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Hypertension, Brain Aging and the Development of Microvascular Pathology

Ungerer Deaglio*

Department of Medicine, Hebrew University of Jerusalem, Jerusalem 91120, Israel

Introduction

Hypertension, commonly referred to as high blood pressure, is one of the most prevalent cardiovascular conditions globally, affecting millions of people and increasing the risk of several severe health conditions. While its immediate effects are often associated with the heart and blood vessels, the long-term consequences of hypertension can extend far beyond these systems, significantly impacting the brain. One of the most concerning effects of chronic hypertension is its role in accelerating brain aging and the development of microvascular pathology. The brain is particularly vulnerable to the damaging effects of high blood pressure due to its unique vascular system. The Blood-Brain Barrier (BBB), the intricate network of blood vessels that provides the brain with necessary nutrients while shielding it from harmful substances, can become compromised under the strain of hypertension. Over time, the persistent pressure on cerebral blood vessels may lead to structural and functional changes in the microvascular architecture, contributing to a range of cognitive impairments and increasing the risk of neurodegenerative diseases, such as Alzheimer's disease and vascular dementia [1].

Hypertension's role in accelerating brain aging is evident in the increasing risk of cognitive decline and the development of dementia. Studies have shown that individuals with untreated or poorly controlled high blood pressure are at a higher risk of developing both Alzheimer's disease and vascular dementia. In the case of Alzheimer's disease, hypertension may contribute to the accumulation of amyloid plaques in the brain, a hallmark of the disease. Hypertension-induced BBB dysfunction and oxidative stress are believed to facilitate the aggregation of amyloid-beta peptides, which are toxic to neurons. Additionally, the reduced cerebral blood flow caused by hypertension exacerbates hypoxia, a condition that accelerates neuronal injury and the death of brain cells. Vascular dementia, on the other hand, arises from direct damage to the blood vessels and is more closely associated with small vessel disease. The progressive damage to the brain's microvasculature impairs normal brain function, leading to symptoms such as memory loss, difficulty with executive function and changes in mood and behavior [2].

Description

Hypertension, defined as a persistent elevation in blood pressure above 130/80 mmHg, is often called the "silent killer" because it frequently causes no symptoms in its early stages. Over time, however, if left untreated, the condition can lead to a range of cardiovascular problems, including heart failure, stroke and kidney disease. When it comes to the brain, the impact of chronic hypertension is profound and multifaceted. One of the first consequences of long-standing hypertension on the brain is the alteration of blood vessel structure. The increased pressure in the arteries causes the walls of the blood vessels to thicken and become stiffer, a process known as arteriosclerosis. In the brain, these changes contribute to a decrease in the elasticity of cerebral arteries, impairing their ability to dilate and regulate blood flow effectively. As blood vessels become less compliant, they also become more prone to damage, such as small vessel ruptures or microbleeds. Over time, this leads to increased resistance to blood flow in the brain's microvascular network. Consequently, the brain receives less oxygen and fewer nutrients, which can contribute to ischemia (reduced blood supply) and subsequent cell death. This chronic reduction in cerebral blood flow is one of the primary mechanisms behind the cognitive decline often seen in individuals with uncontrolled hypertension [3].

The Blood-Brain Barrier (BBB) is a highly selective permeability barrier that protects the brain from toxins, pathogens and other harmful substances circulating in the blood. In a healthy brain, the endothelial cells of the BBB are tightly connected, forming a protective layer around the brain's blood vessels. However, under the persistent pressure of high blood pressure, these tight junctions can begin to break down. Hypertension-induced BBB dysfunction increases the permeability of the blood-brain barrier, allowing potentially harmful substances, such as inflammatory cytokines, reactive oxygen species and even components of the blood plasma, to enter the brain. This leads to an inflammatory response that further damages the blood vessels and neurons, contributing to both microvascular pathology and neurodegeneration. The impaired BBB is also associated with increased oxidative stress, which further accelerates neuronal damage and contributes to the pathogenesis of neurodegenerative diseases. One of the key radiological hallmarks of brain damage associated with hypertension is the presence of White Matter Hyperintensities (WMHs). These are areas of the brain that appear brighter than normal on MRI scans, indicating changes in the brain's white matter. White matter is critical for efficient communication between different brain regions and WMHs are believed to reflect microvascular injury, including the disruption of small blood vessels in the deep white matter of the brain. Small Vessel Disease (SVD), often referred to as hypertensive arteriopathy, is another important pathology linked to hypertension. It involves the degeneration of the small arteries and arterioles in the brain, leading to reduced blood flow and ischemia in certain brain areas. The loss of small vessels can lead to cognitive impairment and the combination of small vessel damage with WMHs significantly contributes to the development of vascular dementia, which is often seen in older adults with a history of hypertension [4].

Endothelial dysfunction also promotes inflammation within the vascular walls. Pro-inflammatory cytokines such as TNF-alpha, IL-1 and IL-6 are upregulated in response to sustained hypertension, leading to further damage to the blood vessel walls. This inflammatory cascade contributes to the thickening of the vascular walls, further impairing blood flow to the brain and exacerbating microvascular injury. As microvascular pathology progresses, it can lead to the expansion of perivascular spaces, which are fluid-filled cavities that surround blood vessels in the brain. These spaces are normally small and play a role in waste removal from brain tissue. However, in conditions like hypertension and aging, these spaces can enlarge, a phenomenon referred to as "virchow-robin spaces." Enlargement of these spaces is often associated with cognitive impairment and has been linked to both small vessel disease and the accumulation of amyloid plaques. The accumulation of perivascular fluid and the loss of small vessels also contribute to cerebral atrophy. The

***Address for Correspondence:** Ungerer Deaglio, Department of Medicine, Hebrew University of Jerusalem, Jerusalem 91120, Israel, E-mail: deaglioun.ereg@glo.il*

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brain shrinks as neurons die and are not replenished due to inadequate blood supply. This shrinkage is particularly evident in the hippocampus, the region of the brain most affected by both hypertension and neurodegeneration, contributing to memory loss and other cognitive deficits [5].

Conclusion

Hypertension is not only a leading risk factor for cardiovascular disease but also a significant contributor to brain aging and microvascular pathology. The effects of high blood pressure on the brain are complex and multifactorial, with hypertension inducing structural changes in the vasculature, impairing blood-brain barrier integrity and reducing cerebral blood flow. These factors, in turn, contribute to cognitive decline and neurodegenerative diseases such as Alzheimer's disease and vascular dementia. The relationship between hypertension and brain health underscores the importance of early detection and effective management of high blood pressure. Controlling blood pressure through lifestyle changes, pharmacological interventions and regular monitoring is critical in reducing the risk of brain aging and mitigating the onset of associated cognitive impairments. Further research into the mechanisms underlying hypertension-induced brain pathology will provide valuable insights into potential therapeutic strategies and help pave the way for innovative treatments aimed at preserving brain health and preventing dementia in aging populations.

Acknowledgement

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Conflict of Interest

None.

References

1. Schmidt, Reinhold, Stephan Seiler and Marisa Loitfelder. "Longitudinal change of small-vessel disease-related brain abnormalities." *J Cereb Blood Flow Metab* 36 (2016): 26-39.
2. Bath, Philip M. and Joanna M. Wardlaw. "Pharmacological treatment and prevention of cerebral small vessel disease: A review of potential interventions." *Int J Stroke* 10 (2015): 469-478.
3. Hachinski, Vladimir C., Paul Potter and Harold Merskey. "Leuko-araiosis." *Arch Neurol* 44 (1987): 21-23.
4. Wardlaw, Joanna M., Eric E. Smith, Geert J. Biessels and Charlotte Cordonnier, et al. "Neuroimaging standards for research into small vessel disease and its contribution to ageing and neurodegeneration." *Lancet Neurol* 12 (2013): 822-838.
5. Caunca, Michelle R., Andres De Leon-Benedetti, Lawrence Latour and Richard Leigh, et al. "Neuroimaging of cerebral small vessel disease and age-related cognitive changes." *Front Aging Neurosci* 11 (2019): 145.

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