Research Article

Usefulness of pulse wave velocity as an indicator of atherosclerosis in subjects with impaired fasting glucose

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Abstract

Background: The prediabetic state with impaired fasting glucose level (IFG) is one of the risk factors for endothelial dysfunction leading to atherosclerosis. Pulse wave velocity is an effective index of arterial stiffness and is widely used for noninvasive assessment of atherosclerosis. **Aims and Objectives:** To assess the usefulness of pulse wave velocity (PWV) as an indicator of atherosclerosis in IFG. Also to compare PWV values in subjects with IFG and those with normal fasting glucose (NFG) levels and to correlate the PWV values with the fasting glucose levels. **Materials and Methods:** Two hundred male subjects were involved in the study. Group 1 comprised subjects with IFG (n = 100). Group 2 comprised subjects with NFG (n = 100). Both the groups were evaluated for physiological parameters-Blood pressure and brachial-ankle pulse wave velocity (ba-PWV) using PeriScope. The biochemical parameters such as fasting blood glucose, HbA1c, and lipid profile were also measured. Statistical analysis was done using SPSS-19 software. All parameters were compared using unpaired Student's t-test. Pearson correlation analysis was done to establish the relationship between two variables. **Results:** Significant differences were found between the ba-PWV values in the IFG and NFG groups (1549.5 ± 60.5 cm/s vs 1351.7 ± 44.0 cm/s, $p < 0.05$). There was also significant positive correlation (r = 0.88) between ba-PWV value and fasting glucose level. The multiple regression analysis showed that IFG level is an independent risk factor for increased ba-PWV levels. **Conclusion:** Our study showed that ba-PWV can be used as an indicator to detect the early development of atherosclerosis in subjects with IFG levels.

KEY WORDS: Pulse wave velocity; Atherosclerosis; Impaired fasting glucose; Arterial stiffness

Introduction

It has been estimated that the prevalence of prediabetes is increasing globally as well as in India day by day and the numbers would further continue to rise as a consequence of the obesity epidemic.[1,2] Individuals with IFG (prediabetes) are at an increased risk of type 2 diabetes mellitus[3,4] and thus are important target for primary prevention. Many studies have confirmed that circulating endothelium factors (mainly Plasminogen activator inhibitor-I) are more in IFG population.[5] This cause damage to the endothelial cells.[6] Endothelial vasodilator dysfunction is a key feature of atherogenesis.[7–9] Arterial stiffness is an early indicator of atherogenesis. Pulse wave velocity (PWV) is a noninvasive method measuring arterial stiffness for the assessment of atherosclerosis, and there have been many reports about the relationship between PWV and the development of atherosclerosis.[10,11]

This study aimed to assess the relationship between arterial stiffness and impaired fasting glucose (IFG) levels.

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Materials and Methods

This cross-sectional study comprised 200 subjects within the age group of 30–45 years. Adult males in the age group of 30–45 years were involved. Subjects with diabetes, hypertension,

cardiovascular diseases; those on lipid lowering agent, vasodilators, antidiabetic and antihypertensive drugs; chronic smokers; and alcoholics were excluded. After getting institutional ethical clearance from Cuttack Medical College, informed consent from the subjects was obtained before the procedures were carried out.

According to American Diabetes Association (ADA) criteria, they were classified into two groups.

Group 1 (IFG): Individuals with IFG, 100–125 mg/dL and HbA1c, 5.7%–6.4%

Group 2 (NFG): Individuals with NFG, <100 mg/dL and HbA1c, $\leqslant 5.6\%$

Physiological parameters such as systolic blood pressure (SBP), diastolic blood pressure (DBP), body mass index (BMI), and bilateral brachial-ankle PWV (ba-PWV) were measured using PeriScope.

Measurement of ba-PWV: This measurement was done in a private lab in Cuttack. After the subject had rested in a supine position for 10 min, cuff wrapped around both arms and ankles, and ECG electrodes were placed. Recording was done through PeriScope–Cardiovascular Analysis System. The instrument has been validated for repeatability and reproducibility.[12]

Biochemical parameters were measured. Fasting blood glucose (FBG) was assessed by glucose oxidase peroxidase method and HbA1c by Ion exchange high-performance liquid chromatography. Serum total cholesterol, triglyceride, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) were analyzed using autoanalyzer.

Statistical Analysis

It was done using SPSS version 19. Kolmogorov–Smirnov test was done to see if the data were normally distributed. Unpaired Student's *t*-test was used to compare the variables. Multiple linear regression analysis was used to determine the independent risk factor. Pearson correlation analysis was done to correlate between variables. Data were expressed as mean ± SD. A p value <0.05 was considered to be of statistical significance.

Results

Table 1 represents demographic and physiological parameters in IFG and NFG group. There was significant increase in BMI, SBP, DBP, pulse pressure, and ba-PWV in IFG group when compared to NFG group.

Table 1: Comparison of demographic and physiological parameters between IFG group and NFG group

	IFG group	NFG group	*p* Value
Age (years)	37.5 ± 4.2	36.4 ± 3.8	0.057
BMI (kg/m^2)	25.3 ± 1.5	23.9 ± 1.0	0.000
SBP (mmHg)	127.7 ± 7.5	119.7 ± 8.2	0.000
DBP (mmHg)	80.2 ± 5.3	78.0 ± 5.0	0.002
PP(mmHg)	47.45 ± 8.3	41.71 ± 10	0.000
Mean ba-PWV(cm/s)	1549.5 ± 60.5	1351.7 ± 44.0	0.000

Table 2 compares biochemical parameters between the two groups. Significant alteration in lipid profile was observed in IFG group.

Table 3 represents Pearson correlation between the variables. Significant strong positive correlation was observed between PWV values and FBG levels and also with HbA1c levels. There was also positive correlation between right and left PWV values.

Discussion

Ba-PWV is a simple and reproducible measure of arterial stiffness. It has good correlation with the aortic PWV, which was obtained by invasive recording.[13,14] Arterial stiffness is an index of vascular health. It is considered as an early marker of atherosclerosis.[14]

Increased glucose levels adversely affect endothelial function. This in turn may propagate the atherosclerotic process.[15] Findings of this study indicate that increased fasting glucose in IFG group is associated with progression of arterial stiffness. Increased arterial stiffness interferes with the hemodynamic buffering effect of the cardiovascular system resulting in coronary artery disease.[16,17] Arterial stiffness is an independent predictor of cardiovascular mortality,[18,19] and it is becoming a crucial point of focus for early detection of cardiovascular disease.[20–22]

Results of our study are similar to those in the study by Ohnishi et al.[23] and Shaw et al.[24] in individuals in the age group of 40–70 years. In this study, individuals in lower age group (30–45 years) with IFG level are also at increased risk of atherosclerotic changes. With aging, progressive stiffening of arterial wall occurs due to degeneration of elastic fibers. Studies have observed that increased arterial stiffness is associated with age-related increase in PWV.[25] Thus, individuals within the age group of 30–45 years were involved in our study.

Our findings support the observation of early development of adverse vascular changes in subjects with impaired glucose levels[26] in other studies.

Table 2: Comparison of biochemical parameters between IFG and NFG group

	IFG group	NFG group	*p* value
FBG (mg/dL)	113.2 ± 6.0	81.5 ± 7.0	0.000
HbA1c (%)	5.9 ± 0.2	5.2 ± 0.3	0.000
Total cholesterol(mg/dL)	193.4 ± 12.2	179.14 ± 10	0.000
Triglyceride(mg/dL)	147.2 ± 9.0	130.1 ± 7.7	0.000
LDL cholesterol(mg/dL)	129.7 ± 7.3	114.9 ± 8.3	0.000
HDL cholesterol(mg/dL)	40.36 ± 5.1	46.9 ± 5.1	0.000

Table 3: Pearson correlation between the variables

	r Value	*p* Value
PWV (cm/s) and FBG (mg/dL)	0.88	0.01
PWV (cm/s) andHbA1c (%)	0.75	0.01
Rt PWV(cm/s) and Lt PWV(cm/s)	0.99	0.000

But the findings by Ando et al.[27] contradict our finding. It shows impaired glucose tolerance and not IFG to be a risk factor for early-stage atherosclerosis. Though the individuals with IFG had slightly increased ba-PWV values, it was not to the significant level. But, in this study, statistically significant difference in the ba-PWV values was obtained between the groups. Increased mean ba-PWV was observed in individuals with IFG when compared to individuals with NFG. There was significant correlation between right and left ba-PWV values and also between mean ba-PWV and fasting glucose levels.

Many studies had not considered glycated hemoglobin levels in the subjects. This implies that certain people in the IFG group may actually have diabetes. In this study, HbA1c levels were assessed and based on that the IFG group was categorized. HbA1c levels show positively significant correlation with ba-PWV.

Borderline risk factors such as high normal blood pressure levels, overweight, high normal levels of cholesterol, triglyceride, LDL, and decrease in HDL levels often coexist with IFG. These alterations may be related to the development of early atherosclerotic changes.

The results of multiple linear regression analysis show that FBG was independently related to ba-PWV regardless of age, blood pressure, BMI, and lipid levels. Seventeen percent of variation in PWV values was due to IFG levels.

Increased ba-PWV indicates that atherosclerotic changes started occurring in the IFG group; hence the risk of cardiovascular disease in subjects with IFG is higher than that in normal subjects. Thus, early intervention in adults with IFG is required to reduce the risk of developing not only diabetes but also cardiovascular abnormalities. It is a wake-up call for prediabetes to act immediately by controlling their diet, doing exercise, and checkup of their blood glucose levels at regular intervals.

Conclusion

Our study showed that ba-PWV can be used as an indicator to detect the early development of atherosclerosis in subjects with IFG levels.

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