REVIEW OF RESEARCH

THE RADIAL PULSE ANALYSIS: REVIEW PAPER

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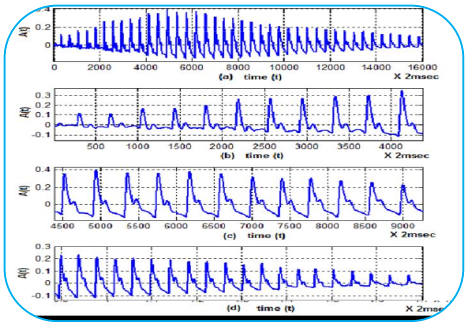
ISSN: 2249-894X
IMPACT FACTOR : 5.7631(UIF)
UGC APPROVED JOURNAL NO. 48514
VOLUME - 8 | ISSUE - 8 | MAY - 2019



ABSTRACT:
Radial pulse is defined as the rhythmic expansion of arterial wall due to the transmission of pressure waves along the wall of arteries that are produced during each systole of the heart. The radial pulse is periodic fluctuation that is caused by the heart and occurs at the same frequency as the heart beat. The pulse diagnosis is one of the most important examinations in Ancient Ayurveda Medicine (AAM) and Traditional Chinese Medicine (TCM). In TCM disease diagnosis is based on the pulse pressure observed at six radial points - three on left wrist and three on right wrists. In AAM diagnosis is done from the information obtained from the three pressure points on either left wrist (in case of men) or on right wrist (in case of women). Some of the researchers have reported development of the pulse data acquisition systems and used the data collected for analysis. Researchers have collected the radial pulse data either by using the equipment developed by them or using the commercially available equipment. Various statistical methods and mathematical models are used for analyzing and interpreting the radial pulse data. The research work relevant to the pulse analysis is reviewed in this paper.

KEYWORDS: *Radial pulse, Traditional Chinese Medicine, Ayurveda .*

INTRODUCTION:

A typical radial (pressure) wave is shown in Fig.1. Generally, there are two main components of this wave: forward moving wave and a reflected wave. The forward wave is generated when the heart (ventricles) contracts during systole. The wave before dicrotic notch reflects the heart systole; the wave after the notch reflects the diastole. Peak1 and peak2 are the percussion wave and dicrotic wave of pulse respectively. The parameters H1, H2 and H3 are the heights of peak 1, valley and peak 2 in pulse respectively. The parameters t1, t2 and t3 are their corresponding time values. W1 and W2 are their widths at the heights 0.9 times of H1 and H2 respectively.

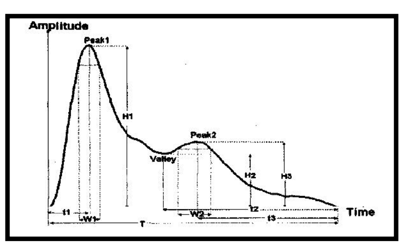


Fig1. : Schematic figure of pulse parameters

Analysis of the pulse can be done in Frequency domain, time domain or mixed domain. Time-domain parameters of pulse signal used by scientists during analysis are shown in Fig. 1. In frequency domain the harmonic components of the radial pulse are calculated and their ratios are used for analysis.

Radial Pulse analysis Work:

Upadhyaya (1) used Dudgeon's sphygmogram for radial pulse sensing and quantitative measurements. The pulse data obtained from a large number of subjects as well as patients at different times during the day was used. The analysis of pulse waveform involved the study of following parameters: Pulse period (Time taken by each pulse wave), length of percussion wave from the point of its start to the highest point of its top (which represents the amount of pressure exerted on the blood flow due to the contraction of left ventricle), distance between two nearest top points of the wave (due to the rate of contraction of left ventricle), angle of deviation of percussion wave and distance of dichrotic notch from the base line.

Upadhyaya studied the above parameters for pulse wave with the three *doshas.* He recorded the pulse waveforms of *Vata, Pitta* and *Kapha dosha* respectively. Upadhaya reported that the *vata* pulse takes minimum pulse period and has smallest length percussion wave. It has least angle of deviation and minimum distance of dicrotic notch from the base line of pulse wave. The *pitta* pulse has medium pulse period, highest length of percussion wave, maximum deviation of angle in bending towards the base and maximum pulse period, medium length of percussion wave, medium deviation of angle in bending towards the base and medium distance of dicrotic notch from the base line.

Lee and Wei (2) analyzed the spectrum of pulse at radial artery at wrist and correlated its spectral features with health condition of the subject. In traditional Chinese medicine, pulse is sensed at three different points, Cun, Guan and Chi, along the radial artery on the wrist of both hands. By applying maximum and minimum pressure at these points, physician detects the condition of the internal organs of the patient. By keeping the condenser microphone ("Bruen & Kjar 4147") at *Cun* and *Guan* positions using approximately minimum and maximum pressure the analog waveforms of pulse were sensed at both the wrists. The recording of pulse at *Chi* position was avoided in order to prevent inconvenience to patient by applying pressure to three close points for long duration. The waveforms were digitized for their use in spectral analysis in terms of spectral energy ratio (SER).

SER is defined as the ratio of the energy of pulse spectral graph (PSG) below 10 Hz to that above 10Hz. The pulse signal is present in the range of 0 Hz-25 Hz and decreases gradually. However Lee and Wei measured the energy from 1 Hz to 50 Hz, assuming the signal below 1 Hz to be due to motion artifact.

The power spectra at eight different points are approximately coinciding with each other. It indicates the pulse waveforms taken from all positions are almost similar for normal person. The SER values calculated for large number of normal subjects showed that maximum energy of pulse signal is concentrated below 10 Hz.

B. H. Wang et al (3) have used the microphone based pulse detecting system for sensing radial pulse at wrist and analyzed the power spectra of four types - normal, smooth, wiry and slow–intermittent – of pulses according to traditional Chinese medicine system. The power spectra of the four kinds of pulse signals are obtained by using the Fast Fourier Transform (FFT) and the power-spectral characteristics are analyzed and compared. The pulse signal was low pass filtered with the cutoff frequency 50 Hz. Further analog pulse signal was digitized by using sampling frequency f_x of 128 Sa/s with a sampling length T of 16 s.

Following are the characteristics of power spectra reported by the author. Power spectra of the normal pulse signal distribute within 25Hz, with the envelope decreasing with increase in frequency. Smooth pulse has over 10 harmonics, normal pulse has about 8, wiry and intermittent pulse have 3-5 harmonics components. The breathing frequency was found around 0.2-0.5 Hz and it is different for different subjects. It was found that the spectral energy of pulse is approximately concentrated below 10 Hz.

Yoon et al (4) proposed a new quantification scheme of specific pulse characteristics. The characteristics were determined using the pressure-adjusting pulse detector, the authors previously developed. Sensor was kept over a pulse point and contact pressure was regulated by varying number of weights (20 g each).Amplitude of the pulse is recorded. Authors used following three characteristics for the quantification of the traditional pulse type classification - (a) The contact pressure at which the maximum amplitude is attained (degree of pulse floating) (b) The height of the maximum amplitude (degree of pulse size) (c) The width of the contact pressure between the two points in the curve at which 80% of the maximum amplitude is attained (degree of pulse strength).

Lau et al (5) studied the relationship between wrist-pulse characteristics and body conditions based on the empirical study of radial pulse contours. They enrolled 30 normal, 30 with heart-problem and 30 with chronic renal failure subjects for this study. Radial pulse waves were measured non-invasively from the Cun, Guan and Chi positions in TCM (*vata ,pitta* and *kapha* positions respectively in Ayurveda) on the left hand. Pressure sensor type PSS-02KAF,from Kyowa Electronic Instrument Co. Ltd. Japan was used. The contour characteristics of each pulse was studied and classified. The study showed the effects of heart and kidney problems on pulse contour. Authors showed that the pulses in the heart-problem group had 4 general contour characteristics and those in the renal failure group have 5.

. Hlimonenko, et al (6) studied the elastic properties of vascular tree noninvasively in human subjects as a function of aging using the shape of peripheral (radial) pulse wave. They used 21 subjects in two age groups, 22-30 and 37-72 years. The special laboratory instrument for photoplethysmographic (PPG) signal amplification was used. For photoplethysmographic (PPG) measurements the finger clip sensor (From Nellcor Durasensor Analog) was used. National Instruments data acquisition board (DAQ) was used to digitize the signals and transmit the digital data to the personal computer. The waveforms were analyzed offline using Lab VIEW programs. They observed that the peripheral pulse has a steep rise and a dicrotic notch on the falling slope in the younger subjects. With older subjects a more gradual rise and fall and no pronounced dicrotic notch were observed. Various parameters used for analysis are defined the PPG pulse shown in Fig 1.4

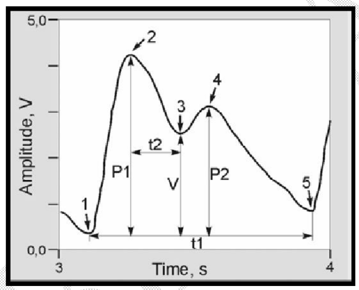


Fig. 2 : PPG signal pulses

The analyzing program calculated ratios t2/t1, P2/P1 and V/P1. It was found that the ratio t2/t1 decreases with age. For the subjects in the age group of 20-30 years, the ratio t2/t1 remains nearly 0.15-0.25, except one subject. With the decrease in age, the t2/t1 starts to decrease to nearly 0.11. The ratio V/P1increases with age and the ratio P2/P1 do not depend on the age. Differences in the ratios P2/P1, t2/t1 and V/P1 between age groups were compared by the authors using the statistical program ANOVA.

Results shows that the two ratios t2/t1 and V/P1 were significantly different in terms of statistics at $p<0.05$. Authors concluded that ratios t2/t1 and V/P1can be used to analyze distensibility of arteries. The decrease in the ratio t2/t1 occurs with an increase in the age. The smaller this number, the stiffer arteries are. The increase of ratio V/P1 happens with increase of age. The greater is this number, the stiffer the arteries are.

Authors found that the position of the second peak of the pulse depends on the age of the subjects. This is attributed to the increase in aortic stiffness and pulse wave velocity. As the vessel gets stiffer during aging process, the reflected wave returns faster and due to the summation of waves the resultant pulse wave changes.

McLaughlin et al (7) developed a fast and easy to use system for the determination of peripheral arterial pulse wave velocity (APWV). They report this to be a reliable and reproducible non-invasive method of measuring peripheral arterial pressure pulse wave velocity in humans. APWV is a measure of the elasticity (or stiffness) of peripheral arterial blood vessels. The pressure pulse velocity varies over the range from about 12 m s^{-1} to15 m s^{-1} in stiff peripheral arteries, whereas in normal arteries it is in the range of 7 to 9 ms^{-1}. Authors reported that the clinical usefulness of the instrument lies in the conversion of the velocity values to values of local stiffness (elasticity) of peripheral arterial walls.

Xu, et al (8) have presented a review of recent achievements in quantitative analyses of modern research on Traditional Chinese Pulse Diagnosis (TCPD). In order to demystify TCPD and prove its efficiency, some fundamental knowledge such as concepts, diagnosis methods, and standard pulse patterns are discussed. Authors have reviewed modern research on TCPD mainly from 4 aspects: objectification of TCPD, analyses of pulse waveform, research into the mechanism of pulse formation, clinic observations, and comparisons on pulse images. For each of these aspects, general background information and a brief explanation on them are given. It is especially important to distinguish the pulse images based on Traditional Chinese Medicine (TCM) and the sphygmogram based on Western medicine. Authors have reported single point pulse acquisition system and have collected pulse data. Furthermore, typical pulse waveforms and their results were processed by modern signal processing methods such as cepstrum, Short-Time Fourier transforms (STFT), and wavelet transform Finally, theprosperities and difficulties of modern research on TCPD are pointed out.

Mahesh et al (9) reported design of a pulse sensor using PVDF material for acquiring the three pulses from the radial artery. They also developed a signal conditioning unit to improve the quality of the signals before they are converted into digital form by the data acquisition card interfacing the computer. The analysis was done offline. Authors classified the pulses on the basis of *siddha* theory which states that the three pulses vary in amplitude in the ratios of 1:2:4 for *kapha, pitta*, and *vata* respectively and the frequencies must be 80-95 beats/min for *vata* pulse, 70-80 beats/min for *pitta* pulse and 50-60 beats/min for *kapha* pulse. The frequency analysis of the same subject was done by Authors. They observed from the data that the *vata* pulse rate is less than the normal range that is 80-90 beats/min where as the *pitta* and the *kapha* pulse is within the normal range. They concluded that the person may have less *vata* constituents. Authors also concluded from the amplitude data of the same subjects that the ratio of *vata*, *pitta*, and *kapha* pulses are in the ratios 1: 0.6: 0.4 respectively which indicates that the person is having more *pitta* and *kapha* constituents

Joshi et al (10) have reported development of a system called "*Nadi Tarangini*" for acquiring human pulse information for diagnosis purpose. Authors recorded the waveforms obtained from using *Nadi Tarangini a*nd reported sample waveforms from the left hand of a patient for *vata*, *pitta* and *kapha doshas* respectively. They further reported that their recorded waveform consists of important time domain features such as percussion wave (P), tidal wave (T), valley (V) and dicrotic wave (D). Authors also reported that as the contact pressure of the sensor over the pulse point increases, the amplitude of the pulse signal first increases, reaching a maximum, and then decreases. After a particular threshold value, the pulse dies and these observations are consistent with the Ayurvedic literature

CONCLUSION:

In this paper the work related to pulse analysis for Ancient *Ayurveda* Medicine (AAM) and Traditional Chinese Medicine (TCM) is reviewed which can be useful for medical purpose.

REFERENCES

1) S. Upadhyaya. Nadi Vijnaana , 1st Edition, Vedic Life Sciences Pvt. Ltd., 1986
2) Chun T. Lee and Ling Y. Wei. Spectrum analysis of human pulse IEEE transactions on Biomedical Engineering, BME-30 (6), (1983), 348.
3) B.H. Wang, J.L. Xiang. Detecting system and power spectral analysis of pulse signals of human body. Proceedings of ICSP1998. (1998), 146
4) Young-Zoon Yoon, Myeong-Hwa Lee and Kwang-Sub Soh. Pulse type classification by varying contact pressure. IEEE Engineering in Medicine and Biology (2000), 106.
5) Lau E, Chwang A. Relationship between wrist-pulse characteristics and body conditions. Proceedings of the EM 2000 conference. (2000).
6) Hlimonenko, I., Meigas, K., Vahisalu, R. Waveform analysis of peripheral pulse wave detected in the finger tip with photoplethysmograph. Meas. Sci. Rev. 3, (2003), 49.

7) J McLaughlin, MMcNeill, B Braun and P D McCormack. Piezoelectric sensor determination of arterial pulse wave velocity. Physiological Measurement Physiology. Meas. 24,(2003), 693.
8) Lisheng Xu, Max Q.-H. Meng, Cheng Shi, Kuanquan Wang, and Naimin Li. Quantitative Analyses of Pulse Images in Traditional Chinese, Medicine Medical Acupuncture. Volume: 20 Issue 3: August 18, 2008
9) S. Mahesh, M. Manivannan, T. Anandan: Three Radial Artery Pulse Sensor Design for Siddha Based Disease Diagnosis" *International Journal of Systemics, Cybernetics and Informatics (IJSCI)*, (2008) 19
10) Aniruddha Joshi, Sharat Chandran, V.K. Jayaraman and B.D. Kulkarni. "*Nadi Tarangini*: A pulse based diagnostic system". *29th Annual International Conference of the IEEE EMBS*, pages 2207-2210, (2007).
11) A.E. Kalange, Development of data acquisition System and analysis of human Pulse for vata, pitta and kapha Dominance in prakruti, Ph.D Thesis, Department of Physics, University of Pune, 2011

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