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Original Article

Cardiac hemodynamic profile and its correlates by Impedance plethysmography in normal individuals of Central India

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Abstract

Evaluation of hemodynamic profile by impedance plethysmography (IPG) provides functional expression of cardiovascular performance with efficacy of treatment. Objective of this study was to establish normative hemodynamic parameters by IPG. In this cross-sectional study hemodynamic parameters including cardiac output (CO), Stroke volume (SV), left ventricular ejection time (LVET), impedance (Zo) Cardiac index (CI) and Stroke index (SI) of 50 normal individuals in mean age 38.9±15.2 years were evaluated. Mean CO and CI were 4.9±0.8L/min and 3.3±0.7 L/min/m^2 respectively. A negative linear co-relation of CI with increasing age and body fat mass was observed. Mean LVET was 336±33ms with a significant positive linear correlation (r = 0.46) with advancing age and body fat mass while a negative linear correlation with BSA. To conclude preliminary normative data of cardiac parameters using IPG, in subjects of central India of different age groups has been presented.

Introduction

Impedance Plethysmography has been developed as non-invasive and cost effective technique for measuring hemodynamic parameters in the recent past (1). It monitors hemodynamic changes in critical care setting and its repeated measurements provide hemodynamic information during the treatment of patients with hypertension, heart failure and pregnant women with cardiac problems and gestosis (2). This technique is useful in other clinical conditions such as deep vein thrombosis (DVT), valvular and ischemic

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heart diseases (3). In a clinical trial conducted by Jindal et al, it was found that IPG has sensitivity and specificity of 97.5% and 98.1% (4).The sensitivity of IPG in the diagnosis of DVT were found to be 77.7% and specificity of 85% (3). Thus a simple, harmless, cheap and easily available technique as IPG is required that may provide cardiovascular evaluation which can play important role in diagnostic, prognostic & therapeutic decision making. There are no detailed studies till date which can be extrapolated and used as a normative data in central India. So there was a need to conduct a study and establish normative baseline laboratory data of cardiac parameters (i.e. SV, CO, Systemic vascular resistance) in our particular region for interpreting various cardiovascular abnormalities. The effect of age and BSA on the hemodynamic parameters was studied by Satyaprabha et al (5) who observed highest cardiac index (CI) in the younger age group followed by a decline and then a peak in the subjects of eldest age group. The derivation of correlation between body fat mass and hemodynamic parameters has not been attempted so far. It is in this connection, this study on IPG was carried out to develop a hemodynamic profile in a group of normal central Indian subjects of different age groups, to find relation between CI with age and body fat mass & to study correlation between left ventricular ejection time (LVET) with age, BSA and body fat mass.

Material and Methods

The study was conducted in Impedance cardiovasography lab, Department of Physiology, Mahatma Gandhi Institute of Medical Sciences, Sevagram. We included healthy subjects of age 18 and above of either sex from Central India. The study was approved by ethics committee of institution (IRB00003623). We obtained a written informed consent from all study participants before enrolling them in the study. Subjects included were relatives of patients admitted to ward and hospital staff. We have excluded subjects who were known to have hypertension, congestive cardiac failure, myocardial infarction, angina, arrhythmias, cardiomyopathy, acute febrile illness, diabetes, stroke, transient ischemic attack, chronic pulmonary obstructive disease, recent tuberculosis, DVT, cardiothoracic surgery, malignancy and any other significant illness or not provide written informed consent. Anthropometric parameters such as height, weight and sternal length were measured and BSA was calculated by DuBois formula. Body fat mass was measured by using Omron body fat monitor model HBF-302 in all subjects.

Impedance plethysmographic testing

Hemodynamic parameters in normal subjects were measured by impedance plethysmograph system developed at Electronics Division of BARC, Mumbai. All recordings were performed as standard method with placement of electrode by Vertical method as validated by Barde et al (6). Cardiac Output is calculated as a product of SV and heart rate (HR). In the case of parameters such as CO & SV that vary with the size of the subject, it has become an accepted practice to evaluate the respective indices in order to eliminate differences arising from BSA variation. Thus CI and SI were evaluated for each subject. SVR was computed from the formula SVR = (mean BP-central venous pressure)/CO x 80; and SVR index (SVRI) as SVR/BSA (Central venous pressure was assumed to be 10 mmHg for all subjects.)

Statistical analysis

Values of the parameters were expressed as Mean±SD. Pearson's correlation coefficient (r) value and p value were calculated using statistical software STATA (version 16, Stata Corporation, Texas, USA). P value <0.05 was considered as significant and <0.001 was highly significant.

Results

Out of 50 healthy subjects 23 (46%) were males and 27 (54%) females. The mean age of subjects was 38.9±15.2 years in the range of 18-70 years. In this age range, majority of the study subjects (30) were from 18-40 years age group. The baseline characteristics and hemodynamic parameters of all the subjects are depicted in Table I.

TABLE I: Baseline Characteristics of study subjects (N=50).

Parameters	*Mean±SD*
Age (years)	38.9±15.2
18-30 years	24±4.06 (36%)
31-45 years	37.8±4.59 (36%)
>45 years	59.4±7.78 (28%)
Height (cm)	158±9.83
Weight (kg)	54±9.98
BSA (m^2)	1.5±0.2
Body fat mass (kg)	14±5.3
Impedance plethysmography profile	
Impedance (Ohm)	30.2±3.99
SV (ml/beat)	70±11
SI (ml/beat/m^2)	45.9±8.54
CO (L/min)	4.9±0.8
CI (L/min/m^2)	3.3±0.7
LVET (ms)	336±33
SVR (dyne s/cm5)	1382±234.6
SVRI (dyne s/cm^5/m^2)	912.8±186.9

(BSA: Body surface area, SV: Stroke volume, SI: Stroke index, CO: Cardiac output, CI: Cardiac index, LVET: Left ventricular ejection time, SVR: Systemic vascular resistance, SVRI: Systemic vascular resistance index)

We could not find significant correlation between CI with age as well as with body fat mass There was a significant positive linear co-relation between LVET and age while there was a significant negative correlation between LVET and BSA however we could not find significant correlation between LVET and body fat mass (Table II).

TABLE II: Correlates of Cardiac index and Left ventricular ejection time

Parameters	*r value*	*p value*
Cardiac index		
Age	−0.094	0.516
Body fat mass	−0.204	0.155
Left ventricular ejection time		
Age	0.60	0.00002
Body fat mass	0.12	0.406
BSA	−0.40	0.004

p value <0.05 is statistically significant. The correlation between the parameters was derived by Pearson's correlation.

Discussion

Impedance Plethysmography with its several advantages is a promising method to measure CO. Cardiac output is the functional expression of cardiovascular performance and can be used to confirm the need for, or efficacy of treatment (6). A pre-requisite in the assessment of abnormal body function is the ability to establish the limits of normal. In this regard, the present study was an attempt to establish normative baseline laboratory data of cardiac parameters using IPG for central Indian population as shown in Table I. Few researchers have addressed normative data for hemodynamic parameters derived from IPG (5, 7). The CI observed in our study (3.3±0.7 L/min/m^2) is comparable to that reported by Satyaprabha et al (5) which was 3.2±0.8 L/min/m^2 but it was more than that reported by Parmar et al (7) 2.91±0.51 L/min/m^2, Sageman et al (8) 2.95±0.66 L/min/m^2. In our study, we found the highest values of CI in the youngest age group (18-30 years). Thereafter a gradual decline was seen, peaking again in the eldest age group (more than 46 years). This trend was similar to that obtained by Satyaprabha et al (5). CI tends to remain within normal limits in a varied range of ages by adjustments in HR in order to provide each and every part of the body tissues a continuous supply of the required nutrients. As the cardiac output is in direct proportion to the overall bodily metabolic activity so the decreasing cardiac index with age is suggestive of reducing bodily activity and so the basal metabolic rate (BMR) (7).

A trend similar to that of CI was obtained for SI in our study. The probable physiological explanation for the same could be that in older ages SV and hence SI decreases mainly due to increased peripheral resistance (afterload) resulting from atherosclerosis. Lower SI values could also be low due to low metabolic rate, small heart size or may be due to any other factor. Exact reason can't be ruled out.

We observed a peak in the SVR in the ages 26-35 years followed by a decrease and finally the highest value was obtained in the subjects of more than 46 years of age. This distribution of SVR seems to be an inverse reflection of the CO compared to the other parameters like mean BP in its derivation.

We found a significant positive linear co-relation between LVET and age and this finding is in support of the notion put forth by Spitaels et al (9) that LVET increases with maturity mainly because of slower HR. Also it has been reported that LVET increases by 2 ms/decade irrespective of changes in heart rate and blood pressure. Furthermore a decline in sympathetic nervous tonus and in myocardial contractility and an increase in aortic impedance may also be the main determining factors in the prolongation of LVET with rising age. A decrease of the aortic compliance, as occurs with aging, has been demonstrated to increase the impedance to ejection and to increase the tension load on the myocardium, independent of changes in aortic pressure (10).

From our knowledge, as there is increment of impedance to blood flow due to higher proportion of fat so it will tend to reduce the amount of SV and CO which is implicated by the inverse relationship of CI (eliminating the effect of BSA) with body fat mass in our observations.

Similarly the prolongation of left ventricular ejection time appears to result directly from mechanical obstruction (which may be due to increased fat) to left ventricular outflow, rather than from any predictable myocardial dysfunction. Thus, LVET increases with increasing body fat mass indicating a longer time taken by the left ventricle to eject its blood.

In a nutshell, the overall dataset obtained in our study particularly for this region was quite similar to such studies conducted by Sathyaprabha et al (5) and Parmar et al (7) in other parts of our country as well as consistent with the standard reference ranges.

Limitations

As the sample size in this pilot study was small therefore we need to establish normative baseline laboratory data in a larger population so as to foster the utility of IPG for clinical and research purposes.

Conclusion

We conclude from the present study that a comprehensive data set of normalized values in our population in different age groups and different gender is possible for cardiac parameters using Impedance Plethysmography and this report is an attempt to supply the necessary data for the resource poor setting of Central India. It is further recommended that a larger group is required to evaluate the significance between different variables in normal population.

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