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The Relationship Between Brainstem Structural Anatomical Parameters and Cognitive Function Impairment Based on the Indonesian Version of Montreal Cognitive Assessment Score in Clinical Dementia Patients

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ABSTRAK

Dementia is a neurodegenerative disorder marked by significant cognitive decline, with structural changes in the brainstem potentially contributing to impairment. However, the relationship between brainstem anatomical parameters and cognitive function in clinical dementia patients remains understudied. This study aimed to investigate this relationship using the Indonesian version of the Montreal Cognitive Assessment (MoCA-Ina) score. An analytical observational design was employed, involving 65 clinical dementia patients who underwent head MRI at Ngoerah Hospital, Denpasar. Parameters measured included midbrain anteroposterior (AP) diameter, midbrain-to-pons ratio, superior cerebellar peduncle (SCP) width, middle cerebellar peduncle (MCP) width, and interpeduncular angle. Cognitive function was assessed using MoCA-Ina, and data were analyzed via correlation and logistic regression tests. Results revealed a moderate positive correlation between midbrain-to-pons ratio and MCP width with MoCA-Ina scores ($r = 0.265$ and 0.447, $p < 0.001$), indicating their predictive value for cognitive impairment. The midbrain-to-pons ratio and MCP width significantly predicted MoCA-Ina scores (coefficients: 28.723 and 1.408, $p < 0.05$). No significant relationships were found for AP diameter, SCP width, or interpeduncular angle. These findings underscore the importance of brainstem structural evaluation in dementia assessment, suggesting that specific anatomical parameters may serve as biomarkers for cognitive decline. This study highlights the potential of MRI in enhancing diagnostic accuracy for dementia, though further research is needed to validate these findings in broader populations.

KEYWORDS dementia, brainstem, midbrain-to-pons ratio, MoCA-Ina, MRI

INTRODUCTION

The aging process in humans is inevitable. The aging process in the brain includes structural changes and decreased function. The elderly population in Indonesia is projected to increase to 48.2 million people (15.77%) by 2035 due to increased life expectancy (UHH) (Rachmah Wati, Syari, and Khodijah Parinduri, 2023). This increase presents a significant public health challenge in optimizing the quality of life of the elderly. Worldwide, about 50 million people suffer from dementia, with an estimated 10 million new cases annually. The prevalence rate of dementia in individuals over 60 years old is about 5-8% (Cao et al., 2020).

Dementia is a major public health issue among older adults, characterized by progressive neurological decline that significantly impacts patients and their families. The four main types of dementia are Alzheimer's Dementia (AD), Vascular Dementia (VaD), Lewy Body Dementia (LBD), and Fronto-Temporal Dementia (FTD) (Zohuri and Dalili, 2023). It is therefore important to identify at-risk individuals, measure disease stages, and monitor progression using specific and sensitive methods.

Although dementia is often diagnosed clinically, definitive confirmation usually requires postmortem examination or brain biopsy—gold standards not achievable in all cases—making diagnosis, staging, and prognosis challenging. A strong correlation exists between cognitive decline and the severity of brain atrophy observed at autopsy. The most effective approach to maintaining brain function is early therapy before irreversible neuronal loss and to prevent or delay cognitive impairment onset.

Structural neuroimaging plays an important role in determining whether mild or moderate vascular changes sufficiently explain cognitive impairment in mixed dementia cases. Magnetic Resonance Imaging (MRI) performed at early dementia symptoms is beneficial for diagnosis, categorization, prognosis, and treatment evaluation. MRI sensitivity in diagnosing dementia is 68% (Creese et al., 2019). Common MRI scores include Schelten's score for medial temporal lobe atrophy, Koedam score for parietal lobe atrophy, Pasquier score for global atrophy, and Fazekas scale for white matter hyperintensities (Zandifar et al., 2020).

To improve diagnostic accuracy, expansion of reliable and validated research is urgently needed. Several hypotheses exist for improving diagnosis in clinical dementia patients with motor impairments, including analyzing atrophy patterns. While MRI research mainly focuses on cortical structures, this study highlights brainstem atrophy patterns.

Several established brainstem measurement methods exist in other neurodegenerative diseases like Progressive Supranuclear Palsy (PSP), including anteroposterior midbrain diameter (AP), midbrain-to-pons ratio, superior cerebellar peduncle (SCP) width, middle cerebellar peduncle (MCP) width, and interpeduncular angle, but data for dementia patients are lacking (Müller et al., 2023). This study applies such measurements to clinical dementia patients to assess correlations, aiming to facilitate diagnosis and improve confidence.

Various instruments detect early cognitive impairment, such as the Mini-Mental State Examination (MMSE), with a sensitivity of 53% (Akbar, Effendy, and Camellia, 2019). Advances have introduced the Montreal Cognitive Assessment (MoCA), developed in Canada, offering 83% sensitivity (Untari et al., 2021). In Indonesia, Nadia H., Silvia L., and Yetty Herutanto conducted validity and reliability tests on the Indonesian-translated Montreal Cognitive Assessment (MoCA-Ina) (Untari et al., 2021). It is valid based on trans-cultural and reliability criteria, allowing Indonesian doctors to apply it. Imaging significantly increases the lower limit of diagnostic accuracy.

Previous research shows that structural brain changes and atrophy change sharply during early stages of cognitive dysfunction, serving as sensitive early biomarkers for progression from Mild Cognitive Impairment (MCI) to dementia. Anatomical atrophy, captured by volumetric MRI, begins before cognitive decline (Zandifar et al., 2020).

Dementia poses a growing global health challenge, affecting approximately 50 million people worldwide, with 10 million new annual diagnoses (Cao et al., 2020). It involves progressive cognitive decline impacting quality of life and healthcare systems. Structural neuroimaging, especially MRI, is critical for diagnosis and monitoring, highlighting cortical atrophy and white matter changes (Zandifar et al., 2020). However, while much focus is on cortical changes, research on brainstem roles in dementia is limited. Neurodegenerative diseases such as PSP demonstrate diagnostic value of brainstem measurements like midbrain-to-pons ratio and cerebellar peduncle widths (Müller et al., 2023), but their relevance in dementia needs exploration.

A significant research gap exists in understanding how brainstem anatomical parameters correlate with cognitive impairment in dementia. Most studies focus on cortical or hippocampal atrophy, overlooking infratentorial structures. For example, midbrain-to-pons ratio has been validated in PSP (Cooperrider et al., 2020) but remains unclear in dementia diagnosis and staging. Similarly, the relationship between cerebellar peduncle measurements

and cognitive function is underinvestigated in dementia, limiting comprehensive neuroimaging assessments and early diagnosis, especially when brainstem involvement precedes cortical changes. Addressing this gap could deepen understanding of dementia pathology and improve diagnostic accuracy.

The urgency of this research is underscored by the rising prevalence of dementia, particularly in aging populations. Early accurate diagnosis is crucial, but current tools like MMSE lack sensitivity (Akbar et al., 2019). The Montreal Cognitive Assessment (MoCA), with higher sensitivity (Davis et al., 2021), offers improvement, but integrating imaging biomarkers could further enhance precision. Brainstem structures, involved in critical neural pathways, may serve as early indicators of cognitive decline, especially in vascular or mixed dementia. Indonesia's aging population is projected to reach 48.2 million by 2035 (Rachmah Wati et al., 2023), emphasizing the need for local diagnostic tools like MoCA-Ina and adapted neuroimaging protocols.

This study's novelty lies in focusing on brainstem structural parameters as potential biomarkers for cognitive impairment in dementia—a seldom-explored perspective. Applying measurements used in PSP research (midbrain-to-pons ratio, cerebellar peduncle widths) to dementia bridges a critical knowledge gap. Findings could pave the way for more comprehensive MRI protocols incorporating cortical and infratentorial evaluations. Clinically, this improves diagnostic confidence and enables earlier intervention, enhancing outcomes. Additionally, it contributes Indonesian population data to global dementia research, supporting culturally adapted diagnostics.

The study aimed to find the relationship between several brainstem structural anatomical parameters (midbrain AP diameter, midbrain-to-pons ratio, SCP width, MCP width, and interpeduncular angle) on brain MRI and the severity of cognitive impairment measured by MoCA-Ina scores in clinical dementia patients. It also aimed to describe MRI's diagnostic role in evaluating cognitive impairment to detect possible etiology and disease stage, emphasizing the need for imaging regardless of MoCA-Ina scores.

RESEARCH METHOD

This research is within the scope of the field of Radiology and Neurology. This study is an analytical observational study with the design used as a cross sectional study. This study assessed several parameters of the anatomical structure of the brainstem based on 5 parameters, namely AP midbrain diameter, midbrain-to-pons ratio, SCP width, MCP width, and interpeduncular ingle. At the same time, an assessment of the severity of the

patient's cognitive impairment was also carried out using the MoCA-Ina score. All data in this study were obtained from medical record data and systems from the Picture Archiving and Communication System (PACS) at Ngoerah Hospital. This research was carried out at the Medical Record Installation and Radiology Installation of Ngoerah Hospital from July to December 2024.

The target population in this study is all patients with clinical dementia. Clinical dementia includes patients with a clinical picture of vascular dementia, Alzheimer's dementia, or dementia of other mixed types. The sample of this study is all patients sent to the Radiology Installation at Ngoerah Hospital for a head MRI examination with clinical dementia in January 2021 until the number of samples is met that meet the inclusion and exclusion criteria so that eligible subjects are obtained.

The sample selection method in this study was carried out, samples of dementia clinical patients for the period January 2021 to June 2024 obtained from SIMARS. Each subject selected through the inclusion criteria is then followed by a search of medical records.

RESULTS AND DISCUSSION

Characteristics of the Research Subject

This study is a correlative test conducted at the Radiology Installation of Ngoerah Hospital Denpasar from July 2024 to December 2024. The research sample was medical record data and head MRI from the Picture and Communication System (PACS) system of dementia patients who were examined at the Radiology Installation of Ngoerah Hospital Denpasar. The number of samples that met the inclusion criteria was obtained as many as 65 research subjects. The data on the characteristics of the research subjects in this study were obtained through descriptive analysis that presented an overall picture of the characteristics of the subjects with clinical dementia. Data normality tests were carried out using Kolmogorov-Smirnov.

Variables with abnormally distributed numerical scales were displayed in the median and interquartile ranges in the form of age, body mass index (BMI), midbrain-to-pons ratio, superior cerebellar peduncle (SCP) width, middle cerebellar peduncle (MCP) width, interpeduncular angle, and Montreal cognitive assessment score (MoCA-Ina). Meanwhile, variables with a numerical scale that is normally distributed are displayed in mean and standard deviation in the form of midbrain AP diameter. Detailed descriptions of the basic characteristics of the research subjects can be seen in Table 1.

Table 1 shows the basic characteristics of the study subjects that the median age of subjects with clinical dementia is 67 years with an interquartile range of 13 years. The median BMI was 22.8 with an interquartile range of 4.5. Of the total 65 subjects with clinical dementia, as many as 33 people (50.8%) were male, while 32 people (49.2%) were female. A total of 41 people

(63.1%) had no history of smoking and 24 people (36.9%) had a smoking habit. Of the total 65 samples, as many as 2 people (3.1%) work as teachers, 28 people (43.1%) are housewives, as many as 18 people (27.7%) and as many as 17 people (26.2%) work as self-employed. A total of 22 people (33.8%) had no history of hypertension and 43 people (66.2%) had a history of hypertension.

Table 1. Basic characteristics of the sample

No.	Research Variables	n = 65
1.	Age (years), median ± IQR	67 ± 13
2.	*Body mass index* (BMI), median ± IQR	22,8 ± 4,5
3.	Gender	
	Man	33 (50,8%)
	Woman	32 (49,2%)
4.	Work	
	Teacher	2 (3%)
	Housewives	28 (42,4%)
	Official	18 (27,3%)
	Self employed	17 (25,8%)
5.	Smoking habits	
	Yes	24 (36,9%)
	No	41 (63,1%)
6.	History of hypertension	
	Yes	43 (66,2%)
	No	22 (33,8%)

Table 2 shows that the diameter of the midbrain AP in subjects with clinical dementia has an average of 11.1 mm with a standard junction of ± 1.63 mm. The median midbrain-to-pons ratio is 0.19 with an interquartile range of 0.02. The median SCP and MCP are 1.9 mm and 7.9 mm, respectively, with an interquartile range of 0.1 and 1. As for the interpeduncular angle, it has a median of 71° with an interquartile range of 8°.

Table 2. Characteristics of the sample based on the structural anatomical parameters of the brainstem

No.	Research Variables	n = 65
1.	Diameter *midbrain* AP (mm), Average ± SB	11,1 ± 1,63
2.	*Midbrain-to-pons ratio*, median ± IQR	0,19 ± 0,02
3.	Wide SCP (mm), median ± IQR	1,9 ± 0,1
4.	Wide MCP (mm), median ± IQR	7,9 ± 1
5.	*Interpeduncular angle* (°), median ± IQR	71 ± 8

The characteristics of the sample based on the MoCA-Ina score are shown in Table 3. The median score of MoCA-Ina is 12 with an interquartile range of 5.

Table 3. Sample characteristics based on MoCA-Ina score

No.	Research Variables	n = 65
1.	MoCA-Ina score, median ± IQR	12 ± 5

The Relationship between Brainstem Structural Anatomical Parameters and Cognitive Function Impairment Based on the Indonesian version of the Montreal Cognitive Assessment Score in clinical patients with dementia

The relationship between the structural anatomical parameters of the brainstem, namely midbrain diameter AP, midbrain-to-pons ratio, SCP width, MCP width, and interpeduncular angle with cognitive function impairment based on the Indonesian version of the Montreal Cognitive Assessment Score in clinical dementia patients was carried out using the Spearman Rank Correlation shown in Table 4. This study showed that there was a sufficient positive relationship between the midbrain-to-pons ratio and cognitive function impairment based on the MoCA-Ina score with a correlation coefficient obtained of 0.272 with a p < value of 0.05. This study also showed that there was a sufficient positive relationship between MCP width and cognitive function impairment based on the MoCA-Ina score with a correlation coefficient obtained of 0.424 with a p < value of 0.05.

Table 4. Data from the Spearman Rank Correlation test of structural anatomical parameters of the brainstem with cognitive function disorders based on the Indonesian version of the Montreal Cognitive Assessment Score.

No.	Structural Anatomy of the Brainstem	MoCA-Ina	
		Correlation Coefficient (r)	**P value**
1.	Diameter *midbrain* AP (mm)	0,225	0,071
2.	*Midbrain-to-pons ratio*	0,272	0,02
3.	Wide SCP (mm)	0,200	0,110
4.	Wide MCP (mm)	0,424	< 0,001
5.	*Interpeduncular angle* (°)	-0,041	0,748

After controlling the confounding variables by analysis, then a multiple linear regression test was carried out, the correlation of the midbrain-to-pons ratio could predict the Moca-Ina score in dementia patients with a coefficient regression of 28.723 and a 95% confidence interval of 7.910 – 49.536 with a p < value of 0.05. The wide correlation of MCP was also found to predict the Moca-Ina score with a coefficient regression of 1.408 and a 95% confidence interval of 0.435 – 2.382 with a p value of < 0.05. (Table 5). These results show that it is independently proven that the brainstem anatomy is related to cognitive impairment based on MoCA-Ina scores.

There was no significant relationship between AP midbrain diameter, SCP width, and interpeduncular angle to MoCA-Ina scores with correlation

coefficients of 0.407, -1.687, and 0.03, respectively, as evidenced by p > values of 0.05 (Table 5).

Table 5. Data from the multiple linear regression test of structural anatomical parameters of the brainstem with cognitive function impairment based on the Indonesian version of the Montreal Cognitive Assessment Score

No.	Research Variables	*Coefficient Regression (B)*	P value	95% *Confidence Interval*
1.	Diameter *midbrain* AP (mm)	0,407	0,298	-0,369 – 1,183
2.	*Midbrain-to-pons ratio*	28,723	0,008	7,910 – 49,536
3.	Wide SCP (mm)	-1,687	0,135	-3,912 – 0,538
4.	Wide MCP (mm)	1,408	0,005	0,435 – 2,382
5.	*Interpeduncular angle* (°)	0,003	0,960	-0,107 – 0,112

Discussion

Characteristics of the Research Subject

The subjects in this study were 65 patients with clinical dementia who underwent a head MRI examination procedure at Ngoerah Hospital, Denpasar, Bali. Of the total 65 subjects, the median age of subjects with clinical dementia was 67 years with an interquartile range of 13 years. The results of this study reflect the suitability of the characteristics of the subjects with the majority of the population who are susceptible to dementia, namely elderly patients with an age range of over 65 years (Luchesi et al., 2021). The age group ≥65 years is the most at risk of developing dementia, with a significant increase at ≥75 years old. Based on epidemiological data, at the age of 65–74 years (early elderly), the risk is still relatively low, but it is starting to increase. At the age of 75–84 years (middle-aged people): the risk increases significantly, with a higher prevalence. At ≥85 years of age (elderly/elderly): The highest risk, with a prevalence of more than 30–50% in some population studies.

Although age is the strongest known risk factor for dementia, it is not an inevitable consequence of biological aging. As we age, the brain undergoes structural and functional changes, such as brain atrophy, reduced number of neurons and decreased synaptic plasticity. In addition, with age, the body experiences increased oxidative stress and chronic inflammation which will contribute to nerve cell damage.

In this study, 33 people (50.8%) were men, while 32 people (49.2%) were women. In this study, no differences between male and female sexes were found. Gender plays a role in the risk of dementia, with significant differences between men and women in prevalence, biological factors, and social factors (Nazirah, 2021). Women have a higher risk of developing Alzheimer's-type dementia than men. A decrease in estrogen after menopause is associated with an increased risk of Alzheimer's, as estrogen has a neuroprotective effect that

helps protect the brain. However, men are more likely to develop vascular dementia due to cardiovascular risk factors such as hypertension, diabetes, and heart disease.

The subjects of this study out of a total of 65 patients had a median body mass index (BMI) of 22.8 with an interquartile range of 4.5. This BMI value indicates that the population of study subjects has a normal/ideal weight. This is in line with the results of a meta-analysis that compared to normal-weight individuals, obese individuals are less likely to live long enough to develop dementia and are more likely to die from conditions known to increase the risk of dementia, such as diabetes and cardiovascular disease (Brenowitz, 2021). Given these findings, differences in survival may have contributed to a lower estimate of the strength of the relationship between BMI and dementia.

The results of this study show that the distribution of dementia patients is mostly housewives at 34.8%, followed by employees at 27.3%, self-employed at 25.8%, and followed by teachers at 3%. This study shows that dementia is more likely in respondents who do not work than respondents who have jobs. This is suspected to be related to psychological stress due to work which can increase the risk of vascular disorders that occur in IRT respondents (Huang et al., 2020). Higher complexity of work with data and humans can reduce the risk of dementia. Job strain can affect cognitive decline.

The smoking history in the subjects of this study was 24 people who smoked (36.9%) and 41 people (63.1%) who did not smoke. This is less consistent with previous research results that smoking has been shown to increase the risk of dementia, including Alzheimer's disease and vascular dementia. Smokers have a 30-50% higher risk of developing dementia compared to non-smokers (Jeong et al., 2023). The chemicals in cigarettes, such as nicotine and carbon monoxide, can cause oxidative stress and chronic inflammation, which contribute to nerve cell damage in the brain. This may be due to the variation and sample size in the population that is examined, the number of subjects is abnormally distributed with the number of male and female patients being approximately the same.

The subjects with a history of hypertension in this study were 43 people (66.2%) and those without a history of hypertension as many as 22 people (33.8%). This result is in line with previous research, namely that blood vessels in elderly patients are thicker and stiffer or called atherosclerosis so that blood pressure increases. Increased blood pressure over time can exacerbate damage to brain structures, including a decrease in the amount of white matter in the prefrontal lobe and an increase in white matter hyperintensity in the frontal lobe (Sierra, 2020). It is suspected that hardening of the walls of blood vessels and disorders of cerebrovascular autoregulation resulting from chronic high blood pressure are correlated with dementia (Canavan and O'Donnell, 2022).

Of the 43 people who experienced hypertension, 14 people (21.2%) were found to have stage I hypertension and as many as 29 people (43.9%) experienced stage II hypertension. According to WHO, stage I hypertension is

defined when systolic blood pressure is 140-159 mmHg and diastolic blood pressure is 90-99 mmHg. Meanwhile, stage II hypertension is defined as systolic blood pressure of 160-179 mmHg and diastolic blood pressure of 100-109 mmHg. A meta-analysis of 136 studies assessing the association between hypertension in middle age and dementia risk reported that systolic blood pressure (SBP) of >130 mmHg in middle age was associated with an increased risk of dementia and cognitive decline by 34% (Ou et al., 2020). Meanwhile, an increase in diastolic blood pressure (DBP) of >90 mmHg was associated with a 51% increased risk of Alzheimer's disease (AD) (Ou et al., 2020).

The meta-analysis further examined the relationship between AD and midlife hypertension, finding a significant association between systolic hypertension (>160 mmHg) and AD (Lennon et al., 2019). However, in a small percentage of studies, no significant association was found between diastolic hypertension and AD. This meta-analysis showed that stage 1 (>140/90 mmHg) and stage 2 (>160/95 mmHg) systolic hypertension in middle age was associated with an increased risk of AD, but no association was found with diastolic hypertension. Similarly, it provides evidence regarding the negative impact of high blood pressure on cognitive performance in middle-aged participants around 40-64 years old (Forte and Casagrande, 2020). However, as we age, this relationship weakens and becomes inconsistent.

Subjects with clinical dementia had a MoCA-Ina score with a median of 12 which when categorized based on the degree of cognitive impairment included the category of moderate impairment. In accordance with the results of previous studies on the early detection of dementia using the MoCA-Ina score using the MoCA score cut-off below 26, the MoCA score accurately detected more than 94% of people with dementia (Davis et al., 2021).

The Relationship between Brainstem Structural Anatomical Parameters and Impaired Cognitive Function Based on MoCA-Ina Score in Dementia Patients

In this study, 5 structural anatomical parameters of the brainstem were examined, namely AP midbrain diameter, midbrain-to-pons ratio, SCP width, MCP width, and interpeduncular angle. The diameter of the AP midbrain in the study subjects had an average of 11.1 mm with a standard junction of ± 1.63 mm. The median midbrain-to-pons ratio is 0.19 with an interquartile range of 0.02 cm. The median widths of SCP and MCP were 1.8 and 7.9 mm, respectively, with an interquartile range of 0.2 and 1 mm.

In this study, a sufficient positive relationship was obtained between the diameter of the AP midbrain and the midbrain-to-pons ratio with the result of the correlation coefficient obtained of 0.329 with a $p <$ value of 0.001. A sufficient positive relationship was also obtained between the width of SCP and MCP with the midbrain-to-pons ratio with the correlation coefficient obtained at 0.432 and 0.279 with a $p <$ value of 0.001. The relationship between SCP and MCP was also obtained with a correlation coefficient of 0.338 with a $p <$ value of 0.001. This describes the characteristics of the size and shape of

the midbrain, where the four variables represent the same relationship, which indicates midbrain atrophy, where the smaller the size of the midbrain will affect cognitive function impairment based on the MoCA-Ina score in dementia patients, where the MoCA-Ina score will be smaller as well.

In this study, a sufficient positive relationship was also found between the midbrain-to-pons ratio, and MCP width with cognitive impairment based on the MoCA-Ina score in dementia patients with a correlation coefficient of 0.265 and 0.447 with a p < value of 0.001, respectively. After a logistic regression test, the correlation of the midbrain-to-pons ratio can predict the Moca-Ina score in dementia patients with an estimated coefficient of 28.723 and a 95% confidence interval of 7.910 – 49.536 with a p < value of 0.05. Every increase in the midbrain-to-pons ratio of 1 can also increase the MoCA-Ina score by 28 units. The wide correlation of MCP was also found to be able to predict the Moca-Ina score with an estimated coefficient of 1,408 and a 95% confident interval of 0.435 – 2,382 with a p value of 0.05 <. Every increase in the width of the MCP by 1 mm, the MoCA-Ina score can also increase by 1.4 units.

Several studies mention that focal infratentorial vascular lesions are mainly found in patients with small vessel type VaD, which is in line with the view that these patients have a wider range of cerebrovascular pathology compared to those who only experience VaD due to large vessel lesions (Sung et al., 2009).

In addition, patients with larger basilar artery diameters were found to have more infratentorial vascular lesions, which may be caused by ateroembolic events associated with vascular ecstasy (Takeda, Rakugi and Morishita, 2020). The study also found the presence of diffuse signaling abnormalities in the pons, which may reflect ischemic pathology of small vessels.

Furthermore, other studies have also found that infratentorial vascular abnormalities are associated with lesions in the basal ganglia and thalamus. Since both the infratentorial and thalamus structures are hemorrhaged by the vertebrobasilar system, this relationship can be explained in part by the involvement of such circulation. In addition, it was found that mesensefalon (midbrain) and cerebellar atrophy occurred in a small percentage of patients (Bastos Leite et al., 2006).

The observed infratentorial vascular lesions are mainly located in the cerebellum and the basilar pons, that is, structures that are currently considered relevant to cognitive processes. Although the clinical scale we used for VaD, which aims to test general and executive cognitive function, does not confirm that these lesions contribute to cognitive impairment, it is likely that the presence of large numbers of supratentorial vascular lesions in our patients may mask the cognitive impact of infratentorial lesions.

In addition, perhaps more specific neuropsychological tests may show more subtle cognitive impacts. Previous studies have shown that

neuropsychological batteries that include visuospasial skills tests produce abnormal findings in patients with dominant infratentorial pathologies, such as large vessel cerebelar infarction, Friedreich's ataxia, and olivopontocerebelar atrophy.

On the other hand, other studies have also found that patients with mesensefalon atrophy have worse general cognitive and executive function than other VaD patients (Bastos Leite et al., 2006). Although mesensefalon atrophy correlates with global cortical atrophy (GCA), which is most likely caused by secondary axonal degeneration due to supratentorial pathology, the association between mesensefalon atrophy and lower MoCA-Ina scores remains significant even after correction for abnormalities representing degenerative and supratentorial vascular pathologies.

These findings suggest that mesensefalon has a contribution to cognitive function independently of the supratentorial structure, and that the assessment of mesensefalon atrophy should be included in the MRI evaluation of patients with dementia.

A growing body of evidence suggests that vascular and degenerative pathologies can occur simultaneously. In addition, neuropathology studies have reported the involvement of cerebellum and mesensefalon in Alzheimer's pathology. Therefore, the cerebellar atrophy and mesensefalon observed in this sample of VaD patients may reflect concomitant Alzheimer's pathology, and the involvement of periaqueductal grisea substance may explain the association between mesensefalon atrophy and cognitive impairment due to impaired mesensefalic connections.

In this study, there was no significant relationship between the interpeduncular angle and the midbrain-to-pons ratio, AP midbrain diameter, SCP width, and MCP width with correlation coefficients obtained of -0.106, -0.068, 0.010, and -0.029, respectively, as evidenced by a p-> value of 0.05. In the context of dementia, the narrowing of the interpeduncular angle in brain imaging can be a finding that indicates a condition such as normal pressure hydrocephalus (NPH), especially when accompanied by other characteristic features. This indicates the possibility of mesensefalon atrophy and dilatation of the interpeduncular cisterna due to a decrease in cerebrospinal fluid pressure (CSF). However, narrowing of the interpeduncular angle alone is not sufficient to diagnose dementia and must be interpreted in the clinical context as well as other imaging findings.

Research Limitations

This study still has several limitations, including The research is retrospective and still uses secondary data from medical record recording (SIMARS) and existing imaging, so there are limitations in controlling confounding variables that may affect the results of the study and allow for variations in data quality. The data used are still limited to patients with clinical dementia who have symptoms only and undergo a head MRI examination at

Ngoerah Hospital Denpasar Bali so the sample may not be fully representative of the general population with dementia

CONCLUSION

The study reveals a significant relationship between certain brainstem anatomical parameters—namely the midbrain-to-pons ratio and middle cerebellar peduncle (MCP) width—and cognitive impairment in clinical dementia patients as measured by the MoCA-Ina score, suggesting these markers may serve as valuable complementary biomarkers alongside traditional cortical assessments. While these parameters showed moderate predictive power for cognitive decline, others like the anteroposterior midbrain diameter and interpeduncular angle did not, indicating the need for further research to clarify which brainstem structures are most clinically relevant. These findings highlight the importance of including infratentorial evaluations in neuroimaging protocols to enhance diagnostic accuracy, especially when cortical atrophy is subtle or absent. Future research should employ longitudinal and multi-center studies with diverse populations to determine the temporal relationship between brainstem atrophy and cognitive decline, validate findings across dementia subtypes, and utilize advanced imaging techniques (e.g., diffusion tensor imaging, volumetric analysis) to better characterize microstructural changes. Additionally, improving the cultural sensitivity of the MoCA-Ina, alongside integrating artificial intelligence for automated brainstem measurement, could enhance early detection and streamline clinical workflows, ultimately advancing dementia diagnosis and patient outcomes.

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