

Pathophysiology of Essential Hypertension – Perspective from Ayurveda

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Abstract

Hypertension is a major contributor for preventable morbidity and mortality. A comprehensive study published in 2025 puts the prevalence in India at about 27 percent¹. For the world's most populous country this figure is a staggering 0.39 billion. For an individual it is a vicious cycle of end organ damage and complications leading to loss of quality of life. Total burden on the country's healthcare and loss of manhours have immense negative impact on the economy too. Secondary hypertension can result due to other systemic diseases eg diabetes. Sedentary lifestyle, diet and genetic predisposition are main contributors for the condition known as essential or primary hypertension which is elevation of blood pressure in absence of any other major condition. Pathogenesis of hypertension involves various factors related to chemical and physical composition of blood as a tissue, the structure and function of blood vessels and heart, status of kidney function etc. In ayurveda pathogenesis of any disease can be deciphered by the state of dosha, dhatu, mala, agni, srotasa and manas. From the perspective of treatment and management, nomenclature is neither essential nor possible for each of the innumerable probable conditions that a physician may encounter². There is no mention of hypertension in Ayurveda as a specific disorder. With the perspective of planning prevention and management; this article aims to summarize the pathophysiological conditions mentioned in the classical texts of ayurveda that lead to the development of essential hypertension.

Keywords: essential hypertension, vyana vata, srotasa, blood vessel, circulation, heart

1. Introduction

Essential hypertension is a condition where there is no other preexisting disease or disorder leading to increase in blood pressure (idiopathic)³. It is a growing threat for the current population specially when all the physical labour has been replaced by machines and activity levels of a normal daily routine are decreasing rapidly. In India it starts with childhood where playgrounds are shrinking and children increasingly stay indoors glued to the screen whether for studies or play. In adulthood occupation keeps the lifestyle majorly sedentary. This has led to emergence of a class of non-communicable diseases termed as lifestyle disorders. Essential hypertension is one of them⁴.

Optimum blood pressure is important for continuous circulation of blood and adequate tissue perfusion. Suboptimal blood pressure may lead to ischemia and higher pressure causes tissue injury which leads to end organ damage. Blood pressure is therefore actively controlled by certain physiological mechanisms in a multi-layered plan for homeostasis. Most important organs for assessment and response are kidney

brain and heart. These organs perform the essential function of regulation of systemic blood pressure to help body adapt to changes in internal and external environment. Compliance and structural integrity of the vascular compartment directly govern the velocity and pressure of the blood flowing through them⁵. Physical and chemical characteristics of tissue being circulated i.e. blood also influences the flow dynamics⁶. All these factors are also influenced by the diet, lifestyle and environment of the individual. In addition to these there is genetic predisposition which leads to racial variation in the prevalence of hypertension⁷.

In Ayurveda human body functions are governed by tridosha (three dosha i.e. Vata, Pitta and Kapha), saptadhatu (seven dhatus i.e. Rasa, Rakta, Mamsa, Meda, Asthi, Majja and Shukra) and trimala (Mutra, Purisha and Sveda)⁸. All the changes whether physiological or pathological are a result of homeostasis (samya) or vitiation (prakopa) of one or more of the three doshas. Vitiated dosha in turn inflicts dhatus which in turn leads to diseases. Srotasa (channels) are responsible for transport and circulation and are also affected by the vitiated dosha⁹.

Another important principle in ayurveda is that of Prakriti. It is the constitutional composition of an individual both physical and mental, that is present from birth. This constitution decides all the physical attributes (height, weight, body shape, hair and skin quality etc), mental characteristics (intellectual prowess, cognitive attributes, psychological traits etc), compatibility for food (ahar) and drugs (aushadha) and also predisposition for types of disorders. Dosha are responsible for articulation of prakriti of an individual therefore classification of prakriti whether mental or physical is based on the dosha involved¹⁰. It can be summarized that dosha are instrumental in forming the constitution, physiology and pathology in human body. Health and illness of an individual depend on balance or vitiation of the three doshas. When elaborating the pathophysiological aspects of any disease the states of all three doshas need to be assessed. Management or treatment of a disorder is planned on the basis of this assessment. As according to ayurveda treatment (chikitsa) is defined as disintegration of pathology (samprapti vighatana)¹¹

2. Concept of circulation in ayurveda

Srotasa - the channels: There is a well-defined concept of transport in ayurveda. Many physiological entities eg rasa dhatu and rakta dhatu, traverse through the whole body to perform their functions. There are specific physical structures involved in providing the pathways for this transport. These channels are named as Srotasa¹² and Dhamani¹³ in classical ayurvedic texts. It is mentioned in all of the classical texts that abnormal channels are the cornerstone of every pathological process progressing to a disease¹⁴.

Hriday – heart: It is the site of Chetana (consciousness- results from optimum function of heart), site for para ojas (vital life sustaining entity) and origin of ten main dhamani¹⁵. It is also termed as a marma (vital anatomical sites of the body) and a pranayatana (site of vital body functions that are essential for sustaining life)¹⁶. It is governed by vyana vayu and prana vayu to maintain adequate blood flow and pressure in srotasa throughout the body¹⁷.

Vata dosha – cause of movements (Gati): Vata dosha performs all the movements in the body¹⁸ at both macro and micro levels. Vyana vata (one of the five types of Vata dosha) is responsible for circulation and its control in the body¹⁹. Two of the important Dhatus (tissue systems) in the body namely Rasa and Rakta, require an uninterrupted circulation to perform their physiological functions. This requires a continuous

force for channelising these tissues through their respective pathways. Vyana vata provides, controls and maintains this force in a pulsatile manner²⁰. Prana vata on the other hand helps in adaptation with the internal and external environment by collaborating with sense organs and influencing the srotasa, Rakta dhatu and Hriday (heart)²¹.

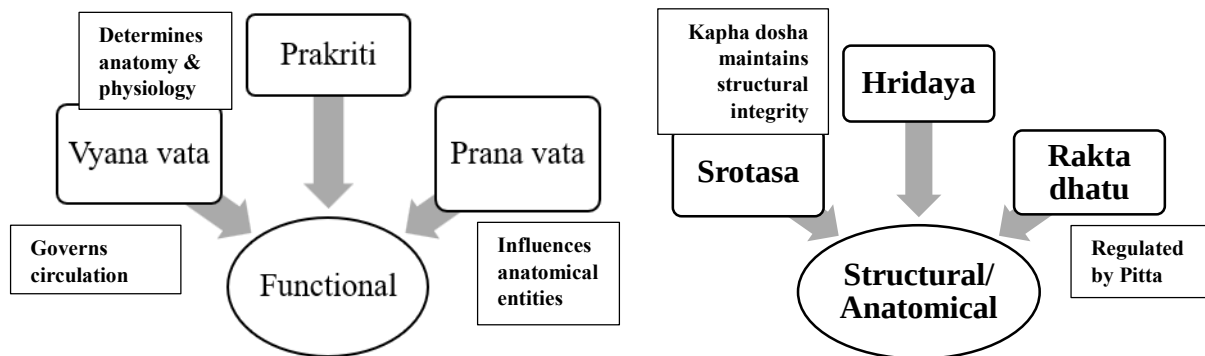
Rakta dhatu: In ayurveda Rakta (blood) is one of the seven important dhatus (tissue classes). It is responsible for sustaining life (jeevanam) in all the tissues of the body²². In order to achieve this, it needs to reach each and every cell in the body. There are many mechanisms involved in the process of establishing contact whether direct or indirect with the target tissues. Apart from optimal functional levels of channels involved, inherent qualities of rakta dhatu also govern its movement throughout the body. Its constituents impart a certain viscosity which in turn decides the quality of flow in the channels²³. Total quantity of rakta dhatu is also an important factor in influencing the flow and its reach to the peripheral tissues²⁴.

Physical constitution (Deha prakriti): According to ayurvedic classical texts, anatomy and physiology of an individual is decided at the time of conception. Predominance of a single dosha or a combination of dosha governs the physical attributes of the foetus. There are seven types of prakriti resulting from combinations of tridosha. Three single dosha predominant ie vata, pitta and kapha prakriti. There are three Dvandvaj prakriti arising from dual dosha predominance namely vatapitta, vatakapaha and pittakapha prakriti. Lastly when three dosha are in equal predominance it gives rise to tridoshaja sama prakriti. Prakriti is an indicator of the genetic profile²⁵ of the individual and determines the protection and predisposition for certain disorders²⁶. Therefore, it is essential to take into account prakriti of an individual when mapping the physiological and pathological events in essential hypertension²⁷.

Mental constitution (Manas prakriti): Satvika, Rajasika and Tamasika are three psychological profiles described in ayurveda. These are expressed due to predominance of satva, raja and tamah guna respectively. Among these Rajasika prakriti displays the attributes of pitta and vata dosha predominance with high levels of emotional excitability and energy. Tamasika prakriti is characterised by inherent inertia and low motivation for any endeavour whether physical or mental. Lastly Satvika manas prakriti is inclined to good morals, purity (mental and physical) and a balanced behaviour in both thought and action. Manas prakriti thus governs the levels of anxiety, stress, lifestyle (sedentary or active), dietary habits and overall sense of wellbeing in an individual²⁸ which in turn decide the predisposition for certain physical disorders including hypertension.

Summarizing the roles of above important elements in the control of circulation, we find that there are two types of entities, physical and functional. The structural elements like srotasa, Hriday and Rakta dhatu provide the anatomical or physical structure for the process of circulation in the body. Others e.g. vyana vata, prana vata and prakriti modulate the anatomical elements to maintain the circulation and blood pressure. These functional elements are also important for adaptation of blood pressure and circulatory function according to changing requirements of the body. Kapha and pitta dosha also have an indirect role in circulation. Kapha dosha is essential for structural integrity of the srotasa²⁹ and Hriday³⁰ (circulatory system). Pitta³¹ dosha on the other hand is a major contributor for physical and chemical properties of Rakta dhatu and thus governs its volume, viscosity etc.

Figure 1: Factors responsible for control of circulation



3. Hypertension

Even a slight change in any of the anatomical structures and functional entities can lead to abnormal circulation. It may be localised and isolated, in which case it is a circulatory disorder limited to an organ or extremity. Certain changes are age related and occur gradually and insidiously over a large period of time while others may occur as a result of a pathological condition. When such changes are systemic e.g. atherosclerosis, they lead to systemic disturbances in circulation.

Hypertension one of the most common systemic disorders of circulation. According to the JNC-7 guidelines a blood pressure reading greater than 140 mm of Hg systolic and 90 mm of Hg diastolic on two separate occasions, should be recognised as hypertension³². It can occur as a result of any other pathological condition e.g. chronic kidney disease, hormonal imbalance etc. and is called secondary hypertension. In majority of cases however hypertension occurs independently and is called essential or primary hypertension³³. It can be deduced from the physiology of circulation that hypertension or increased blood pressure is a multifactorial pathogenesis. According to ayurveda alteration in the condition of one or more of the following factors is responsible for altered blood circulation and resultantly blood pressure.

4. Significance and functions of factors effecting blood pressure

Srotasa:

As we know there are dedicated channels of transport in human body, termed as srotasa in ayurveda. Body components exist in different states viz. liquid, gaseous and solid state. These channels are structurally and functionally optimised for specific transport requirements (e.g. bronchi for air). Rakta dhatu flows through rakta vahi srotasa (Dhamini or blood vessels). Characteristics of these srotasa e.g. diameter, lumen and compliance, modulate the circulation of rakta dhatu throughout the body. This circulation requires a certain force (blood pressure) to maintain continuous tissue perfusion. This force is generated by heart (hriday) and controlled by the modulation of raktavahi srotasa (blood vessels). Vyana vata is responsible for this function³⁴.

Change in vascular resistance modulates blood pressure and resultantly the organ perfusion. This mechanism is expressed by Hagen Poiseuille equation $R = \frac{8 \eta L}{\pi r^4}$, where R is resistance of the blood flow, L is length of the blood vessel, η is viscosity of blood and r is the radius of the blood vessel. It is evident that a very small change in the lumen of blood vessel results in a corresponding change that

amounts to the fourth power, in the resistance to the flow. Therefore, a small dilatation of the blood vessels produces much larger reduction in the blood pressure³⁵.

Norepinephrine is released in the blood as a result of adrenergic response. It binds to alpha 1 receptors on the smooth muscles of the vasculature to cause vasoconstriction. At cellular level endothelin, angiotensin II, vasopressin, thromboxane and dopamine bring about vasoconstriction³⁵.

Vasodilatation on the other hand is caused by binding of epinephrine to the beta 2 receptors of the vascular smooth muscles. Nitrous oxide, adenosine, histamine, prostacyclin, prostaglandin D2 and E2, vasoactive intestinal peptide, carbon di oxide and bradykinin are the molecules that work at cellular level to achieve vasodilatation³⁵. Thus, physical and functional characteristics of Raktavahi srotasa are important regulators of blood pressure. When affected by vitiated Vyana vata their derangement is a major contributor in pathology of essential hypertension.

Hridaya:

As discussed, Hridaya is the site of Vyana vata and is important organ for sustenance of life. Constant pumping action of Hriday (heart) creates the force required to start and maintain the circulation and tissue perfusion. Total amount of blood pumped by heart in 1 minute is called cardiac output which can be expressed as a product of stroke volume and heart rate ($CO = SV \times HR$). Blood pressure is directly related to cardiac output and systemic vascular resistance ($BP = CO \times SVR$). Both heart rate and stroke volume are under dynamic control through autonomic nervous system, endocrine and paracrine signalling systems. A complex network of chemoreceptors, baroreceptors and feedback mechanisms works in synchrony with these to regulate cardiac output, heart rate and resultantly the blood pressure in a physiological range. Autonomic control via sympathetic drive causes increase in cardiac output whereas parasympathetic drive results in a decreased output⁵.

In ayurvedic classics this regulation is a function of Prana³⁶ and Vyana³⁷ vata. Prana vata is responsible for the perception of stress as it controls the sense organs (Indriya) and intellect (Budhi). Vyana vata generates and controls all the movements whether gross or microscopic. Activation of autonomic nervous system is therefore the result of a collaboration of both classes of vata. This is a major factor in modulating the heart, blood pressure and resultantly the circulation, for adaptation as the environment changes. When vitiated, both the classes of vata influence the function of heart which gives rise to hypertension

Rakta dhatu:

Flow through the circulatory system also depends upon the properties of the matter undergoing transport. Pure state of matter either liquid or gas. follow specific laws of physics while flowing. Poiseuille's law, continuity equation and Bernoulli's principle are some of the defining principles of hydrodynamics. Blood however is not a simple liquid. It is a tissue consisting of living cells, electrolytes dissolved in the liquid part of the tissue with some heavy molecules suspended in it³⁸. Blood is also a dynamic tissue that changes its composition (e.g. oxygen concentration) according to the environment, which is essential for this tissue to perform multiple functions. These changes influence the flow in real-time e.g. occurrence of tachycardia in low oxygen surroundings and erythrocytosis when exposed to rarified atmosphere of high altitude³⁹.

Characteristics of Rakta dhatu are governed by all three dosha, Pitta being predominant. This leads to aberrations of haemoglobin (abnormal ranjana⁴⁰ karma) leading altered oxygen carrying capacity. Vitiating dosha also affect viscosity and rheology of blood either resulting in increased blood volume or peripheral resistance. Compensatory changes occur in blood vessels (srotasa), heart (Hridaya) and blood pressure to correct the in order to maintain tissue perfusion. Vyana vata controls the movement of fluid and electrolytes through body tissues and is capable of altering viscosity and volume of blood (Rakta dhatu) e.g. sodium retention and volume expansion. This directly affects the systemic blood pressure, and leads to hypertension.

5. Other factors:

Non - modifiable

Genetic profile and/or Prakriti of an individual imparts predisposition to certain conditions. Genetic predisposition for hypertension is polygenic as confirmed in recent studies^{42,43}. There are genetic variations that render salt sensitive i.e. a small increase in daily salt intake results in blood volume expansion due to sodium retention causing high blood pressure. This is the population of sodium conservers. Similar propensity exists for uric acid⁴⁴ leading to hyperuricemia that is a contributing factor for essential hypertension⁴⁵. Familial dyslipidaemia was also found to be associated with the risk of hypertension⁴⁶.

It has been found that manas prakriti (Rajas) can make an individual prone to mental stress, anxiety and hypertension⁴⁷. If such a populace stays in a disturbing and stressful environment, they are more prone to develop circulatory disturbances and hypertension due to persistent and increased sympathetic drive. Whereas in a stress free environment with a controlled diet and lifestyle occurrence of essential hypertension was found to be delayed⁴⁸.

6. Modifiable

Diet and life style influence overall health and wellness of an individual and is a very important easily modifiable factor for hypertensive condition. It is documented that diets with high salt, fat content, smoking and alcohol⁴⁹ are associated with increased risk of hypertension specially in the genetically predisposed population.

Similarly sedentary life due to occupational conditions or otherwise also predisposes an individual for developing hypertension. It has been observed that physically inactive population was more likely to develop essential hypertension than physically active one⁵⁰.

7. Discussion -Pathophysiology of Hypertension

According to Ayurveda all the movements whether gross or microscopic in nature are controlled by Vyana vata. This includes blood circulation, tissue supply, transport and exchange of metabolites, ions and gases e.g. oxygen from visible respiration to cellular exchange. Critically important processes of maintaining the force of circulation, blood pressure and resultant organ perfusion, are a function of Vyana vata. This is achieved by direct or indirect control of heart function i.e. chronotropic and ionotropic functions and control of blood pressure through modulation of systemic vascular resistance resulting from vasoconstriction and vasodilatation.

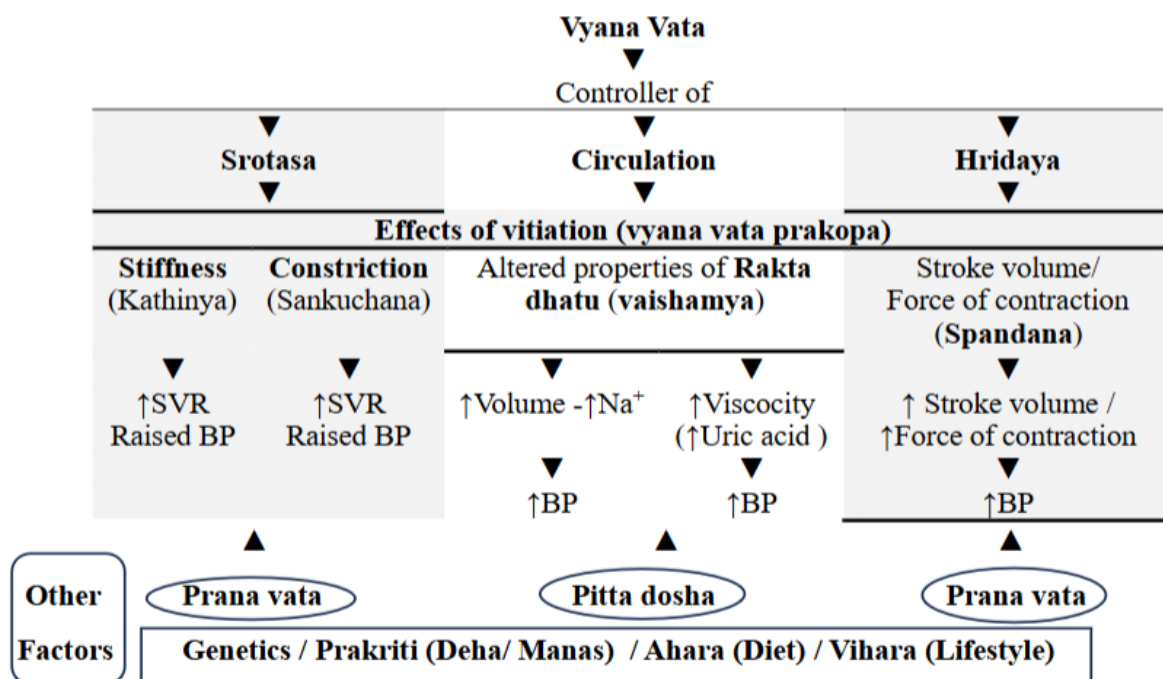
Vata dosha when in balanced state (samyak) maintains optimal health. There are two scenarios in vitiation of vata. One where the vata actions are weakened (kshaya) resulting in diminished or suboptimal functions. Functional site of Vyana vata is heart (hridaya), channels (srotasa) e.g. blood vessels and whole body i.e. at cellular level (sarva sharira). Therefore, Vyana vata kshaya leads to disturbance in the circulation either due to decreased SVR resulting from incompetent blood vessels (srotasa), or due to negative inotropic and chronotropic effects on the heart.

Other pathway of vitiation leads to vata becoming excessively dominant. In this condition body exhibits enhanced characteristics of vata in structure and function e.g. loss of elasticity (due to excessive ruksha guna). When vata dosha is vitiated its inherent properties (atma guna) appear in aggravated or exaggerated form⁵¹ in the specific sites of the type of vata that is vitiated. Vitiated Vyana vata also causes stiffness and deranged movements at its specific site i.e. heart and throughout the body (hridaya and sarva sharira). Vitiated Vyana vata causes stiffness⁵² of srotasa leading to loss of compliance (due to ruksha guna of vata dosha). Evidently vitiation of Vyana vata results in hardened blood vessels that offer more resistance to the blood flow.

Vitiated vata also affects the tissues (dhatu). Through deranged movement of electrolytes and metabolites through the srotasa, physical and chemical properties of Rakta dhatu (e.g. viscosity) are altered. This influences rheology and pressure of blood. As site of Vyana vata is heart and whole body therefore its vitiation affects the flow of blood throughout the body. Body responds to these changes by initiating compensatory processes e.g. change in vascular tone.

Along with the non-modifiable genetic predispositions (Prakriti) and modifiable factors diet and lifestyle (ahara and vihara), the above pathological events pave way for essential hypertension.

Table:1



8. Conclusion

Essential or primary hypertension has a multifactorial origin. These factors can be classified as modifiable or non-modifiable. Assessment and examination of the patient unveil substantial information about the factors related to genetic predispositions (prakriti) of a patient e.g. sodium conservers (salt sensitivity). Vyana vata controls the heart and blood circulation thus maintains the blood pressure in physiological range for optimal organ perfusion. In vitiated state it imparts its properties (guna) in aggravated form to its site of function i.e. heart and blood vessels. This leads to loss of elasticity or compliance and hardening of these important structures of circulatory system. Resultantly there is a pathological rise in vascular resistance causing elevated blood pressure or hypertension.

According to ayurvedic classics vitiation of Vyana vata may result individually due to its own specific causes (nidana), which is called independent (svatantra) vitiation. It can also be caused by obstructive pathologies due to vitiation of other dosha i.e. pitta and kapha. It can also be vitiated as a result of vitiation of Prana vata induced alterations. Thus, it can be concluded that although Rakta dhatu, Prana vata, kapha and pitta dosha have their own share in genesis of essential hypertension, vitiation of Vyana vata is the cornerstone in each and every pathological pathway for the disorder.

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