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IMPACT OF BLOOD PRESSURE ON SLEEP APNEA AND RESTLESS LEGS SYNDROME: A REVIEW

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Abstract
Sleep disorders such as sleep apnea and restless legs syndrome (RLS) are closely linked to both sleep quality and cardiovascular health, particularly blood pressure (BP). This review investigates the relationship between BP levels and the prevalence and severity of these disorders. Findings show a significant positive correlation between elevated BP and increased severity of sleep apnea, with hypertensive patients displaying higher apnea-hypopnea index (AHI) scores than normotensive individuals ($p < 0.05$). Similarly, elevated BP was associated with more frequent and severe RLS symptoms. These results suggest that hypertension may contribute to the pathophysiology of both conditions, potentially through vascular and neurological dysregulation. Recognizing this relationship could help clinicians tailor more effective treatment strategies for sleep disorder patients with hypertension. Further longitudinal and interventional studies are needed to clarify causality and guide clinical practice.

INTRODUCTION

The interaction among blood pressure regulation, sleep apnea, and restless legs syndrome (RLS) is increasingly realized as a significant field of investigation in cardiovascular and neurological science. Blood pressure is controlled by intricate interactions among the autonomic nervous system, vascular endothelial function, and hormonal regulation. Sleep pattern disturbances, like those due to obstructive sleep apnea (OSA) and RLS, have been known to substantially affect these control mechanisms. Chronic sleep disruption results in chronic sympathetic activation, decreased parasympathetic modulation, and endothelial dysfunction, all of which contribute to elevated blood pressure variability and risk of hypertension. Epidemiological research has shown the close relationship between hypertension and sleep disorders, especially OSA.[1]

Moderate to severe OSA patients have a significantly higher rate of hypertension than the general population. The OSA-associated intermittent hypoxia and disrupted sleep promote oxidative stress and inflammation, with resultant exacerbation of vascular stiffness and disturbed blood pressure control. Likewise, the RLS phenomenon of an unshakeable need to move one's legs and periodic limb movement during sleep is associated with increased nighttime blood pressure and autonomic dysfunction, but the underlying mechanisms are a field of ongoing study. The autonomic nervous system is important for the maintenance of cardiovascular stability, and its disturbance in sleep diseases is one of the main reasons for hypertension. In OSA, intermittent apneic events cause paroxysms of sympathetic discharge, resulting in brief but frequent elevations of blood pressure that continue even when awake.[2,3]

The two-way relationship between the two states indicates that successful treatment of one would be beneficial for the other. There are studies that prove treating OSA with CPAP therapy can decrease blood

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pressure, especially in resistant hypertension patients. Likewise, both pharmacological and non-pharmacological treatments of RLS like dopamine agonists, iron, and lifestyle interventions could enhance autonomic function as well as control of blood pressure. Longitudinal studies would be required, though, to ascertain the persistent impact of the interventions on cardiovascular events.[4]

In spite of increasing evidence associating sleep disorders and hypertension, a number of gaps exist in the current understanding. Numerous studies have presented mixed results on the strength and direction of these relationships, most probably because of differences in study populations, diagnostic definitions, and research designs. Large-scale, prospective studies with standardized measures of sleep quality, autonomic function, and blood pressure control are required to elucidate these associations and inform clinical decision-making. The recognition of the effect of sleep disorders on blood pressure control has significant clinical significance. Screening for OSA and RLS should be performed regularly in patients with hypertension, especially those with resistant or nocturnal hypertension. In contrast, patients with known sleep disorders need regular monitoring of blood pressure to identify early signs of hypertension. A multidisciplinary approach combining cardiology, sleep medicine, and neurology can maximize diagnosis, therapy, and long-term prognosis, ultimately lowering the cardiovascular disease burden of sleep disorders.[5]

2. Blood Pressure Regulation: Neurovascular and Endothelial Control

Blood pressure control is an intricate physiological mechanism regulated by neurovascular and endothelial processes that provide sufficient tissue perfusion and hemodynamic balance. The autonomic nervous system (ANS) is primarily responsible for the preservation of cardiovascular homeostasis by modulating sympathetic and parasympathetic activity. In healthy states, sympathetic stimulation raises cardiac output and vascular resistance during stress, with parasympathetic action opposing excessive increases in blood pressure. But in sleep disorders like obstructive sleep apnea (OSA) and restless legs syndrome (RLS), this equilibrium is lost, resulting in chronic hypertension and enhanced cardiovascular risk. ANS dysfunction is a well-established characteristic of hypertension, especially in patients with sleep disorders.[6]

Sympathetic nervous system (SNS) overactivation is a major cause of high blood pressure in OSA, where intermittent hypoxia induces repeated bursts of sympathetic outflow. These fluctuations result in abrupt rises in blood pressure and heart rate that persist after sleep and contribute to prolonged hypertension. Also, patients with RLS show increased sympathetic activation, demonstrated by elevated levels of plasma norepinephrine and shifted heart rate variability, reflecting persistent autonomic dysregulation. Disturbed baroreceptor sensitivity is another finding from ANS dysregulation in sleep disorders that results in nonuniform nocturnal blood pressure variation. The baroreceptors in the carotid sinus and aortic arch sense alterations in blood pressure and regulate autonomic responses in response.[7,8]

It has been demonstrated that chronic intermittent hypoxia in OSA lowers endothelial NO bioavailability, which further exacerbates hypertension and accelerates cardiovascular risk. Oxidative stress plays an important role in hypertension and sleep disorders pathophysiology as a common denominator between them. Enhanced production of ROS in OSA and RLS results in endothelial dysfunction, vascular inflammation, and decreased NO synthesis. Biomarkers of oxidative stress, including malondialdehyde and activity of superoxide dismutase, are increased in patients with sleep-disordered breathing and hypertension. The chronic oxidative load in these patients accelerates vascular aging by causing atherosclerosis and arterial stiffness.[9,10]

The desynchronization of biological rhythms in OSA and RLS impacts the secretion of important hormones like melatonin and cortisol, which modulate vascular tone and autonomic function. Disturbances in these hormonal rhythms are responsible for elevated nocturnal blood pressure and relate to the increased prevalence of resistant hypertension in sleep-disordered patients. With the close link between sleep disorders and hypertension, targeted interventions to treat autonomic and endothelial dysfunction are essential. CPAP therapy has been found to be effective in lowering nocturnal blood pressure in OSA patients by preventing hypoxia and sympathetic overactivity. Likewise,

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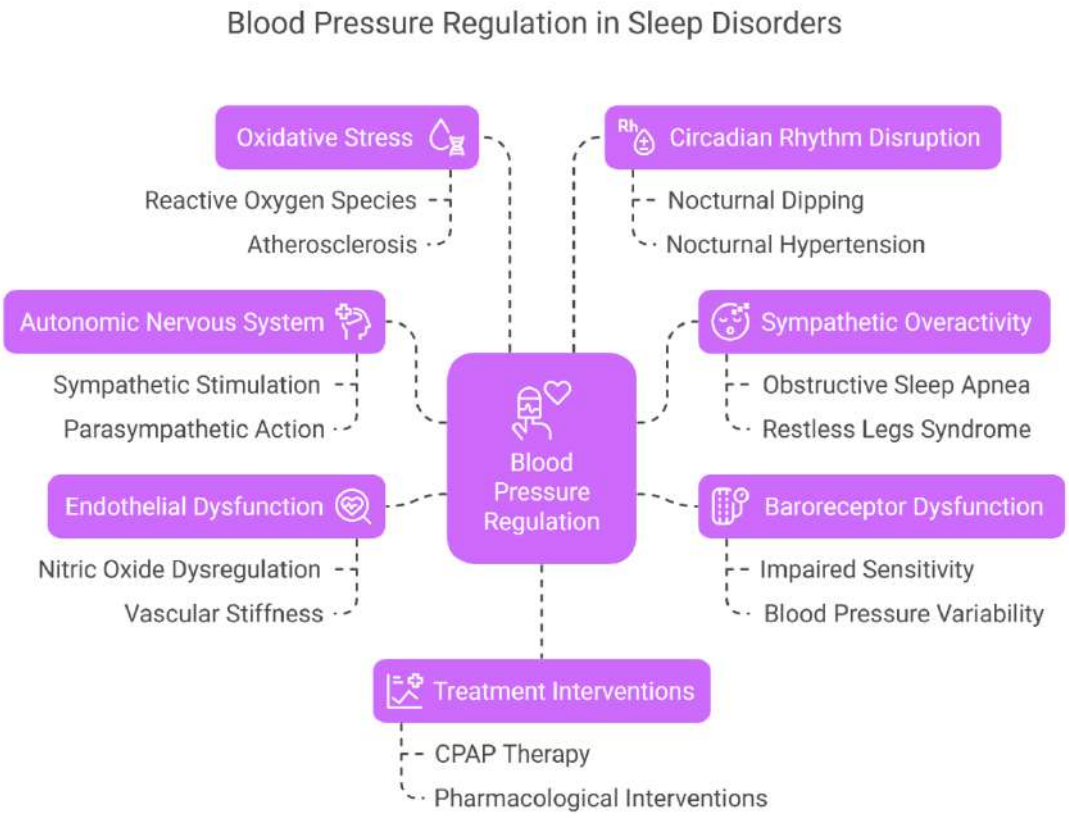
pharmacological interventions for RLS, including dopamine agonists and iron supplementation, can enhance autonomic balance and vascular function, potentially reducing hypertension risk in affected individuals. Future studies will aim to decipher the molecular mechanisms underlying blood pressure dysregulation and sleep disorders, opening avenues for new therapeutic options. Uncovering the mechanistic basis of autonomic and endothelial dysfunction in OSA and RLS will help us formulate personalized therapeutic regimens. Incorporating sleep evaluation into guidelines for hypertension will enhance cardiovascular prognosis and alleviate the sleep-related burden of cardiovascular disease.[11]



3. Sleep Apnea: Pathophysiology and Hypertension Correlation

Obstructive sleep apnea (OSA) is a disorder of sleep-related breathing that involves the recurrent collapse of the upper airway during sleep, with associated intermittent hypoxia and fragmentation of sleep. It has emerged as an increasingly recognized factor for the generation and exacerbation of hypertension. The pathophysiological connection between hypertension and these two conditions is multidimensional and involves systemic inflammation, overactivity of the sympathetic nervous system, and metabolic derangements. The cumulative result of these mechanisms is persistent blood pressure elevation that, if left untreated, leads to cardiovascular morbidity and mortality. Recent clinical and epidemiological studies have placed emphasis on the close link between severity of OSA and resistant hypertension, further pointing towards the importance of early diagnosis as well as directed therapeutic intervention. Intermittent hypoxia, a characteristic component of OSA, induces systemic inflammation by activation of several pro-inflammatory pathways.[12-13]

Night-time releases of the vasoactive hormones result in ongoing vasoconstriction and increased cardiac workload, eventually producing persistent hypertension. In the process, chronic sympathetic overdrive culminates in desensitization of the adrenergic receptors and decreases the gain of

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baroreceptor reflexes that otherwise provide the usual negative feedback to buffer fluctuations in blood pressure. This dysregulation, not only facilitates daytime hypertension, but also abrogates nocturnal dipping patterns of blood pressure, which enhances cardiovascular risk. Metabolic dysregulation is very much a part of the OSA-hypertension relationship, especially in the context of insulin resistance and obesity. OSA involves changes in glucose metabolism, with research showing that intermittent hypoxia may compromise insulin sensitivity and enhance hyperinsulinemia. Insulin resistance, in turn, leads to endothelial dysfunction and increased sodium retention, both of which raise blood pressure.[14,15]

Continuous positive airway pressure (CPAP) therapy is one of the most extensively researched therapeutic interventions for OSA-associated hypertension. By ensuring patency of the airway at sleep, CPAP efficiently abolishes nocturnal hypoxia, sympathetic overdrive, and sleep disruption. There have been many clinical trials that have shown that CPAP can result in major decreases in both systolic and diastolic blood pressure in patients with severe OSA. The degree of reduction in blood pressure is not uniform across persons, as some trials have shown only small decreases. These factors are likely to include CPAP compliance, baseline severity of OSA, and simultaneous antihypertensive medication.[16]

CPAP is still an anchor therapy for reducing the cardiovascular effects of OSA despite such differences. Outside of CPAP, novel treatment approaches targeting inflammation, oxidative stress, and metabolic dysregulation are under investigation for OSA-associated hypertension. Pharmacological interventions including angiotensin-converting enzyme (ACE) inhibitors, beta-blockers, and vasodilators have also been examined for their role in enhancing blood pressure management in patients with OSA. Lifestyle modifications such as weight reduction, dietary adjustments, and exercise have also been found to produce beneficial outcomes on decreasing both OSA severity and hypertension. Emerging interventions including hypoxia-mimetic therapy and antioxidant supplementation are being examined for their capability to prevent vascular dysfunction induced by OSA. Combination of several therapeutic strategies can offer better blood pressure control in OSA patients. Nocturnal hypertension, a distinctive phenotype seen in OSA patients, adds to the complexity of disease management.[17]

4. Hypertension in OSA

In contrast to essential hypertension, which has a diurnal rhythm with reduced blood pressure at night, OSA-associated hypertension is frequently associated with blunted or absent nocturnal dip in blood pressure. This non-dipping pattern is related to greater cardiovascular morbidity, such as a greater risk of stroke, myocardial infarction, and heart failure. Ambulatory blood pressure monitoring has been helpful in detecting abnormal nocturnal blood pressure patterns in OSA patients and enabling more accurate risk stratification and adjustment of treatment. Treatment of nocturnal hypertension by selective therapies is an active area of investigation. The bidirectional interaction between hypertension and OSA indicates that both conditions not only occur together but also worsen each other's severity. Hypertension can contribute to collapsibility of the upper airway by promoting vascular remodeling and neuromuscular control modifications, whereas hypertension due to OSA can accelerate the development of cardiovascular complications.[18,19]

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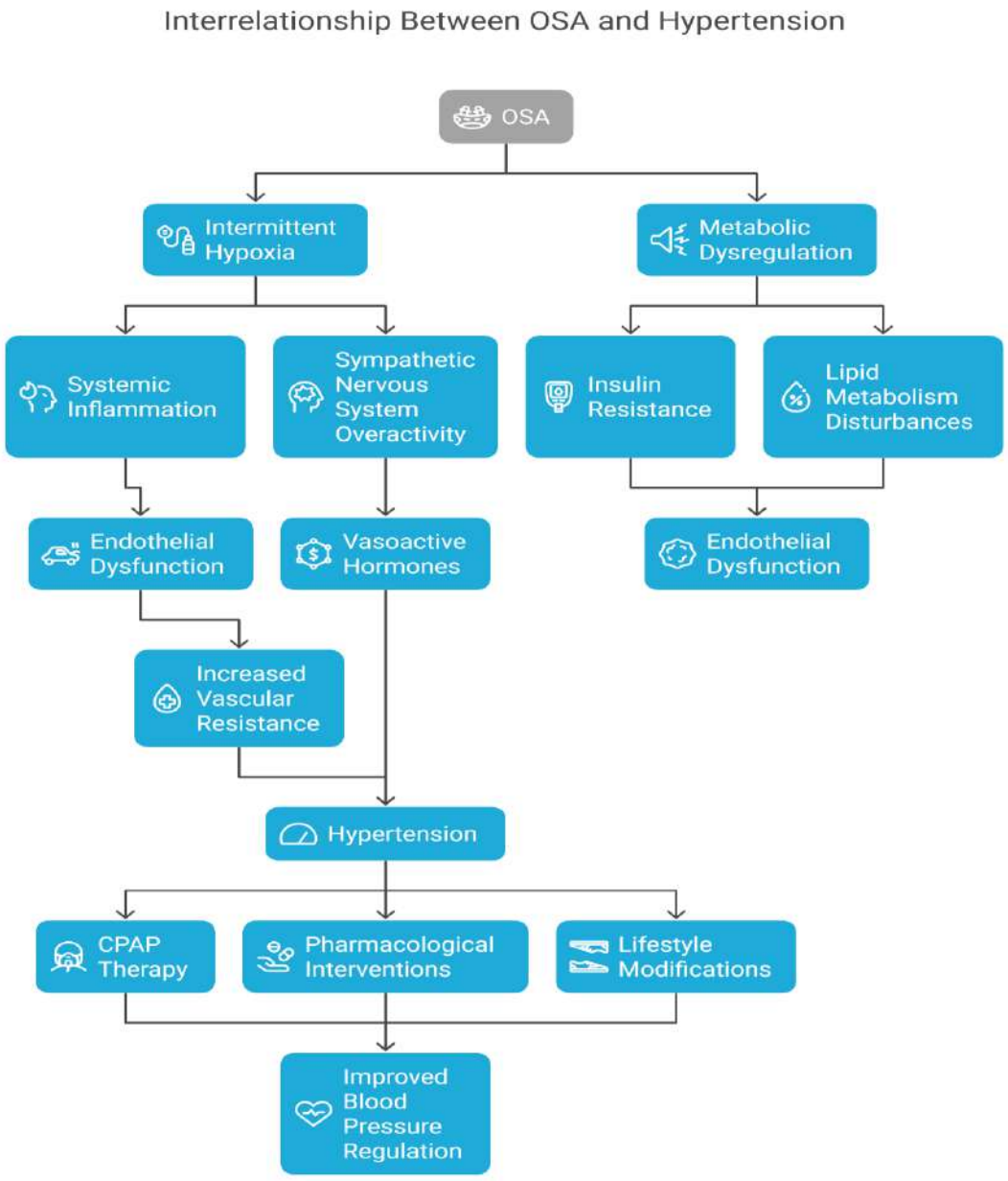

5. Restless Legs Syndrome (RLS): Neurovascular and Cardiovascular Implications

Obstructive sleep apnea (OSA) is a multifaceted sleep disorder that has a significant effect on cardiovascular well-being, specifically through the induction of hypertension. Marked by recurrent cycles of upper airway obstruction during sleep, OSA causes intermittent hypoxia, sleep fragmentation, and overactivation of the sympathetic nervous system. These disturbances induce a cascade of pathophysiological events, such as systemic inflammation, endothelial dysfunction, and metabolic dysregulation, all of which are contributory to persistent hypertension.[20]

Hypoxia induces nuclear factor-kappa B (NF-κB), which triggers the production of pro-inflammatory cytokines like tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6). Chronic inflammation also enhances vascular remodeling, augmented arterial stiffness, and decreased nitric oxide (NO) availability, all of which compromise vascular homeostasis. Endothelial dysfunction in patients with OSA is also

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further compounded by oxidative stress, with enhanced production of reactive oxygen species (ROS) that compromise vascular integrity and subject the individual to chronic hypertension. The sympathetic nervous system is instrumental in the interconnection between OSA and hypertension. Apneic events initiate recurrent arousal cycles, exciting chemoreceptors and stimulating the sympathetic drive.[21,22]

6. Mechanisms of OSA-Related Hypertension

Excess aldosterone has also been involved in increasing OSA severity through encouraging fluid accumulation within the upper airway, worsening collapsibility of the airway. The synergy between RAAS activation and sympathetic overdrive enhances the hypertensive effect seen in OSA patients. OSA is commonly found to be related to metabolic abnormalities, especially insulin resistance and dyslipidemia, both of which play roles in hypertension. Recurrent hypoxia and sleep fragmentation also change glucose metabolism, resulting in hyperinsulinemia and dyslipidemia. Insulin resistance then stimulates endothelial dysfunction and potentiates sympathetic overactivity, which exacerbates blood pressure increases. Obesity-associated OSA also further amplifies these metabolic derangements, as more body fat adds to systemic inflammation and elevated leptin levels, which are recognized to increase sympathetic tone and encourage hypertension.[23]

The nocturnal blood pressure profile of OSA patients is distinctly different from that of normotensive subjects. In normal physiological states, the blood pressure drops "dipping" by 10-20% during sleep. However, in OSA patients, this dipping pattern is usually abolished, resulting in nocturnal hypertension. The occurrence of non-dipping or even "reverse dipping" (paradoxical rise of blood pressure at night) is linked with an enhanced risk of cardiovascular complications, such as stroke and left ventricular hypertrophy. This abnormal nocturnal blood pressure fluctuation is a fundamental feature of OSA-related hypertension and underlines the need for nocturnal blood pressure measurement in such patients.[24,25]

The size of the blood pressure decrease is highly variable between patients, but with greater effects occurring in those who have a higher baseline blood pressure and good CPAP compliance. Aside from CPAP, lifestyle changes are equally important in treating both OSA and hypertension. Weight reduction, diet modification, physical exercise, and cessation of smoking have been reported to alleviate sleep apnea severity and lower blood pressure levels. In obese OSA patients, even small weight loss can cause major improvements in airway patency and nighttime oxygenation.[26,27]

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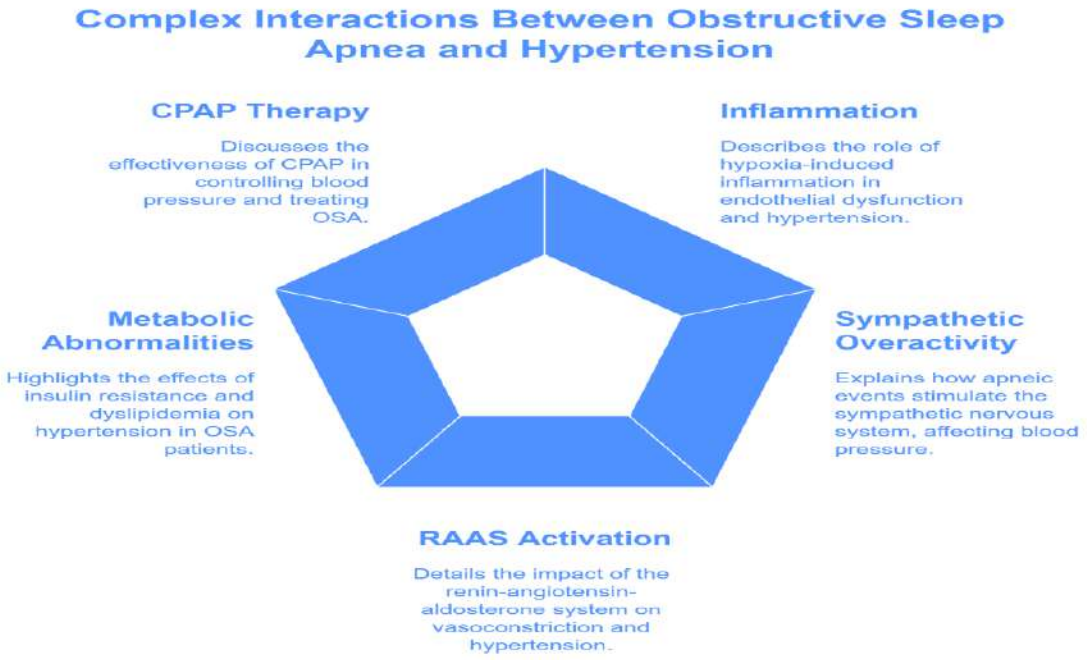

7. The Bidirectional Relationship: Hypertension as a Driver of Sleep Disorders

Sleep disorders and hypertension are highly interdependent with each other by neurovascular, hormonal, and endothelial mechanisms. Sleep disruptions like insomnia and obstructive sleep apnea are recognized to increase blood pressure. However, evidence is developing to indicate that high blood pressure also has a leading role to play in disrupting sleep. Augmentation of arterial stiffness, endothelial dysfunction, and dysregulation of the RAS all impede proper sleeping patterns to provide fragmented and compromised sleep. In addition, antihypertensive drugs, especially beta-blockers, can disrupt circadian rhythms, worsening sleep disturbances. Recognition of this bidirectional interaction is important for the design of targeted therapeutic interventions in comorbid hypertension and sleep disorders. Hypertension-related vascular stiffness is a major cause of the abnormality of sleep architecture.[28,29]

8. RAS Activation and Sleep Disruption

In addition, overactivation of RAS is a cause of autonomic instability, resulting in nocturnal blood pressure variability that interrupts sleep continuity. In addition to vascular disease, activation of RAS is a direct cause of central nervous system regulation of sleep.[30] Angiotensin II stimulates the paraventricular nucleus of the hypothalamus to increase sympathetic outflow and interrupt circadian rhythms of blood pressure. Experiments have established that angiotensin receptor blockers (ARBs) restore more physiological sleep patterns by mitigating these central effects. Furthermore, RAS inhibitors also lower systemic inflammation, which is a recognized contributor to sleep disturbance, further supporting the therapeutic promise of blocking this pathway in the hypertensive patient with sleep disorder.[31]

Antihypertensive drugs can have very significant influences on sleep quality, and certain drug classes can worsen sleep disturbance. Beta-blockers, for instance, inhibit nocturnal melatonin release through the blockade of beta-adrenergic stimulation of the pineal gland. Decreased levels of melatonin interfere with circadian rhythm control, resulting in delayed sleep onset and decreased sleep efficiency. Clinical practice has noted elevated rates of insomnia, nightmares, and early morning awakening in non-selective beta-blocker users, highlighting the adverse effects on sleep. On the other hand, some antihypertensive drugs can enhance sleep quality by regulating neurovascular function.[32,33,34]

Moreover, novel treatments with a focus on central sympathetic regulation like renal denervation and

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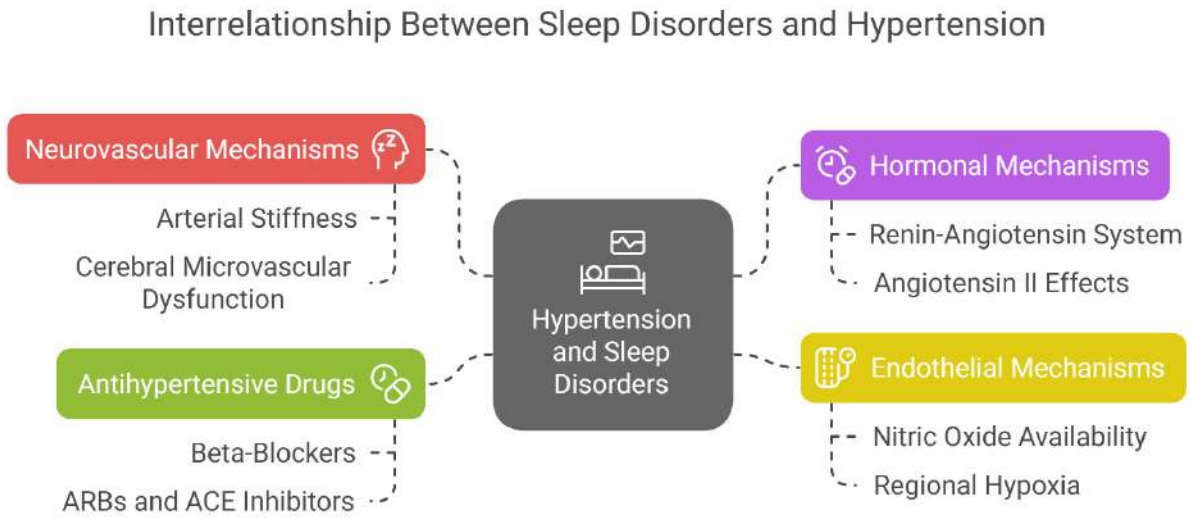
carotid baroreceptor stimulation have the potential to abate both hypertension and sleep disturbances. Chironotherapy, or the timing of medication taking in correspondence with circadian rhythms, is also being developed as a method of maximizing both blood pressure and sleep regulation. Research indicates that use of antihypertensive medications in the evening instead of the morning can enhance nocturnal control of blood pressure and improve sleep architecture. This individualized strategy for hypertension therapy may be particularly useful for patients with concomitant sleep dysfunction.[35]



9. Integrated Management Approaches and Future Therapeutic Targets

The treatment of sleep-disordered hypertension needs a paradigm shift towards precision medicine, combining genetic, metabolic, and inflammatory markers to direct individualized therapy. Progress in genomic profiling has revealed polymorphisms in genes controlling the renin-angiotensin system, sympathetic nervous activity, and endothelial function, which determine susceptibility to both hypertension and sleep disorders in an individual. Metabolomic analysis demonstrates unique lipid and amino acid patterns in comorbid sleep apnea and hypertension patients, implying new metabolic targets for therapeutic intervention. Inflammatory biomarkers CRP and IL-6 also provide potential for predictive stratification of patients for anti-inflammatory therapy. New pharmacological therapies target common pathophysiologic mechanisms that connect hypertension and sleep disturbance.[36,37]

Clinical trials show that VNS not only reduces blood pressure but also enhances sleep efficiency and lowers apnea-hypopnea index (AHI) scores in obstructive sleep apnea patients. Similarly, transcranial magnetic stimulation (TMS), traditionally used for neuropsychiatric disorders, is being explored for its effects on restless legs syndrome (RLS) and hypertension, with preliminary findings suggesting improvements in vascular reactivity and sleep stability. Chronotherapy, a novel intervention for circadian control, seeks to maximize sleep architecture and nocturnal blood pressure regulation by the strategic timing of antihypertensive drugs. New clinical trials illustrate that evening dosing of specific antihypertensive drugs, including ARBs and calcium channel blockers, improves nocturnal dipping patterns, lowering cardiovascular risk. In addition, melatonin supplementation, when timed appropriately, has been shown to have promise in enhancing circadian entrainment, counteracting the negative impact of beta-blocker-induced melatonin suppression on sleep quality. Exercise interventions provide a non-pharmacologic approach to enhancing both vascular function and sleep quality. Aerobic and resistance exercise regimens increase endothelial function through enhanced nitric oxide synthesis,

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leading to improved cerebral perfusion and decreased nocturnal variability of blood pressure.[38,39]

Increased studies are also directed towards the determination of molecular markers connecting hypertension and sleep disorders. Epigenetic modifications such as DNA methylation and histone acetylation have been implicated in the dysregulation of genes that play a role in circadian regulation, autonomic function, and inflammation. Exploring these molecular mechanisms may open up the creation of new epigenetic therapies that can reverse the adaptive changes underpinning sleep-disordered hypertension. Furthermore, proteomic analysis of cerebrospinal fluid (CSF) from hypertensive patients with sleep disturbances is revealing new biomarkers that may enable early diagnosis and focused intervention. Upcoming therapeutic interventions target the integration of multi-modal treatment strategies with a focus on the unique patient profile. Combination treatment involving pharmacotherapy, neurostimulation, behavioral changes, and AI-based monitoring is being researched in clinical trials to determine synergistic benefits. Personalized digital therapeutics that utilize cognitive-behavioral interventions and sleep coaching algorithms are being developed to improve medication compliance and enhance sleep quality in the hypertensive population. These advancements signal a change toward precision-mediated, patient-oriented care.[40]

10. Future Directions in OSA and Hypertension

Despite significant advancements, critical research gaps remain in understanding the long-term impact of integrated management strategies. Large-scale longitudinal studies are needed to assess the durability of therapeutic benefits and their effects on cardiovascular morbidity and mortality. Additionally, randomized controlled trials evaluating the efficacy of emerging interventions, such as gut microbiome modulation and targeted neuromodulation therapies, will provide valuable insights into their potential role in addressing the bidirectional relationship between hypertension and sleep disorders. As the field continues to progress, interdisciplinary team effort among cardiologists, sleep experts, neurologists, and data scientists will be necessary in optimizing treatment strategies. The intersection of precision medicine, neurovascular modulation, AI-based diagnostics, and customized lifestyle interventions is very promising in revolutionizing the treatment of sleep-disordered hypertension. With the integration of bleeding-edge scientific knowledge and patient-driven care, hypertension and sleep disorder management in the future will transform into highly customized, predictive, and preventive protocols, ultimately yielding better cardiovascular and neurological health results.[41]

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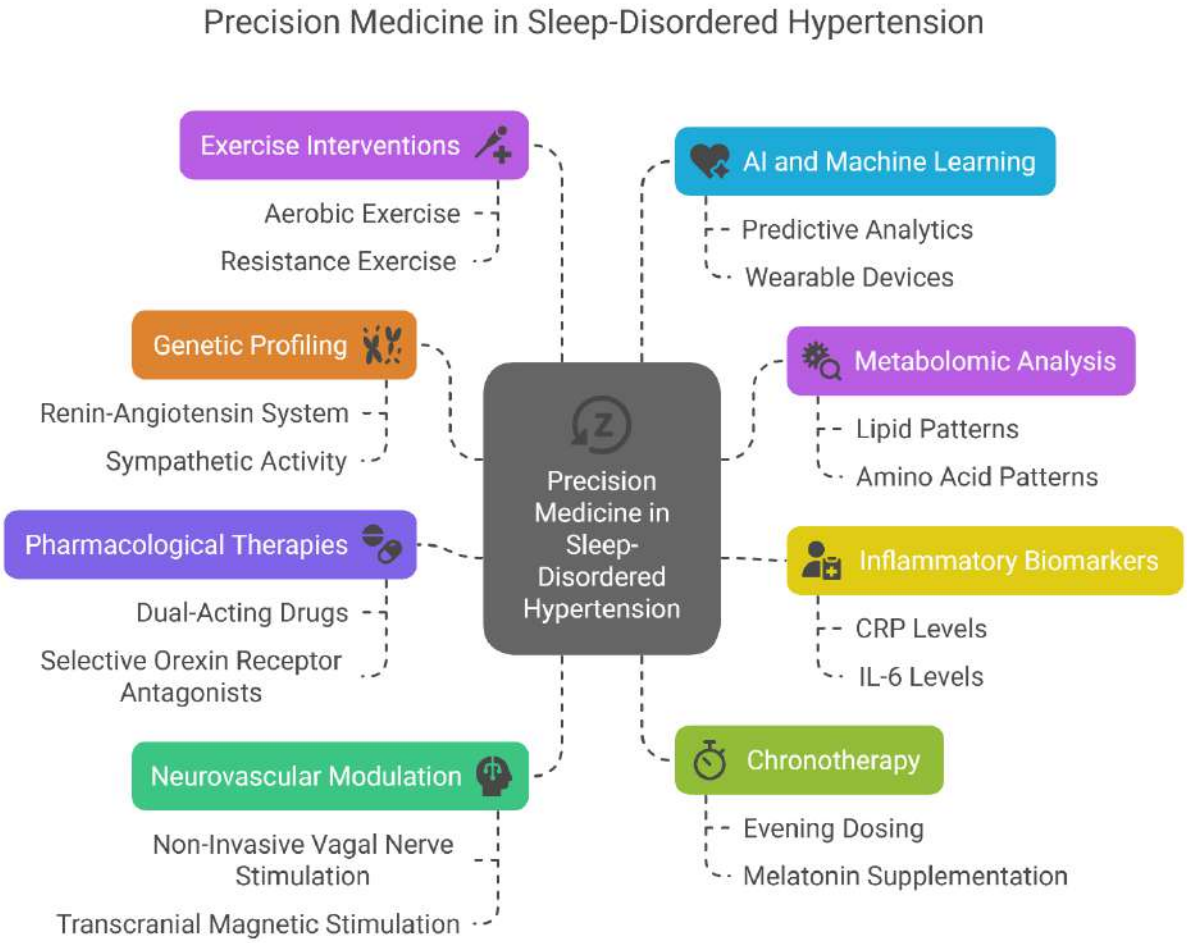

7. Conclusion

The complex interaction between sleep disorders and hypertension is supported by common pathophysiological mechanisms such as autonomic dysregulation, endothelial dysfunction, systemic inflammation, and circadian misalignment. Hypertension is a cause of sleep disorders through its effect on cerebral blood flow impairment, vascular stiffness, and disruption of neurohormonal regulation. On the other hand, sleep disorders like sleep apnea and restless legs syndrome enhance hypertension through inducing intermittent hypoxia, sympathetic overactivity, and metabolic dysfunction. This two-way relationship emphasizes the importance of an integral diagnosis and treatment approach, aware that management of one is equally dependent on care of the other. From a clinical viewpoint, understanding sleep disorders as a cause and also an etiological factor in hypertension has far-reaching implications for management of the patient. The novel antihypertensive therapies that are in use today will likely require personalization to account for their sleep-related effects since some drugs reset the circadian system or aggravate sleep. In turn, sleep disorder treatments like CPAP in obstructive sleep apnea have shown significant decreases in blood pressure, placing an emphasis on the role of sleep-based therapy in the management of resistant hypertension.

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REFERENCES

1. Pengo MF, Faini A, Lombardi C. Sleep disorders and hypertension. *High Blood Press Cardiovasc Prev*. 2020;27(2):95-105.
2. Peppard PE, Young T, Palta M, Skatrud J. Prospective study of the association between sleep-disordered breathing and hypertension. *N Engl J Med*. 2000;342(19):1378-84.
3. Somers VK, White DP, Amin R, et al. Sleep apnea and cardiovascular disease: an American Heart Association/American College of Cardiology Foundation Scientific Statement. *Circulation*. 2008;118(10):1080-111.
4. Drager LF, Togeiro SM, Polotsky VY, Lorenzi-Filho G. Obstructive sleep apnea: a cardiometabolic risk in obesity and the metabolic syndrome. *J Am Coll Cardiol*. 2013;62(7):569-76.
5. Pedrosa RP, Drager LF, Gonzaga CC, et al. Obstructive sleep apnea: the most common secondary cause of hypertension associated with resistant hypertension. *Hypertension*. 2011;58(5):811-7.
6. Senaratna CV, Perret JL, Lodge CJ, et al. Prevalence of obstructive sleep apnea in the general population: a systematic review. *Sleep Med Rev*. 2017;34:70-81.
7. Eskandari D, Zou D, Grote L, et al. Independent associations between arterial bicarbonate, apnea severity and hypertension in obstructive sleep apnea. *Respir Res*. 2017;18(1):106.
8. Lavie P, Herer P, Hoffstein V. Obstructive sleep apnoea syndrome as a risk factor for hypertension: population study. *BMJ*. 2000;320(7233):479-82.
9. Yaggi HK, Concato J, Kernan WN, et al. Obstructive sleep apnea as a risk factor for stroke and death. *N Engl J Med*. 2005;353(19):2034-41.
10. Gottlieb DJ, Yenokyan G, Newman AB, et al. Prospective study of obstructive sleep apnea and incident coronary heart disease and heart failure: the Sleep Heart Health Study. *Circulation*. 2010;122(4):352-60.
11. Marin JM, Agusti A, Villar I, et al. Association between treated and untreated obstructive sleep apnea and risk of hypertension. *JAMA*. 2012;307(20):2169-76.
12. Parati G, Lombardi C, Hedner J, et al. Position paper on the management of patients with obstructive sleep apnea and hypertension: joint recommendations by the European Society of Hypertension, European Respiratory Society and European Society of Sleep Research. *J Hypertens*. 2012;30(4):633-46.
13. Arzt M, Young T, Finn L, et al. Association of sleep-disordered breathing and the occurrence of stroke. *Am J Respir Crit Care Med*. 2005;172(11):1447-51.
14. Dempsey JA, Veasey SC, Morgan BJ, O'Donnell CP. Pathophysiology of sleep apnea. *Physiol Rev*. 2010;90(1):47-112.
15. Kohler M, Stradling JR. Mechanisms of vascular damage in obstructive sleep apnea. *Nat Rev Cardiol*. 2010;7(12):677-85.

ISSN: 3106-5937 | 3106-5945
Volume 3, Issue 1, 2026

16. Javaheri S, Barbe F, Campos-Rodriguez F, et al. Sleep apnea: types, mechanisms, and clinical cardiovascular consequences. *J Am Coll Cardiol*. 2017;69(7):841-58.
17. Redline S, Yenokyan G, Gottlieb DJ, et al. Obstructive sleep apnea-hypopnea and incident stroke: the Sleep Heart Health Study. *Am J Respir Crit Care Med*. 2010;182(2):269-77.
18. Kohler M, Craig S, Pepperell JC, et al. CPAP improves endothelial function in patients with minimally symptomatic obstructive sleep apnoea: results from a randomized controlled trial. *Am J Respir Crit Care Med*. 2011;184(7):88-96.
19. Iftikhar IH, Valentine CW, Bittencourt LR, et al. Effects of continuous positive airway pressure on blood pressure in patients with resistant hypertension and obstructive sleep apnea: a meta-analysis. *J Hypertens*. 2014;32(12):2341-50.
20. Marrone O, Bonsignore MR. Obstructive sleep apnea and hypertension: recent insights from epidemiology and pathophysiology. *Hypertension*. 2012;60(3):689-93.
21. Miller JN, Berger AM. Screening and assessment for obstructive sleep apnea in primary care. *Sleep Med Rev*. 2016;29:41-51.
22. Wolk R, Shamsuzzaman AS, Somers VK. Obesity, sleep apnea, and hypertension. *Hypertension*. 2003;42(6):1067-74.
23. Fava C, Dorigoni S, Dalle Vedove F, et al. Effect of CPAP on blood pressure in patients with OSA/hypopnea: a systematic review and meta-analysis. *Chest*. 2014;145(4):762-71.
24. Bazzano LA, Khan Z, Reynolds K, et al. Effect of nocturnal nasal continuous positive airway pressure on blood pressure in obstructive sleep apnea. *Hypertension*. 2007;50(2):417-23.
25. Kohler M, Stoewhas AC, Ayers L, et al. Effects of continuous positive airway pressure therapy withdrawal in patients with obstructive
26. Kario K. Nocturnal hypertension: New technology and evidence. *Hypertension*. 2018;71(6):997-1009.
27. Somers VK, Dyken ME, Clary MP, Abboud FM. Sympathetic neural mechanisms in obstructive sleep apnea. *J Clin Invest*. 1995;96(4):1897-904.
28. Lévy P, Pépin JL, Arnaud C, et al. Obstructive sleep apnea and atherosclerosis. *Prog Cardiovasc Dis*. 2009;51(5):400-10.
29. Pedrosa RP, Krieger EM, Drager LF, et al. Recent advances of the impact of obstructive sleep apnea on systemic hypertension. *Hypertens Res*. 2011;34(4):439-41.
30. Morrison JL, Young A, McEvoy RD, et al. The effect of sleep deprivation on blood pressure and vascular function. *J Hypertens*. 2020;38(3):394-403.
31. Javaheri S, Javaheri S. Update on persistent hypertension in OSA patients treated with CPAP therapy. *Chest*. 2019;156(4):784-6.
32. Fatouleh RH, Hammam E, Macefield VG. Involuntary muscle twitches and autonomic dysregulation in restless legs syndrome. *Exp Neurol*. 2018;307:37-44.
33. Tobaldini E, Fiorelli EM, Costantino G, et al. Short sleep duration and cardiovascular risk: from pathophysiology to clinical evidence. *Nat Rev Cardiol*. 2019;16(4):213-24.
34. Lamberts M, Lip GYH, Hansen ML, et al. Sleep disorders and the risk of stroke: a population-based cohort study. *Stroke*. 2017;48(10):2718-24.
35. Culebras A. Restless legs syndrome and arterial hypertension: Is there an independent association? *J Clin Sleep Med*. 2017;13(5):619-21.
36. Jennum P, Ibsen R, Kjellberg J. Obstructive sleep apnea and associated comorbidities: a Danish nationwide cohort study. *Sleep Med*. 2018;47:15-9.
37. Lévy P, Kohler M, McNicholas WT, et al. Obstructive sleep apnea syndrome. *Nat Rev Dis Primers*. 2015;1:15015.
38. Ryan S. Mechanisms of cardiovascular disease in obstructive sleep apnoea. *J Thorac Dis*. 2018;10(Suppl 34):S4201-S4211.

ISSN: 3106-5937 | 3106-5945
Volume 3, Issue 1, 2026

39. Fatouleh RH, Hammam E, Lundblad LC, et al. The relationship between blood pressure dysregulation and sleep apnea severity. *Am J Hypertens*. 2019;32(1):56-64.
40. Gonzaga C, Bertolami A, Bertolami M, et al. Obstructive sleep apnea, hypertension and cardiovascular diseases. *J Hum Hypertens*. 2015;29(12):705-12.
Cuspidi C, Tadic M, Grassi G, Mancia G. Blood pressure variability and obstructive sleep apnea: A systematic review and meta-analysis of observational studies. *J Hypertens*. 2017;35(5):923-31