Management of Hypertension by Ayurvedic Principles.

Pravin Ashok Mali*1, Dinesh Mali2

1. HOD & Reader, Dept. of Kayachikitsa,
2. Lecturer, Dept. of Shalya Tantra,

K.D.M.G.S Ayurvedic College, Chalisgaon, Dist- Jalgaon, Maharashtra, India

*Corresponding author: drpravinmali79@gmail.com

Abstract
Different theories have been proposed to explain hypertension from an Ayurvedic perspective, but there is no consensus amongst the experts. A better understanding of the applied physiology and etio-pathogenesis of hypertension in the light of Ayurvedic principles is being attempted to fill this gap. A detailed review of available Ayurvedic literature was carried out to understand the physiology of blood pressure and etio-pathogenesis of hypertension from the perspective of Ayurveda. Many parallels were drawn from the concepts such as Shad Kriyakala (six stages of Dosha imbalance) and Avarana of Doshas (occlusion in the normal functioning of the Doshas) to the modern pathogenesis of hypertension to gain a deeper understanding of it. Hypertension without specific symptoms in its mild and moderate stages cannot be considered as a disease in Ayurveda. It appears to be an early stage of pathogenesis and a risk factor for development of diseases affecting the heart, brain, kidneys and eyes etc. Improper food habits and modern sedentary lifestyle with or without genetic predisposition provokes and vitiates all the Tridoshas to trigger the pathogenesis of hypertension. It is proposed that hypertension is to be understood as the Prasara-Avastha which means spread of vitiated Doshas from their specific sites, specifically of Vyana Vata, Prana Vata, Sadhaka Pitta and Avalambaka Kapha along with Rakta in their disturbed states. The Avarana (occlusion of normal functioning) of Vata Dosha by Pitta and Kapha can be seen in the Rasa-Rakta Dhathus, which in turn hampers the functioning of the respective Srotas (micro-channels) of circulation.

Keywords: Hypertension, Ayurveda, Blood pressure, Rakta-chap, Raktadab, Etio-pathogenesis

1. Introduction
In this modern era of specialties and super-specialties in medical care, Ayurveda stands out by its holistic approach towards the body as one single entity. The body with all its parts co-existing with interdependence and mutual interaction makes it difficult to comprehend when approached separately. In recent times, humanity has begun to realize this holistic approach to health with the
multidimensional aspects of body, mind and soul [1] preached by Ayurveda ages ago. In the present times, life has been made easy for man with modernization every step of the way, but he has also paid for it by becoming prey to many lifestyle diseases. The diseases occur due to his faulty life style and stressful psychological conditions. These factors affect one’s mind and homeostasis of the body by several psychosomatic mechanisms and lead to many lifestyle diseases such as diabetes and hypertension. As per World Health Organization report, about 40% of people aged more than 25 years had hypertension in 2008 [2]. Hypertension is directly responsible for 57% of all stroke deaths and 24% of all coronary heart disease (CHD) deaths in India [3]. It is the most potent risk factor for diseases of the brain, kidney, heart and peripheral arteries which may prove fatal if not managed effectively [4]. Hypertension is a silent killer because most sufferers (85%) are asymptomatic [5]. In 95% of the cases of hypertension, the exact underlying causes are still unknown [6] but is believed to be due to genetic and environmental factors [7].

Hypertension cannot be considered as a Vyadhi (disease) as per Ayurveda but it can be understood by assessing the involved Doshas, Dooshyas (entity which is affected by morbid Dosha), Srotas etc. Many Ayurvedic scholars have proposed different theories about how hypertension can be understood in Ayurveda, but there is no standardized and widely accepted view about the Ayurvedic pathogenesis of this condition. There are still many controversies related to this disease in Ayurveda. Thus, this is an attempt to thoroughly understand hypertension and interpret it in terms of Ayurvedic principles, considering all the existing views.

2. Previous theories – Ayurvedic view

Various Ayurvedic scholars have coined different names for hypertension such as: Raktagata Vata, Siragata Vata, Avrita Vata, Dhamani Prapurana, Rakta Vikshepa, Vyana Prakopa, Raktamada, Uchharaktachapa, Vyana Atibala etc. [8]. In each of these terms, different points of view have been adopted, but no one has denied the fact that in hypertension, the main pathogenesis occurs in Rakta along with the blood vessels. This being the only factor in common, many previous authors have given separate views on the Ayurvedic pathogenesis of this condition. As modern science is well advanced in understanding hypertension, we must understand all that is known about this disease and suitably correlate it to Ayurvedic principles for better understanding.

3. Concept of blood pressure in Ayurveda

At first, it is essential to understand the physiological aspects of blood pressure in Ayurveda which is fundamentally based on the theory of Tridosha [9]. The blood first ejected out of the heart, is then distributed to all parts of the body, and, thereafter, is returned back to the heart through the blood vessels termed as ‘Sirah’ in Ayurveda [10]. This return of Rasa (blood) towards heart is controlled by the function of Samana Vata [9], [11]. As it is known, blood pressure is the lateral pressure exerted by the flow of blood on the walls of the arteries [12]. The two components of blood pressure are the systolic and diastolic blood pressure [13]. The heart has its pacemaker (SA node) that generates electrical impulses on its own, which makes the heart contract during the systole. This self-excitatory function of the heart
can be attributed to the functioning of the Vata Dosha, in particular the Vyana Vata as it is seated in the heart and is responsible for blood circulation [9], [14]. Charaka clearly describes that Vyana Vata, a component of Vata Dosha constantly forces the blood out of the heart and distributes it [9], [15]. Thus it can be said that the systolic BP attained during contraction of the heart is controlled by Vata (Vyana Vata). Though the SA node generates impulses on its own, the rate of its impulse generation is controlled by the autonomic nervous system via sympathetic and para-sympathetic nerve fibers emerging from the brain. It is the Prana Vata situated in the Moordha (Brain) [Ashtanga Hridaya, Sutra Sthana, 12/4] that controls the Hridaya (heart) and does Dhamani Dharana (arterial perpetuation) [16] and thus heart rate is controlled by Prana Vata. In this context it can be understood as Vyana Vata and Prana Vata denote the nervous control of circulation because Vata, in general, denotes all neural mechanisms [9], [17]. The diastole is attained when the heart muscles relax. Here, diastolic blood pressure is only due to blood flowing through the narrow structures of the chambers of the heart and arteries and there is no active push by the heart. Thus diastolic BP can be taken under the domain of Kapha Dosha (Kapha maintains the structural integrity of body organs), mainly the Avalambaka Kapha [Ashtanga Hridaya, Sutra Sthana, 12/15] because it is the resistance offered by the structure of the heart and the blood vessels that controls the diastolic blood pressure. Thus the peripheral resistance (faced by blood in the blood vessels) determines the diastolic BP. This is mainly influenced by the diameter and elasticity of the blood vessels which can be considered under the purview of Kapha Dosha. The vascular tone is also controlled by the autonomic nervous system which alters the diameter of the arteries as and when required [18]. As Dhamani Dharana is a function of Prana Vata [Asthanga Samgraha, Sutra Sthana, 20/2], the peripheral resistance offered by the arteries due to vasoconstriction caused by sympathetic action of nerves can be understood as a function of Prana Vata. The Auto-rhythmicity of the heart is due to the action potential created by the rapid influx of Na+ and Ca++ ions and efflux of K+ ions across the membrane of the SA node [19]. The involvement of these chemical ions can be taken under the purview of Pitta due to its Tikshna (rapidness) Drava (fluidity) and Sara (diffusion/dispersion) Guna, [Asthanga Samgraha, Sutra Sthana, 1/26] mainly Sadhaka Pitta situated in the heart. The basal metabolic rate (BMR) has a direct but imperfect positive correlation with the pulse rate and pulse pressure of the heart [20]. This is on the basis of Read's and Gale's formulae [21], [22]. This means to say that variations in the basal metabolic rate cause changes in blood pressure as well. Thus the basal metabolic rate can be understood as a result of the action of Agni or Pitta, more precisely, Pachaka Pitta [Ashtanga Hridaya, Sutra Sthana, 12/10–12]. The blood volume and viscosity can be determined by the quality and quantity of the Rasa and Rakta Dhatus. These also determine the cardiac output. The heart (Hridaya) and the blood vessels (Rasavaha Srotas) form the Prana Vaha Srotas and their Srotomulas which are mainly involved in the blood circulation [23] along with that Medavaha Srotas, Mutarvaha Srotas, Swedavaha srotas and Udakavaha Srotas play an important role. Thus the Doshas, Dhatus and Srotas
4. Blood pressure regulation and the role of Tridosha

Blood Pressure in the body is regulated by multiple mechanisms. Short-term Neural mechanisms and Long-term Renal, Hormonal and Local vascular mechanisms [9].

Short term mechanisms include the Nervous mechanism controlled by the vasomotor center of the brain via autonomic stimulation through Baroreceptor and feedback of Chemoreceptors [24], [25]. This CNS regulation of Blood pressure can be understood mainly as a Vata function, typically Prana Vata (taking the help of Kapha in case of Baroreceptors and Pitta in case of Chemoreceptors).

Long term regulation of blood pressure is by:

1) Pressure Diuresis and Pressure Natriuresis – Kidneys excrete water and sodium through urine (Kleda nirvahanam) [Asthanga Samgraha, Sutra Sthana, 19/20] to bring down the blood volume to regulate the blood pressure. This mechanism can be attributed to elimination of Kapha in the form of Kleda by the function of Apana Vata [Asthanga Samgraha, Sutra Sthana, 20/2]

2) Renin-Angiotensin Mechanism – The Kidneys secrete Renin in response to low blood pressure as a result of which Angiotensin II is secreted to bring about vasoconstriction along with defective sodium and water homeostasis and thereby increasing blood pressure [26]. This can be attributed to the function of Pitta.

3) Hormonal regulation of Blood pressure: There are about 15 different hormones secreted which can create variations in the blood pressure. They are involved in the blood pressure have been discussed.

Adrenalin, Nor-Adrenalin, Thyroxin, Aldosterone, Vasopressin, Angiotensins, Serotonin, Bradykinin, Prostaglandins, Histamine, Acetylcholine, Atrial Natriuretic Peptide etc. [27].

All these being chemical substances causing regulation of blood pressure, may come under the perview of Pitta Dosha.

4) Local mechanism of BP regulation at the blood vessel level- There are local vasoconstrictors like endothelins and local vasodilators like CO2, H+ ions, Lactate, Adenosine and Nitric oxide which cause change in peripheral resistance thus influencing the BP [28]. This again can be understood as a function of Pitta.

Thus, the role played by the Tridoshas in regulation of blood pressure has been discussed.

5. Etiological risk factors related to hypertension

By definition, the causes of essential hypertension are unknown but many genetic and environmental factors and their mutual interactions act as risk factors for the development of this condition [7]. These factors are: high salt and spicy food intake, alcohol consumption and use of tobacco, low Calcium and Potassium intake, psychological stress, heredity, intake of fatty food which causes obesity and hyperlipidemia leading to atherosclerosis in blood vessels and physical inactivity (sedentary lifestyle) [29]. Among these, high salt and spicy food, alcohol consumption, use of tobacco, low Calcium and Potassium intake and psychological stress may vitiate Pitta, Vata and Rakta, while physical inactivity, dullness and habitual intake of fatty foods are Kapha and Medovardhaka Nidanas (etiological factors increasing fat) [Charaka Samhita, Sutra Sthana, 21/4]. Family history (heredity) is due to Beeja
dosha (genetic defects). Most of these Nidanas are mentioned together as Rakta Dusti Karana by Charaka in the Vidhishonitiya Adhyaya [Charaka Samhita, Sutra Sthana, 24/5–10] and in the context of Pittaja Hridroga [Charaka Samhita, Sutra Sthana, 17/32].

6. Pathology of hypertension in Ayurveda based on the modern view

Essential hypertension is defined as chronic elevation in arterial blood pressure (BP) > 140/90 mmHg with no definable causes [30]. The various genetic and environmental factors mentioned earlier interact with each other and influence the pathogenesis of this condition. The main determinants of blood pressure as seen earlier are the cardiac output and peripheral resistance. Cardiac output is determined by the stroke volume and heart rate [31]. So, for increase in blood pressure, there should be increase in either cardiac output or peripheral resistance. This happens when due to the influence of risk factors one or more of the different regulatory mechanisms of blood pressure gets hampered causing the blood pressure to increase. Defects in renal Sodium homeostasis causes decreased Na excretion leading to increased salt and water retention [32]. This increases the plasma and extra cellular fluid thus increasing the cardiac output. This is one mechanism which leads to hypertension. This may be understood as the pathology due to Dooshana (vitiation) of Pitta and Rakta due to Ati Katu & Lavana Rasa sevena (excess intake of pungent and salty items) [Charaka Samhita, Chikitsa Sthana, 4/6]. The other mechanism is increased functional vasoconstriction due to impaired hormonal actions leading to increased peripheral resistance [33]. This may be understood as Pitta Dushti due to endocrinal defects. Impaired functioning of the autonomic nervous system causing rise in blood pressure may be seen as Dushti of Vata. Sushruta has mentioned that Vata Dooshita Rakta (blood vitiated by Vata) is both Sheeghra gama (fast moving) and Askandi (hemodilution) [Sushruta Samhita, Sutra Sthana, 14/21]. Both these factors lead to changes in peripheral resistance. Hemodilution increases cardiac output [34] and Vata being Ruksha (dry) and Sheeta (cold) in nature may causes stiffness of vessels which increases peripheral vascular resistance and leads to hypertension [35].

The third mechanism is due to defects in the vascular smooth muscles (atherosclerotic changes caused by factors like hyperlipidemia) where the blood vessels lose their normal tone and this increases peripheral resistance, thus causing hypertension [36]. This pathology may be due to the vitiation of Kapha Dosha and Medo Dhathu. Based on these points it can be deduced that the pathology of hypertension involves one or all the three Doshas which in turn affects the Rasa and Rakta Dhatus to cause this condition.

7. Concept of Avarana in the pathogenesis of hypertension

As blood circulation is mainly the function of Vata (Vyana vata) [9], its impairment is certain in Hypertension [37] It may be impaired by its own Prakopa (aggravation) due to Vataja Nidanas (etiological factors for Vata) or may get vitiated by the influence of other Doshas and Dhathus. This is where the concept to occlusion of normal functioning of Vata plays a major role in the pathogenesis of hypertension. The normal course of Vata can be occluded by Pitta, Kapha, Rakta and or Medas [Charaka Samhita, Chikitsa Sthana; 28/61–69]. These Anya-Dosha Avarana
pathologies can be considered under the hypertension due to increased hormonal and enzymal action [38], decreased sodium excretion [39], change in the chemical constituents in the blood and atherosclerotic changes in the arteries due to lipid deposition [40]. Another type of occlusive pathology happens when there is Anyonya Avarana of Vata (mutual occlusion between subtypes of Vata). The subtypes of Vata such as Prana and Vyana Vata obstruct each other and cause the disease [Charaka Samhita, Chikitsa Sthana, 28/200–215]. This condition can be considered as hypertension due to hampered autonomic nervous system as it plays an important role in the regulation of blood pressure [41], [42], [33]. Charaka and Sushruta have enumerated and explained many different types of mutual occlusions of Dosha and occlusion of one Dosha by other Dosha or Dhatu and in many of these conditions; symptoms of hypertension such as giddiness, headache, and fatigue have been mentioned. These conditions are: Pittavritavata, Vyanavrita Prana, Pittavrita Prana, Pittavrita Vyana, Pittavrita Samana and Pittavrita Udana [Charaka Samhita, Chikitsa Sthana, 28/221–230]. Other conditions where these symptoms are seen together are Amashayagata Vata [Sushruta Samhita, Nidana Sthana, 1/32–39]. Rakta Dushti & Pradoshaja Vikara [Charaka Samhita, Sutra Sthana, 24/5–10] and Pittaja Hridroga [Charaka Samhita, Sutra Sthana; 17/32]. Vyana Vata is said to be responsible for Sweda (sweat) and Asruk Sravana (ejection of blood) and if it gets vitiated it produce diseases which will affect the entire body [Charaka Samhita, Sutra Sthana, 24/11–16]. This can be correlated to hypertension as excessive perspiration is a symptom of hypertension.

8. Symptomatology of hypertension and Samprapti based on Kriyakala

Mild to moderate hypertension in most cases does not exhibit any symptoms. But sudden or severe hypertension produces symptoms like headache, giddiness, palpitations, excessive sweating, fatigue, exertion dyspnoea and insomnia [43]. In Ayurveda, a disease should have specific Lakshanas (symptoms) to be called a Vyadhi [44], thus hypertension being asymptomatic (in its mild and moderate forms) is not described as a disease in Ayurveda. In the different stages of a disease, Prasarvastha is the stage where the Doshas move out from their respective sites and along with Rakta circulate all over the body, causing certain mild, nonspecific symptoms [Sushruta Samhita, Sutra Sthana, 21/28]. This in turn hampers the functions of the respective Srotas in the beginning and later they bring about structural changes as well, leading to Kha-Vaigunya. Then, these Doshas get lodged at susceptible sites of Kha-Vaigunya which in this case can be: heart, brain, kidneys, eyes and blood vessels. It is at this stage that the actual Sthana Samshraya (vitiated Doshas getting stuck in a particular site) and Vyakta Avastha (manifestation of specific symptoms) occur, causing diseases of these vital organs. Later, in the Bheda avastha (complicated stage), there occurs severe damage to these organs, making the disease Asadhya (incurable) and sometimes leading to death itself. Thus, hypertension can be taken as a sub-clinical condition where the disease process is still in progress making it a risk factor for more dangerous diseases of the heart, brain, kidneys, eyes etc. according to Ayurveda.

9. Principles of management

Ayurveda gives more emphasis to the
prevention and promotion of the health. Avoiding etiological factors of disease is considered as the first line of management [Sushruta Samhita of Sushruta, Uttara Tantra, 1/25]. In the management of hypertension, non-pharmacological methods such as correction of lifestyle, diet etc. is proven to reduce the risk of Coronary heart disease (CHD) which is leading cause of morbidity and mortality worldwide [45]. The role of Ayurveda is more pertinent here, many of the chapters in classical texts such as Dinacharya Adhyaya, Ritucharya Adhyaya, Matrashteeeya, Navegannadharniya Adhyaya etc. are particularly dedicated to healthy lifestyle. These include the harmonious living pattern by a deeper understanding of human life and its interaction with nature. Adopting Ayurveda guidelines may be helpful to reduce the increasing incidence and management of lifestyle disorders which include hypertension [46], [47]. This will also reduce the risks which are associated with the drug therapy. Long-term drug treatment can be expensive and side-effects can threaten patients' adherence to the medicines [48]. In general, reducing body weight, stopping smoking, healthy diet and increasing physical exercise are routinely recommended by most of the physicians [49]. While treating this condition Prasara Avastha of all the Tridosha and Rasa, Rakta and Meda Dushti should be taken in to consideration and along with lifestyle modifications, appropriate Vata Anulomana (maintaining normal course of Vata) Tridoshahara (normalizing all Tridosha), and Rasa, Rakta Prasadakar (blood purifying), Medohara (reducing excess fat) Chikitsa may be adopted.

10. Conclusion

Improper life-style and food habits, psychological stress factors like Atichinta (excess worry), Bhaya (fear), Krodha (anger), Alasya (dullness) etc., with or without genetic predisposition provokes and vitiates all the three Doshas to trigger the pathogenesis of hypertension. Anya Dosha Avarana and Anyonya Avarana are the mechanisms of pathogenesis. Though modern science considers hypertension as a disease, from the Ayurveda point of view it should be understood as the Prasaravastha of all the Doshas along with Rakta which circulate all over the body until they get lodged at a site of Kha-Vaigunya. This decides the organ of impact of the disease process (whether brain, heart, kidneys, eyes or blood vessels). With the help of recent advancements in the medical science the, diagnosis of this condition has been made possible at an early stage and thus effective management can be offered at this stage itself to avoid risk of damage to vital organs. Thus, hypertension can be understood as a psycho-somatic hemodynamic condition where Vata Pradhana Tridoshas are vitiated affecting the Rasa-Rakta Dhatas as Dooshyas with both Sarva Shareera (whole body) and Manas (mind) as its Adhisthana (site). For effective management of hypertension, lifestyle modifications should be given more emphasis and if necessary appropriate drug therapy should also be given.

References

1. Ross C.L. Integral healthcare: the benefits and challenges of integrating complementary and alternative medicine with a conventional healthcare practice. Integr Med Insights. 2009:4:13–20. [PMC free article] [PubMed]
2. World Health Organization- 2013. Global brief on hypertension.http://apps.who.int/iris/bitstream/10665/79059/1/WHO_DCO_WHD_2013.2_eng.pdf?ua=1 [Accessed on 7 July 2017] [Google Scholar]

3. Gupta R. Trends in hypertension epidemiology in India. J Hum Hypertens. 2004;18:73–78. [PubMed] [Google Scholar]

4. Kannel W.B. Hypertension: reflections on risks and Prognostication. Med Clin North Am. 2009;93(3) 541-Contents. [PMC free article] [PubMed] [Google Scholar]

5. Chen S. Essential hypertension: perspectives and future directions. J Hypertens. 2012;30(1):42–45. [PMC free article] [PubMed] [Google Scholar]

6. Nguyen Q., Dominguez J., Nguyen L., Gullapalli N. Hypertension management: an update. Am Health Drug Benefits. 2010;3(1):47–56. [PMC free article] [PubMed] [Google Scholar]

7. Forjaz C.L.M., Bartholomeu T., Rezende J.A.S., Oliveira J.A., Basso L., Tani G. Genetic and environmental influences on blood pressure and physical activity: a study of nuclear families from Muzambinho, Brazil. Braz J Med Biol Res. 2012;45(12):1269–1275. [PMC free article] [PubMed] [Google Scholar]

8. Dhamle Madhumati. Department of Basic Principles, Institute of Post Graduate Teaching and Research in Ayurveda; 2001. Post Graduate Thesis on – the study of Yojana-Chatushka of Charaka and Yojana for the management of RaktashritaVyadhi (hypertension) [Google Scholar]

9. Patwardhan K. The history of the discovery of blood circulation: unrecognized contributions of Ayurveda masters. Adv Physiol Educ. 2012;36:77–82. [PubMed] [Google Scholar]

10. Joshi H., Singh G., Patwardhan K. Ayurveda education: evaluating the integrative approaches of teaching Kriya Sharira (Ayurveda physiology) J Ayurveda Integr Med. 2013;4(3):138–146. [PMC free article] [PubMed] [Google Scholar]

11. Shristava S., editor. Sharngadhara Samhita of Sharngadhara. Chaukhambha Orientalia; Varanasi, India: 2013. p. 52. Purva Khanda, Chapter 6, Verse 8. [Google Scholar]

12. Xu C., Xiong H., Gao Z., Liu X., Zhang H., Zhang Y. Beat-to-Beat blood pressure and two-dimensional (axial and radial) motion of the carotid Artery wall: physiological evaluation of arterial stiffness. Sci Rep. 2017;7:42254. [PMC free article] [PubMed] [Google Scholar]

13. Franklin S.S., Lopez V.A., Wong N.D., Mitchell G.F., Larson M.G., Vasan R.S. Single versus combined blood pressure components and risk for cardiovascular disease: the Framingham heart study. Circulation. 2009;119(2):243–250. [PMC free article] [PubMed] [Google Scholar]

14. Paradkar H., editor. Ashtanga Hridaya of Vagbhata (with the
commentaries “Sarvanga Sundara” of Arunadatta and “Ayurveda rasayana” of Hemadri) Chaukhamba Surbharati Prakashana; Varanasi, India: 2002. p. 193. Sutra Sthana; Doshabhediya Adhyaya, Chapter 12, Verse 6. [Google Scholar]

15. Tripathy Brahmananda., editor. Caraka Samhita of Agnivesha, Charaka Chandrika Hindi commentary. 1st ed. Chaukhamba Orientalia; Varanasi: 1999. p. 558. Chikitsa Sthana; Grahanidosha chap. 15, Verse 36. [Google Scholar]

16. Murthy Srikantha K.R., editor. Astanga Samgraha of Vagbhata. 9th ed. Chowkhamba orientalia; Varanasi: 2012. p. 368. Sutra Sthana, Doshabhedeeya Adhyaya, Chap 20, Verse 2. [Google Scholar]

17. Tripathi P, Patwardhan K, Singh G. The basic cardiovascular responses to postural changes, exercise, and cold pressor test: do they vary in accordance with the dual constitutional types of Ayurveda? Evid Based Complement Altern Med; doi:10.1155/2011/251850. [PMC free article] [PubMed]

18. Gordan R., Gwathmey J.K., Xie L.-H. Autonomic and endocrine control of cardiovascular function. World J Cardiol. 2015;7(4):204–214. [PMC free article] [PubMed] [Google Scholar]

19. Sembulingam, Sembulingam Prema. 5th ed. Jaypee brothers medical publishers (P) Ltd.; New Delhi: 2010. Properties of cardiac muscle. Essentials of medical physiology; p. 509. [Google Scholar]

20. Snodgrass J.Josh, Leonard William R., Sorensen Mark V., Tarskaia Larissa A., Mosher M.J. The influence of basal metabolic rate on blood pressure among indigenous Siberians. Am J Phys Anthropol. 2008 Oct;137(2):145–155. [PubMed] [Google Scholar]

21. Reule S., Drawz P.E. Heart rate and blood pressure: any possible Implications for management of hypertension? Curr Hypertens Rep. 2012;14(6):478–484. [PMC free article] [PubMed] [Google Scholar]

22. Fronczek R., Overeem S., Reijntjes R., Lammers G.J., van Dijk J.G., Pijl H. Increased heart rate variability but normal resting metabolic rate in hypocretin/orexin-deficient human narcolepsy. J Clin Sleep Med JCSM. 2008;4(3):248–254. [PMC free article] [PubMed] [Google Scholar]

23. Trikamji J., Ram N., editors. Commentary Nibandha Sangraha of Dalhana on Sushruta Samhita of Sushruta, Sharira Sthana; Dhamaneyakaranam Shareeram Adhyaya. 1st ed. Chaukhambha Sanskrit Sansthan; Varanasi: 2012. p. 386. Ch. 8, Verse 12. [Google Scholar]

24. Zanutto B.S., Valentinuzzi M.E., Segura E.T. Neural set point for the control of arterial pressure: role of the nucleus tractus solitarius. Biomed Eng OnLine. 2010;9:4. [PMC free article] [PubMed] [Google Scholar]

25. Timmers H.J.L.M., Wieling W., Karemaker J.M., Lenders J.W.M. Denervation of carotid baro- and chemoreceptors in humans. J
26. Kotsis V., Stabouli S., Papakatsika S., Rizos Z., Parati G. Mechanisms of obesity-induced hypertension. Hypertens Res. 2010;33:386–393. [PubMed] [Google Scholar]

27. Chopra S., Baby C., Jacob J.J. Neuro-endocrine regulation of blood pressure. Indian J Endocrinol Metab. 2011;15(Suppl. 4):S281–S288. [PMC free article] [PubMed] [Google Scholar]

28. Aliya S. Effects of vasodilation and arterial resistance on cardiac output. J Clin Exp Cardiol. 2011;2:170. [Google Scholar]

29. Buttar H.S., Li T., Ravi N. Prevention of cardiovascular diseases: role of exercise, dietary interventions, obesity and smoking cessation. Exp Clin Cardiol. 2005;10(4):229–249. [PMC free article] [PubMed] [Google Scholar]

30. Messerli F.H., Williams B., Ritz E. Essential hypertension. Lancet. 2007 Aug 18;370(9587):591–603. PMID: 17707755. [PubMed] [Google Scholar]

31. Vincent J.-L. Understanding cardiac output. Crit Care. 2008;12(4):174. [PMC free article] [PubMed] [Google Scholar]

32. Wang D., Wang Y., Liu F.-Q., Yuan Z.-Y., Mu J.-J. High salt diet affects renal sodium excretion and ERRα expression. Int J Mol Sci. 2016;17(4):480. Mihailidou AS, ed. [PMC free article] [PubMed] [Google Scholar]

33. Charkoudian N., Rabbitts J.A. Sympathetic neural mechanisms in human cardiovascular health and disease. Mayo Clin Proc. 2009;84(9):822–830. [PMC free article] [PubMed] [Google Scholar]

34. Vázquez B.Y.S., Martini J., Tsai A.G., Johnson P.C., Cabrales P., Intaglietta M. The variability of blood pressure due to small changes of hematocrit. Am J Physiol Heart Circ Physiol. 2010;299(3):H863–H867. [PMC free article] [PubMed] [Google Scholar]

35. Mayet J., Hughes A. Cardiac and vascular pathophysiology in hypertension. Heart. 2003;89(9):1104–1109. [PMC free article] [PubMed] [Google Scholar]

36. Leitschuh M., Chobanian A. Vascular changes in hypertension. 1987 Sep;71(5):827–841. PMID: 3306205. [PubMed] [Google Scholar]

37. Agrawal S., Pol H., From 5th World Ayurveda Congress 2012 Bhopal, Madhya Pradesh, India. 7–10 Dec 2012 PA01.17. A clinical study to evaluate the effect of extract based herbal formulation on hypertension – a single blinded standard controlled randomized study. Anc Sci Life. 2012;32(Suppl. 1):S66–S67. [Google Scholar]

38. Freel E.M., Connell J.M.C. Mechanisms of hypertension: the expanding role of aldosterone. J Am Soc Nephrol JASN. 2004;15(8):1993–2001. [PMC free article] [PubMed] [Google Scholar]

39. Ha S.K. Dietary salt intake and hypertension. Electrolytes Blood Press. 2014;12(1):7–18. [PMC free article] [PubMed] [Google Scholar]

40. Cecelja M., Chowienczyk P. Role
of arterial stiffness in cardiovascular disease. JRSM Cardiovasc Dis. 2012;1(4) cvd.2012.012016. [PMC free article] [PubMed] [Google Scholar]

41. Joyner M.J., Charkoudian N., Wallin B.G. A sympathetic view of the sympathetic nervous system and human blood pressure regulation. Exp Physiol. 2008;93:715–724. [PMC free article] [PubMed] [Google Scholar]

42. Wallin B.G., Charkoudian N. Sympathetic neural control of integrated cardiovascular function: insights from measurement of human sympathetic nerve activity. Muscle Nerve. 2007;36:595–614. [PubMed] [Google Scholar]

43. Katz J.N., Gore J.M., Amin A., Anderson F.A., Dasta J.F., Ferguson J.J. Practice patterns, outcomes, and end-organ dysfunction for patients with acute severe hypertension: the Studying the Treatment of Acute hyperTension (STAT) registry. Am Heart J. 2009;158(4):599–606. [PubMed] [Google Scholar]

44. Trikamji J., editor. Commentary Ayurveda Dipika of Chakrapanidatta, Charaka Samhita by Agnivesha, Sootra Sthana, Dirghamjivitiyam Adhyaya. 1st ed. Chaukhambha Orientalia; Varanasi: 2007. p. 7. Chap 1, Verse 24. [Google Scholar]

45. Mannu G., Zaman M., Gupta A., Hu R., Myint P. Evidence of lifestyle modification in the management of hypercholesterolemia. Curr Cardiol Rev. 2013;9(1):2–14. [PMC free article] [PubMed] [Google Scholar]

46. Patwardhan B. Public perception of AYUSH. J Ayurveda Integr Med. 2015;6(3):147–149. [PMC free article] [PubMed] [Google Scholar]

47. Chandola H.M. Lifestyle disorders: Ayurveda with lots of potential for prevention. Ayu. 2012;33(3):327. [PMC free article] [PubMed] [Google Scholar]

48. Kawachi I., Malcolm L.A. The cost-effectiveness of treating mild-to-moderate hypertension: a reappraisal. J Hypertens. 1991;9:199–208. [PubMed] [Google Scholar]

49. Elhani S., Cleophas T.J., Atiqi R. Lifestyle interventions in the management of hypertension: a survey based on the opinion of 105 practitioners. Netherlands Heart J. 2009;17(1):9–12. [PMC free article] [PubMed] [Google Scholar]

**Conflict of Interest:** Non

**Source of funding:** Nil

**Cite this article:**

Management of Hypertension by Ayurvedic Principles.

Pravin Ashok Mali, Dinesh Mali

Ayurlog: National Journal of Research in Ayurved Science- 2020; (8) (4):01- 11