REVIEW

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Integrating biomedic mechanism in sidhakarya meditation for the prevention of aortic aneurysm

I Gusti Ngurah Putra Eka Santosa[1*], I Gusti Ngurah Angga Nugraha[2], Ni Kadek Diah Puspita[2], Putu Gede Ananda Krishna Dipayana[2], Agung Istri Aiswarya Novitrianti[2]

[1]Physiology Division, Biomedic Department, Faculty of Medicine, Universitas Mahasaraswati Denpasar
[2]Bachelor of Medicine Program, Faculty of Medicine, Universitas Mahasaraswati Denpasar

*Corresponding author:
I Gusti Ngurah Putra Eka Santosa; Physiology Division, Biomedic Department, Faculty of Medicine, Universitas Mahasaraswati Denpasar; ekasantosa@unmas.ac.id

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ABSTRACT

Aortic aneurysm remains a significant cardiovascular challenge characterized by the progressive weakening and excessive dilation of the aortic wall, which poses a high risk of spontaneous rupture. This degenerative pathology is primarily driven by uncontrolled oxidative stress and chronic inflammation that compromise the mechanical integrity of endothelial cells and elastin fibers. Despite rising global mortality, the condition's asymptomatic nature often complicates primary prevention and homeostatic reinforcement efforts. This review aims to explain how multilevel cellular communication pathways contribute to aortic aneurysm pathogenesis and how these pathways are modulated by Sidhakarya meditation. This Balinese mind-body practice addresses vascular degradation through a three-stage neurophysiological transition—Preparation, Core, and Closing—that shifts the autonomic nervous system from sympathetic dominance to parasympathetic activity. Clinical evidence indicates that this intervention reduces Malondialdehyde (MDA) levels by 30% and lowers systemic blood pressure, effectively mitigating the hemodynamic shear stress associated with abnormal vessel dilation. By stabilizing the Hypothalamic-Pituitary-Adrenal (HPA) axis and enhancing heart rate variability, the protocol optimizes the aorta's elastic response and structural resilience. Ultimately, bridging indigenous spiritual wisdom with modern biomedical mechanisms offers a culturally resonant and evidence-based framework for sustainable cardiovascular prophylaxis.

Keywords: aortic aneurysm, meditation, physiology, prevention.
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INTRODUCTION

Aortic aneurysm represents a critical cardiovascular pathology characterized by the progressive weakening and excessive dilation of the aortic wall, which significantly elevates the risk of spontaneous rupture. Recent epidemiological data indicate that global mortality associated with aortic aneurysms rose from approximately 94,700 cases in 1990 to 172,427 cases in 2019, reflecting an 82.1% increase despite a slight decline in age-standardized death rates.[1] This escalating burden is compounded by the predominantly asymptomatic nature of the condition, which frequently results in late-stage diagnosis and complicates primary prevention efforts. Consequently, a deeper understanding of the early markers and mechanisms of aortic degeneration is essential for developing proactive strategies to mitigate these adverse outcomes.

The pathophysiology of aortic aneurysms is fundamentally driven by uncontrolled oxidative stress, chronic inflammation, and the subsequent degradation of the vascular wall's structural integrity. Research demonstrates that oxidative imbalance specifically damages aortic endothelial cells and elastin fibers, thereby compromising the overall mechanical strength of the vessel.[2] While current clinical management primarily focuses on reactive interventions—such as surgical repair or late-stage antihypertensive therapy—there is a distinct lack of mechanism-based strategies designed to arrest early vascular decline through homeostatic reinforcement. Therefore, identifying preventive approaches that stabilize redox status and modulate the body's internal stress response has become a critical necessity in modern cardiovascular medicine.

Non-pharmacological interventions, particularly mind-body practices, are emerging as potent strategies for cardiovascular risk modulation by targeting the physiological correlates of stress and inflammation. Specifically, Sidhakarya meditation—a traditional Balinese practice—has been shown to reduce Malondialdehyde (MDA) levels by 30% within six weeks, indicating a significant reduction in lipid peroxidation and cellular damage.[3] These findings align with broader clinical evidence where yoga-based interventions significantly improved endothelial function and total antioxidant capacity through the downregulation of adhesion molecules and endothelin-1.[4] Within the high-risk demographic of Bali,

where hypertension and smoking remain dominant risk factors, integrating such ethnomedical practices into a personalized medicine framework offers a culturally resonant and physiologically plausible method for enhancing vascular health.[5]

The primary purpose of this study is to systematically elucidate how multilevel cellular communication pathways, specifically juxtacrine, paracrine, synaptic, and endocrine signaling, contribute to aortic aneurysm pathogenesis and how these pathways are modulated by meditative practices. By analyzing the influence of Sidhakarya meditation on autonomic regulation and inflammatory homeostasis, this research aims to provide a robust theoretical foundation for its use as an evidence-based complementary intervention. Furthermore, this review seeks to bridge the gap between traditional ethnomedicine and modern biomedicine, ultimately contributing a new conceptual framework for holistic vascular prevention. By validating these integrative strategies, this work supports the development of sustainable, culturally informed public health programs that enhance the adaptive capacity of patients against cardiovascular disease.[5]

RESULTS

Physiology of Meditation

In the modern physiological context, meditation is conceptualized not merely as a spiritual or religious practice but as a systemic psycho-physiological intervention capable of influencing bodily systems at a cellular level. Regular meditative activity stimulates the parasympathetic nervous system through enhanced vagal nerve activity, thereby inducing a comprehensive relaxation response. This state facilitates a significant reduction in heart rate, peripheral vasodilation, and decreased blood pressure, which directly bolsters the stability of the cardiovascular system. For the prevention of aortic aneurysms, this controlled hemodynamic pressure is a critical determinant in maintaining the structural integrity of the aortic wall.[5]

The body's physiological response to meditation is fundamentally explained through the lens of neurovisceral integration theory, which posits that cardiovascular stability is governed by the interplay between the autonomous nervous system and central emotional regulation centers, including the prefrontal cortex and limbic system. Recent clinical evidence of an eight-week mindfulness-based intervention significantly enhances coherence between cerebral and cardiac activity. This shift signifies a robust strengthening of the relationship between central neural modulation and the heart's response.[6] Consequently, these neurophysiological changes provide a plausible mechanism for how mind-body practices can stabilize the vascular environment against degenerative changes.

Beyond the regulation of autonomic neural pathways, meditation exerts a multifaceted biochemical influence that reinforces the body's resilience to oxidative and mechanical stress. Meditative processes are known to decrease systemic cortisol levels, modulate the secretion of epinephrine and norepinephrine, and upregulate the expression of nitric oxide synthase to facilitate essential vasodilation. This synergy of neural and hormonal modulation fosters a state of deep relaxation, increases the body's adaptive capacity to internal stressors, and strengthens vascular tissue resilience against chronic mechanical strain. Within the Sidhakarya framework, this physiological state represents a harmonization between internal energy (prana) and the physical soma, culminating in a simultaneous achievement of physiological and spiritual equilibrium.[5]

From a biomedical perspective, meditation exerts a significant influence on the nervous, hormonal, and cardiovascular systems through the activation of the Hypothalamic-Pituitary-Adrenal (HPA) axis and the enhancement of vagal tone. This process facilitates a transition from excessive sympathetic activity to parasympathetic dominance, resulting in favorable physiological effects such as reduced blood pressure, decreased heart rate, and vascular vasodilation. By mitigating shear stress on the vessel walls, these changes optimize the elastic response of the aorta, thereby suppressing the risk of abnormal dilation or aneurysm formation. This systemic activation aligns with the core principles of deep relaxation in Sidhakarya Meditation, where breath control and body awareness serve as the primary entry points for these biomedical influences.[5]

In the context of cardiovascular physiology, the benefits of meditation are primarily mediated by the stimulation of the vagus nerve, which strengthens Heart Rate Variability (HRV) and enhances endothelial vasodilatory responses. Contemporary clinical research indicates that a 6- to 8-week meditation program consistently lowers systolic and diastolic blood pressure by 10–15 mmHg in hypertensive individuals while concurrently elevating plasma nitric oxide levels essential for maintaining vascular compliance.[7] These findings corroborate results from national anti-aging scientific forums that emphasize the role of relaxation techniques and complementary therapies as integral components in the preventive management of degenerative cardiovascular diseases. Consequently, incorporating such structured meditative practices into clinical protocols is essential for improving long-term vascular health and preventing chronic arterial stiffening.

The biomedical mechanisms of meditation further encompass the downregulation of stress hormones, including cortisol and adrenaline, which are released by the adrenal glands. Attenuating the activity of the Hypothalamic-Pituitary-Adrenal (HPA) axis directly reduces systemic inflammatory responses and oxidative stress, both of which are critical pathogenic drivers in the degenerative processes of the aortic wall. Specifically, research conducted in Bali on Sidhakarya Meditation revealed a significant reduction in the oxidative stress biomarker Malondialdehyde (MDA) alongside an increase in total antioxidant capacity following a six-week intervention.8 These data indicate that meditation provides direct protective effects on vascular tissue integrity, extending beyond psychological benefits to offer tangible biomedical prophylaxis against tissue degradation.

Beyond the cardiovascular system, meditation modulates Central Nervous System (CNS) activity, particularly within the prefrontal cortex and amygdala, which govern stress and emotional regulation.

This modulation effectively diminishes chronic sympathetic activity, a known contributor to the long-term structural damage of large vessels such as the aorta. Recent neurophysiological studies suggest that rhythmic meditation enhances functional connectivity between the limbic system and autonomic brainstem centers, resulting in a more adaptive and controlled stress response.9 In the context of aortic aneurysm, effective stress management contributes to a sustained reduction in intravascular pressure while simultaneously preserving the elasticity of the vascular wall.

Sidhakarya Meditation

Meditation represents one of the oldest forms of mind-body intervention inherited across diverse civilizations. For millennia, these practices have manifested through prayer, poetry, and rituals that systematically integrate physical movement, breath control, and heightened consciousness. Within Eastern traditions, meditation is conceptualized not merely as a technique but as a profound pathway toward the unification of humanity and the universe. This knowledge is symbolically preserved through lontar (palm-leaf manuscripts), mantras, and performing arts to safeguard its sanctity, ensuring that the deepest meanings are accessible primarily to those who are spiritually prepared .

Conversely, in Western contexts, meditation is predominantly utilized as a pragmatic method for relaxation, stress management, and cognitive focus, particularly within clinical and educational frameworks.[13] Although these applications have demonstrated significant empirical efficacy, they frequently operate independently of the practice's philosophical roots, such as the awareness of self-essence and cosmic harmony. Therefore, integrating cultural values and spirituality with modern neurophysiological findings provides a vital bridge for a comprehensive understanding of these practices, specifically in the context of Sidhakarya Meditation derived from Balinese culture.[3,7]

The structure of Sidhakarya Meditation comprises three primary stages: Preparation, Core, and Closing; which represent a coordinated physiological and psychological transition toward holistic equilibrium. Each phase serves a specific neurophysiological function, reflecting a seamless synthesis of spiritual tradition and scientific mechanism.

a. The Preparation Stage

During this initial phase, practitioners are directed to attenuate sympathetic nervous system activity while increasing parasympathetic tone. This transition is characterized by a reduction in brainwave frequency from beta (13–30 Hz) to the alpha-theta range (8–12 Hz and 4–7 Hz). Such a shift indicates a move from cognitive-analytical processing to a reflective-intuitive mode, which is marked by heightened somatic awareness and a diminished stress response.[14]

b. The Core Stage

This phase represents the optimal state for fostering neuroplasticity, defined as the brain's capacity to adapt and establish new neural connections. The neuroendocrine system plays a central role here; the release of "DOSE" hormones (dopamine, oxytocin, serotonin, and endorphins) facilitates feelings of profound tranquility and compassion.15 Simultaneously, the Hypothalamic-Pituitary-Adrenal (HPA) axis reaches systemic stability, leading to reduced cortisol levels and enhanced physiological resilience.[15]

c. The Closing Stage

The final phase serves an integrative function where brainwave activity stabilizes into alpha patterns with low gamma coherence, signifying synchronization between the left and right cerebral hemispheres. This state, known as heart-brain coherence, occurs when the autonomic nervous system, endocrine system, and emotional centers function harmoniously to produce neuro-psychospiritual balance.6 In Balinese tradition, this stage embodies nyidhakarya, or the unification of individual and universal consciousness.

These three stages form a cohesive continuum that begins with relaxation, proceeds through transformation, and culminates in integration. From a biomedical perspective, this sequence is understood as a natural physiological mechanism for restoring homeostatic balance through the modulation of neural pathways, hormonal secretions, and conscious perception. Consequently, Sidhakarya Meditation provides tangible evidence of how Balinese indigenous wisdom can bridge the gap between sacred ritual and modern medicine, establishing itself as an evidence-based, measurable mind-body therapy applicable in a universal health context.

Integrating Local Spirituality and Modern Medicine

The integration of local Balinese spirituality with modern medical frameworks reflects a holistic health paradigm that emphasizes the equilibrium of an individual's physical, psychological, and spiritual dimensions. Within the context of aortic aneurysm prevention, Sidhakarya teachings and traditional Balinese meditative practices serve as essential entry points for enhancing somatic awareness and cardiovascular regulation. Concurrently, biomedicine provides the explanatory framework for the physiological mechanisms underlying these therapeutic effects, such as the modulation of the autonomic nervous system and the enhancement of arterial elasticity. This interdisciplinary collaboration enriches public health strategies by ensuring that preventive approaches are both scientifically grounded and culturally resonant.[10]

This integrative approach demonstrates that spiritual traditions are not antithetical to medical rationality but rather function as complementary components of a comprehensive healthcare system. For instance, Sidhakarya meditation is culturally defined as a ritual of prana purification, while biomedical evidence describes it as the stimulation of parasympathetic activity that directly influences blood pressure and vascular tension. Clinical studies further substantiate that structured spiritual practices significantly enhance heart rate variability (HRV), reduce blood pressure, and improve endothelial function. Ultimately, these practices offer measurable clinical benefits for the health of large vessels such as the aorta.[7]

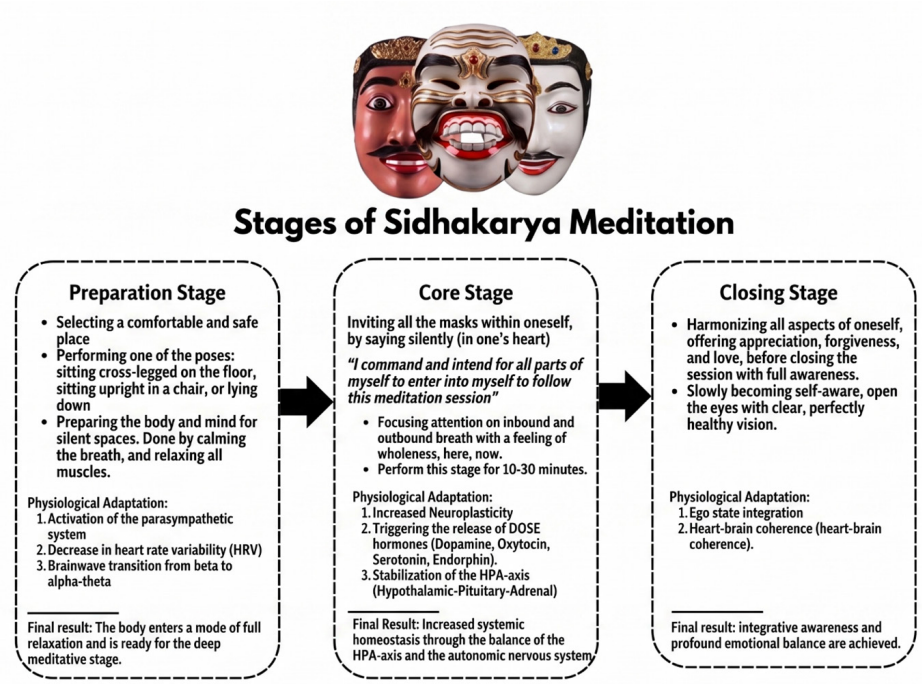

Figure 1. Sidhakarya Meditation Stages

In the context of clinical implementation, the integration of local spirituality represents a strategic mechanism for increasing community acceptance of modern medical interventions. The Balinese population, possessing a deep-seated familiarity with spiritual rituals, more readily adopts medical prevention programs when these initiatives are framed within familiar cultural narratives. This alignment adheres to the principles of community-based intervention, where health is viewed as the result of a multifaceted interaction between clinical protocols and sociocultural practices. Consequently, the inclusion of cultural heritage in healthcare delivery has been shown to enhance patient adherence to long-term cardiovascular prevention strategies.[11]

This integration facilitates the development of regional health policy models that are uniquely adapted to local social and cultural contexts. Synthesizing Balinese spirituality with biomedical mechanisms provides a robust foundation for public health policies that are anchored in indigenous wisdom yet supported by scientific evidence. In the management of aortic aneurysm, such an approach not only reinforces prevention through the control of physiological risk factors but also fosters greater community participation in cardiovascular maintenance. Therefore, this integrative model supports the creation of sustainable health initiatives that are both culturally relevant and clinically effective.[12]

Modern research continues to reinforce the connection between the stability of the autonomic nervous system, blood flow, and the health of the walls of large blood vessels such as the aorta. Activation of the parasympathetic nervous system through meditation or deep breathing techniques—which are also part of the Sidhakarya ritual—has been shown to lower blood pressure and improve arterial compliance, or the flexibility of blood vessels. A study showed that rhythmic breathing techniques significantly improve endothelial function and enhance aortic elasticity, thereby reducing the risk of abnormal dilation.[16] Thus, there is a strong conceptual bridge between the Balinese spiritual understanding of the hear rate and modern biomedical findings regarding the role of the aorta as the body's central distributor of life.

CONCLUSION

The management of aortic aneurysms requires a strategic transition from purely reactive curative interventions toward evidence-based preventive frameworks that integrate modern biomedical mechanisms with traditional ethnomedical practices. Current research suggests that Sidhakarya meditation effectively mitigates the fundamental pathophysiological drivers of vascular degradation—specifically oxidative stress and chronic inflammation—by modulating the Hypothalamic-Pituitary-Adrenal (HPA) axis and enhancing parasympathetic activity. By harmonizing the spiritual concept of prana (life energy) with the physiological regulation of vascular elasticity, this integrative approach bridges the gap between Balinese cultural wisdom and cardiovascular science to foster holistic hemodynamic stability. Consequently, it is recommended that academic institutions and regional governments establish multidisciplinary research centers to validate these traditional interventions, thereby positioning Bali as a sustainable international model for integrative medical tourism and community-based cardiovascular health.

CONFLICT OF INTEREST

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All authors contributed equally in the writing process of this article.

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