such patients.

Study Design

Was a cross sectional study, patient's characteristics including demographic data, anthropometric data, BP measurement, laboratory data profile, medications prescribed and medical problems were recorded .Body mass index (BMI) was calculated as weight in (Kg) divided by height measured in meter squared (m2). HTN was defined as either having a resting seated systolic BP (SBP) of at least 140mmHg, or diastolic BP (DBP) of at least 90mmHg or use of antihypertensive medications.

Blood Samples

Biochemistry data, including glucose, hemoglobin A1c (HbA1c), low density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglycerides, Hb A1C were taken at the time of hospital admission.

Measurement of Arterial Stiffness (CAVI)

CAVI was measured with a VaseraVS-1500A vascular screening system (Fukuda Denshi, Tokyo, Japan) by the method described previously. ECG electrodes were placed on both wrists, a microphone for detecting heart sounds was placed on the sternum, and cuffs were wrapped around both the arms and ankles, with the patient lying supine. After a 10-min rest, the examination was performed. The measurements were taken prior to do coronary

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angiography CAVI was determined using the following formula: **CAVI=a{(2ρ/ΔP)×ln(Ps/Pd)PWV2}+b** where a and b are constants, ρ is blood density, ΔP is Ps–Pd, Ps is systolic blood pressure, and Pd is diastolic blood pressure. The average value of right and left CAVI was used for analyses.

Coronary angiography: The patients underwent coronary angiography to exclude coronary artery disease (CAD), Critical coronary artery stenosis was pointed out when there is at least 70% luminal narrowing of the coronary artery.

III. STATISTICS

Values were expressed as mean±SD, frequency and percentages .students t-test was used to compare various variables and the $\chi 2$ test and Fishers Exact test were used to test differences between categorical variables. Spearmans correlation Coefficient was calculated to evaluate the relationship among parameters. HF and LF were log-transformed (Log HF and Log LF) prior to analysis due to skewness. All statistical analyses were carried out using SSPS for windows version 17.0 (SSPS Inc. Chicago, IL, USA) and a p-value <0.5 was considered to indicate statistical significance.

Anova method was used to compare among different groups.

IV. RESULTS

In total, 155 consecutive patients were evaluated. The basic characteristics of those patients are seen in table 1. The mean age is 59.3±6.4, male comprises 76% of the study population, 76% of them are hypertensive and 45% are diabetic, the mean CAVI is 9.1±0.89.All the patients underwent coronary angiography for the exclusion of coronary artery disease for various indications. 38% had normal coronary angiography, 20.8% has single vessel disease (1VD), 18.7% has two vessel disease (2VD) and 22.5% has three vessel disease (3VD).

Then we compare the CAVI variable among four groups (No Vessel disease, 1VD, 2VD and 3VD) using Anova grouping as in figure 1. As compared to 1VD, CAVI was significantly higher than normal (mean±SD) (9.35±1.05 Vs 8.138±6.73) (P<0.05), Those with 2VD has significantly higher CAVI than those with no vessel disease (mean±SD) (9.8±0.84 Vs 8.13±6.73) (P<0.05), Those with 3VD has significantly higher CAVI than those with No vessel disease (mean±SD) (11.48±1.1 Vs 8.138±6.73), (P<0.001).

Those with 3VDS has significantly higher CAVI than those with 2VD (mean±SD) (11.48±1.1 Vs 9.8±0.84) (P<0.05). No significant statistical difference in CAVI value between those with 2VD Vs 1VD (mean±SD) (9.35±1.05 Vs 9.8±0.84) (P=0.148). Then we divided the total population study into 4 groups, as in figure 2:-(1) group 1 those with No DM and NO CAD, (2) Group 2: No DM and CAD, Group 3: DM and No CAD and finally those DM and CAD.

We found a significantly higher CAVI in those with Group 4 Vs group 1 (mean±SD) (10.73 ±1.323Vs 7.986± 0.981) (p<0.001), Significantly higher CAVI in group 4 Vs group 3 (mean±SD) (10.73 ±1.323 Vs 7.874±1.089) (p<0.001) and significantly higher CAVI in group 4 Vs group 2 (mean±SD) (10.73 ±1.323 Vs 9.865±1.346)

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($p<0.05$), No statistical difference between group 1 and group 3($P=0.739$).

Clinical Characteristics

Age	59.3±6.4
Male sex%	76
BMI(Kg/M2)	27±3.3
Systolic BP(mmHg)	152±12.7
Diastolic BP(mmHg)	86±7
LDL-Cholesterol(mg/dl)	115±28.3
HDL-Cholesterol (mg/dl)	52±17
Triglyceride (mg/dl)	163±13.6
Creatinine (mg/dl)	0.9±0.3
FBS (mg/dl)	133.5±18
HbA1C (%)	7.2±0.94
Diabetes (%)	46
Dyslipidemia (%)	90%
Hypertensive (%)	72%
Antihypertensive (%)	80%
CAVI	9.1±0.89
No vessel disease (%)	38
Single vessel disease (1VD) (%)	20.8
Two vessel diseases (2VDs) (%)	18.7
Three vessel diseases (3VDS) (%)	22.5

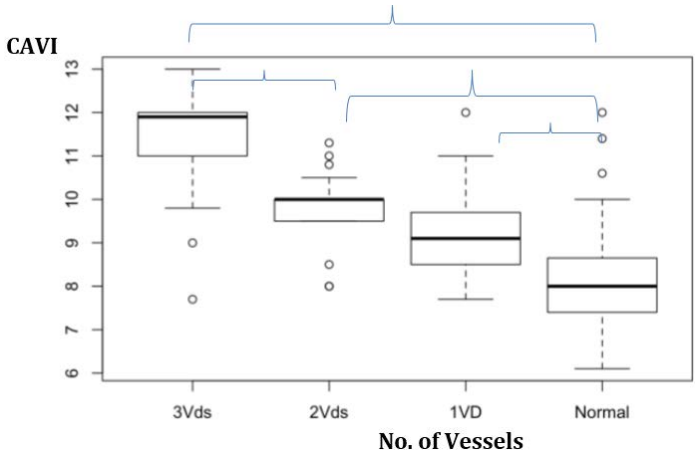

Figure 1: correlation of CAVI with the number of coronary artery having critical stenosis

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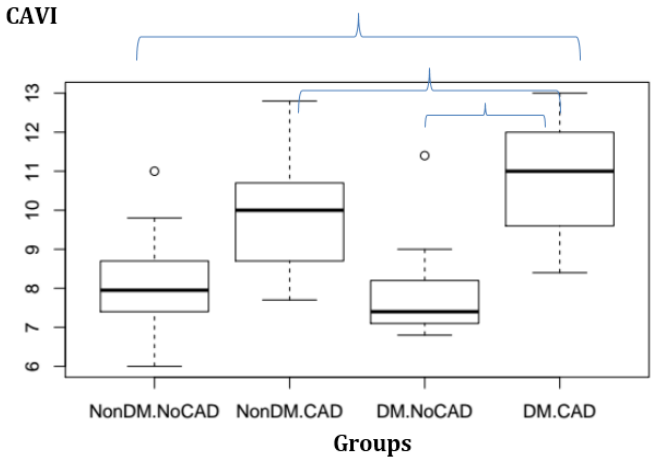

Figure 2: Correlation among different Patients Subgroups

V. DISCUSSION

In our study, we showed that the marker of arterial stiffness CAVI was significantly correlated with the number of coronary arteries that haves critical stenosis, this linear correlation confirms the previous studies (13,14), making the test a good non-invasive testing for predicting the presence of clinically significant CAD. However, in our study, CAVI show no significant relations between those with single vessel disease or two vessel disease, both groups are clearly significantly higher than those normal coronaries on angiography, with 9.3 as a mean for CAVI to separate those with clinically significant CAD.

As Diabetes is a major cause of cardiovascular death (15), being a major risk factor for atherosclerosis and abnormal vascular function (16,17). Predicting the severity and extent of CAD in those patients is of paramount importance. Our study showed that in those subgroups of patients with CAD and Diabetes has significantly higher CAVI value with a mean of 10.7, significantly higher than those with diabetes but no CAD on Angiography. Thus higher CAVI values in diabetic patients can effectively anticipate the presence of clinically significant coronary artery disease .Up to our knowledge this is the first study to show this correlation. While in diabetic patients with no CAD, CAVI value was not different from those without diabetes, making low CAVI values as predictor of less probability of presence of CAD. Finally CAVI can be a possible non-traditional risk stratification tool for the extent of CAD in diabetic and non-diabetic population, further studies are need to confirm these observations.

REFERENCES

[1] O'Rourke MF, Staessen JA, Vlachopoulos C, Duprez D, Plante GE. Clinical applications of arterial stiffness; definitions and reference values Am J Hypertens. 2002 May; 15(5): 426-44.
[2] Nyeer: The effect of blood pressure alternation on pulse wave velocity. Br Heart J. 1964 Mar;26:261-5
[3] Shirai K1, Utino J, Otsuka K, Takata M. A novel blood pressure-independent arterial wall stiffness parameter; cardio-ankle vascular index (CAVI). *J Atheroscler Thromb.* 2006 Apr; 13(2):101-7.
[4] Kawasaki, S. Sasayama, and S.I. Yagi, "Non-invasive assessment of the age related changes in stiffness of major branches of the human arteries," *Cardiovascular search,* vol. 21, no. 9, pp. 678–687, 1987.
[5] J.C. Bramwell and A. V. Hill, "Velocity of the pulse wave in man," Proceedings of the Royal Society of London, pp. 298–306, 1922.

DOI: 10.37200/IJPR/V24I4/PR201505
Received: 16 Jan 2020 | Revised: 17 Feb 2020 | Accepted: 26 Feb 2020

[6] K. Sakane, T. Miyoshi, M. Doi et al., "Association of new arterial stiffness parameter, the cardio-ankle vascular index, with left ventricular diastolic function," *Journal of Atherosclerosis and Thrombosis*, vol. 15, no. 5, pp. 261–268, 2008.

[7] K. Nakamura, T. Tomaru, S. Yamamura, Y. Miyashita, K. Shirai, and H. Noike, "Cardio-ankle vascular index is a candidate predictor of coronary atherosclerosis," *Circulation Journal*, vol. 72, no. 4, pp. 598–604, 2008.

[8] A. Ichihara, N. Yamashita, T. Takemitsu et al., "Cardio-Ankle Vascular Index and Ankle Pulse Wave Velocity as a Marker of Arterial Fibrosis in Kidney Failure Treated by Hemodialysis," *American Journal of Kidney Diseases*, vol. 52, no. 5, pp. 947– 955, 2008.

[9] T. Okura, S. Watanabe, M. Kurata et al., "Relationship between cardio-ankle vascular index (CAVI) and carotid atherosclerosis in patients with essential hypertension," *Hypertension Research*, vol. 30, no. 4, pp. 335–340, 2007.

[10] Takaki A, Ogawa H, Wakeyama T, et al. Cardio-ankle vascular index is a new noninvasive parameter of arterial stiffness. *Circ J* 2007; 71(11): 1710-17

[11] Saoh-Asahara N, Suganami T, Majima T, et al. and the Japan Obesity and Metabolic Syndrome Study (JOMS) Group Urinary Cystatin C as a Potential Risk Marker for Cardiovascular Disease and Chronic Kidney Disease in Patients with Obesity and Metabolic Syndrome. *Clin J Am Soc Nephrol* 2011; 6: 265-273.

[12] Horinaka S; Yabe A; Yagi H; Ishimura K; Hara H; Iemua T; Matsuoka H. Comparison of atherosclerotic indicators between cardio ankle vascular index and brachial ankle pulse wave velocity. *Angiology*. 2009; 60(4): 468-76 (ISSN: 1940-1574).

[13] Miyoshi T, Doi M, Hirohata S Cardio-ankle vascular index is independently associated with the severity of coronary atherosclerosis and left ventricular function in patients with ischemic heart disease. *J Atheroscler Thromb*. 2010 Mar 31; 17(3): 249-58.

[14] Park JB, Park HE, Choi SY Relation between cardio-ankle vascular index and coronary artery calcification or stenosis in asymptomatic subjects. *J Atheroscler Thromb.* 2013; 20(6): 557-67.

[15] N.J. Morrish, S.L. Wang, L.K. Stevens et al., "Mortality and causes of death in the WHO multinational study of vascular disease in diabetes," *Diabetologia*, vol. 44, no. 2, pp. S14–S21, 2001.

[16] L. De Angelis, S.C. Millasseau, A. Smith et al. "Sex differences in age-related stiffening of the aorta in subjects with type 2 diabetes," *Hypertension*, vol.44,no.1,pp.67–71,2004

[17] E. Kimoto, T. Shoji, K. Shinohara et al. "Preferential stiffening of central over peripheral arteries in type 2 diabetes," *Diabetes*, vol.52, no.2, pp. 448–452, 2003.

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