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Emerging Biomarkers and Novel Therapies in Hypertension: A Review

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ABSTRACT
Hypertension remains one of the most prevalent and modifiable risk factors for cardiovascular morbidity and mortality worldwide. Despite the availability of effective antihypertensive medications, a significant proportion of patients fail to achieve optimal blood pressure control due to heterogeneous pathophysiology, delayed diagnosis, and variable therapeutic response. Emerging biomarkers and novel therapeutic strategies have gained attention for their potential to improve early detection, risk stratification, and personalized management of hypertension. This review synthesizes current evidence on emerging circulating, genetic, inflammatory, endothelial, and metabolic biomarkers implicated in hypertension pathogenesis. In parallel, advances in pharmacological and non-pharmacological therapies including novel drug classes, device-based interventions, and precision medicine approaches are critically examined. Biomarkers such as microRNAs, natriuretic peptides, inflammatory cytokines, and markers of endothelial dysfunction show promise in predicting disease progression and treatment response. Novel therapies, including angiotensin receptor–neprilysin inhibitors, endothelin receptor antagonists, aldosterone synthase inhibitors, and renal denervation, represent significant advances beyond conventional therapy. Integration of biomarker-guided treatment strategies may transform hypertension care by enabling targeted interventions and improving long-term cardiovascular outcomes. However, challenges related to clinical validation, cost-effectiveness, and implementation remain. Continued translational research and large-scale clinical trials are essential to bridge the gap between discovery and routine clinical practice.

Keywords: Hypertension; biomarkers; novel therapies; precision medicine; endothelial dysfunction; cardiovascular risk

INTRODUCTION

Non-communicable diseases account for about 68% of global deaths (60% in India), with cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes responsible for over 80% of premature mortality. Major risk factors including tobacco use, physical inactivity, unhealthy diet, alcohol consumption, and air pollution drive this burden, making their prevention essential for improving health outcomes and economic stability.[1,2]
Hypertension is a major global health challenge and a leading cause of cardiovascular disease, stroke, and premature mortality. Despite therapeutic advances, blood pressure control remains inadequate for many patients due to the heterogeneous and multifactorial nature of the condition. Emerging biomarkers and novel therapies offer promising opportunities for improved risk stratification and personalized hypertension management.3,4
In recent years, lifestyle-related conditions such as diabetes, cardiovascular diseases, and obesity have increased markedly, largely driven by sedentary behavior, unhealthy diets, and rising stress levels. Dietary modifications grounded in preventive medicine, particularly the DASH diet, play a key role in supporting long-term cardiovascular health. When effectively adopted, DASH dietary patterns improve overall health and significantly reduce the risk of cardiovascular complications.[2,4,5]

Pathophysiological basis for biomarker discovery

Hypertension develops through a complex interaction of body systems. Overactivation of the renin–angiotensin–aldosterone system and the sympathetic nervous system increases blood vessel constriction and fluid retention, raising blood pressure. At the same time, endothelial dysfunction reduces nitric oxide availability, limiting normal vessel relaxation. Chronic inflammation and oxidative stress further damage blood vessels, while impaired renal sodium handling and vascular remodeling help sustain elevated blood pressure. Understanding these mechanisms has helped identify biomarkers that reflect disease progression and guide targeted management.[6,7]

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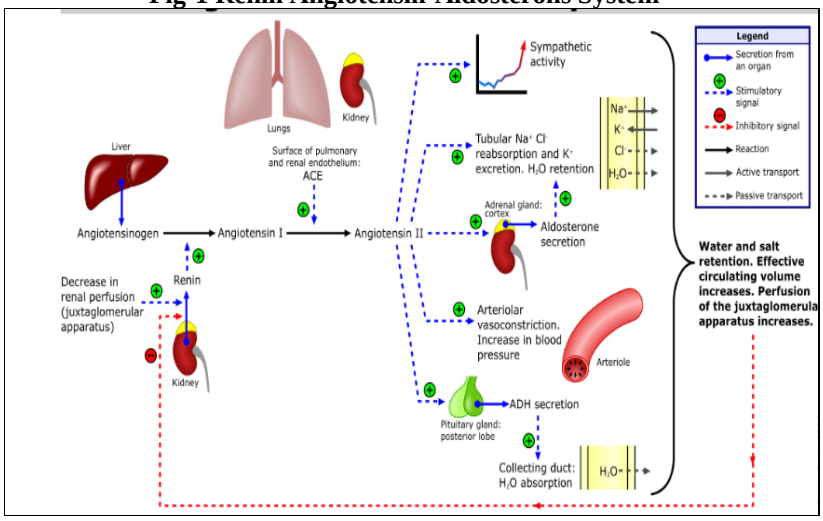
Fig-1 Renin Angiotensin-Aldosterons System [8]



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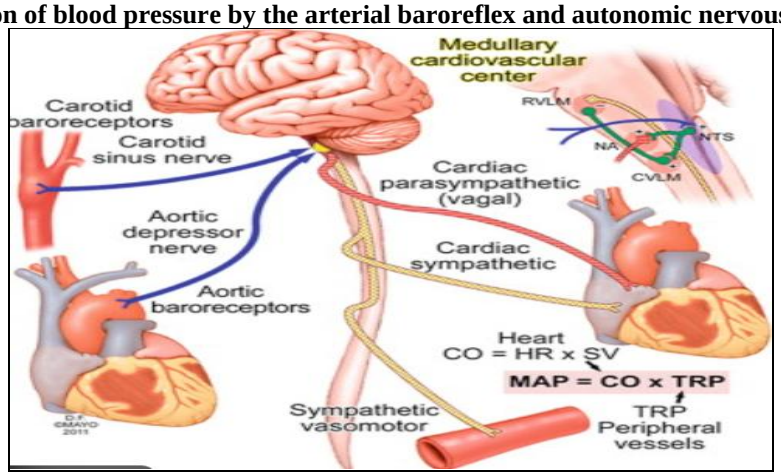
Shows:

Kidney → Renin → Angiotensin I → Angiotensin II → Vasoconstriction + Aldosterone → Blood Pressure

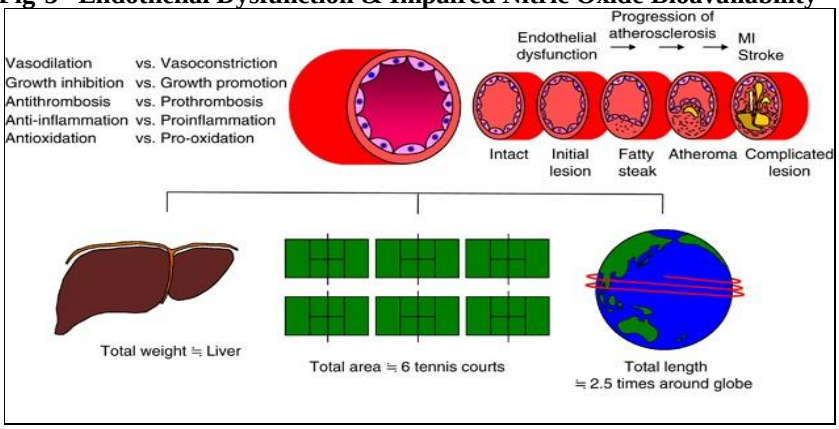
Fig-2 Sympathetic Nervous System Over-activity

Regulation of blood pressure by the arterial baroreflex and autonomic nervous system [9]



This Image has been taken from Wehrwein EA, Joyner MJ. Regulation of blood pressure by the arterial baroreflex and autonomic nervous system. Autonomic Nervous System and Accessed on 02/2/2026.

Fig-3 Endothelial Dysfunction & Impaired Nitric Oxide Bioavailability [10]



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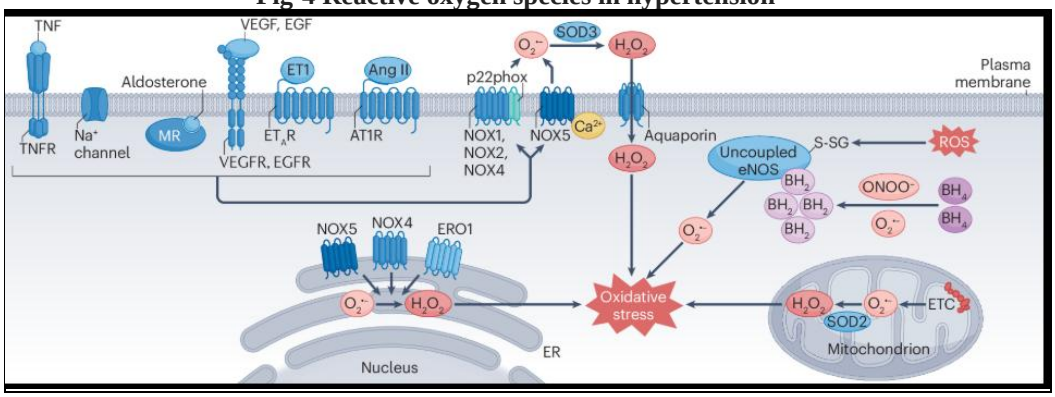
This Image has been taken from Higashi Y, Kihara Y, Noma K. Endothelial dysfunction and hypertension in aging. Hypertension Research and Accessed on 02/2/2026.

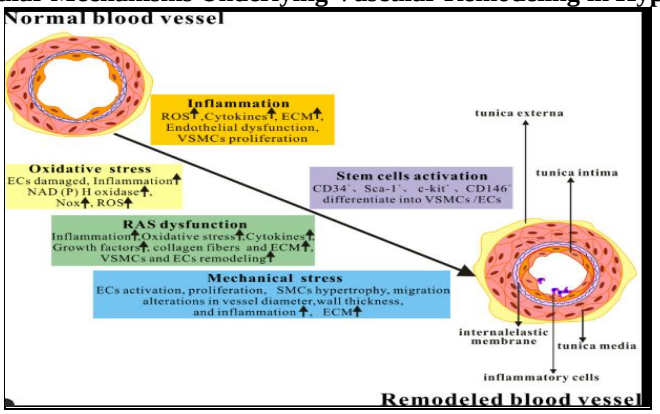
Inflammation & Oxidative Stress

Fig-4 Reactive oxygen species in hypertension [11]



This Image taken from Camargo LL, Rios FJ, Montezano AC, Touyz RM. Reactive oxygen species in hypertension. Nature Reviews Cardiology and Accessed on 02/2/2026.

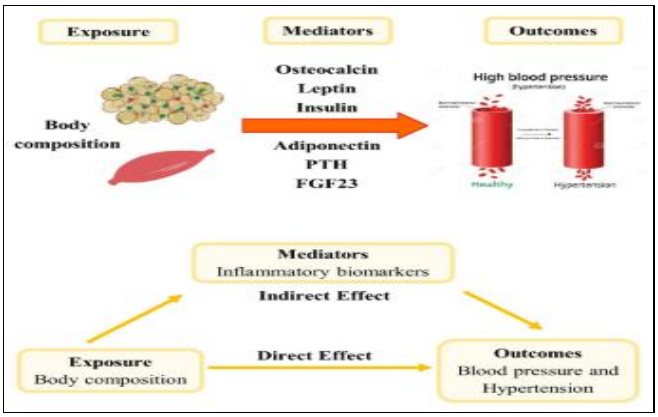
Fig-5 Molecular Mechanisms Underlying Vascular Remodeling in Hypertension [12]



This Image taken from Zeng X, Yang Y. Molecular Mechanisms Underlying Vascular Remodeling in Hypertension. Reviews in Cardiovascular Medicine. and Accessed on 02/2/2026.

Emerging biomarkers in hypertension

Fig-6 Role of Inflammatory Biomarkers in Mediating Causal Effect of Life Course Body Composition on Hypertension [13]



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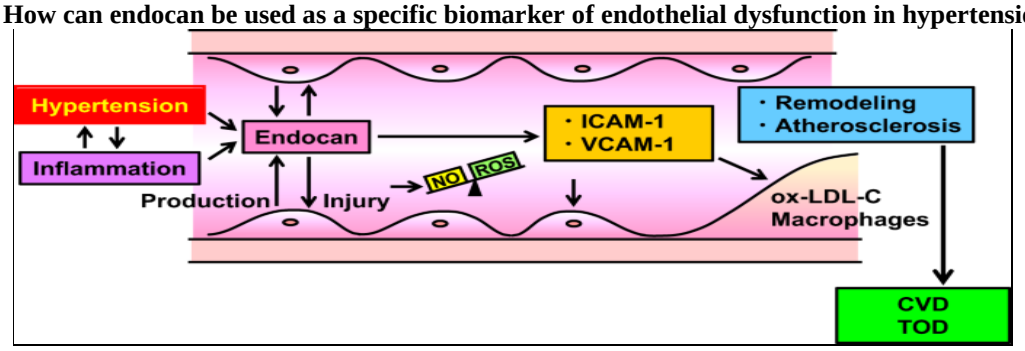
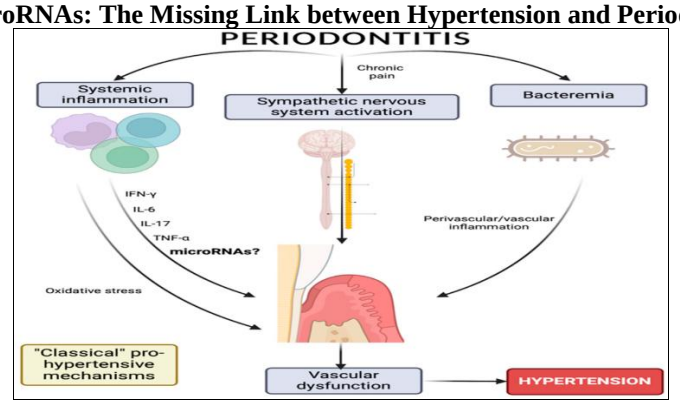
This Image taken from Fu L, Li Y, Cheng H, Xiong J, Xiao P, Dong H, et al. Role of Inflammatory Biomarkers in Mediating Causal Effect of Life Course Body Composition on Hypertension. Hypertension and Accessed on 02/2/2026.

Fig-7 How can endocan be used as a specific biomarker of endothelial dysfunction in hypertension? [14]



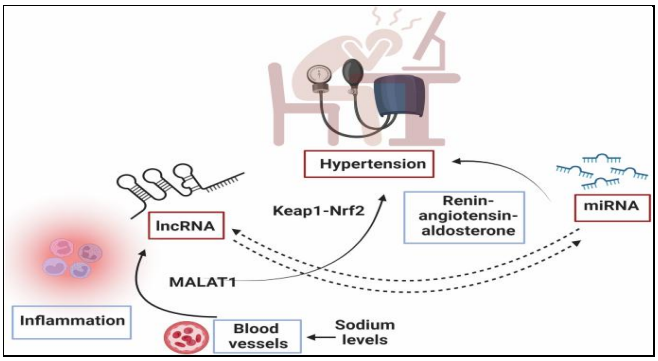
This Image taken from Hirooka Y. How can endocan be used as a specific biomarker of endothelial dysfunction in hypertension? Hypertension Research. and Accessed on 02/2/2026

Fig-8 MicroRNAs: The Missing Link between Hypertension and Periodontitis? [15]



This Image taken from Rodriguez NM, Loren P, Paez I, Constanza Martínez, Chaparro A, Salazar LA. MicroRNAs: The Missing Link between Hypertension and Periodontitis? International Journal of Molecular Sciences and Accessed on 02/2/2026

Fig-9 Interplay between lncRNAs and microrNAs in hypertension [16]



This Image taken from Sudhakaran G. Interplay between lncRNAs and microrNAs in hypertension. Hypertension Research. and Accessed on 02/2/2026.

Inflammatory biomarkers: Low-grade inflammation plays a crucial role in hypertension. Elevated levels of C-reactive protein (CRP), interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), and monocyte chemoattractant protein-1 have been associated with incident hypertension and target organ damage.[17]

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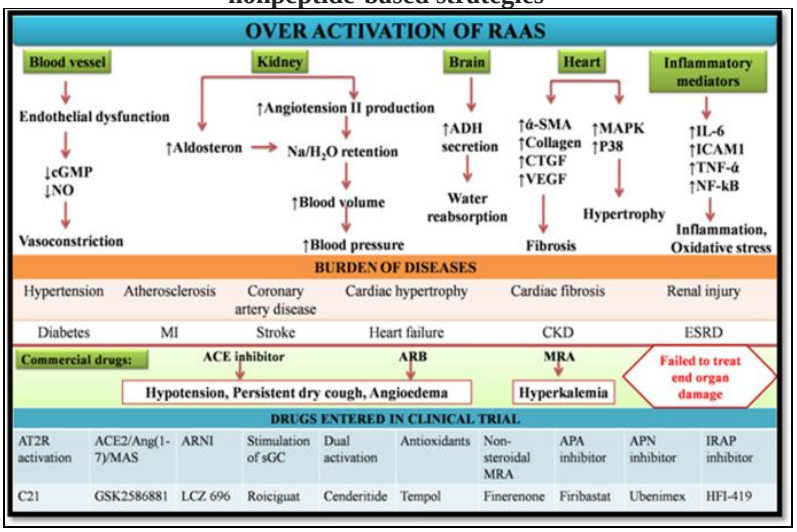
Endothelial dysfunction markers
Endothelial dysfunction precedes sustained hypertension. Biomarkers such as asymmetric dimethylarginine (ADMA), endothelin-1, and reduced nitric oxide metabolites indicate impaired vasodilation and increased vascular stiffness.[18]

Cardiac and renal biomarkers
Natriuretic peptides (BNP, NT-proBNP) reflect cardiac strain and volume overload, while markers such as cystatin C and urinary albumin-to-creatinine ratio signal early renal involvement in hypertensive patients.[19]

Genetic and epigenetic biomarkers
Genome-wide association studies have identified multiple loci linked to blood pressure regulation. MicroRNAs (e.g., miR-21, miR-155) and DNA methylation patterns are emerging as epigenetic regulators influencing vascular tone and renal sodium handling.[20]

Metabolic biomarkers
Insulin resistance, dyslipidemia, and adipokine imbalance contribute to hypertension. Leptin, adiponectin, and markers of oxidative stress have been linked to obesity-related hypertension.[21]

Fig-10 Novel therapeutic approaches in hypertension
Novel therapeutics for the treatment of hypertension and its associated complications: peptide- and nonpeptide-based strategies [22]



This Image taken from Ghatage T, Goyal SG, Dhar A, Bhat A. Novel therapeutics for the treatment of hypertension and its associated complications: peptide- and nonpeptide-based strategies. Hypertension Research and Accessed on 02/2/2026

Fig-11 Renal denervation for patient with hypertension? [23]

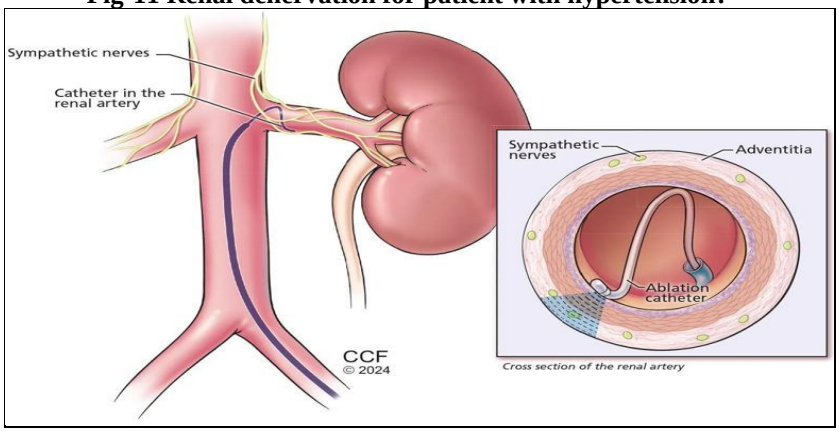


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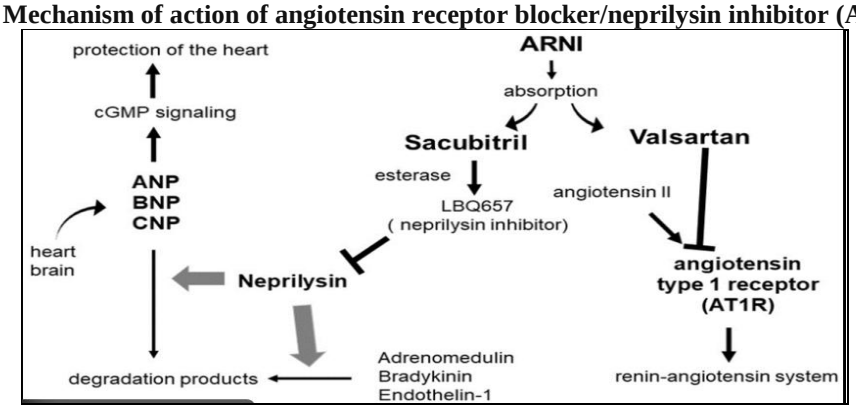
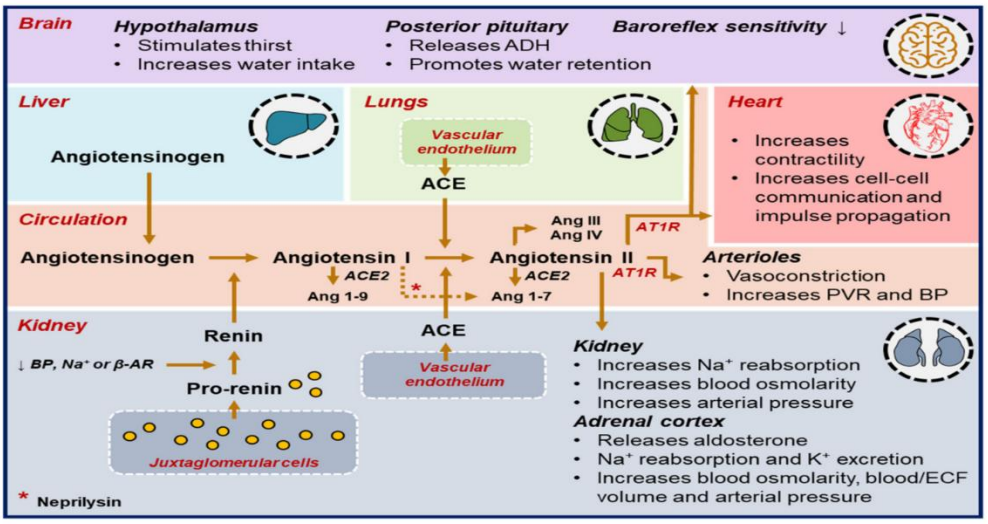
Fig-12 Mechanism of action of angiotensin receptor blocker/neprilysin inhibitor (ARNI) [24]



This Image taken from Mangmool S, Duangrat R, Parichatikanond W, Kurose H. New Therapeutics for Heart Failure: Focusing on cGMP Signaling. International Journal of Molecular Sciences and Accessed on 02/2/2026

Fig-13 Angiotensin Receptor-Neprilysin Inhibitor (ARNI) and Cardiac Arrhythmias [25]



This Image taken from Sutanto H, Dobrev D, Heijman J. Angiotensin Receptor-Neprilysin Inhibitor (ARNI) and Cardiac Arrhythmias. International Journal of Molecular Sciences and Accessed on 02/2/2026

NOVEL PHARMACOLOGICAL THERAPIES

Novel pharmacological therapies for hypertension focus on targeting specific pathophysiological pathways beyond conventional drug classes, aiming to improve blood pressure control, especially in resistant or high-risk patients. These therapies include angiotensin receptor–neprilysin inhibitors, which enhance natriuretic peptide activity while suppressing the renin–angiotensin system; aldosterone synthase inhibitors, which reduce aldosterone production without affecting cortisol synthesis; and endothelin receptor antagonists, which counteract potent vasoconstrictive and pro-fibrotic effects of endothelin-1. In addition, emerging anti-inflammatory and antioxidant agents are being explored as adjunctive treatments to address vascular inflammation and oxidative stress. Together, these novel pharmacological approaches represent an important shift toward mechanism-based and personalized hypertension management, offering new options for patients with inadequate response to standard therapies.[26,27]

Precision medicine and biomarker-guided therapy

Integration of biomarker profiles with clinical characteristics enables more accurate stratification of patients according to underlying disease mechanisms. Precision medicine approaches use this information to predict individual treatment responses, identify patients at higher risk of complications, and guide personalized therapy

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selection. By tailoring interventions to specific biological profiles, these strategies have the potential to improve blood pressure control rates while minimizing adverse effects.[28,29]

CONCLUSION

Emerging biomarkers and novel therapies are reshaping the understanding and management of hypertension. Biomarker-guided approaches offer the potential to move beyond traditional one-size-fits-all treatment toward precision medicine. Continued research, clinical validation, and health system integration are essential to realize the full potential of these innovations in reducing the global burden of hypertension.

REFERENCES

1. Garg, Ram Kumar. The alarming rise of lifestyle diseases and their impact on public health: A comprehensive overview and strategies for overcoming the epidemic. Journal of Research in Medical Sciences 30(1):1, January 2025. | DOI: 10.4103/jrms.jrms_54_24
2. Garg RK. Sustainable development and the battle against non-communicable diseases (NCDs). Int J Prev Med 2024;15:21.
3. Garg, Ram Kumar. To Fight Noncommunicable Diseases, We Need to Understand Risk Factors, Health Results, and Intervention Methods. Journal of the Practice of Cardiovascular Sciences 9(3):p 237-241, Sep–Dec 2023. | DOI: 10.4103/jpcs.jpcs_70_23
4. Oparil S, Acelajado MC, Bakris GL, et al. Hypertension. Nat Rev Dis Primers. 2018;4:18014. Published 2018 Mar 22. doi:10.1038/nrdp.2018.14
5. Garg RK. DASH therapy and hypertension: A novel approach to manage blood pressure. Indian J Community Med 2024;49:775-6.
6. Harrison DG, Coffman TM, Wilcox CS. Pathophysiology of Hypertension: The Mosaic Theory and Beyond. Circ Res. 2021;128(7):847-863. doi:10.1161/CIRCRESAHA.121.318082
7. Hengel FE, Benitah JP, Wenzel UO. Mosaic theory revised: inflammation and salt play central roles in arterial hypertension. Cell Mol Immunol. 2022 May;19(5):561-576. doi: 10.1038/s41423-022-00851-8. Epub 2022 Mar 30. PMID: 35354938; PMCID: PMC9061754.
8. Comcomgroup. RAAS - Glug Glug Glug... - Human Anatomy and Physiology Society (HAPS) [Internet]. Human Anatomy and Physiology Society (HAPS). 2017 [cited 2026 Feb 2]. Available from: https://www.hapsweb.org/publications-news/haps-blog/2017/12/04/raas-glug-glug-glug/?utm_source=chatgpt.com
9. Wehrwein EA, Joyner MJ. Regulation of blood pressure by the arterial baroreflex and autonomic nervous system. Autonomic Nervous System. 2013;117(1):89–102.
10. Higashi Y, Kihara Y, Noma K. Endothelial dysfunction and hypertension in aging. Hypertension Research. 2012 Sep 13;35(11):1039–47.
11. Camargo LL, Rios FJ, Montezano AC, Touyz RM. Reactive oxygen species in hypertension. Nature Reviews Cardiology [Internet]. 2024 Jul 24 [cited 2025 Feb 24]; Available from: https://www.nature.com/articles/s41569-024-01062-6
12. Zeng X, Yang Y. Molecular Mechanisms Underlying Vascular Remodeling in Hypertension. Reviews in Cardiovascular Medicine. 2024 Feb 20;25(2):72–2.
13. Fu L, Li Y, Cheng H, Xiong J, Xiao P, Dong H, et al. Role of Inflammatory Biomarkers in Mediating Causal Effect of Life Course Body Composition on Hypertension. Hypertension. 2025 Feb 12
14. Hirooka Y. How can endocan be used as a specific biomarker of endothelial dysfunction in hypertension? Hypertension Research. 2023 Dec 19;47(3):794–5.
15. Rodriguez NM, Loren P, Paez I, Constanza Martínez, Chaparro A, Salazar LA. MicroRNAs: The Missing Link between Hypertension and Periodontitis? International Journal of Molecular Sciences. 2024 Feb 6;25(4):1992–2.
16. Sudhakaran G. Interplay between lncRNAs and microrNAs in hypertension. Hypertension Research. 2024 Dec 17;48(3):1250–1.
17. Zhang Z, Zhao L, Zhou X, Meng X, Zhou X. Role of inflammation, immunity, and oxidative stress in hypertension: New insights and potential therapeutic targets. Front Immunol. 2023;13:1098725.
18. Meena SK, Meena M, jeph D. Role of Endothelial Dysfunction in the Progression of Hypertension: A Biomarker-Based Study. Journal of Contemporary Clinical Practice. 2025 Mar;11(3):511-517.
19. Oyama S, Takahashi H, Hayashi H, et al. Combination of brain natriuretic peptide and urinary albumin as a predictor of cardiovascular-renal events in outpatients with chronic kidney disease. Fujita Med J. 2023;9(2):105-112.
20. Karabaeva RZ, Vochshenkova TA, Mussin NM, Albayev RK, Kaliyev AA, Tamadon A. Epigenetics of hypertension as a risk factor for the development of coronary artery disease in type 2 diabetes mellitus. Front Endocrinol (Lausanne). 2024;15:1365738.

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21. Zorena K, Jachimowicz-Duda O, Ślęzak D, Robakowska M, Mrugacz M. Adipokines and Obesity. Potential Link to Metabolic Disorders and Chronic Complications. Int J Mol Sci. 2020;21(10):3570.
22. Ghatage T, Goyal SG, Dhar A, Bhat A. Novel therapeutics for the treatment of hypertension and its associated complications: peptide- and nonpeptide-based strategies. Hypertension Research [Internet]. 2021 Mar 17;1–16. Available from: https://www.nature.com/articles/s41440-021-00643-z
23. Leen Al-Yacoub, Bassil E, Thomas G, Laffin L, Aravinda Nanjundappa, Khaled Ziada, et al. Should my patients with hypertension be referred for renal denervation? Cleveland Clinic Journal of Medicine [Internet]. 2024 Sep 1 [cited 2025 Oct 22];91(9):539–43. Available from: https://www.ccjm.org/content/91/9/539
24. Mangmool S, Duangrat R, Parichatikanond W, Kurose H. New Therapeutics for Heart Failure: Focusing on cGMP Signaling. International Journal of Molecular Sciences [Internet]. 2023 Aug 16;24(16):12866. Available from: https://pubmed.ncbi.nlm.nih.gov/37629047/
25. Sutanto H, Dobrev D, Heijman J. Angiotensin Receptor-Neprilysin Inhibitor (ARNI) and Cardiac Arrhythmias. International Journal of Molecular Sciences. 2021 Aug 20;22(16):8994.
26. Addison ML, Ranasinghe P, Webb DJ. Novel Pharmacological Approaches in the Treatment of Hypertension: A Focus on RNA-Based Therapeutics. Hypertension. 2023 Nov;80(11):2243-2254.
27. Ye D, Cruz-López EO, Veghel RV, Garrelds IM, Kasper A, Wassarman K, Tu HC, Zlatev I, Danser AHJ. Counteracting Angiotensinogen Small-Interfering RNA-Mediated Antihypertensive Effects With REVERSIR. Hypertension. 2024 Jul;81(7):1491-1499.
28. Wang RC, Wang Z. Precision Medicine: Disease Subtyping and Tailored Treatment. Cancers (Basel). 2023;15(15):3837.
29. Naithani N, Sinha S, Misra P, Vasudevan B, Sahu R. Precision medicine: Concept and tools. Med J Armed Forces India. 2021 Jul;77(3):249-257. doi: 10.1016/j.mjafi.2021.06.021. Epub 2021 Jul 3.

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