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Case Study

Unlocking the Nexus of Neuroinflammation in the Olfactory Bulb Association to Parkinson's Disease

Fatma Rana Yilmaz [1], Aamer Mohammad [2,*]

[1] Nile University of Nigeria, College of Health Sciences; yilmazrana1999@gmail.com
[2] Rajiv Gandhi University of Health Sciences; aamer.mohammadmd@gmail.com
* Correspondence: aamer.mohammadmd@gmail.com; Tel.: +234-708-469-9404

Abstract

Our study investigates the link between neuroinflammation in the olfactory bulb (OB) and Parkinson's Disease (PD), aiming to understand how environmental factors such as viruses and particles trigger a cascade leading to -synuclein aggregation and PD development. Histological studies of PD brains identified -syn abnormalities in anterior olfactory structures at Braak's stage 1, with expanded post-mortem analysis including the OB. The vulnerability of the olfactory epithelium and OB to inflammation was assessed, considering age-related changes, along with the role of microglia as both a protective barrier and contributor to neuroinflammation. Animal models demonstrated the entry of toxins, viruses, and nanoparticles via the olfactory route. Findings highlight associations between viral infections, including the 1918 influenza pandemic, chronic rhinitis, and the presence of influenza A virus in PD brains. Neurotropic viral entry was shown to induce -syn aggregation and widespread inflammation, while activated microglia contributed to pathogen clearance but also disrupted the blood-brain barrier. Metal particles such as aluminum and iron were also identified as contributors to chronic inflammation. These findings underscore the critical role of OB neuroinflammation as a trigger for PD and suggest environmental factors as key contributors to disease pathogenesis, offering potential avenues for early intervention and therapeutic strategies.

Keywords: Parkinson's disease; neuroinflammation; olfactory bulb; alpha-synuclein; microglia; viral infections; environmental factors; neurodegeneration

1. Introduction

Our study investigates the link between neuroinflammation in the olfactory bulb (OB) and Parkinson's Disease (PD), aiming to understand how environmental factors such as viruses and particles trigger a cascade of events leading to -synuclein aggregation and the development of PD [1–3]. We conducted histological studies of PD brains, pinpointing -syn abnormalities in the anterior olfactory structures at Braak's stage 1 [4]. We expanded post-mortem examinations to include the OB and assessed the vulnerability of the olfactory epithelium and OB to inflammation, considering age-related epithelial changes, while also exploring the role of microglia in the OB and their potential as a barrier against exogenous pathogens [5,6]. We also examined the entry of toxins, viruses, and nanoparticles into the OB using animal models [7]. Our research highlights the association between viral infections and PD, including the 1918 influenza pandemic and childhood infections, while chronic rhinitis and the presence of influenza A virus in PD brains support this link. Animal studies reveal the impact of neurotropic viruses entering via the olfactory route, leading to

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-syn aggregation and widespread inflammation [8]. Activated microglia were found to play a pivotal role in pathogen clearance but also disrupt the blood-brain barrier, notably in the OB [9]. Furthermore, metal particles like aluminum and iron were identified as potential contributors to PD through chronic inflammation [10]. This study unveils the critical role of OB neuroinflammation as a trigger for PD, with environmental factors significantly influencing PD pathogenesis, offering potential avenues for intervention and prevention [11,12]. Our findings enhance our understanding of this neurodegenerative disease and present prospects for future PD research and treatments.

2. Case Presentation

This case study focuses on the pathological association between neuroinflammation in the olfactory bulb and the development of Parkinson's Disease. Histological and post-mortem analyses of PD brains revealed early -synuclein abnormalities localized in anterior olfactory structures at Braak's stage 1, indicating the olfactory bulb as a potential initial site of disease pathology.

Further investigation demonstrated increased vulnerability of the olfactory epithelium and olfactory bulb to inflammatory processes, particularly with age-related epithelial changes. The role of microglia within the olfactory bulb was evaluated, showing dual functionality as both a defense barrier against exogenous pathogens and a contributor to neuroinflammatory damage through disruption of the blood-brain barrier.

Experimental animal models confirmed that neurotropic viruses, toxins, and nanoparticles can enter the brain via the olfactory route, triggering -synuclein aggregation and widespread neuroinflammation. Clinical correlations were observed with historical viral outbreaks, including the 1918 influenza pandemic, and conditions such as chronic rhinitis, further supporting the environmental contribution to PD pathogenesis.

Additionally, chronic exposure to metal particles such as aluminum and iron was identified as a contributing factor in sustaining inflammatory responses within the olfactory system, potentially accelerating disease progression.

3. Discussion

The findings in this case study emphasize the olfactory bulb as a critical entry point and early site of pathological changes in Parkinson's Disease. The interaction between environmental triggers and neuroimmune responses appears to initiate and propagate -synuclein pathology.

Microglial activation plays a complex role, balancing pathogen clearance with potential neurotoxicity due to prolonged inflammation and blood-brain barrier compromise. The study also reinforces the hypothesis that external agents—including viruses and particulate matter—can access the central nervous system via the olfactory pathway.

These insights align with broader evidence linking neuroinflammation to neurodegenerative diseases and highlight the importance of early detection and targeted intervention strategies focusing on environmental and inflammatory factors.

4. Conclusion

This case study demonstrates that neuroinflammation in the olfactory bulb is a significant contributing factor in the initiation and progression of Parkinson's Disease. Environmental exposures, combined with immune responses, create a pathway for disease development that begins outside traditional central nervous system boundaries.

Understanding these mechanisms opens new opportunities for preventive strategies, early diagnosis, and therapeutic interventions targeting the olfactory system and neuroinflammatory pathways.

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Abbreviations

The following abbreviations are used in this manuscript:

PD	Parkinson's Disease
OB	Olfactory Bulb
-syn	Alpha-synuclein
BBB	Blood–Brain Barrier
CNS	Central Nervous System

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