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Research

Age-Related Sensory Impairment and Cognitive Decline in Geriatric

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ABSTRACT

Background: Incidence of sensory impairment and cognitive decline were increase with aging, each would give a considerable impact on public health and quality of life especially in geriatric population. Several mechanisms have been proposed to account for the correlation between sensory impairment and cognitive decline and the common mechanisms were sensory deprivation, information degradation, cognitive load, resource allocation and or social isolation. Prolonged reductions in the quality or quantity of sensory input lead to cognitive deterioration due to neuronal atrophy. This study aimed to determine whether age related sensory impairment with cognitive decline.

Subjects and Method: This was a cross-sectional study design conducted at geriatric clinic, Dr. Moewardi General Hospital, Surakarta, from May 31 to July 1, 2018. A sample of 54 elderly aged ≥60 years old was selected by consecutive sampling. The dependent variable was cognitive decline. The independent variables were presbyacusis, presbyastasis, olfactory impairment, diabetes, and hypertension. Presbycusis was measured by Pure Tone Audiometry. Presbyastasis was measured by Dynamic Visual Acuity (DVA) test. Olfactory dysfunction was measured by sniffing test. Cognitive decline was assessed by MoCA-Ina questionnaire. The data were analyzed by Chi-square test.

Results: The mean age of subjects was 70.5 years old ranging from 61-81 years old and most of the subjects were females (72.2%). Pure tone audiometry test revealed that 44.4% patients had presbycusis. Dynamic Visual Acuity test showed that 25.9% patients had presbyastasis. Sniffing test revealed that 29.6% patients had olfactory dysfunction. Presbyacusis (OR= 11.9; 95% CI= 1.3 to 105.5; p= 0.008) and olfactory dysfunction (OR= 10.8; 95% CI= 1.8 to 61.9; p= 0.002) increased cognitive decline, and they were statistically significant. Presbyastasis decreased cognitive decline (OR= 0.9; 95% CI= 0.1 to 5.3; p= 0.948), but it was statistically non-significant

Conclusion: Sensorineural health may serve as a marker of brain aging therefore sensory measures can be used as screening tools for cognitive decline risk.

Keywords: sensory impairment, presbycusis, presbyastasis, olfactory dysfunction, cognitive decline

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BACKGROUND

Sensory impairment and cognitive decline were increase with aging, each would give a considerable impact on public health and quality of life especially in geriatric population. As the rapid growth of the elderly population, the issue of dementia and cognitive decline will become increasingly important because of the increase incidence of Alzheimer's disease (AD) and related disorders. Recent study have focused on the transitional period from normal cognitive aging to dementia, namely mild cognitive impairment (MCI). It is signified by a measurable deterioration in cognitive function that is greater than expected based on an individual's age and education but which has not meaningfully affects a person's daily functioning (Rambe and Fitri, 2017).

Age related sensory impairment might have a causal role in cognitive decline. Peripheral hearing, balance and olfactory function decline with age and have been found to be associated with incident dementia and cognitive decline (Baek et al., 2010; Roberts et al., 2016; Semenov et al., 2016; Sogebi et al., 2016). Age related sensory impairment may be an important clinical marker for cognitive decline and may help identify persons at increased risk. Sensory impairment can often be prevented or modified, thus by targeting it in geriatric population, could have potential to delay cognitive decline.

There were some possible mechanisms involved in correlation between sensory impairment and cognitive decline. The common mechanisms were sensory deprivation, information degradation, cognitive load, resource allocation and or social isolation but the evidence is not clear. The sensory deprivation suggested that prolonged reductions in the quality or quantity of sensory input leads to cognitive deterioration due to neuronal atrophy. While in olfactory dysfunction may involve shared neuropathology such as neurofibrillary tangles in areas of the brain involved in olfactory processes. Some studies have revealed that the hippocampus system manages and maintains the flow of information in the cognitive system for individuals to carry out specific objectives or functions and in patients with vestibular disorders this system may be compromised, in turn affecting the individual's attention system (Brandt et al., 2005; Sogebi et al., 2016; Wilson et al., 2007; Yamada et al., 2015).

The aim of the study is to determine whether age related sensory impairment (hearing, vestibular and olfactory) are associated with cognitive decline in geriatric.

SUBJECTS AND METHOD

1. Study design

This was a cross sectional study carried out at Geriatric Clinic, Dr. Moewardi Hospital, Surakarta, Central Java, from May to July 2018.

2. Population and sample

Total of 54 geriatry were selected using consecutive sampling. Inclusion criteria were age more than 60 years old, fully cooperative, able to read and write, with history of either hearing loss, balance disorder and or olfactory dysfunction, without history of chronic otitis externa, chronic otitis media, chronic rhinitis and or rhinosinusitis, no history of trauma or stroke. All subjects underwent physical and ENT examination and cognitive assessment.

3. Study variables

The dependent variable was cognitive decline. The independent variables were presbyacusis, presbyastasis, olfactory impairment, diabetes, and hypertension.

4. Definition operational of variables

a. Sensory Impairment Measurement

Hearing Impairment (Presbyacusis)

Hearing was measured in a sound treated booth using pure tone audiometry, based on guidelines of the American Speech Language Hearings Association. Hearing impairment according to World Health Organization (WHO) was defined as a pure-tone average of the thresholds at 0.5, 1, 2, and 4 kHz greater than 25 dB Hearing Level for the better ear. Hearing impairment determined the level at which hearing loss begins to impair daily communication (WHO Media centre, 2016).

Vestibular Impairment (Presbyastasis)

Dynamic Visual Acuity (DVA) test was used to determine bilateral vestibular disorder, and this was an indirect indicator of Vestibulo-Ocular Reflex (VOR) function. Dynamic Visual Acuity was done by passive head shaking while the patients reads a Snellen Chart (Goebel).

b. Olfactory Dysfunction

The sniffing stick test (Heinrich Burghart GmbH, Wedel, Germany) was used for testing the subjects odor perception. The sniffin stick test battery comprises 3 different steps that evaluate olfactory dysfunction by analyzing odor threshold (T), odor discrimination (D) and odor identification (I). The results of this test are presented as the sum of scores for TDI. Score TDI >30.5 is considered normosmic, otherwise hyposmia is considered (Kobal et al., 2000).

c. Cognitive Decline

Cognitive decline was determined with Montreal Cognitive Assessment-Indonesia version (MoCA-INA) questionnaire. The MoCA-INA has been developed as a brief cognitive screening tool to detect mild-moderate cognitive impairment. It has been found to have high sensitivity and specificity for the detection of mild cognitive impairment. The MoCA assess several cognitive domains including executive function, visuospatial function, attention and concentration, memory, language, calculation and orientation. The Indonesian version of MoCA, namely MoCA-INA has been developed and validated in Indonesia and it can be used as a cognitive screening tool with score equal to or less than 26 on the MoCA showed cognitive decline (Rambe and Fitri, 2017).

d. Diabetes

Diabetes and hypertension were included as independent variables because they have been found to be a risk factors for dementia (Sogebi et al., 2016). A diagnosis of diabetes was established based on a fasting glucose >125 mg/dl, or a positive history of a physician diagnosis plus treatment with oral anti-diabetic drugs or insulin.

e. Hypertension

The diagnosis of hypertension was established based on a systolic blood pressure >140 and/or diastolic blood pressure ≥90 mmgHg or treatment with antihypertensive medications. Age (<70 years old/≥70 years old), gender (male/ female), level of education (<high school/≥high school) were based on medical record and or self-report.

5. Statistical Analysis

Correlation between presbyacusis, presbyastasis, olfactory impairment, diabetes, hypertension, and cognitive decline was measured using Chi square test.

6. Research Ethics

Informed consent was obtained from all subjects prior to each examination and approval for this study was obtained from the Ethics Committee Moewardi General Hospital.

RESULTS

1. Univariate analysis

The mean age of subjects was 70.5 years old ranging from 61 to 81 years old, 72.2% were females, and 35.2% had college. There were 24 subjects (44.4%) with presbycusis, 14 (25.9%) with presbyastasis, 16 (29.6%) with olfactory dysfunction and 8 (14.8%) had results that suggested cognitive decline. The sample characteristics were shown in table 1.

Table 1. Sample Characteristics

Variables	Categories	n	%
Sex	Male	15	27.8
	Female	39	72.2
Age (years old)	61-70	28	51.9
	71-80	23	42.6
	>80	3	5.6
Level of education	Primary education	9	16.7
	Junior high school	15	27.8
	Senior high school	11	20.4
	College	19	35.2
Hypertension	Yes	34	63
	No	20	37
DM	Yes	28	51.9
	No	26	48.1
Presbycusis	Yes	24	44.4
	No	30	55.6
Presbyastasis	Yes	14	25.9
	No	40	74.1
Olfactory dysfunction	Yes	16	29.6
	No	38	70.4
Cognitive decline	Yes	8	14.8
	No	46	43.7

2. Bivariate analysis

Proportion of geriatric with cognitive decline is 11.9 fold greater if a geriatric has presbycusis (OR= 11.9; 95% CI= 1.3 to 105.5; p= 0.008), while proportion of geriatric with cognitive decline is 10.8 fold greater if a geriatric has olfactory dysfunction (OR= 10.8; 95% CI= 1.8 to 61.9; p= 0.002). Geriatric with prebyastasis had lower risk to cognitive decline (OR= 0.9; 95% CI= 0.1 to 5.3; p= 0.948), but it was statistically non-significant (Table 2).

Tabel 2. Correlation analysis of age related sensory impairment and cognitive decline

Independent Variable	OR	95% CI		p
		Lower limit	Upper limit	
Presbyacusis	11.9	1.3	105.5	0.008
Presbyastasis	0.9	0.1	5.3	0.948
Olfactory dysfunction	10.8	1.8	61.9	0.002
Age ≥70 years old	0.2	0.0	1.4	0.135
Education ≥senior high school	2.3	0.5	11.1	0.443
Hypertension	1.0	0.2	4.8	1.000
DM	0.1	0.0	1.0	0.052

DISCUSSION

The most age group in our sample study were in the 61-70 year age range (51.9%). The sample study consisted mostly of female subjects (72.2%). These findings are similar to those in other published studies, Gazzola et al. (2012) in elderly subjects with vestibular dysfunction (82.9%) and also in English community-dwelling adults aged ≥ 50 years old by Liljas et al. (2018), probably due to the majority of female among the elderly population in general.

We found that age related sensory impairment (hearing, vestibular and olfaction) is quite common in geriatric. These findings are consistent with previous studies. Hearing loss is the leading cause of disability among men above the age of 60 years, and is the second most common contributor to years lived with disability for women in this age group (World Health Organisation, 2018). Ferreira et al. (2014) found that dizziness is a very prevalent symptom in the elderly, with 24.3 % had imbalance and this findings coexisting with co-morbidities and use of multiple medications. Decreased olfactory function is very common in the older population, being present in >50% of individuals aged between 65 and 80 years and in 62–80% of those >80 years of age (Attems et al., 2015).

In this study we found the total number of presbycusis was higher in geriatric followed by olfactory dysfunction and presbyastasis (44.4%, 25.9%, 29.6% respectively). Schubert et al. (2017) showed that hearing impairment (presbyacusis) being the most prevalent of sensory impairment besides visual and olfactory impairment in middle aged adults, similar results have been shown by Fischer et al. (2017) in elderly.

Communication impairment caused by hearing loss can also lead to social isolation in geriatric, and epidemiologic and neuroanatomic studies (Bennett et al., 2006) have demonstrated associations between poor social networks and cognitive decline (Barnes et al., 2004). The results of our study would also seem to support this possible mechanism because the risk of cognitive decline associated with hearing loss only appeared to increase at hearing tresholds >25 dB which is considered the tresholds at which hearing loss begins to impair verbal communication. An alzheimer's neuropathology is suggested by animal studies demonstrating that environmental enrichment (possibly analogous in humans to having access to auditory and environmental stimuli) can reduce β-amyloid levels in transgenic mouse models (Lazarov et al., 2005).

Regarding factors related to the incidence of cognitive decline, there was significant correlation between presbycusis and olfactory dysfunction with cognitive decline, but not for presbyastasis (Table 2).

Some of peripheral vestibular diseases are frequently associated with sensorineural hearing loss (SNHL) and hearing loss are known to negatively influence cognition themselves (Livingston et al., 2017). Multiple cohort (Gurgel et al., 2014; Lin et al., 2013) and cross-sectional studies (Lin, 2011; Lin et al., 2011; Loughrey et al., 2018) have demonstrated that SNHL is an independent risk factor for cognitive decline and even dementia. Therefore, the question is raised whether the observed cognitive deficits in vestibular patients are a result of these other comorbidities or whether they can be independently attributed to vestibular loss (Dobbels et al., 2019; Smith, 2017). Nonetheless, prevalence of SNHL in Bilateral Vestibulopathy (BVP) patients range from 31 to 44% (Lucieer et al., 2018). Therefore, it is uncertain whether the cognitive impairment demonstrated in BVP patients could be solely attributed to the loss of vestibular input as suggested in previous studies. These cognitive deficits in BVP patients might be partially caused by a concomitant hearing loss.

The mechanisms by which vestibular dysfunction is associated with cognitive dysfunction are unclear, although several potential pathways have been hypothesized. Loss of peripheral vestibular input may lead to atrophy of areas within the cortical vestibular network, which notably includes the dorsal thalamus, the temporo-parietal junction, and the hippocampus. Atrophy of these structures may in turn result in impairments in visuospatial memory and perception (Dieterich and Brandt, 2008;

Ventre-Dominey, 2014). Indeed, a study of 10 patients with bilateral vestibular failure found that these patients developed significant hippocampal atrophy, and associated impairments in visuospatial tasks such as navigation in a virtual maze (Brandt et al., 2005).

Alternatively, the association between vestibular and cognitive dysfunction may relate to a reduction in cognitive resources available in the setting of vestibular loss. According to Kahneman's Capacity Model of Attention, an individual has a set amount of attention and cognitive resources available to allocate to mental tasks. The increased instability in gaze and posture associated with vestibular loss may require that increased attentional resources be allocated by the brain to maintaining balance and orientation (Nascimbeni et al., 2010). This leads to decreased cognitive reserve available for other tasks, particularly those that require processing by similar cognitive networks. Finally, vestibular dysfunction has been associated with affective disorders such as anxiety and depression, which may in turn contribute to cognitive dysfunction (Gurvich et al, 2013).

Olfaction is invariably impaired in AD. Olfactory involvement is present in up to 90 % of patients with AD. Occurring in early AD, olfactory dysfunction can predict the conversion of MCI to AD. Mild Cognitive Impairment is a diagnostic label for a defined cognitive syndrome that denotes a transitional stage between normal aging and dementia. Populations affected by MCI have been shown to be at higher risk than the general population for developing dementia. Recent research on MCI patients, has demonstrated that 47% of MCI olfactory impaired subjects progressed to dementia while only 11% of MCI olfactory-normal subjects progressed to dementia at 2 year follow up (Conti et al., 2013).

The olfactory bulb area often shows the typical pathology in Alzheimer's disease (neurofibrillary tangle and amyloid deposit) (Kovács, 2004). These pathologic changes have also been shown in the peripheral and central olfactory cortices, and in layer II and III of the entorhi- nal cortex in AD. According to Braak's stage, neurofibrillary tangle that begins in the olfactory bulb (OB) has also been correlated with olfactory dysfunction in AD (Conti et al., 2013).

Other variables i.e age, level education, HT, DM were found not statistically significant (table 2). The correlation between those variables with cognitive function have been inconsistent in previous studies (Livingston et al., 2017; Wysocki et al., 2012). Hypertension is associated with increased rate of cognitive decline specifically in vulnerable individuals at the earliest stages of dementia, but once the cognitive decline process has been triggered, additional contributions to cognitive decline by HT diminish (Wysocki et al., 2012). DM is associated with incident cognitive impairment, dementia & Alzheimer disease as a result of cerebrovascular disease & neurodegenerative processes (Ben Assayag et al., 2017). Dementia stage was not taken into account and might be one reason for their negative results.

Based on the results of this study, it can conclude that age related sensory impairment (hearing, vestibular and olfactory) are associated with cognitive decline in geriatric. Future study is needed to understand how sensory impairment influence cognitive function and what happens when more than one sensory system is impaired. Leveraging large population studies and conducted longitudinal studies in future to reevaluate directions of causality among study variables, is one potential means to answer it.

AUTHOR CONTRIBUTION

Dewi Pratiwi, Aulia Hervi Anggraini, and Febri Arianto Bayu contributed to collected the data; measured presbyacusis, presbyastasis, olfactory impairment, blood glucose level, and blood tension; did data analysis; and wrote the manuscript.

CONFLICT OF INTEREST

We declare that there was no conflict of interest.

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