Hypothesis

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Relationship between Vestibular Dysfunction and Cognitive Impairment in Elderly Patients: Peripheral Vertigo or Central Vertigo

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Abstract

Background: Recent research suggests an association between vestibular impairment and cognitive impairment. Mild cognitive impairment (MCI) and dementia patients are associated with increased rate of vestibular loss. The vestibular system consists of the peripheral vestibular organs and the associated extensive vestibular cortical pathway. We investigate whether vertigo (peripheral vertigo or central vertigo) is correlated with an increased risk of dementia or MCI and clinical relevance of vertigo types.

Methods: From August 2019 to January 2020, 300 patients, aged ≥ 32 years and vertigo with/without cognitive impairment symptoms were retrospectively enrolled. A logistic regression analysis was performed for vertigo types that showed a significant difference between dementia/MCI and non cognitive impairment groups. First, we reviewed vertigo with previous diagnosed 177 dementia/MCI and 123 non cognitive impairment control groups, and the differences in relevance of vertigo types between these groups were examined. Second, the patients with vertigo were classified into 2 groups: peripheral (Acute vestibular neuritis, Meniere's disease, Benign paroxysmal positional vertigo, Autonomic related vertigo, and so on) or central (Stroke, Vertiginous migraine and Epilepsy vertigo) types. Third, dementia groups included AD, VaD and Mixed types. Finally, this study evaluated risk factors for vertigo in cognitive impairment patients.

Results: Among 177 MCI/dementia patients with a mean age of 75.30 years, 56 (31.63%) developed vertigo. The frequency of vertigo types (peripheral vertigo or central vertigo) was different in dementia with vertiginous patients compared to non dementia/MCI groups {peripheral vertigo 14.70% *vs.* 79.70%; central vertigo 18.10% *vs.* 24.40%}. In this study, total 56 vertigo patients were divided into two groups based on peripheral type (n=31) or central type (n=25). Among, 300 patients with vertigo, there was that negative relevance in cognitive impairment patients and peripheral vertigo groups compared to positive relevance in MCI/dementia patients and central vertigo types {odds ratio (OR) 52.73 vs 8.71; 95% confidence interval (CI) 23.08-120.45 and 3.55-21.39, respectively].

Conclusion: The classification of vertigo is different depending on dementia/MCI or not. The proportion of central vertigo has a tendency to positive relevance with cognitive impairment groups. The findings of our study may provide direction for potentially useful diagnostic tests and vestibular-targeted therapy such problem in cognitive impairment patients.

Keywords: Cognitive impairment; Dementia/MCI; Vestibular dysfunction; Peripheral vertigo; Central vertigo

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Introduction

Dizziness/Vertigo and balance disorders are frequent problem, especially in older age persons. Ageing deteriorate physical and functional changes including a body balance and cognitive abilities [1]. Cognition may be defined as the ability to use a variety of internal abilities to respond adaptively to external environmental factors. As part of the response to external stimulation, there are balance and dizziness control using by vision, vestibular function, somatosensory system and cognition.

The peripheral vestibular end-organ consists of the otolith organ which transduces linear acceleration; and the semi-circular canals which transduce angular acceleration [2]. From there the signal pass to the vestibular pathway, the brainstem and cerebellar circuits, vestibular thalamic projections, vestibulospinal projections, and finally the vestibular cortical network [3].

The vestibular system contributes to feedback for posture acial perception [4] and body representation. Some clinicians have long noted a connection between vestibular dysfunction and cognitive impairment, and have reported that disorders of memory loss and cognitive impairment are common among patients with dizziness and vertigo. Other authors have suggested that the hippocampus system manages and maintains the flow of information in the cognitive system for individuals to carry out specific objectives or functions. This system may be compromised in patients with vestibular disorders, in turn affecting the individual's attention system.

Dementia is most common neurodegenerative disease. With an aging population, we are facing a rising of both vestibular disorders and neurodegenerative disorder. Dizziness and imbalance are important symptoms in neurodegenerative disease due to their association with falls [5]. We analyzed the type of vertigo in patients with/without cognitive impairment and studied its association. Central vertigo in dementia/MCI was significantly more positive relevance than peripheral vertigo. The vestibular examination may have a potential role in the identification of neurodegenerative disease, especially in the initial stages cognitive impairment patients.

Materials and Methods

Study design

From August 2019 to January 2020, 300 patients, aged ≥ 32 years and vertigo symptoms were retrospectively enrolled. Male and female patients aged 32 years or more with a diagnosis of peripheral or central vertigo and complaints of dizziness and/or functional body unbalance for at least six months were enrolled. All participants were performed balance testing and vestibular function test on a subset of 300 vertigo patients and cognitive testing on 177 dementia/MCI persons. A logistic regression analysis was performed for vertigo types that showed a significant difference between dementia/MCI and non cognitive impairment groups. First, we reviewed vertigo with previous diagnosed 177 dementia/MCI and 123 non cognitive impairment control groups, and the differences in relevance of vertigo types between these groups were examined. Second, the patients with vertigo were classified into 2 groups: peripheral (Acute vestibular neuritis, Meniere's disease, Benign paroxysmal positional vertigo, Autonomic related vertigo, and so on) or central (Stroke, Vertiginous migraine and Epilepsy vertigo) types. Third, dementia groups included AD, VaD and Mixed types.

Balance testing

Balance test has been done on firm or foam padded support surfaces. This test examined the participant's ability to stand unassisted under four test conditions that were designed to test the sensory inputs that corporate to balance related to the vestibular system, vision, and proprioception. Test condition 4 was checked to test vestibular function: participants had to maintain balance on a foam-padded surface to obscure proprioceptive input with their eyes closed to eliminate visual input. Balance testing was scored on a pass/fail trial. Test failure was defined as (1) to open the eyes for balance, (2) to move the arms or feet in order to achieve stability, (3) to be falled down or required operator intervention to maintain balance. Expecially, we focused on test condition 4, designed to distinguish patients who could not stay standing when relying on vestibular pathway input.

Vestibular function tests

Vestibular-evoked myogenic potentials (VEMP), a commercial electromyographic system, was used. Electromyogram signals were amplified and band-pass filtered, 20–2000 Hz for the cervical vestibular-evoked myogenic potentials (cVEMPs) and 3–500 Hz for the ocular vestibular-evoked myogenic potentials (oVEMPs). The cVEMP data was able to test to procedure of saccular function and the oVEMPs assess utricular function.

Cognitive function testing

Cognitive function testing consisted of the digit symbol substitution (DSS) subtest of the Wechsler Adult Intelligence Scale, Third Edition (WAIS III). The Mini Mental State Examination (MMSE), the Clock Test (CT), and the Verbal Fluency Test (VFT) were applied to evaluate cognitive processing. It evaluates time and spatial orientation, word recording, attention, calculation, evocation, language, and visual/constructive praxis. It has been used with success to evaluate cognition in elderly individuals.

Statistical analysis

Data are presented as the mean ± standard deviation (SD). A χ^2 test and multivariate regression analysis were used for statistical analysis. All variables with a significance level of $p < 0.05$ in the univariate analysis were included as independent variables in a forward stepwise regression method for the multivariate analysis. A value of $p < 0.05$ was considered statistically significant.

Results and Discussion

Among 177 dementia patients with a mean age of 75.30 years, 56 (31.63%) developed vertigo. The frequency of vertigo types (peripheral vertigo or central vertigo) was different in cognitive impairment with vertiginous patients compared to non dementia/MCI groups {peripheral vertigo 14.70% *vs.* 79.70%; central vertigo

18.10% *vs.* 24.40%}. In this study, total 56 vertigo patients were divided into two groups based on peripheral type (n=31) or central type (n=25). Among, 300 patients with vertigo, there was that negative relevance in cognitive impairment patients and peripheral vertigo groups compared to positive relevance in dementia/MCI patients and central vertigo types {odds ratio (OR) 52.73 *vs.* 8.71; 95% confidence interval (CI) 23.08-120.45 and 3.55-21.39, respectively].

We hypothesized that patients with cognitive impairment will have poorer vestibular function relative to non dementia/MCI groups. And we observed in this study a significantly positive relevance of central vertigo among individuals with dementia/MCI compared to peripheral vertigo type. Also, patients with vertigo/dizziness or balance disorder commonly complain cognitive deficits, such as poor attention, memory and visuospatial orientation. It has been hypothesized several potential pathways that disorders of 'higher vestibular functions' involve more than one sensory pathway as well as cognitive related domains (for example, spatial orientation, memory and attention).

In particular, there are several hypotheses related to the fact that central vertigo was more related to cognitive impairment than peripheral vertigo type. This one hypothesis is that with dementia, vertigo is one of the first symptoms and there's a specific form of this disease called posterior or diffuse cortical atrophy, affecting cerebellum, leading to vertigo and balance problems [6]. Therefore dementia would be associated with central vertigo.

There are other hypotheses related to the fact that central vertigo was more related to cognitive impairment than peripheral vertigo type. This hypothesis is that disorders of higher vestibular function are a subtype of central vertigo where the lesion is not in the brainstem or cerebellum but isolated in the higher cortical representative domain of the brain [6]. This often involves other domain function such as the cognitive disturbance of spatial orientation, attention, spatial and memory ability. Therefore, like dementia/MCI, cortical function disorder causes "higher vestibular dysfunction" which could be conceived to relate to central type vertigo compared to peripheral vertigo.

On a similar hypothesis, central vertigo is also thought to have different balance control ability depending on the domain of brain. For example, distinct vestibular pathways have been presented between the vestibular nucli and the ipsilateral and contralateral (crossing at pontine and midbrain level) parieto-insular vestibular cortex (PIVC), providing potential connection for functional vestibular nuclei [7,8]. These findings confirm and support evidence of a relevance between vestibular dysfunction and cognitive impairment. Therefore, central vertigo, rather than peripheral vertigo, has a structural and functional association with dementia/MCI; it may be the core of this paper that it would be a strong positive correlation.

Conclusion

Finally, a clear mechanistic understanding of the role of the dysfunction of central vestibular systems in neurodegenerative disease needs to be warranted. The findings of our study may provide direction for potentially useful diagnostic tests and vestibular-targeted therapy such problem in cognitive impairment patients.

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