STUDY OF ARTERIAL PARAMETERS IN DIABETES MELLITUS USING IMPEDANCE PLETHYSMOGRAPHY

Chintan V Parmar[1], Divyeshkumar L Prajapati [2], Pradnya A Gokhale[3], Hemant B Mehta[4], Chinmay J Shah[5]

[1]Assistant Professor, Dept. of Physiology, Shakhsi Medical College and Research centre, Guna, Madhya Pradesh. [2]Assistant Professor, Dept. of Physiology, GMERS Medical College, Himmatnagar, Gujarat. [3] Professor, Dept. of Physiology, GMC, Baroda, Gujarat. [4] Professor & Head, Dept. of Physiology, GMC, Bhavnagar, Gujarat [5]Associate Professor, Dept. of Physiology, GMC, Bhavnagar, Gujarat

Abstracts: **Background And Objectives:** Impedance Plethysmography (IPG) is a simple, low cost and non–invasive tool to assess the central and peripheral blood flow in human body. The literal meaning of IPG is "Recording of the blood volume changes indirectly in any part of the body by measurement of its electrical impedance. Diabetes is a one of the leading cause of peripheral vascular diseases (PVDs) which begins mainly from distal part of lower extremities in diabetic patients. So Blood flow measurement in lower extremities may become useful predictor of PVDs. The Objective of present study was to measure blood flow index (BFI) in patients of type 2 diabetes mellitus. **Method:** The study was carried out on two group- diabetic (n=100, 53 male; 47 female) and control group (n=50, 27 male; 23 female) in the cardiovascular laboratory, Department of physiology, Govt. Medical College, Bhavnagar. **Results:** BFI was lower in thigh and calf of Diabetic group compared to Control group. BFI had negative correlation with LDL and HBA_1C. **Interpretation & Conclusion:** Blood flow in lower extremities of diabetic group was reduced compared to control group. Poor control of diabetes affects blood flow in lower extremities of diabetic patients. By this simple, harmless, inexpensive, objective and non-invasive hemodynamic test, we can predict earlier onset of PVD in case of Diabetic patients and this test may replace other invasive hemodynamic test for screening vascular disorders.

Key Words: Blood flow index, Diabetes Mellitus, Impedance Plethysmography, Non-invasive, Peripheral vascular diseases.

Author for correspondence: Dr. Divyeshkumar L Prajapati, Department of Physiology, , GMERS Medical College, Himmatnagar–383001. e- mail: divyesh0501@gmail.com Mob. No.—8141003354.

Introduction:

Peripheral vascular disease (PVD), commonly referred to as peripheral arterial disease (PAD) or peripheral artery occlusive disease (PAOD), refers to the obstruction of large and medium sized arteries not within the coronary, aortic arch vasculature, or brain[1]. PVD can result from atherosclerosis, inflammatory processes leading to stenosis, an embolism, or thrombus formation. Risk factors contributing to PAD are smoking, diabetes mellitus, dyslipidemia, hypertension, obesity etc[1].

Diabetes mellitus is a significant risk factor for the development of peripheral arterial disease (PAD) [2]. Figures suggest that PAD occurs 20 times more often in people with diabetes compared with the non-diabetic population [3]. A reduced blood supply to the lower limb, due to arterial disease, is a common cause of foot ulceration in patients with diabetes. Of all lower extremity amputations, 40–70% are related to diabetes, with the majority occurring as a result of PAD [4,5]. It would be necessary to identify reduced blood flow through lower limbs early before PAD has been occurred which allow early implementation of appropriate treatment to prevent the diabetic foot[6]. Further, prevention of foot problems may be easier than treating foot problems. There is a general consensus that diabetic patients should receive regular vascular assessment to allow early identification of vascular changes and prompt intervention to prevent deterioration[7-9].

Angiography[1] is a routinely used invasive procedure to investigate PVD While in case of non-

invasive methods, Doppler Ultrasound[10], Strain gauge plethysmography[11], Pulse volume recorder[12], Electrical impedance plethysmography[13-17], Ankle brachial pressure index[18] has been made in developing new non-invasive methods to investigate PVD.

In Angiography[1], catheter is inserted into the common femoral artery and selectively guided to the artery in question. While injecting a radio dense contrast agent, an X-ray is taken. Any flow limiting stenoses found in the x-ray can be identified which give information about the anatomical status of the arterial and venous tree but not about the hemodynamic of the circulation in the limb. The site of block is very important in patients who are likely to undergo surgery. In these patients, arteriography is essential. In rest of the patients undergoing conservative therapy, arteriography need not be performed. Impedance plethysmography thus offers a good screening procedure for the patients with PAD[19].

Doppler ultrasound[2], a popularly used method for diagnosing of PVD, can detect and measure blood flow by measurement of high-frequency sound waves that are reflected off of tissues. It has the advantage of locating the block anatomically but is insensitive to the deeper blood vessels. Threefold cost of the Doppler system and requirement of a skilled operator gives an edge to impedance technique over the Doppler[20].

The ankle-brachial index (ABI) is the most documented of these methods, but in diabetic patients, calcification of artery walls (medial sclerosis) frequently causes falsely elevated ankle pressure values[21,22]. A complementary method might be necessary to exclude medial sclerosis.

Impedance Plethysmography is superior to other plethysmographic methods (volume displacement plethysmograph, strain gauge plethysmograph and photo plethysmograph), as it is directly related to the electrical property of the blood[13].

In our country, few institutes [19,23-26] have added IPG studies to their routine procedures as these techniques are simple, non invasive, low cost, objective and informative. In future, Impedance Plethysmography (IPG) may become a useful non-invasive tool in determining the hemodynamic of the circulation in limbs or in diagnosis of peripheral vascular diseases.

The Objectives of present study were (1) To measure Blood flow index (BFI) in patients of type 2 diabetes mellitus and compare it with that of control group and (2) To correlate parameters like HbA_1C and LDL with BFI.

Material and Methods:

After obtaining prior approval for the study from Institutional Review Board (IRB) of Government Medical College, Bhavnagar and taking informed consent from the participants, the present study using Impedance Plethysmography (IPG) was conducted on study as well as control group in the Department of Physiology, Government Medical College, Bhavnagar, Gujarat.

A control group of healthy, non-diabetic subjects (Male–27; Female-23) without peripheral occlusive arterial disease was included for comparison with diabetic patients (study - DM group- Male-53; Female-47) who did not have clinically evident peripheral occlusive arterial disease to define normal values for several variables of interest.

Subject preparation

The age, sex, height and weight of the subjects were recorded. Each subject was given a thorough Clinical Examination as a preliminary measure to exclude patients having any sign or symptom regarding PAD in study group and to exclude volunteers with any condition affecting vascular function.

After giving brief information about the procedure to alleviate any apprehension and to assure full relaxation during the test & obtaining written consent from each participant, the IPG recording was done in supine position at room temperature on Impedance plethysmograph (Nivomon Series Product computerized software by L & T Company) in the cardiovascular laboratory, Department of physiology, Govt. Medical College, Bhavnagar.

Surface stick on type E.C.G. electrodes were used on the chest of the subject in 3 limb lead configurations as left arm, right arm and left leg as shown in Figure 1.

The accessory band electrodes (I1, I2 - current electrodes and V1, V2 – sensing electrodes) were strapped to the body segment of interested area of the subject by choosing appropriately sized bands at the desired location to capture the IPG waveform as shown in figure 2 as follows:

(1) For Thigh, I1 at Forehead, I2 at Feet, V1 at Below umbilicus and V2 at Above knee

(2) For Calf, I1 at Forehead, I2 at Feet, V1 at Below knee and V2 at Above ankle were placed.

In present study, Inter-electrode distance between V1 and V2 was tried to maintain less than 10 cm for each site as mentioned above.

I1, V1, V2 and I2 of IPG cable were connected to the band electrodes at the extremities of the measurement area to capture the IPG waveform. The IPG waveform was recorded at least for 30 seconds but to reduce the noise interference in the averaged waveform, long recording to a maximum of 150 seconds was taken. As soon as waveform acquisition was stopped, BFI was displayed on the screen.

Statistical analysis

The statistical analysis of the data obtained in the above recordings was performed by computer programs using Microsoft excel and statistical software named GraphPad InStat – [DATASET1.ISD].

Mann-Whitney comparison test was used to compare BFI between study and control group.

Spearman correlation coefficient (r) was measured to correlate the parameters HbA1C and LDL with BFI.

Result:

TABLE 1(a)
Physical parameters of Males in study and control group (Mean ± SD)

Parameters	Age (years)	Height (cm)	Body mass index (BMI)	Heart Rate (beats/min)	Blood pressure (mmHg)
Study group (53)	60.19±10.88	159.96±4.54	24.62±3.86	76.52±9.84	129±6.47
Control group (27)	59.81±13	162.89±5.37	22.83±2.54	71.11±9.42	126.3±10.04

TABLE 1(b)
Physical parameters of Females in study and control group (Mean ± SD)

Parameters	Age (years)	Height (cm)	Body mass index (BMI)	Heart Rate (beats/min)	Blood pressure (mmHg)
Study group (47)	53.91±10.71	151.51±5.77	24.38±5.87	79.45±6.05	126.74±10.87
Control group (23)	57.91±11.15	151.57±7.18	25.15±2.85	77.30±8.70	122.43±10.46

TABLE 2
Blood flow index (BFI) in study and control group (Mean ± SD)

BLOOD FLOW INDEX (BFI) (MEAN±SD)						
	THIGH			CALF		
	DIABETIC GROUP	CONTROL GROUP	p value	DIABETIC GROUP	CONTROL GROUP	p value
MALES	0.56±0.09	0.61±0.09	0.0173	0.58±0.13	0.75±0.12	<0.0001
FEMALES	0.55±0.1	0.66±0.19	0.011	0.62±0.11	0.73±0.16	0.0014
Note: p value < 0.05 indicates significance.						

TABLE 3
Effect of HbA_1C and LDL on BFI of study group (Correlation coefficient r)

	BLOOD FLOW INDEX (BFI)	
	THIGH	CALF
HBA1C (Male)	r = - 0.2470	r = - 0.2549
(Female)	r = - 0.2195	r = - 0.3332
LDL (Male)	r = - 0.03708	r = - 0.2165
(Female)	r = - 0.1689	r = - 0.3145
Note: '+' sign indicates positive correlation '-' sign indicates negative correlation		

Discussion:

The physical parameter of males and females of both groups as shown in Table no. 1(a) and 1(b) indicates that both groups were comparable.

Blood flow index (BFI) that were recorded in males and females of both groups as shown in Table no.2- Blood flow index (BFI) in study and control group indicates that there is significant reduction in Blood flow index (BFI) at thigh and calf region in Diabetic group compared to that of Control group. This may be due to decrease production of Nitric oxide and increase production of Endothelin-1 and angiotensin-II because of greater oxidative stress on blood vessels caused by Hyperglycemia, Hyperlipidemia and insulin resistance[27].

BFI had a negative correlation with both HbA_1C and LDL as shown in Table no.3- Effect of HbA1C and LDL on BFI of study group (Correlation coefficient r) indicates Poor control of diabetes indicated by increase in HbA_1C reduces blood flow in both site-thigh and calf of lower extremity. Increase LDL level also reduces the blood flow by increasing oxidative stress on endothelium[27].

Thus, People with diabetes are more prone to PAD than nondiabetics. Regular follow up assessment allows early identification of a reduced arterial blood flow to the lower extremities which, in turn, allows the implementation of management strategies earlier to prevent PAD.

Conclusion:

In present study, it was found that Diabetes has a worse influence on blood flow in lower limb as it progresses.

The present study reveals following conclusions:

- There is significant reduction in Blood flow index (BFI) at thigh and calf region in

Diabetic group compared to that of Control group.

- BFI had a negative correlation with both HbA_1C and LDL in Diabetic group.

It is suggested that IPG may become an important clinical tool to study the central as well as peripheral circulation. This simple, harmless, inexpensive, objective and non-invasive hemodynamic test may replace other invasive hemodynamic test for screening vascular disorders at any age provided that one has predetermined normative data because of their so many advantages compared to other methods just described in introduction section.

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