

PULSE WAVE VELOCITY IN NADI PARIKSHA

[Syeda Tanzeel Saher](#)¹, Anup Bhosgikar², Sanjeev Kumar Jyoteppa³

¹Final Year P.G. Scholar, Department of Rachana Shareera, N. K. Jabshetty Ayurvedic Medical College and P.G. Center, Bidar, Karnataka, India

²Associate Professor, N. K. Jabshetty Ayurvedic Medical College and P.G. Center, Bidar, Karnataka, India

³Associate Professor, N. K. Jabshetty Ayurvedic Medical College and P.G. Center, Bidar, Karnataka, India

Corresponding Author: sahertanzeel@gmail.com

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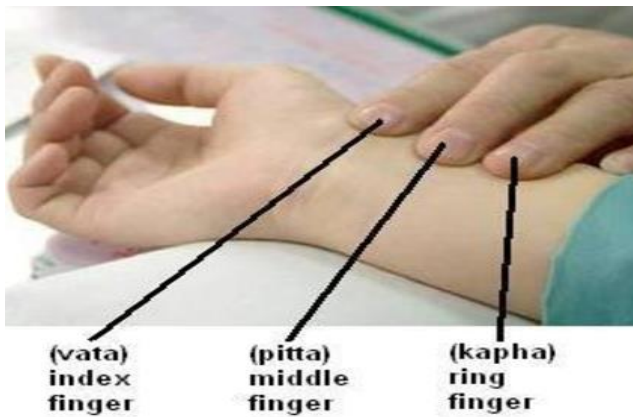
ABSTRACT

This is an analytical study of the diagnostic method prescribed in Ayurveda. Ayurveda has a holistic & person-centric approach towards health & disease which in turn necessitates consideration of several factors in process of the diagnostic workshop. Developing & validating diagnostic tools for diseases enumerated in an ayurvedic classical textbook can help standardize the clinical approach. However diagnostic research is a very less explored area in Ayurveda & there are no established standards for developing & evaluating diagnostic tools. Ayurveda has thousands of years of rich experience in *Nadi Pariksha* with strong literature support. Hence need is to know the *Nadi* with a scientific approach. Ayurvedic pulse diagnostic is the unique & non-invasive diagnostic method that determines the state of *dosha*. Recently, Pulse Wave Velocity has gained significant research interest as it is considered to be a strong indicator of cardiovascular diseases. As per ayurvedic texts, qualities of the pulse such as *Gati*, *Vega*, *Sthiratwa* & *Khatinatwa* of *dhamani* plays a major role. In the current review, these properties were analyzed & compared with modern pulse parameters namely- Pulse Wave Velocity, Pulse Rate Variability, Arterial Stiffness. As a result, it is important to study these modern parameters in the context of Ayurveda to bring the hidden secrets of *Nadi Pariksha* to light. There is a need to develop the framework for this and bring a scientific approach to pulse-based diagnosis which is the need of the day.

Keywords: *Nadi Pariksha*, *dhamani*, Pulse Wave Velocity, pulse diagnostic, arterial stiffness.

INTRODUCTION

Ayurveda is well known for *Nadi Pariksha*, and classical texts have emphasized its significance in the assessment of *Tridosha* which are the basis of disease diagnosis and prognosis. Traditional texts of Sharangdhara Samhita, Yogaratnakara Baswarajeeyam and Bhavaprakasha have discussed the detail of *Nadi Pariksha* in a set of Shlokas. *Nadi Pariksha* is an ancient Ayurvedic non-invasive diagnostic technique through the pulse which help diagnose physical, mental, and emotional imbalances in the body. Also, the diagnosis of *dosha* aggravation helps determine personalized wellness regimens, develops detoxification process, decide personalized diet and exercise programmes. There is a precise description of *dosha* predominance in the texts which can be sensed from specific locations on the radial artery and accordingly *vata dosha* is felt at the root of the thumb which can be sensed with the index finger, next to it is *pitta dosha* which can be sensed with middle finger followed by *kapha dosha* sensed by the ring finger. As per Ayurveda balanced *Tridoshas* represent sound health and vitiated *doshas* lead to diseases. [1]



Ayurvedic *Nadi pariksha* (significance pulse analysis):

1. It is a unique measure of individual health.
2. Identifies risk of upcoming diseases (prognosis).
3. Gives an idea of health status.
4. Identifies *dosha* imbalance.
5. Can diagnose diseases like diabetes, paralysis, infertility, skin diseases, hypertension, mental disorders etc.

METHOD OF NADI PARIKSHA

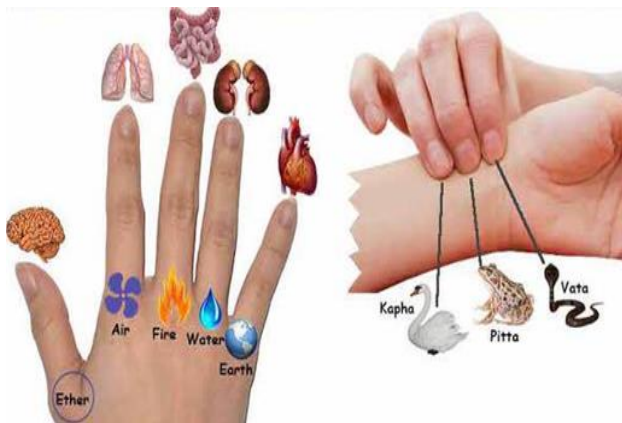
Ayurveda has rich experience in pulse-based diagnosis, but it is subjective and is highly dependent on the skill of the physician. In the recent past, there is a growing research interest in acquiring the pulse from *Tridosha* locations and analyzing the pulse waveforms scientifically in the context of Ayurveda. The pulse patterns of *vata*, *pitta* and *kapha* doshas were studied in detail by Upadhyaya as part of the clinical and experimental studies on *Nadi Pariksha* using Dudgeon Sphygmograph. It was a detailed study covering the systematic review of ayurvedic literature, hemodynamics and statistical analysis of pulse patterns representing *vata*, *pitta* and *kapha* doshas of normal and diseased persons. The mean pulse rate and mean pulse pressure were studied across *vata*, *pitta* & *kapha doshas* and the significance of pulse parameters rate, rhythm, volume, force, tension, character and hardness of the artery were analyzed in the context of Ayurveda. In similar lines, Vasant has analyzed the physiological significance of pulse parameters *Gati* (movement), *vega* (rate), *tala* (rhythm), *bala* (force), *tapamana* (temperature), *akruti* (volume and tension) and *kathinya* (consistency of the vessel wall) across *vata*, *pitta* and *kapha doshas*. These initial studies accentuated the importance of the pulse parameters in analyzing *Tridoshas* more scientifically compared to qualitative analysis. In this review, the pulse measuring locations used in *Tridosha* analysis were highlighted and qualities or properties of *Nadi* as explained in Ayurveda classics were discussed. The physiological significance of the qualities of *Nadi* was analyzed and compared with the modern pulse parameters which include pulse wave velocity, arterial stiffness and pulse rate variability. In this review, the role of modern instruments in studying the traditional pulse parameters was discussed. Sharangdhara Samhita mentioned that the presence of pulse at the wrist signifies the existence of life. The physician should recognize the health and ill health of a person from its activities. [2] All the diseases can be diagnosed from *Nadi* and are well explained by Yogaratnakara, it was compared with strings of veena playing all the

ragas which signify the importance of *Nadi Pariksha*. The speed, stability and *gati* of the pulse vary with the aggravated *doshas* and assessing such variations with ***Nadi Pariksha* is an art and science of its own**. The traditional ayurvedic practitioners were adept in pulse-based diagnosis and used to diagnose the diseases effectively by just placing fingers on the radial artery. The physician should examine with his right-hand pulse below the right thumb. In females, *Nadi* is more palpable in the left hand and males in the right hand. As such first, the elbow (*kurpar*) of the patient should be slightly flexed to the left and the wrist slightly bent to the left with the fingers distended and dispersed. The physician should examine repeatedly for three times by applying and releasing pressure alternately over *nadi*, to assess the condition of *dosha*. It also indicates *sadhya* and *asadhyata* that is a prognostic index of the disease.^[3] Traditionally *Nadi Pariksha* was done by sensing the pulse at three locations on radial artery and assessing *doshas* from palpation of the pulse. The qualities or properties of the *Nadi* are vital in assessing *doshas* as part of *Nadi Pariksha*. The classical texts have emphasized the significance of *gati*, a unique quality of the pulse, as part of *Nadi Pariksha* and as per texts, *gati* plays a key role in disease diagnosis. There is no equivalent term for *gati* in modern medicine and pulse movement is the closest matching term in modern medicine which can be associated with *gati*. There are many other qualities of pulse apart from *gati* (pulse movement) which texts have highlighted and, in this review, the *gati* and other qualities of pulse were discussed in detail. The stability of the pulse has been dealt with in detail in the texts while explaining *Nadi Pariksha* and the texts have used terms *sthir* (stable) and *capal* (unstable) while explaining the stability of the pulse. The stability is referred to as *sthiratva* in *doshadi vijnaniya adhyaha (sutrasthana)* of *Astanga Hridayam* while explaining *prakruta dosha karma*.^[4] The texts have not used the term *sthiratva* while explaining *Nadi Pariksha*, but this term can be used to represent the stability of the pulse and can be closely associated with modern parameter pulse rate variability. The texts have used the term *kathinya* to explain the hardness of the artery

and reference to *kathinya* is available only in Basavarajeeyam. In *dviteeya prakarana* of Basavarajeeyam while explaining the signs of *mrityu nadi* the term *kathinya* has been used and in *triteeya prakarana* of Basavarajeeyam the term *kathinya* is used to explain the nature of *kapha*. The term *kathin* (hard) represented as *kathinya* corresponds to hardness of the artery and can be closely associated with modern pulse parameter arterial stiffness.^[5]

Gati's of Nadi (pulse movement):

Our classics has mentioned the *gati* of *Nadi* very beautifully by comparing it with nature wherein the movement of the pulse has been compared with the movement of animals, birds and reptiles. The *dosha* predominance can be well assessed with *gati* which is a very unique way of diagnosis in Ayurveda According to the texts the movement of *vata* pulse, well known as *sarpa gati*, will be curved resembling the movement of *SARPA* (snake) and *JALOUKA* (leech). Bhavaprakasha has not compared the *gati* with the movement of animals or birds but similar to Basavarajeeyam explained it to be of *vakra* in nature. The movement of *pitta* pulse, well known as *MANDUKA gati* (frog), was compared with the movement of frog which will be hopping and jumping in nature and was explained with the words *capal* and *utplutya* which signifies the jumping nature. The slow movement (*manda gati*) is the significance of *kapha* pulse, well known as *HAMSA gati* (swan).^{[2][3]} The Ayurveda texts have explained the *gati* of the pulse when more than one *dosha* is present and according to the texts *gati* will be of *sarpa* and *manduka* in nature if both *vata* and *pitta doshas* are in aggravation, similarly, it will be of *sarpa* and *hamsa* in nature if *vata* and *kapha doshas* are in aggravation and will be of *manduka* and *hamsa* in nature if *pitta* and *kapha doshas* are in aggravation. It is quite evident from the texts that *gati* plays a significant role in assessing the *dosha* predominance and traditional Ayurveda doctors were adept in assessing *gati* from *Nadi*.



Vega (speed of the pulse):

The speed of the pulse is another aspect on which Ayurveda has laid much importance in understanding various physiological, psychological and pathological states of the person. According to Sarangadhara and Bhavaprakasha, the increase in lust and anger results in *fast Nadi* and on the other hand *nadi* will be slow due to the increase in sorrow and fear. Sarangadhara has related the speed of the *Nadi* to digestive fire and said *Nadi* will be fast when the digestive fire is active and will be slow when the digestive fire is weak. Traditionally Ayurveda doctors used to assess the speed of the pulse from *Nadi* but now with the advent of biomedical instruments measuring the speed of pulse has become simple and sophisticated. Pulse wave velocity is another parameter with significant research interest and can be associated with *vega* and there is a need to study this parameter in the context of Ayurveda.

Sthiratva (stability of the pulse):

The Ayurveda classics have discussed the stability of the pulse in detail with a mention of intermittent *nadi* which will be sometimes slow, sometimes fast and sometimes stops in between. Basavarajeeyam has used the term *sthitva* Shiva to explain the intermittent pulse while explaining the qualities of *sannipatha* *Nadi*. As per the texts, which is intermittent and is sensed in locations other than the specified place indicates to be fatal which may lead to the early death of the patient. Basavarajeeyam and Yoga Ratnakara have termed it as *asadhya nadi* and as per Basavarajeeyam it is the nature of *mrityu nadi* also.^[6] The stability of the pulse

also depends on the various physiological and psychological states of the person. According to Sarangadhara Samhita *nadi* will be strong and steady in healthy persons and the *nadi* of a hungry person will be irregular when compared to that of a person who has just taken the food.^[7]

Kathinya (arterial stiffness):

The hardness of the artery is closely associated with *kathinya* and only Basavarajeeyam has discussed the nature of *kathin nadi* in detail. As per Basavarajeeyam *vata nadi* will be hard and the hardness of the artery has been explained with the words *kathor* and *kathin* whereas the hardness of the artery due to *pitta* and *kapha doshas* was not mentioned. The hardness (*kathin*) and roughness (*khara*) of the artery correspond to *vata dosha* as per Ayurveda and Basavarajeeyam compared *vata nadi* with a string of *veena* which signifies the hardness of the *vata nadi*. The blood flow in hardened arteries will be fast compared to normal arteries which imply that *vata* pulse will be fast which is in agreement with Ayurveda.^[8] According to Basavarajeeyam if *nadi* is *kathin*, very slow-moving in a curved manner, if it is displaced from its original position then it is considered as *mrityu nadi* and is an indicator for the early death of the patient.

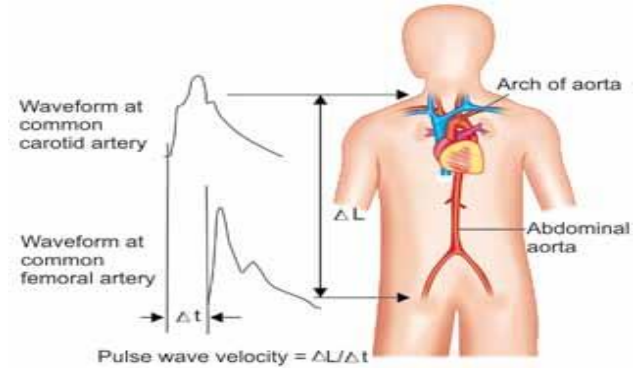
Pulse locations:

Ayurveda has laid much emphasis on sensing the pulse at radial artery primarily to assess *doshas*, but it has not limited the pulse location to just radial artery but has clearly defined that the pulse can be sensed from eight locations. The classical text Basavarajeeyam has mentioned about eight locations to sense *nadi* and accordingly there are two at radial artery, two at the ankle, two at neck region and two at nasal region. It is also mentioned that the knowledge of *vata*, *pitta* and *kapha doshas* can be obtained from radial artery and *Nadi Pariksha* based on radial artery has been widely practised as it is important to assess *Tridoshas* for any disease diagnosis and treatment. Though radial artery plays a major role in disease diagnosis and treatment, *nadi* at neck and nasal regions was also considered as important *nadi* in diagnosis and prognosis of the disease. Fear, sorrow, anger, lust and fever are some

of the symptoms which can be sensed from the *nadi* at neck and similarly the diseases about the head, eyes and ears can be diagnosed from the nadi at the nose. The status of life and health, fever and its relief is sensed from *nadi* at the ankle. It is evident from the literature of Ayurveda that *nadi pariksha* has a major role in disease diagnosis and is not limited to radial artery but extended to other arteries.^[9] As per modern physiology, the pulse is palpated at radial, carotid, femoral, brachial and ankle arteries and this is in line with the description in Ayurveda except that there was no mention of the femoral artery in Ayurveda and arteries at the nasal region in modern physiology are not highlighted. The significance of radial artery-based pulse diagnosis is well understood in Ayurveda and has been widely practised but the *Nadi* at other locations are not explored much.

PULSE WAVE VELOCITY (PWV)

Modern Physiology has given very much importance to the measurement of the pulse. PWV is a measure of arterial stiffness or the rate at which pressure waves move down the vessel. The blood flows faster in aorta compared to the peripheral network and the speed varies from meters per second aorta to mm per second in the peripheral network. The velocity of the pulse wave is termed as pulse wave velocity and normally ranges from 5 – 15 m/sec {mean value = 6m/sec}. It is continued as a strong predictor of future cardiovascular events and all-cause of mortality. The European society of hypertension and the European society of cardiology has suggested a threshold of 10 m/sec considering the true anatomical distance travelled by pulse wave. The studies have shown significant results with PWV in modern medicine and the context of Ayurveda in *tridosha* analysis. PWV is used clinically as a measure of arterial stiffness and can be readily measured non-invasively in humans, with measurement of carotid to femoral pulse wave velocity (cfPWV). Carotid femoral technique is GOLD STANDARD and as a first step, it can be used to study the pulse wave velocity with *tridosha* analysis.



Relationship between arterial stiffness and pulse wave velocity:

It can be derived from Newton's second law of motion ($F=ma$) applied to a small fluid element, where the force on the element equals the product of density (mass/unit volume) and acceleration.

$$c_0 = \sqrt{\frac{B}{\rho}} \rightarrow \begin{array}{l} \text{Bulk Modulus} \\ \text{Density of fluid} \end{array}$$

The Frank / Bramwell-Hill equation:

For an incompressible fluid (blood) in a compressible (elastic) tube (e.g., an artery)

$$PWV = \sqrt{\frac{V \cdot dP}{\rho \cdot dV}}$$

Where;

V is the volume per unit length, dV is changed in volume

P is pressure, dP is changed in pressure

These equations assume that:

- There is little or no change in the vessel area.
- There is little or no change in wall thickness.
- There is little or no change in density (i.e., blood is assumed incompressible).

Variation in pulse wave velocity in the circulatory system:

Since the wall thickness, radius and incremental elastic modulus vary from blood vessel to blood vessel, PWV will also vary between vessels. Most measurements of PWV represent an average velocity over several vessels (e.g., from the carotid to the femoral artery).

Pulse pressure and arterial stiffness:

Pulse exerted on walls of blood vessels or arteries during systole is lowest if blood vessels are of high

compliance/low stiffness. People with high elastic & compliant arterial walls have narrow pulse pressure. Stiffer and harder blood vessel wall, wider the pulse pressure & more the heart has to work to pump blood into arteries.^[10]

PROCEDURE OF MEASUREMENT OF PWV

Clinical recording of PWV

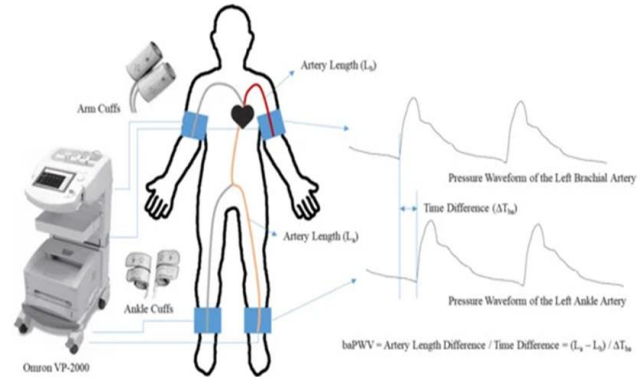
1. Patient Preparation Phase:

He/she should be informed about the procedure. The clothing, watches, jewellery etc should be removed before recording the patient height, weight is checked. He/she should lie on the examination table in a supine position then the Blood pressure is recorded.

2. Implementation Phase:

First patient data are introduced into the computer. The proximal distance is measured, to do this a measurement is taken using index & middle fingers from the glottis until the carotid pulse is found, the site where the pulse is stronger is marked, look for proximal part of sternal manubrium & mark it out & proceed to measure the proximal distance. Then we measure the distal distance, to do this we look for the femoral pulse at the internal third of the inguinal fold where the pulse is strongest & we mark it out, we then proceed to make a distal measurement from the sternal manubrium to the femoral pulse

The data is introduced into the computer remembering the enter the distances in millimetres. Then electrodes are placed on to the patients to obtain a continuous electrocardiographic recording. With the head tilted to one side, we look for a pulse again and apply a tonometer to that point a strong stable and reproducible wave must be obtained that we can register for some 10-30 seconds. To continue pulse is seen again at femoral region once confirmed apply tonometer over the femoral artery once again strong wave must be obtained then we can register for 10-30 seconds. The result of the pulse wave velocity is appreciated with more detail; the exact results of the wave velocity can be obtained.



A range of invasive or non-invasive methods can be used to measure PWV. The method is using two simultaneously measured pressure waveforms. PWV, by definition, is the distance travelled (delta x) by the pulse wave divided by the time (delta t) taken by the wave to travel that distance.

$$PWV = \frac{\Delta x}{\Delta t}$$

Contraction of the left ventricle generates pulse wave which is propagated throughout the arterial tree. An increase in arterial stiffness is associated with an increase in the propagation speed of pulse waves in arteries.

PWV is calculated as the travel speed of a pulse wave between two points on the same artery. Brachial-ankle PWV is calculated by subtracting the heart-brachial artery PWV from heart-ankle PWV.^[11]

Merits Of PWV

1. PWV is a measurement of arterial stiffness that is an independent predictor of cardiovascular risk.
2. It can be measured simply & non-invasively by measuring carotid & femoral pulse pressure & time delay between two or by other methods relying on pulse wave analysis.
3. Direct measurement of aortic compliance is possible by Magnetic Resonance Imaging (MRI).
4. For primary prevention – PWV may be a useful predictor of future cardiovascular events in patients with end-stage renal disease & hypertension.^[12]
5. For secondary prevention – PWV may be a useful predictor of a patient with acute coronary syndromes & heart failure.

6. Elevated PWV is a predictor of progression of pathophysiological abnormalities in early stages such as hypertension, chronic kidney diseases etc

Demerits Of PWV

1. PWV varies directly with wall stiffness and is related to the wall thickness and elasticity & inversely to the arterial radius.
2. It has many drawbacks, as PWV is lumped parameter, as proximal aorta changes due to most of the systolic damping function occurring here.
3. The value is affected by age, gender, blood pressure – so it should be adjusted for these factors.

CONCLUSION

Ayurveda has thousands of years of experience in *Nadi Pariksha*, and classical texts have emphasized the significance of *Nadi* in disease diagnosis and prognosis. The texts have explained the nature of *Nadi* and its variations in a very qualitative manner using the traditional parameters *gati*, *vega*, *sthira*, and *kathinya*. The traditional parameters are closely associated with the modern parameters such as pulse wave velocity, pulse rate variability and hardness of the artery which was discussed in this review thoroughly. *Nadi Pariksha* has been said as one of the ***Ashta Sthana Pariksha***. This system of examination cannot be practised easily because of the non-availability of detailed descriptions about *Nadi Pariksha* in Ayurvedic literature and the lack of practice in the field of science. Current guidelines by the European society of hypertension state that measured PWV larger than 10m/sec can be considered as an independent marker of end-organ damage. It is important to study these modern parameters in the context of Ayurveda to bring the hidden secrets of *Nadi Pariksha* to light. As for *Nadi Pariksha* repeated checking of *Nadi* and my experience only one can gain victory over accessing *Nadi* ie, *Vata*, *Pitta*, *Kapha*. But in PWV without much experience and with limited knowledge also one can perform PWV, as it is a simple and computer-based procedure. So, we have to adopt these techniques to bring advances in Ayurvedic diagnostic as well as to improve and validate our

Ayurvedic Science. There is a need for extending the recent advancements in pulse measurement techniques and instruments to develop the framework for *Nadi Pariksha* and bring the scientific approach to pulse-based diagnosis which is the need of the day.

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