Identifying Tridosha for Disease Characterisation in Morphology of an IPG Pulse Waveform

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Abstract

In Ayurveda, Ashtavidha Pariksha are described for diagnosis of a disease. In this Nadi Pariksha has been given primary importance. Physical palpation of the Nadi tells us about the levels of circulating Tridosha in the body. Peripheral Pulse Analyser developed by Electronics Division; BARC is based on the principle of Impedance Plethysmography. It has been successfully used in the past for the diagnosis of peripheral vascular occlusive diseases, assessment of cardiac function and variability analysis. Significant difference in variability spectrum in health and disease, as observed in BARC's preliminary study at J.J. Hospital, has led us to study Tridosha - the fundamental elements of health using variability analysis of impedance Plethysmographic signals. Few trials on control subjects at BARC and comprehensive trials at CDAC, Pune have shown 78% agreement between heart rate variability and subjective assessment of Prakruti of the individual. The peripheral pulses have shown different morphology from individual to individual and also within the same individual at different time instants. A retrospective analysis of these signals has suggested manifestation of Vata, Pitta and Kapha (the fundamental elements of health) in different phases of the cardiac cycle and an inverse relation between amplitudes of HF, MF & LF in variability spectrum and that of physical examination by an Ayurvedic Physician. Also it has been observed that different disease conditions change the waveform along the time segment as well. These observations are described in this paper.

Keywords – Impedance Plethysmography, Peripheral Pulse, Pulse Morphology, Prakruti, Fundamental Elements of Health- Vata, Pitta, Kapha(Tridosha), Prakopa, Prasara, Dosha-Awastha,Ashrayasthan, Sanga.

Introduction

In Ayurveda Ashtavidha Pariksha i.e. eight methods are described for diagnosis of a disease. It is a standard custom of ancient texts, to describe the multiple factors in any Sutra or verse, in order of importance. Likewise in Ashtavidha Pariksha, Nadi Pariksha or Pulse examination is given foremost place. In Ayurveda we have studied two hypotheses namely, Pinda-Brhmanda Nyaya and Anshansha Kalpana. As per the Pinda- Brahmanda Nyaya, whatever elements we see in the nature, we find same elements in the smallest part of the human body as well and visa versa. According to Anshansha kalpana, all the elements found in any organism, are found in the seed of that organism in the same proportion but in minute quantities.
Nadi Pariksha is done to analyse and estimate the quantity of Tridosha in the body. Tridosha i.e. Vata, Pitta and Kapha are considered as the fundamental elements of health. A balance between these three is considered as Prakruti or healthy status and any imbalance in theses three is considered as Vikruti or ill health. As per ancient Ayurvedic text, Nadi can be examined at various places but commonly it is examined at the wrist of the person. Conventionally it is examined at right wrist of the males and left wrist of the females. Ideally it should be examined in the early morning and on empty stomach.
Dosha usually stay at their place of residence i.e. Ashrayasthan and come in the body hollows to do their function. Some of the dosha are utilised during this process. After the process is over the remaining dosha goes back to their original place of residence. These activities of dosha were not perceptible quantitatively and so were difficult to demonstrate by modern techniques. We have tried to record these activities using Peripheral Pulse Analyser developed by BARC, which is based on their technique of Impedance Plethysmography.

What is Impedance Plethysmography ?

Impedance Plethysmography first introduced by Jan Naboer in 1940 and Impedance Cardiography by W.G. Kubicek in 1966, are the applications of electrical impedance measurement in human body for the assessment of central and peripheral blood flow.
Biological tissues such as muscle, bone etc, and biological fluids such as blood, urine, cerebrospinal fluid etc. are neither good conductors of electricity as metals nor they are bad conductors as wood. This intermediate property of the biological matter makes the measurement of electrical conduction through them, feasible by simple instruments. The conductivity is either expressed directly or by its reciprocal, resistivity. This resistance offered by the tissue is called Impedance. Measurement of this impedance in various tissues tells us about the capacity of electrical conduction of that tissue.

Thus when two electrodes of an impedance-measuring instrument are applied to a body segment, we get the Impedance (Z) between those two electrodes. As the electrodes are applied to the body surface and NOT inside the body, this becomes a NON-INVASIVE technique and so more acceptable and more safe and simple to use. Small changes in the impedance of the body segment caused by physiological processes like blood circulation, respiration etc. are obtained by subtracting the Initial value of impedance also known as Basal Impedance (Zo) obtained from a control sample from the instantaneous impedance and is called $\Delta Z(t)$ waveform. The Z is also differentiated in respect of time to get the rate of change of impedance or dZ/dt waveform. Since $\Delta Z(t)$ and dZ/dt are produced by physiological processes, it is possible to extract the changes produced by one particular process by either suppressing the other process or by signal processing techniques. Measurement of these physiological processes from these impedance signals is known as Impedance Plethysmography, Impedance Cardiography or Impedance Cardio-Vasography.[1]

Electronic Division, Bhabha Atomic Research Centre developed their 1st model of Impedance Plethysmograph (IPG) in 1978 and installed it at Department of Surgery, Seth G.S. Medical College & KEM Hospital and Department of Medicine, Grant Medical College & J.J. Hospital, Mumbai for the assessment of central and peripheral blood flow in human body. Extensive clinical trials on 100 normal subjects and 10,000 patients with peripheral vascular occlusive diseases at KEM Hospital during 1978 to 1990 and comparison of IPG observations with Angiography observations in more than 500 subjects revealed the sensitivity and specificity of the indigenously developed technique to be 96% and 98% for the diagnosis of peripheral arterial occlusive disease [2] and more than 80% for the diagnosis of deep vein thrombosis [3].

The IPG technique has undergone several renovations during the past 31 years such as development of microprocessor based impedance plethysmograph system, introduction of simple and reliable calibration for dZ/dt waveform [4]. Correction of formula for estimating peripheral blood flow [5], introduction of normalized dZ/dt waveform for easy assessment of peripheral blood flow [6] and development of PC based Impedance Cardiovasograph system [7].

The clinical applications of Impedance plethysmography do not end with measurement of central and peripheral blood flow but more important applications are in advance stages of development at several institutes [8,9]. For instance, the fluctuations in heart rate, peripheral blood flow or stroke volume are being explored to study the effect of different diseases on the autonomic nervous system (ANS).

In this application, continuous IPG signal is recorded from a body segment for a period of five minutes. BFI values are then obtained from this signal as a function of time and interpolated to get equi-spaced values. Fourier transform of this time series then gives the rhythm of fluctuations. Figure 2 shows typical heart rate fluctuations in time and frequency domain obtained from a normal subject. The peak at 0.012 Hz. represents activity of thermo-regulation/ Baro-receptor reflex/ sympathetic nervous system and those at 0.105 Hz. and 0.236 Hz. represent activity of parasympathetic nervous system and respiration respectively.

The Variability Analyzer system developed at BARC gives variability; in heart rate, stroke volume and peripheral blood flow from a single data acquisition from the subject, which is not feasible with any other commercial instruments. Preliminary study carried out on 300 subjects has shown that ANS activity gets selectively modified in the presence of major diseases [10].

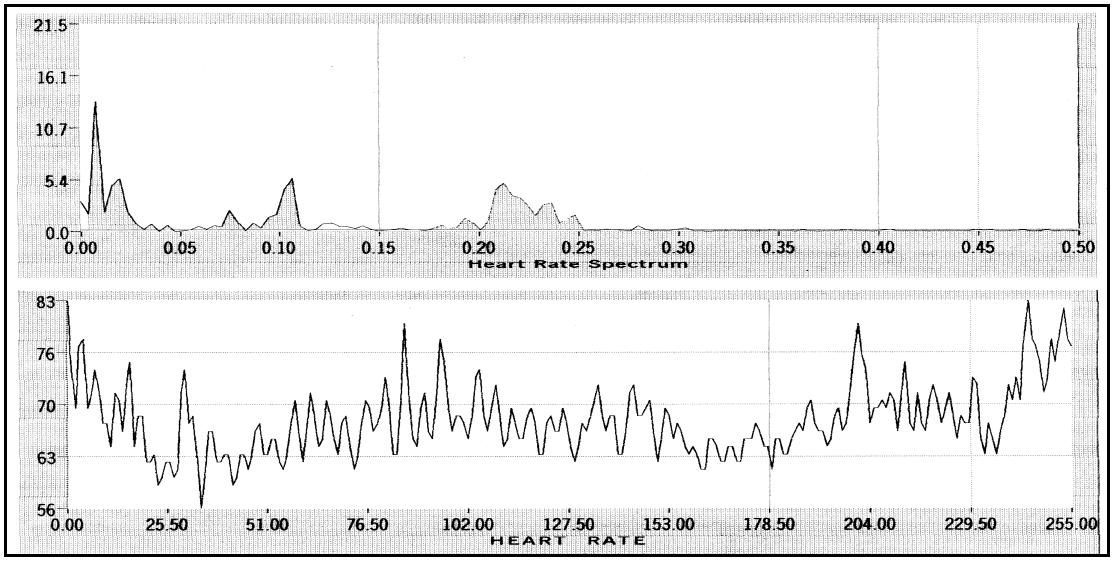

***Fig. 2**: Typical heart rate fluctuations in time (lower) and frequency domain (upper) in a normal subject. Three peaks,*

centered around 0.012, 0.105 and 0.236 Hz, are prominent. These are termed as Low Frequency (LF), Mid Frequency (MF) and High Frequency (HF) peaks respectively.

Peripheral Pulse Analyzer

Electronic Division, BARC has developed a Peripheral Pulse Analyzer based on the principle of IPG. In this system IPG waveform is simultaneously recorded from three different locations on the wrist corresponding to Vata, Pitta and Kapha locations of Ayurvedic System of Medicine and termed as dZ3, dZ2 and dZ1 respectively. With the subject in supine position, the carrier electrodes are applied around the upper arm and the palm; the sensing electrodes S1 to S4 are applied 2cm apart from each other with S4 on the distal segment around the wrist Thus impedance signals dZ1, dZ2 and dZ3 recorded from S1-S2, S2-S3 and S3-S4 correspond to Kapha, Pitta and Vata locations respectively.

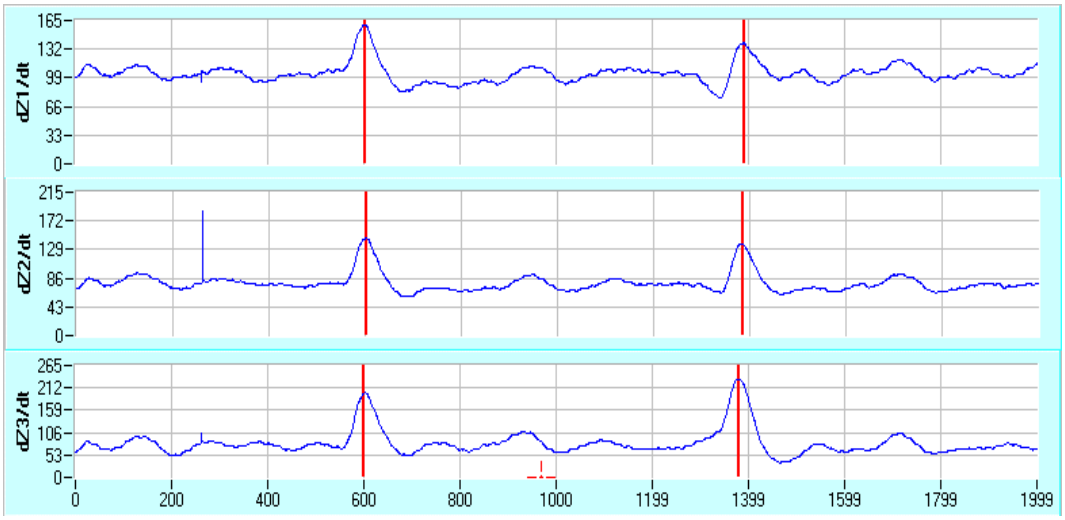

Fig. 3: *dZ1, dZ2 and dZ3 waveforms recorded simultaneously from Kapha, Pitta and Vata locations respectively. In the first cycle, peaks in dZ1 and dZ3 are coincident and precede that of dZ2 where as in the second cycle peak in dZ3 precedes that of dZ2 and peak in dZ2 precedes that of dZ1.*

Preliminary trials carried out with this system on a group of control subjects before and after lunch have indicated that the amplitude of any signal, say dZ3, appears proportional to Vata element and likewise for dZ1 and dZ2. Physiologically the peak in dZ1 should precede to that of dZ2 and dZ2 should precede to that of dZ3. Also the amplitude should be gradually increasing from dZ 1 to dZ3. But most significant observation from this data is that sometimes peak in dZ3 appears before that of dZ2 or dZ1, which is not consistent with the human anatomy and physiology as shown in Figure 3.

Assessment of Tridosha

According to Sankhya Ideology followed by the ancient medical science Ayurveda, all living or non-living things are made from combination of five basic principles-Pruthvi, Jala, Tej, Vayu & Aakash. There are certain elements in the body, which are released in the Srotasa or body hollows at certain intervals, but are not thrown out of the body. They take part in body functions and are re-absorbed in the body. These are called Dosha. They also play a major role in building up the body. They are three, namely-Vata, Pitta & Kapha. These are the fundamental elements of health in a living body. Like all, these are also made up of five basic principles and contain combinations of various characteristics of these five principles. [10,12],

Srotasa are the channels through which Dosha as well as nutrients, signals etc flow from one part to other part of the body. In normal conditions Srotasa are supposed to be open for easy passage of the Dosha or nutrients or signals etc. Whenever there is some obstruction in these Srotasa, either by any material blockage or by spasmodic constriction of the channel it is called Sanga or Srotorodha. [10,12] Any such obstruction increases the resistance to the flowing matter. for example in coronary blockages it is a material blockage of the Srotasa or coronary vessel (Kaphavruddhi) or it could be a narrowing due to atherosclerotic changes or it could be a acute spasmodic constriction of the coronary artery(Vatvruddhi). In case of bundle branch blocks it is a blockage of the signal, which again relates to Vatavruddhi.

Harmony or a balance between the three elements signifies the health and is called the Doshaprakruti of the person. This is termed like wise as Vataj, Pittaj, Kaphaj, Vata-Pittaj, Pitta-Kaphaj, Kapha-Vataj and Sannipataj depending upon the dominance of these elements. Any imbalance in either of them leads to Vikruti or disease condition.[10,12]

It is observed that apart from the underlying disease, the Dosha dominance of an individual changes with age. For instance Kapha is more dominant in the childhood, Pitta is more dominant in the middle age and Vata is dominant in old

age. (In present times Pitta dominance is seen in twenties and thirties and Vata dominance is seen beyond forties.) . [10,11,12] Also rhythmic variations are found in these Dosha in an individual during a day as shown in Table II

In Ayurveda we know that certain Doshakala are explained. There are three different stages or Avastha observed in the cycle of three Dosha. These are termed as Vruddhi, Kshaya and Prasara, i.e. growth, reduction and expansion or flow to other parts. It is evident that growth or reduction in quantity of Dosha occurs in its own place (Ashrayasthan), whereas flow or expansion occurs to other parts of the body. Normally growth & reduction of each Dosha occurs twice during the day. The time involved is so termed as the Vruddhikaka & Kshayakaka of that Dosha. Increase in the quantity of any Dosha beyond normal limit is called Prakopa. And when the Prakupit (increased Dosha) starts flowing to other body parts it is called Prasara. Prasara usually occurs when that particular Dosha has increased beyond controllable limits. In normal conditions, when one particular Dosha increases, in an attempt to keep the balance between the three Dosha, the other two dosha reduce. In Prakupit stage of any one of the Dosha, it is difficult to maintain this balance. So when the balance is lost, we get a diseased condition [12]. We have tried to record these fluctuations of Dosha levels during the day, as well as at different ages and in different disease conditions.

The observation that HF peak in HRV spectrum goes on reducing as the age advances and may touch the base line in cases of severe illness **suggests that strength of the HF peak may have inverse relation with the level of Vata element in the body. Similarly MF & LF may have inverse relations with Kapha & Pitta levels in the body.**

In view of this, we have started with a project to record variability spectrum in normal subjects as well as subjects with various disease conditions under observation of senior Ayurvedic Physicians; so that this observation can be verified. The results obtained so far are quite encouraging. Our observation in control subjects as well as in patients have shown 78-80% correlation between the Dosha dominance determination by variability analysis and that assessed by Ayurvedic physicians.

While these observations are encouraging, since the size of data is small at present (around 100), further study in a large number of subjects is required to achieve the target of disease characterization.

Table II

Fundamental Elements	*Dominance*		*Function*	*Ailments Type*
	During Day	*By Age*		
Kapha	Early Morning	Childhood	Bonding of Elements	Chronic in nature, Arterial blocks, Obstructive diseases, Arthritis, Malfunctioning of Reproductive System
Pitta	Mid Day	Middle Age	Processing of Nutrients and Signals	Digestive System, Endocrinal System, Hormonal imbalance, Personality related
Vata	Evening	Old Age	Transportation of Nutrients and Signals	Conduction defects, Brittleness, Fullness in Kapha conjunction and excessive emptiness in Pitta conjunction

Pulse Morphology and Tridosha

During the above studies, it was observed that shape or pattern (morphology) of the peripheral pulse changes significantly in an individual as a function of time. Also there is marked variation in the pulse pattern from subject to subject. Another important observation is that the amplitude of the pulse and impedance value varies in dZ1, dZ2 & dZ3 waveforms in disease conditions. Physiologically and anatomically, a gradual increase in impedance and amplitude is expected from dZ1 to dZ3. But in many cases amplitude and impedance value is found to be more in dZ1 or dZ2 than dz3. Also in normal conditions clinically pulse is not palpable at kapha location (dZ1) at wrist. Only when there is Srotorodha or Sanga, we start feeling the pulse at dZ1. That is why in normal conditions impedance at dZ1 is expected to be less than that of dZ2 & dZ3. During normal body processes easy conversion and free flow of the nutrients is expected, so in normalcy pulse is palpable only at Pitta (dZ2) or Vata (dZ3) locations.

As observed in previous studies, in an IPG cycle pre- Systole & early Systole represents Kapha. Mid & late Systole represents Pitta and Diastole represents vata. In present study it has been observed that time interval and the amplitude of the abovementioned segments of an IPG cycle are directly related to disease conditions pertaining to that particular Dosha. This may either be in the form of Vruddhi or Kshaya of the respective Dosha. Further analysis with a large size of data may help to clearly establish the relation and then it can be used for disease characterisation.

Discussion

Impedance Plethysmography has been in use in Clinical Medicine for the past 70 years for the assessment of central and peripheral blood circulation. Peripheral pulse palpated at the wrist level has been given considerable importance by the Ayurvedic Physicians in ancient medical system of India for the purpose of disease characterization. We have tried to record the peripheral pulses of human subjects, both control as well as in disease conditions; under observation of senior Ayurvedic physicians. We have observed an inverse relation between the Dosha Dominance of a subject by palpation method and the amplitudes of LF, MF and HF peaks in the variability spectrum. Since an increase in level of one of the Dosha increases the trigger level of corresponding ANS activity, therefore a decrease in this activity of ANS is expected. An abnormal increase in the level of any Dosha leads to Sanga or Srotorodha, thus further increasing the trigger level which in turn further decreases the ANS activity. Based on our observations on peripheral pulse morphology, we had proposed a hypothesis for representation of Tridosha during three phases of an IPG cycle. We are further trying to substantiate our hypothesis based on a study of about 100 subjects to show that Kapha, Pitta and Vata are represented by pre and early systolic phase, mid systolic phase and diastolic phase respectively. Also pulse morphology changes in respective segments of IPG cycle; in diseases pertaining to the respective Dosha. These observations need revalidation by multi-centric trials on large number of subjects in order to use this technique for diagnostic disease characterization.

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