Indian Journal of Modern Research and Reviews

This Journal is a member of the *'Committee on Publication Ethics'*

Online ISSN:2584-184X

Research Article

Neurocardiology and the Bidirectional Brain-Heart Axis: Modern Concepts in Neurocardiovascular Physiology

Dr. Shahan Layek [1*], Tania Khatun [2], Mohammad Nomanuddin [3]

[1] Independent Researcher, West Bengal, India

[2] M.Sc. in Medical Laboratory Technology, NSHM College of Management and Technology, Durgapur, West Bengal, India

[3] Department of Food Science and Technology, SRM Degree & PG College, Karimnagar, Telangana, India

Corresponding Author: * Dr Shahan Layek

DOI: https://doi.org/10.5281/zenodo.20488009

Abstract

The human brain and cardiovascular system are intimately interrelated through neural, hormonal, autonomic and inflammatory communication pathways. Emerging in the scientific literature, neurocardiology is a discipline centred around the bidirectional communication between the brain and heart, known as the brain-heart axis. Contemporary advancements in neurophysiology, cardiovascular physiology, neuroimaging, artificial intelligence and wearable technology have enabled an enhanced comprehension of brain-heart relationships. Emotional distress, autonomic dysfunction, neuroinflammation, sleep disorders and lifestyle are significantly impactful on cardiovascular function; while cardiovascular disease has negative effects on cerebral circulation and neural systems.

Physiological markers for brain-heart communication include heart rate variability, vagal tone and autonomic balance, along with the newest concepts such as neurocardiovascular synchrony and network physiology, along with digital biomarkers, in the new paradigm of physiology. Here we review modern concepts in neurocardiology, including the brain-heart axis anatomical and physiological structure, neurocardiovascular regulation and dysfunction, digital health monitoring, and the prospects in future studies. Understanding of brain-heart interactions may have crucial implications for the development of personalised medicine and novel therapies for neurological and cardiovascular disorders.

Manuscript Information

- **ISSN No:** 2584-184X
- **Received:** 04-04-2026
- **Accepted:** 28-05-2026
- **Published:** 30-05-2026
- **MRR:**4(5); 2026: 376-380

- **Plagiarism Checked:** Yes
- **Peer Review Process:** Yes

How to Cite this Article

Layek S, Khatun T, Nomanuddin M Neurocardiology and the Bidirectional Brain-Heart Axis: Modern Concepts in Neurocardiovascular Physiology. Indian J Mod Res Rev. 2026;4(5):376-380.

Access this Article Online

www.mrrjournal.in

KEYWORDS: Neurocardiology, Brain-Heart Axis, Autonomic Nervous System, Heart Rate Variability, Neurocardiovascular Physiology, Neurophysiology.

INTRODUCTION

The brain and heart are the most prominent organs and are in close functional integration through a network of biological pathways, including neural, endocrine, immunological, and vascular channels. This network interconnectivity between the brain and heart has been described as the brain-heart axis. [1]

Neurocardiology, a new discipline, is of immense importance due to its impact on cardiovascular disease, Neurologic disorder, stress physiology and precision medicine. Cardiovascular and neurophysiology have been previously studied as a distinct set of systems; however, recent evidence suggests that autonomic and hormonal systems are critically regulating Cardiovascular response.[2]

Furthermore, brain regulation of cerebral blood flow may be mediated by direct neuronal connections with cerebral vasculature. Emotional stress, sleep disorder, neuroinflammation, and digital habits may severely affect the healthy functioning of the cardiovascular system, whereas heart or cardiovascular disease can compromise cerebral circulation, neuronal performance, and brain functions. Moreover, with recent technological advancements such as wearable biosensors, heart rate variability analysis, functional imaging and AI, brain-heart interaction is now studied as part of a new concept, namely neuro-cardiovascular synchrony or network physiology.[4]

This review is an attempt to introduce the modern concept of neurocardiology and the bidirectional brain-heart axis, along with their related physiological regulation, disease implications, and future research aspects.[6]

Anatomical and Physiological Background of the Brain-Heart Axis

Brain-heart interactions are mostly conveyed through the autonomic nervous system, consisting of sympathetic and parasympathetic divisions. Information received in the central autonomic network by a wide range of brain areas, including the hypothalamus, amygdala, insular cortex, anterior cingulate cortex, medulla oblongata, and brainstem nuclei, allows it to control peripheral autonomies.[3]

The sympathetic nervous system is responsible for the increase in heart rate, myocardial contractility, and blood pressure mediated via catecholamines. On the contrary, the parasympathetic system, which is mainly conveyed through vagal nerves, decreases heart rate and allows a better cardiovascular recuperation and conservation of energy resources.[2]

Incoming information regarding cardiovascular parameters travels to the brain through afferent autonomic fibres. Receptors such as baroreceptors and chemoreceptors, mechanoreceptors that continuously monitor arterial pressure and oxygen blood content, relay heart function information to central processing centres to generate autonomic output responses in an acute feedback system. [13]

Hypothalamic-Pituitary-Adrenal (HPA)Axis and Brain-Heart Interconnection

The HPA axis plays a pivotal role in brain-heart interaction. Activation of the HPA axis by psychological stress leads to the release of cortisol, resulting in the induction of sympathetic nervous system activity, endothelial dysfunction, and inflammation processes. Chronic activation of the HPA axis increases cardiovascular risk. Brain-heart communicates through the autonomic nervous system and cardiovascular regulation[8]

The Autonomic Regulation in Neurocardiovascular Physiology

Autonomic regulation is considered one of the primary regulating processes in neurocardiovascular physiology. Maintenance of autonomic equilibrium between the activity of the sympathetic and parasympathetic systems guarantees cardiovascular stability and adaptation.[13]

Excessive sympathetic activity may contribute to the pathophysiology of hypertension, cardiac arrhythmias, heart failure, anxiety disorders and stress-related cardiovascular disorders. Increased stimulation of sympathetics may lead to overproduction of catecholamines, oxidative stress, increased vascular resistance and increased oxygen consumption in myocardial tissue.[2]

The cardioprotective action is exerted mainly through parasympathetic influence. This parasympathetic regulation, mainly the activation of the vagal component of the nervous system, improves heart rate variability, reduces inflammation, provides stress relief and helps emotional recovery. Decreased HRV can be used as an index of autonomic regulation dysfunction, and it's an independent risk factor for increased cardiovascular morbidity.[1]

The importance of heart rate variability in brain-heart interaction

Heart rate variability, as a readily available non-invasive physiological marker, allows indirect monitoring of the interplay between the brain and the heart and reflects both parasympathetic and sympathetic control of the cardiovascular system. Decreased HRV is associated with anxiety disorders, depression, hypertension, diabetes, and a variety of cardiovascular disorders.[4]

Emotional Stress and Neurocardiovascular Dysfunction

Contemporary lifestyle has several stressors like increasing psychological stress levels, increasing digital overload and decreasing sleep hours and their quality, which can cause emotional instability. Emotional stress has a significant impact on cardiovascular physiology via autonomic and neuroendocrine pathways.[18]

Stress stimulates the amygdala and hypothalamus, upregulates the sympathetic nervous system activity and cortisol secretion. Longer-term stress results in endothelial dysfunction, hypertension, inflammation, insulin insensitivity and atherogenesis.[6]

Another significant example of neurocardiovascular interaction is Takotsubo cardiomyopathy, which occurs in the context of acute emotional stress and results in reversible myocardial dysfunction.[10]
Depression and anxiety disorders are also strongly associated with CVD. Depressed patients have reduced HRV, autonomic imbalance, systemic inflammation and an increased cardiovascular risk.[8]
Recent data points to the potential influence of social isolation, prolonged digital screen time and social media addiction on autonomic regulation and cardiovascular dynamics. Such factors are becoming more relevant in current neurocardiovascular physiology.[5]

Neuroinflammation and the Brain–Heart Axis

Inflammation has important implications for neurocardiovascular communication in relation to neuroinflammatory pathways that may be involved with autonomic regulation, vascular, and cardiac function.[9]
Chronic stress or systemic disease may release pro-inflammatory cytokines, which influence the area of autonomic regulation of the brain. Similarly, cardiovascular disease, such as heart failure, may give rise to the neuro-inflammatory response as well as cognitive impairment.[10]
The vagus nerve has an anti-inflammatory role through the cholinergic anti-inflammatory pathway. Vagal stimulation may have potential therapeutic applications for inflammatory and cardiovascular diseases by inhibiting inflammatory cytokines.[9]
In addition, neuroinflammation has been linked to stroke, neurodegenerative disease, hypertension and metabolic disease. Future work into the relationship between inflammation, autonomic dysregulation and vascular physiology is an important area of investigation.[13]

Sleep, Circadian Rhythm, and Brain–Heart Communication

Sleep function is essential for neurocardiovascular homeostasis. During sleep, there is a redistribution of autonomic regulation toward parasympathetic dominance, facilitating cardiovascular recuperation and neuronal repair.[12]
Chronic sleep deprivation and sleep disturbance affect autonomic regulation and HRV. Alters sympathetic balance, which results in raising BP, and has effects on endothelial function. Overall, chronic sleep disturbance causes Hypertension, Obesity, DM, stroke, and Heart disease.[12]
The body's autonomic functions, such as blood pressure, heart rate, and hormones, are all governed by circadian rhythms. For example, shift work, blighted eyes staring at computers or TV are all issues that may, could, modulate the signal being sent from the brain to the heart.[3]
Mental exposure to blue light emitted from digital devices inhibits melatonin secretion and may influence autonomic balance. Recent evidence suggests that long-term digital exposure may be involved in stress-related neurocardiovascular dysregulation.[5]

Wearable Technology and Digital Biomarkers

The influence of technology on neurocardiovascular research is undeniable. Using technological innovations, devices like smart watches, fitness bands, bio-sensors, and nervous monitors can measure and process afferent, efferent and cardio signals in every class of the disease. Those devices are capable of tracking data in real time, analysing how the neuro-cardiovascular system behaves during different kinds of situations. With the advent of this proliferation of data from wearable technology, researchers have more information about the manifestation of diseases or their products in a multimodal way.[15]
Wearable tech-based digital biomarkers may introduce the capability of gathering significant information related to stress, autonomic functioning, mood and cardiovascular risk. The ability to perform continuous recordings could potentially allow early identification of physiological anomalies and customise healthcare.[14]
Artificial intelligence and machine learning algorithms are increasingly being applied to the analysis of neurocardiovascular data. AI-based models have been suggested to improve the prediction of arrhythmias, stress-related disorders, and cardiovascular events.[6]
Remote physiological monitoring and telemedicine are increasingly relevant in a post-pandemic world. Both are well-suited to continuous monitoring of neurocardiovascular health and to approaches to preventive medicine.[7]

Neurocardiovascular Disorders

A few of the disorders that show the tight association of neurological and CV-system are listed below. Stroke is one of the most prominent examples of neurovascular dysfunction. Hypertension, atrial fibrillation and endothelial dysfunction are major factors in cerebrovascular disease.[13]
Autonomic failure often occurs in neurodegenerative diseases like Parkinson's and Alzheimer's. Patients can present with orthostatic hypotension, low HRV and abnormal cardio-relaxing reflex.[19]
Other factors, such as autonomic anomalies resulting from epilepsy, may impair cardiovascular regulation. Neurocardiovascular interactions may be altered in sudden unexpected death in epilepsy (SUDEP).[3]
Sensorimotor disturbances have also been associated with cardiovascular disease states. Heart failure is associated with diminished cerebral perfusion and would be predicted to contribute to cognitive decline. Atrial fibrillation causes an increased stroke risk, and long-term hypertension damages the cerebral microvasculature. [10]

Emerging Concepts in Neurocardiovascular Physiology

Contemporary physiological sciences are tending toward systems biology and integrated network physiology. Instead of studying isolated organ systems, network physiology describes functional interactions among several systems.[20]
Neurocardiovascular synchronisation…Occurs when there is a synchronised oscillatory relationship between neural and cardiovascular function. Such interactions can be elucidated

through the use of computational modelling and signal processing procedures.[16]

Another emerging idea is precision medicine. Personalised analysis of autonomic nervous system function, HRV, genetic risk, inflammatory condition and digital biomarkers could lead to a greater success rate of prevention and treatment.[14]

Bioelectronic medicine is another field that is receiving increased focus. Methods such as vagus nerve stimulation, neuromodulation, and non-invasive brain stimulation could potentially be therapeutic in cardiovascular and neurological diseases.[9]

Space physiology has also been a useful model in regard to neurocardiovascular adaptation. Short and long duration microgravity exposure can be used as a model to investigate autonomic activity, vessel control and cerebral circulation.[13]

Future Directions

The future of the neurocardiology field would be to combine concepts and advancements in neuroscience, physiology of the nervous and cardiovascular system, computational biology and AI, and wearable technology. By exploring the use of big data and applying machine learning algorithms, the relationship between the individual heart and mind will be understood better understood.[6]

More research is needed to uncover consistent digital biomarkers for neurocardiovascular dysregulation. Combining wearable monitoring with healthcare visits may help in preventing the progression of disease.[14]

Additional research into neuroinflammatory mechanisms, vagus nerve regulation, bodily day/night cycles, and psychophysiological processes might provide new treatments.[9]

Working across disciplines will be vital, bringing together physiologists, neurologists, cardiologists, engineers and computational scientists.[20]

CONCLUSION

Neurocardiology and the brain-heart axis are current and fast-advancing subspecialties of modern physiology. 2–4 Bidirectional nervous system-heart interactions are mediated by complex autonomic, neuroendocrine, inflammatory and vascular routes. 4 Emotions, sleep disorders, inflammation and the digital world are relevant active principles affecting neurocardiovascular regulation. Breakthroughs in Wearable devices, Digital biomarkers, AI, and systems physiology are redefining the way we look at the brain-heart relationship. Heart rate variability and autonomic balance have gained significant importance in the paradigm of neurocardiovascular health.

The knowledge of neurocardiovascular physiology might be helpful for the advancement of precision medicine, early detection of disease and innovative therapeutic interventions. Further interdisciplinary research should be encouraged to explore this fascinating yet very important field.

Conflict of Interest

The authors state there is no conflict of interest regarding the publication of this paper.

Funding

This project has not been externally funded.

Authors' Contributions

Conception of the work, review of literature, drafting and critical revision of the manuscript, and final approval were provided by all authors.

Ethical Approval

Because the author is a narrative review of some free-appearing literature and manuscripts that have already passed mandatory inspection from various other bodies, there was no need for ethical approval.

Acknowledgement

The authors want to express their gratitude to researchers and scientists whose existing papers assisted him for the preparation of this review paper.

REFERENCES

1. Armour JA. Neurocardiology: anatomical and functional principles. *Heart Rhythm*. 2008;5(6 Suppl):S2-S6.
2. Thayer JF, Lane RD. The role of vagal function in the risk for cardiovascular disease and mortality. *Biol Psychol*. 2007;74(2):224-242.
3. Benarroch EE. The central autonomic network: functional organisation, dysfunction, and perspective. *Mayo Clin Proc*. 1993;68(10):988-1001.
4. Shaffer F, Ginsberg JP. An overview of heart rate variability metrics and norms. *Front Public Health*. 2017;5:258.
5. McCraty R, Zayas MA. Cardiac coherence, self-regulation, autonomic stability, and psychosocial well-being. *Front Psychol*. 2014;5:1090.
6. Tawakol A, Ishai A, Takx RAP, et al. Relation between resting amygdalar activity and cardiovascular events: a longitudinal and cohort study. *Lancet*. 2017;389(10071):834-845.
7. Sgoifo A, Carnevali L, Pico-Alfonso MA, Amore M. Autonomic dysfunction and heart rate variability in depression. *Stress*. 2015;18(3):343-352.
8. Carney RM, Freedland KE. Depression and coronary heart disease. *Nat Rev Cardiol*. 2017;14(3):145-155.
9. Tracey KJ. The inflammatory reflex. *Nature*. 2002;420(6917):853-859.
10. Xhyheri B, Manfrini O, Mazzolini M, Pizzi C, Bugiardini R. Heart disease and depression. *Eur Heart J*. 2012;33(9):1027-1038.
11. Malik M. Heart rate variability. *Ann Noninvasive Electrocardiol*. 1996;1(2):151-181.
12. Palagini L, Bruno RM, Gemignani A, et al. Sleep loss and hypertension: a systematic review. *Curr Pharm Des*. 2013;19(13):2409-2419.
13. Raj SR. Autonomic dysfunction in cardiovascular disease. *Cardiol Clin*. 2013;31(1):1-12.
14. Lehrer PM, Kaur K, Sharma A, et al. Heart rate variability biofeedback improves emotional and physical health and

performance: a systematic review and meta-analysis. *Front Psychol*. 2020;11:569059.
15. Ernst G. Heart-rate variability—more than heartbeats? *Front Public Health*. 2017;5:240.
16. Shaffer F, Meehan ZM, Zerr CL. A critical review of ultra-short-term heart rate variability norms research. *Front Neurosci*. 2020;14:594880.
17. Appelhans BM, Luecken LJ. Heart rate variability as an index of regulated emotional responding. *Rev Gen Psychol*. 2006;10(3):229-240.
18. Kim HG, Cheon EJ, Bai DS, Lee YH, Koo BH. Stress and heart rate variability: a meta-analysis and review of the literature. *Psychiatry Investig*. 2018;15(3):235-245.
19. Forte G, Favieri F, Casagrande M. Heart rate variability and cognitive function: a systematic review. *Front Neurosci*. 2019;13:710.
20. Smith R, Thayer JF, Khalsa SS, Lane RD. The hierarchical basis of neurovisceral integration. *Neurosci Biobehav Rev*. 2017;75:274-296.

About the Corresponding Author

Dr. Shahan Layek is an Independent Researcher based in West Bengal, India. His academic interests span interdisciplinary research, social sciences, education, and contemporary societal issues. He is actively engaged in scholarly writing and research dissemination through publications, contributing to the advancement of knowledge and evidence-based academic discussions.