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Determination of Cardiac Pumping Function and Blood Flow in Detecting the High Pressure and Low-Pressure Conditions

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ABSTRACT:

The advancement for a System is being made self-rulingly for assessing the progression of blood in volume utilizing the procedure of impedance plethysmography. For approving this estimation, the stroke volume is likewise estimated with the assistance of Echocardiogram instrument with its mechanical assembly. The approval is done for the high weight and low-pressure subjects. At first the equipment signal molding hardware has been created dependent on the impedance plethysmographic beginning. The greatest pinnacle sufficiency is resolved with the assistance of that gadget and the blood stream volume is determined every moment premise. All the while the stroke volume is determined by taking the contrast between end diastolic volume and end systolic volume. A direct relapse examination is created between top abundancy of impedance plethysmographic waveform and the stroke volume by utilizing bend fitting procedure. The conditions of high weight and low weight is considered as the clinical condition in this examination and the relapse investigation is being completed. For 10 subjects, the assurance over the straight connection coefficient has been made and it is 0.80 (p esteem <0.002) is being come about between the varieties in the pinnacle voltage sufficiency of impedance waveform that has been obtained from lower arm and the stroke volume varieties earlier and after the 24 seconds inhale hold action state. Furthermore, the mean zone variety under the bend of impedance and the stroke volume variety were likewise straightly related ($r=0.78$, $p<0.004$). As the synopsis, the work over the impedance plethysmography estimated from lower arm for making the assessment of heart beat reaction over various time span in the stroke volume of cardiovascular muscle loans the best proposal over the potential for observing the exhibition of heart siphoning.

Keywords: End Systolic Volume (ESD), End Diastolic Volume (EDV), Stroke Volume (SV), Impedance Plethysmography (IPG)

INTRODUCTION:

The ancient technique of acquiring the hemodynamic measurements under the clinical setting is considered to be the Gans Swan Catheter [1][2]. However, many queries have been raised since the procedure followed for the measurement is invasive one and it leads to many constraints for the person undergoing these types of tests. In that traditional days, it is very difficult to undergo the non-invasive type of diagnosis due to the lack of equipments and even if it is there the measurement accuracy is not upto the adequate level added to that the trained clinical physicians are also in the lagging phase in using these non-invasive instruments. Insights over the clinical aspects has gained from the invasive methodology of monitoring in the ill subjects which has been explored to minimally ill patients with which it is being influenced with hypertension, failure of heart, abnormal blood pressure etc. Hence, the development of a technique has been initialized to acquire the relevant data of homodynamic nature from the various groups of subjects under the suitable clinical setting environment [3][4]. A methodology would ideally declare to be as non-invasive and explored with minimum cost with respect to equipment as well as acquisition time. It must also ensure that it should be highly reliable and accurate system in establishing the decision by the clinical doctors. Impedance Plethysmography is one of the techniques which makes the measurement of variation in the volume of blood (blood volume of venous as well as the arteries pulsation) for the specific segment of the body.

MATERIALS AND METHODS:

Asthe variation in the blood volume is being resulted, the variation in the electrical impedance in terms of resistance will also be resulted. This measurement of electrical impedance is made by inducing the minute amount of AC current through the segment of the body [5][6]. This technique is determined to be as non-invasive technique since the total quantity of AC current is very minimum in such a way that the subjects does not realize any physical impact over the current passing through the electrodes. By making the variations over the blood volume measurement, the clinical physicians could make the detection of disorders in the blood flow such as initial stage of arteriosclerosis, arterial occlusive diseases, disturbances over the blood flow functionally deep vein thrombosis, migraines and few disturbances resulted due to the common atrial blood flow [7][8]. The essential objective is to establish the development of clinically assisted devices which could be connected with computer and should be incorporated with the adequate software and ensure easy adaptable learning. The significant amount of datum collection addition with would pave a good path of realistic and innovative research that could be realized with the bioimpedance medical applications.

HARDWARE DESCRIPTION

The description over the distribution of electric potential in the conductor is made by Maxwell [5]. This makes the statement true when the analysis is being made for the human biological tissues, which were considered to be as the best conductors [6][7]. Accounting that the organism of human might be regarded as the source of electrical free region that the human tissues are mostly conductive and anisotropic in its characteristics and that the neglection of magnetic fields could be made and the relation which is being resulted has been bought into the reductions of following equations [8].

$$\left.\begin{aligned} \nabla . j &= 0 \\ j &= \sigma * E \\ E &= -\nabla \emptyset \end{aligned}\right\} \quad (1)$$

All the quantities are declared as the localization function and it's the electrical field frequency. For solving this equation, the assumption for the configuration over the measurement of impedance determines the dependency over the boundary conditions [9]. The measurement of tetrapolar system is mainly utilized in the genesis of impedance plethysmography. The four-electrode system configuring the impedance measurement apparatus is being depicted in figure 1. The hardware model of 4-electrode impedance measurement system is shown in figure 2.

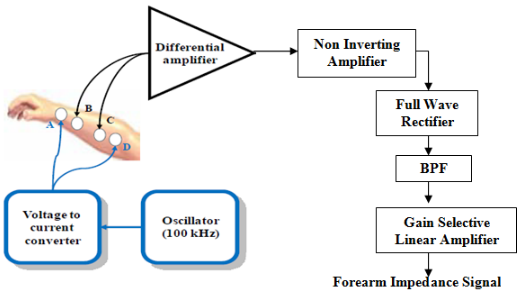

Fig.1. Impedance Measurement

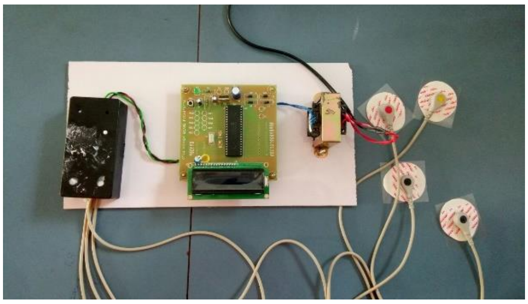

Fig.2. Hardware model of Four-Electrode Impedance System

In few applications, the requirement of this configuration allows the special location of this electrodes to be placed. In figure 1 it is evident that the exact position of electrodes placed on the forearm of the human subject in which the minute flow of current is subjected into the body through the surface. There are two different electrode pairs, placement of external electrodes which has to be stimulated is being made as long as the distance of minimum 5 cm is being maintained between the recording and the stimulating electrodes [10]. The placement of electrode has to be well and predefined so as to extract the pure signal with minimum amount of current passing into the body with which the adequate amplification circuitry could acquire the signal with necessary amplification and determine the resistive variations inside the body [11].

This measurement device of impedance plethysmography is the best method of convenience for making the conduction of measuring the variation of blood volume rather than the stroke volume of the cardiac muscle [12].

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The declaration of ideal electrodes is made to be as the band electrodes even though the working of the point electrodes would also be made if wiring over several are clubbed together. The working on the conduction of the duct tape will also be made over replacing the electrodes of special case [14].For making the measurements very accurate, over the variations in the electrical conductivity the following equation would be satisfied between the source of current (I) and the measured value of impedance (Z_0). As an equivalent circuit, the configuration of tetra polar electrode has been depicted in figure 3.

$$\left|\frac{\Delta I}{I}\right| << \left|\frac{\Delta Z}{Z}\right| \qquad (2)$$

The assumption made in such a way that, $\left|\frac{\Delta Z}{Z}\right| \sim 0.01$ or very lesser the demand for the second equation is made in such a way that the specially constructed current source must ensure the output impedance of very high value and the stray capacitance of very low value.

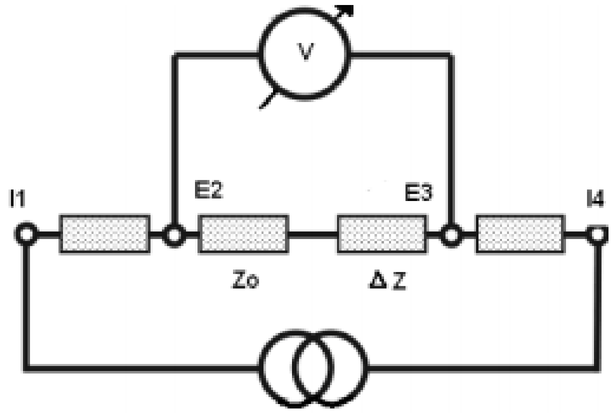

Fig.3. Configuration of Tetra Polar Electrode – an equivalent electrical circuit

Its very hard in practice, to realize these requirements under any technical aspects. There are few problems in relation with the hardware measurement. They are as follows.

1. Knowledge over the distribution of electric field after the process of excitation. In the practical state, the distribution of uniform potential allows the interpretation of adequate and accurate data.
2. Biological property over the tissues, hardware technical data determination, and the usage of frequency at the time of measurement.
3. The parameter of influencing the impedance of electrode is normally unknown one which makes the limitation over the excitation of current accuracy along with its measurements.
4. The electrode construction and the limitations over the measurements in terms of adequate measurement of current density.

RESULTS AND DISCUSSIONS:

The forearm impedance signal that has been acquired has been depicted in the sketch 4. The high voltage amplitude of the signal has been viewed as the variable component at the terminal time stamp as the comparison is made with the baseline signal component. Evidently, it could be realized that the peak to peak voltage has been noticed to be very high value immediately after the measurement has been taken with 24 second

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breathe hold activity as again the comparison is made with the condition of baseline. It is depicted in figure 5.

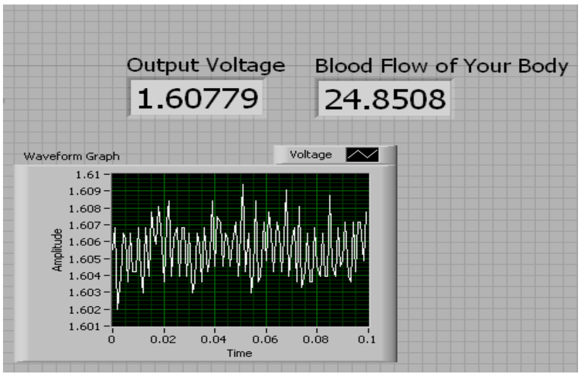

Fig.4. Impedance plethysmographic signal in normal clinical condition for High Pressure subject

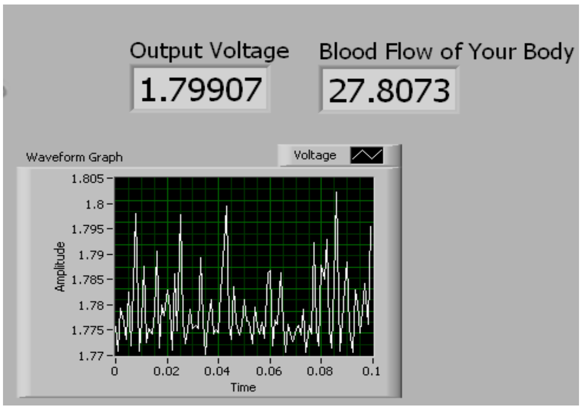

Fig.5. Impedance plethysmographic signal after 24-sec breathe hold activity for High Pressure subject

Table1. A Parametric value obtained from the forearm impedance plethysmography for the 10 male

Parametric Conditions	Peak voltage(volts)		Mean area	
	Before	After	Before	After
Maximum	2.91	3.26	1.215	1.155
Minimum	1.32	1.68	0.290	0.326
Average	2.11	2.51	0.546	0.599
Standard Deviation	0.53	0.47	0.249	0.219
P value	<0.002		<0.02	

subjects with HP and LP state.

Table 2. A Parametric value obtained from the Echocardiogram for the 18 healthy subjects.

Parametric Conditions	End Systolic Volume(ml)		End Diastolic Volume(ml)		Stroke Volume(ml)	
	Before	After	Before	After	Before	After
Maximum	54.6	52.6	124.3	124.4	69.5	71.5
Minimum	25.4	21.4	63.3	76.6	37.8	55.4
Average	37.8	34.6	89.6	91.3	52.5	56.7
Standard Deviation	9.5	9.5	16.9	14.6	7.6	8.7
P value	<0.02		<0.3		<0.004	

Table 1 makes the dealing over the parameters with which the measurement is being made from the forearm impedance plethysmographic device for the 10 male High Pressure and Low-Pressure subjects prior and later with the 24 second breathe hold mechanism. Table 3 makes the dealing over the parameters with which the measurements are carried out from the echocardiogram device for the 10 male High Pressure and Low-Pressure subjects prior and later with the 24 second breathe hold mechanism.

Prior to the 24 second breathe hold mechanism the mean average value of the peak voltage with which the measurement is made from the forearm impedance plethysmography is of 2.11±0.53 volts. After the activity ofbreath hold mechanism is completed the mean average value of peak voltage amplitude increases to 2.51±0.47 volts with the correlation coefficient(p value) less than 0.002.

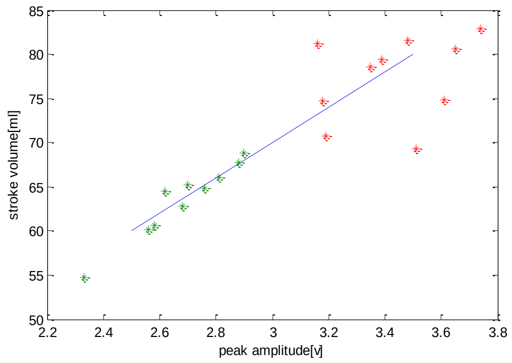

Fig 6: Graphical analysis between the various peak amplitude. Totally 20 data points are plotted in the graph.

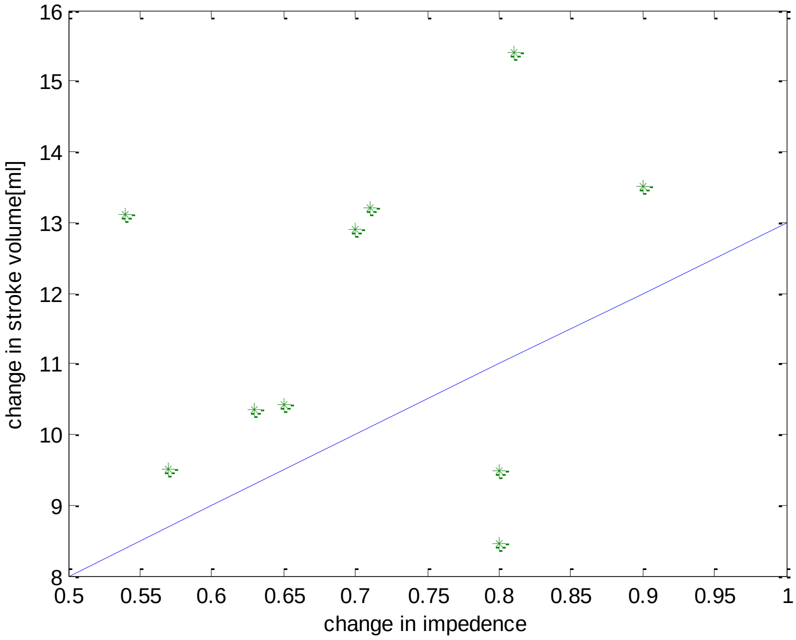

Fig 7: High Pressure and Low-Pressure Subjects measured before and after the 24 secondsbreathe hold process.

Figure 6 depicts the the peak amplitude of electrical impedance waveform and the stroke volume before and after the 24 second breathe hold mechanism for the 10 High Pressure and Low-Pressure subjects. This simulation results have been carried out by the linear regression analysis and the curve fitting method. Already few research studies have been undergone in determining the correlation of blood flow and stroke volume for normal subjects inclusive of both male and female. In this proposed study, the correlation coefficient is acquired with the adequate value for easier estimation .

CONCLUSION

The measurement under biomedical signals must be very precise and it must be very reliable and non-invasive technique as of taken from different subjects. The technique of electrical impedance is capable of making the precise, minimally invasive and accurate measurements which will be able to aid in the clinical diagnosis. This paper produces the documentation over the design of the impedance measuring apparatus and the construction of the apparatus which could be able to determine the resistivity of blood in terms of velocity of blood flow through veins and it could be realized with the cardiac pumping function with which the direct correlation could be made in making the adequate estimation. It is the non-invasive and the cost-effective technique with which the analysis and the measurement could make the proper assistance to the cardiologists with an essential tool for diagnosis for the patient care who has maximum disorders of blood flow and cardiac problems. This method could make the early diagnosis of the diseases associated with heart which will lead to serious effects who will be maximally exposed to these problems. As a feature work, it will be carried out in enhancing the development of such devices with computational intelligence techniques.

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