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Comparison of Blood Flow Index of Upper And Lower Extremities in Young Healthy Males Using Impedance Plethysmography.

Tanu Atreya*, Jyotsna Shukla, Amitabh Dube, Aditya Atreya.

Department of Physiology, Department of PSM, S.M.S Medical College Jaipur 302021, Rajasthan, India.

ABSTRACT

Impedance plethysmography (IPG) is the recording of instantaneous volume by measurement of electrical impedance. It is an indirect assessment of blood volume changes in any part of the body segment from changes in the electrical impedance of that segmentTo compare the blood flow index (BFI) of upper and lower extremities in young healthy males. The study was carried out in different segments of upper and lower extremities of 30 healthy young males (aged 30-40years) by Nivomon (L&T) in the employees of SMS Medical college Jaipur. Subjects were screened after measuring Height, weight and excluding the risk factors contributing to peripheral vascular diseases like smoking ,DM ,dyslipidemia, hypertension ,obesity etc. Hemodynamic parameters measured using IPG were Basal impedance(zo) and Blood flow index(BFI). BFI was found to the significantly high in upper extremities than in lower extremities. However the difference of blood flow index was insignificant when compared between arm and forearm also when compared between thigh and calf. Impedance plethysmography may become an important clinical tool for the study of peripheral blood flow. It is simple, inexpensive and non-invasive hemodynamic test for screening peripheral vascular diseases at a certain age provided that one has predetermined normal data of blood flow index.

Keywords: Blood flow index (BFI) ,Impedance plethysmography (IPG),Peripheral vascular diseases(PVD),Basal impedance(z_o)

Corresponding author

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INTRODUCTION

Peripheral vascular disease (PVD) commonly referred as peripheral arterial occlusive disease (PAD).It refers to the obstruction of large and medium sized arteries but not within the coronary, aortic arch vasculature, or brain[1].PVD can result from atherosclerosis, inflammatory processes leading to stenoses, an embolism, or thrombus formation. Risk factors contributing to PAD are smoking, Diabetes mellitus, dyslipidemias, hypertension, obesity etc. Angiography is a routinely used invasive procedure to investigate PVD [1] While in case of non-invasive methods, Doppler Ultrasound [2,] Strain gauge plethysmography [3], Pulse volume recorder [4] Electrical impedance plethysmography [5-9] have developed to investigate PVD.

The literal meaning of Impedance Plethysmography is "Recording of instantaneous volume (of an object) by measurement of electrical impedance". It has, however become a synonym for "indirect assessment of blood volume changes in any part of the body from changes in the electrical impedance of the body segment", Nyboer [10-11].In this technique, the electrical impedance of any part of body is measured by either constant current method or bridge method and variation in the impedance are recorded as a function of time. Since blood is a good conductor of electricity, the amount of blood in a given body segment is reflected inversely to the electrical impedance of the body segment. Pulsatile blood volume increase in the body segment caused by the systemic

Blood circulation therefore, causes proportional decrease in the electrical impedance. A variation in the electrical impedance thus yields adequate information about the blood circulation [11.]

Angiography [1] gives information about the anatomical status of arterial and venous tree but not about hemodynamics of the circulation in the limb. Arteriography is essential in patients of PVD who are likely to undergo surgery to know the site of block .In rest of the patients undergoing conservative therapy, arteriography need not be performed. IPG shall offer the good screening procedure for the patients with PAD. [12]

Doppler ultrasound [2]a popularly used method for diagnosis of PVD has the advantage of locating the block anatomically but is insensitive for 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 [5]. IPG 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 [5.]

In our country, few institutes [13-17]have added IPG studies to their routine procedures as, these techniques are simple, non-invasive, low cost, objective and informative. However before IPG studies can be applied clinically, acceptable limits of variability in normal control groups must be established. Few Indian studies available [13-17] were carried out without age grouping, covering mostly adult age groups. Wider population coverage with age grouping has been done in the present study with greater emphasis on BFI.

In future, Impedance Plethysmography (IPG) may become a useful non-invasive tool in determining the hemodynamic of the circulation in limbs or in the diagnosis of peripheral vascular diseases at any age provided that one has a predetermined normative data.

MATERIAL AND METHODS

The study was carried out in different segments of upper and lower extremities of 30 healthy young males (aged 30-40 years) by Nivomon (L&T) in the employees of SMS Medical College Jaipur. After detailed inquiry of medical history the subjects with diabetes, hypertension or other risk factors contributing to peripheral vascular diseases like dyslipidemia and smoking were excluded. Informed written consent was obtained from all the participants and experimental protocol was approved by ethical committee of the college. Subjects were screened after measuring height, weight, basal blood pressure and basal heart rate. The experiment was carried out in the morning. Exclusion criteria for the selection of the subjects: smokers, diabetes, hypertension, deep vein thrombosis, heart problems, any peripheral vascular disease like buerger disease etc. and drugs like steroids, hypolipidemic drugs, drugs affecting autonomic functions etc.

A typical impedance plethysmograph system is comprised of sine-wave generator followed by voltage to current converter. This current (4mA) is passed through the body segment of interest with the help of two surface electrodes (I_1,I_2).These wires made of braided wire were applied in the form of loop around the body segment. Voltage signal developed along the current path is sensed with the help of another pair of electrodes, called as the voltage electrodes (v_1, v_2).

The amplitude of the signal thus sensed is directly proportional to the electrical impedance of the body segment between the electrodes V_1 and V_2. The amplification and detection of this signal yields an output signal, which is proportional to instantaneous impedance (Z) of the body segment. Initial value of the impedance, also known as basal impedance (Zo) is obtained and numerically displayed on the panel [18].

Subject Preparation

The height & weight of subjects were recorded. Each subject was given a thorough clinical examination as a preliminary measure as detailed out in the preformed to exclude any pathology and affecting vascular function.

After giving brief information about the procedure to alleviate apprehension and to assure full relaxation during the test .The IPG recording was done in the supine position at 25-26°c room temperature by Nivomon.

Surface stick on the type of the E.C.G. electrodes were used on the chest of the subjects in 3 limb lead configuration as left arm, right arm and left leg.

The accessory band electrodes (I_1,I_2-current electrodes and V_1,V_2-sensing electrodes) were strapped to the body segment in the interest area of the subject by choosing appropriately sized bands at the desired location to capture the IPG waveform as follows:

- For arm,I_1 at forehead, I_2 at palm, V_1 at Near shoulder and V_2 at Above elbow;
- For forearm,I_1 at forehead, I_2 at palm, V_1 Below the elbow and V_2 the Above wrist;
- For thigh,I_1 at forehead I_2 at feet,V_1 Below the umbilicus and V_2 Above the knee .
- For calf, I_1 at forehead, I_2 at feet, V_1 Below the knee and V_2 Above the ankle were placed.

In the present study, Inter-electrode distance between V_1 and V_2 was tried to maintain less than 10 cm for each site as mentioned above.

I_1, V_1, V_2 and I_2 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 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, all results of arterial parameters Basal impedance &Blood flow index (Z0 and BFI) were displayed on the screen.

Analysis of data

Numerical data are expressed as mean ± SD (analysis was performed using Microsoft excel software, Microsoft corporation USA 2003.Data between the study groups were compared using paired student t-test. Statistical significance was assigned at $p<0.05$.

RESULTS

Table 1- shows subjects characteristics of study group. It shows that basal flow was found to the significantly high in upper extremities than in lower extremities. However the difference of blood flow index was insignificant when compared between arm & forearm and when compared between thigh and calf.

Table 1: Comparison of Blood flow index (BFI) between upper and lower extremities

Parameters	Basal impedance (zo)	Blood Flow Index	P Value
	Mean ± SD	Mean ± SD	
Arm	50.6±.9	.76±.01	<0.001**
Forearm	55.7±1.31	.76±.009	<0.001**
Thigh	62.05±.96	.57±0.01	<0.001**
Calf	57.38±15	.71±.01	<0.001**

Data expressed as mean ± SD *p value<0.05 significant, **p value < 0.001 (highly significant).

Table 1 shows that the basal impedance (z0) is higher in lower extremities than in upper extremities. BFI remains more or less same throughout the age with higher BFI in upper extremities than lower extremities.

DISCUSSION

Impedance plethysmography (IPG) may become important clinical tool to study the central as well as peripheral circulation. Arterial parameters basal impedance and blood flow index (zo and BFI) may become useful tool in determining the hemodynamic of the

circulation in limbs or in the diagnosis of peripheral vascular diseases at any age provided one has a predetermined normative data to know the following things in peripheral arterial occlusive diseases(PVDS).[13]

- To locate the level or levels of arterial obstruction.
- To determine the extent of the arterial obstruction.
- To decide the status of the collateral circulation.
- To determine the flow in the artery proximal and distal to the block (arterial run off).
- To study the effect of various drugs on the peripheral arterial circulation.
- To select patients for arteriography study (who need surgery).
- To provide aid in the selection of modality of therapy.
- To study the benefits derived from surgical procedures such as sympathectomies, vascular bypass operations, etc.
- To carry out follow up of patients with peripheral arterial occlusions.

CONCLUSION

In the present study the blood flow index was found to be significantly high in upper extremities than in the lower extremities .However the difference of blood flow index was insignificant when compared between arm and forearm also when compared between thigh and calf.

Impedance plethysmography may become an important clinical tool to study of peripheral blood flow. It is simple, inexpensive non-invasive hemodynamic test for screening peripheral vascular diseases at a certain age provided that one has predetermined normal data of blood flow index.

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